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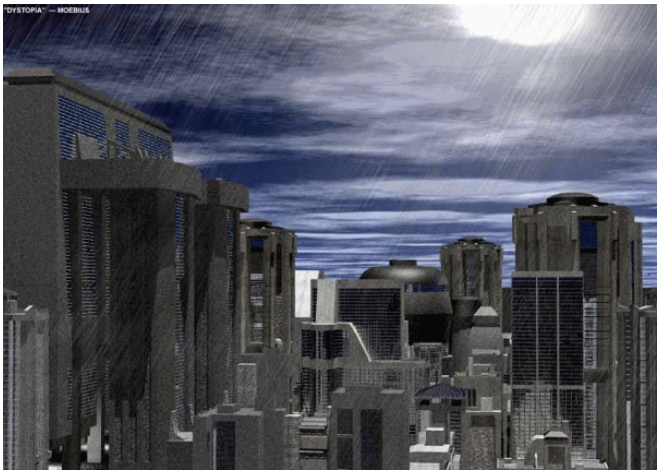
CLIMATE PROGRESS

Exclusive: Caldeira calls the vision of Lomborg's Climate Consensus "a dystopic world out of a science fiction story"

September 5, 2009



If you don't do aggressive greenhouse mitigation starting now, you pretty much take geo-engineering off the table as a very limited (but still dubious) add-on strategy.

The only upside I can see to all of the media coverage Bjorn Lomborg is getting for his do-nothing climate "consensus" is this one sentence by *NYT* reporter John Broder:

> Critics in the environmental movement call him a "**delayer**" who believes that the problem will solve itself through the miracle of as-yet-unidentified science.

Apparently all of my critiques haven't gone for naught (see "The Bjorn Irrelevancy: Duke dean disses Danish delayer"). Well, ok, those critiques didn't stop Broder from writing an unjustifiably warm piece on the pro-warming man I called "the second most famous Danish delayer after Hamlet (see "Lomborg's main argument has collapsed").

Note to Broder: I'm not in the "environmental movement" nor have I even been. I'm in the "stop humanity's self-destruction movement," which isn't quite so easy to pigeonhole. But I digress.

Juliet Eilperin had a much better piece in the *Washington Post*, which actually included a response from real climate scientists:

> The group, headed by statistician Bjorn Lomborg, issued a report by five economists that suggested it made more sense to spend money on marine cloud whitening research and green energy development than to protect forests, clean up diesel emissions or significantly raise the price of carbon....
>
> Several scientists questioned whether focusing on geoengineered solutions at the expense of major carbon reductions would adequately address the effects of climate change. Carnegie Institution senior scientist Ken

> Caldeira, a geoengineering expert, said such a strategy "misses the point."
>
> **"Geoengineering is not an alternative to carbon emissions reductions," he said. "If emissions keep going up and up, and you use geoengineering as a way to deal with it, it's pretty clear the endgame of that process is pretty ugly."**
>
> Brad Warren, who directs the ocean health program at the advocacy group Sustainable Fisheries Partnership, noted that even if marine cloud whitening worked, it would fail to address the fact that human-generated carbon emissions are making the seas more acidic and threatening marine life.
>
> "I haven't seen anything in the area of geoengineering that protects the ocean from the chemical consequences of greenhouse gas emissions," Warren said.

The group's inane results are here, and I'll discuss the voodoo economics behind them later. But the comment of Ken Caldeira caught my eye. I've known him for many years and I asked him if he could explain his remarks. His response (boldface added):

> *Nobody has written about this that I know of, but ….*
>
> **If we keep emitting greenhouse gases with the intent of offsetting the global warming with ever increasing loadings of particles in the stratosphere, we will be heading to a planet with extremely high greenhouse gases and a thick stratospheric haze that we would need to main more-or-less indefinitely. This seems to be a dystopic world out of a science fiction story.** First, we can assume the oceans have been heavily acidified with shellfish and corals largely a thing of the past. We can assume that ecosystems will be greatly affected by the high CO2 / low sunlight conditions — similar to what Earth experienced hundreds of millions years ago. The sunlight would likely be very diffuse — maybe good for portrait photography, but with unknown consequences for ecosystems.
>
> We know also that CO2 and sunlight affect Earth's climate system in different ways. For the same amount of change in rainfall, CO2 affects temperature more than sunlight, so if we are to try to correct for changes in precipitation patterns, we will be left with some residual warming that would grow with time.
>
> And what will this increasing loading of particles in the stratosphere do to the ozone layer and the other parts of Earth's climate system that we depend on?
>
> On top of all of these environmental considerations, there are socio-political considerations: We we have a cooperative world government deciding exactly how much geoengineering to deploy where? What if China were to go into decades of drought? Would they sit idly by as the Climate Intervention Bureau apparently ignores their plight? And what if political instability where to mean that for a few years, the intervention system were not maintained ... all of that accumulated pent-up climate change would be unleashed upon the Earth ... and perhaps make "The Day After" movie look less silly than it does.
>
> Long-term risk reduction depends on greenhouse gas emissions reduction. Nevertheless, there is a chance that some of these options might be able to diminish short-term risk in the event of a climate crisis.

I would add the grave risk that that after injecting massive amounts of sulfate aerosols into the atmosphere for a decade or more, we might discover some unexpected bad side effect that just gets worse and worse. After all, the top climate scientists underestimated the speed and scale of greenhouse gas impacts (and the magnitude of synergistic ones, like bark beetle infestations and forest fires).

We would be in incompletely unexplored territory — what I call an experimental chemotherapy and radiation therapy combined. There is no possible way of predicting the long-term effect of the thick stratospheric haze (which, unlike GHGs, has no recent or paleoclimate analog). If it turned out to have unexpected catastrophic impacts of its own (other than drought), we'd be totally screwed.

No surprise, then, that science advisor John Holdren told me in April that he stands by his critique:

> "The 'geo-engineering' approaches considered so far appear to be afflicted with some combination of high costs, low leverage, and a high likelihood of serious side effects."

Even geoengineering advocate Tom Wigley is only defending "a complementary combined mitigation/geoengineering scenario, an overshoot concentration pathway where atmospheric carbon dioxide reaches 530 ppm before falling back to 450 ppm, coupled with low-intensity geoengineering," with the goal of stabilizing global temperature rise at 2°C, in case we can't stabilize at 450 ppm. You can see a good discussion of that at the *Bulletin of Atomic Scientists*' expert roundtable response to Alan Robocks' excellent piece, "20 reasons why geoengineering may be a bad idea."

Well, stabilizing at 530 ppm requires doing a massive amount of mitigation starting now — only 2 or 3 fewer wedges than what is needed for 450 (see "How the world can (and will) stabilize at 350 to 450 ppm: The full global warming solution").

Ignore the delayers, already, status quo media. The time for aggressive greenhouse gas reduction is now.

Related Post:

- Science on the Risks of Climate Engineering: "Optimism about a geoengineered 'easy way out' should be tempered by examination of currently observed climate changes"

This entry was posted by Joe on Saturday, September 5th, 2009 at 10:19 am and is filed under Geoengineering. You can follow any responses to this entry through the RSS 2.0 feed. Both comments and pings are currently closed.

41 Responses to "Exclusive: Caldeira calls the vision of Lomborg's Climate Consensus "a dystopic world out of a science fiction story""

1. *Len Ornstein* says:
   September 5, 2009 at 11:07 am

   There are a couple of other climate 'fixes', published in the September issue of Climatic Change (that most also will call "geoengineering"), but that provide from 8 to 13 GtC/yr in 'new' biosequestration that suffers from very few – or none of the downsides of 'standard' geoengineering:

   Irrigated afforestation of the Sahara and Australian Outback to end global warming

   http://www.springerlink.com/openurl.asp?genre=article&id=doi:10.1007/s10584-009-9626-y

   and

   Replacing coal with wood: sustainable, eco-neutral, conservation harvest of natural tree-fall in old-growth forests

http://www.springerlink.com/openurl.asp?genre=article&id=doi:10.1007/s10584-009-9625-z

Hope this helps.

Len Ornstein

2. *paulm* says:
September 5, 2009 at 11:16 am

... extremely high greenhouse gases and a thick stratospheric haze that we would need to main more-or-less indefinitely...

Sounds like Venus coming to us.

3. *david g swanger* says:
September 5, 2009 at 11:56 am

I've written in twice to defend the consideration of geoengineering.

This would be a good time to say that I agree completely with Caldeira and that geoengineering makes no sense without agressive or radical mitigation at the same time. Just wanted to make that clear, if it wasn't from previous postings.

[*JR: Thanks. I have no illusions about how desperate we will be to avert catastrophe come the 2020s -- let alone the 2030s or 2040s. If we don't start the aggressive mitigation now, though, we close out so many options for them, other than unbridled suffering.*]

4. *DonkasaurusPost* says:
September 5, 2009 at 12:57 pm

Even the NY times piece cited above takes the rampantly common and somewhat skewed approach of making points "safely" through the use of ascribing it to "critics."

Yes, it is true that "critics" and others, call him a delayer. But does one have to be a "critic" to do so? No.

What is also not being given enough attention, in addition to the fact the geo-engineering itself is extremely reckless, very expensive, and otherwise highly questionable, is that to look at it, at this premature point in time is a ridiculously backward approach, itself given undue attention because of the constant politically driven misframing of this issue.

To wit;

> When a body is hemorrhaging blood, and the hemorrhaging stops, some action may still need to be taken to return to decent health, or even to preserve life itself. But no one on the battlefield or in the hospital sits there and goes "well, let's let the blood continue to flow, because while he may lose the use of the leg, or part of the brain, maybe, theoretically, we can keep him from losing his life." [Rather], you work to stop the flow of blood – the immediate problem. *You don't put off this effort by looking at ways, after the fact, to potentially mitigate that harm which has already accumulated from that which could not or was not already arrested.*
>
> ...[Geo-engineering] is a pathetic attempt to once again ignore sensibly dealing with the problem — as was decrying greenhouse gas concentrations' potentially overpowering role in world climate and ecological change in the first place.

> ...But of course the problem for the new breed of denyers and [delayers], is the same problem that led most to denounce the existence of the basic, incontrovertible, underlying science in the first place: Our economy was built on coal and oil; and, not understanding economics, they can not see that the proactive acts necessary to change this ***is in itself*** productive economic activity, as productive as any economic activity as was produced by coal and oil use in the first place, if not, now, in the long run, far more so.>

http://donkasauruspost.com/2009/09/05/the-seriously-donkey-way-to-address-problematic-man-induced-greenhouse-gas-expansion/

5. *Phillip Huggan* says:
   September 5, 2009 at 1:42 pm

   The volunteer who invented the cloud making hypothesis that WSJ attributes to Bjorn probably would've done so years ago with a tiny venutre cap or thinktank stipend. Be interesting to get some estimates on how much the cloud ship/float solution costs; my attempts here didn't last overnight (I get why this recession happened). Doesn't solve ocean acidification as CP points out and like all cloud solutions doesn't ensure low clouds are created over Greenhouse-ish higher altitude clouds, I think.

   I'm thinking these devices would resemble oil rigs in appearance. Power sources would hopefully be future wave, solar or offshore wind, hopefully cheaper than 10 cents/kWh despite remote location.
   IDK much about the mechanical processes of aerosolizing seawater, but probably desalination-like expensive even in future.
   Curved steel is made by contractors like Boeing and General Dynamics. Is expensive.
   Maybe you need one million of these things (much less for R+D)? Maybe they cost a billion dollars a pop in construction and maintenance costs later this century? That's one quadrillion dollars, or a global wartime economy for a couple decades. I'm guessing an extreme underestimate because there is likely to be some limiting substrate.

6. *ecostew* says:
   September 5, 2009 at 8:56 pm

   Well, shame on our Congress (i.e., members that don't or chose not to get themselves informed/grounded in peer-reviewed climate/energy science & members that choose to make it a higher priority of being re-elected)if legislation is not moved forward – future generations will never forgive you, including your children!

7. *Rick Covert* says:
   September 5, 2009 at 10:57 pm

   Joe,

   What about Terra Prieta or sequestration of carbon by way of charcoal and how many wedges would it merit? It seems like a geoengineering solution with very few if any downsides. It seems like we need to do this anyway and it aids in soil fertility while sequestering CO2 into the soil in a highly stable form of carbon. Tim Flannery has been a big booster for this solution.

8. *Bob Wallace* says:
   September 6, 2009 at 1:15 am

Len, I haven't been able to read the entire article, only the abstract (ISP problems), but...

"Replacing coal with wood: sustainable, eco-neutral, conservation harvest of natural tree-fall in old-growth forests"

That just sounds out of whack.

Have you ever looked at the volume of coal that a plant goes through each day? Ever stand outside and watch the railroad cars flow in?

Have you ever walked through an old growth forest and inventoried the windfalls? That is windfalls per year, not several years accumulation.

And have you thought of the method and energy required to get that downed wood out of a mature forest without cutting your way through?

I've looked at coal plants.

And there's about a thousand acres of old growth Douglas fir that abuts my land. A big tree going down is a rare thing. In the 40+ acres that I view regularly there hasn't been a windfall in the last six years, and I don't know how many years had passed before I started watching. Nothing on the ground looks less than 25 years down.

On my 60 acres there has been one big tree fall in the last six years. Certainly not a railroad car of energy in it, big oak as it was.

9. *J4zonian* says:
September 6, 2009 at 10:42 am

I think we have to be careful of the arguments we make. Is there really "no possible way of predicting the long-term effects of the stratospheric haze"? How bout if we use the same types of computer models we're constantly having to defend from the attacks of the flat-earthers? Instead of giving denialists a huge opening to walk through by making a grand and sweeping statement that's almost certainly false, maybe it would be enough to say there will no doubt be unexpected effects–which is almost certainly true–and leave it at that.

P.S. should be " "an" experimental chemotherapy and radiation..."

[*JR: The statement is true, but I added a further clarification. Your concern is misplaced for two reasons. First, as I explained, the fact is that scientists have underestimated the scale and speed of climate impacts from GHGs using their models. And who predicted the devastation from the bark beetle? The positive, amplifying carbon cycle feedbacks have turned out to be much worse than we thought, whereas the negative feedbacks all appear to be weaker or nonexistent. Second, the climate models at least have the benefit of both the recent GHG and temperature record -- nd the paleoclimate record. The fact that the models do reproduce recent temperature trends when you include all forcings, including human ones, gives us confidence in them. But I am unaware of a paleoclimate or recent analog for a massive, sustained injection of aerosols -- let alone one that occurred during a massive sustained injection of GHGs. There's a reason the dictum for doctors is "First, do no harm."*]

10. *Leland Palmer* says:
September 6, 2009 at 11:04 am

Trying to visualize the problem, it's hard to visualize a happy ending to Abrupt Climate Change (ACC) without biomass/CCS, called BECS (Biomass Energy with Carbon Storage) by Read and Lermit in the

following paper.

We need active remediation of this problem, acting in parallel with mitigation efforts.

The coal fired power plants constitute a currently existing way to process billions of tons of carbon per year. It they could be modified to transfer carbon from biomass (and indirectly the atmosphere) into the earth, this opens up the potential of carbon negative energy production, in which active remediation is done at the same time as useful electricity is generated.

http://www.etsap.org/worksh_6_2003/2003P_read.pdf

> Under strong assumptions appropriate to imminent ACC, pre-industrial CO2 levels can be restored by mid-century using BECS...
>
> Introduction
>
> Taking steps to insure against abrupt climate change (ACC – NAS, 2001) was identified by Schelling (1992) as the primary rationale for greenhouse gas mitigation. ACC was recognized in the third Assessment Report of the IPCC as an issue that 'haunts the climate change problem' (IPCC, 2001).
>
> However, ACC has been neglected by policy makers, who, without regard to the specific technological requirements of ACC insurance, have struggled to achieve consensus through negotiated commitments to generalized emissions reductions in response to the 'absent problem' of gradual climate change (Michaelson, 1998).
>
> Recent advances in technological understanding (Obersteiner et al, 2001) suggest the availability of an insurance strategy that addresses the issue in
> terms of policy-driven technological change, whilst offering side benefits in terms of fuel security and sustainable development. Crucial to such a strategy – and not discussed in this paper – would be improved scientific understanding of ACC to yield the capacity to recognize precursor signals of an imminent bifurcation in climate dynamics.
>
> Also not discussed in detail in this paper is an aspect of the new technological understanding that is advancing rapidly, that is technologies for carbon capture and storage (CCS), disposing of CO2 underground and maybe in deep oceans.
>
> Both CCS and bio-energy are technology types rather than specific technologies. CCS involves either pre or post combustion separation of CO2 in either new plant or retrofitted, and its disposal in a variety of receptors, including secondary oil recovery, coal bed methane, exhausted hydrocarbon reservoirs, saline aquifers, and maybe deep ocean.
>
> **Bio-Energy can provide energy carriers to meet final demands for both stationary and transportation needs, through a variety of technology chains involving numerous sources of biomass raw materials derived from wastes or from dedicated land used for energy plantations or for annual energy crops. Whichever is specified, the combination of a pair of technologies involving one from each type leads to an energy system with negative emissions characteristics, i.e. Bio-Energy with Carbon Storage technology (BECS) and – in combination with raised energy efficiency and non-fuel renewables – it leads also to the potential to return rapidly to pre-industrial CO2 levels (Obersteiner et al, op cit).**
>
> **Negative emissions energy systems are key to responding to ACC because – taking account of rising levels on non-CO2 greenhouse gases, for which no means exists for accelerating natural removal processes – the need may be to get to CO2 levels below pre-industrial.**

> **This cannot be done by natural absorption, even with zero emissions energy3. In this context it should be noted that the 'two times CO2' criterion much cited in the literature, is a social construct devised as a basis for model comparison and influenced by outdated ideas as to what level it is feasible to aim for: it has no scientific basis as an indicator of what the FCCC's Art 2 'non-dangerous' level is, and does not indicate a threshold for precipitating ACC.**

The language of the paper is somewhat stilted and dense, but it does represent a road map to a better future than that provided by greenhouse gas mitigation alone, I believe.

What we need is massive remediation, at the same time as massive mitigation, running parallel and in tandem with the mitigation efforts.

For active remediation, we need to actively transfer carbon out of the atmosphere, and find a reservoir to put it in, somewhere where it does not cause greenhouse effects.

Carbon capture and storage, for geological storage or in situ mineral carbonation, provides such a solution:

http://www.pnas.org/content/105/29/9920.full.pdf+html

> Carbon dioxide sequestration in deep-sea basalt
>
> Developing a method for secure sequestration of anthropogenic carbon dioxide in geological formations is one of our most pressing global scientific problems. Injection into deep-sea basalt formations provides unique and significant advantages over other potential geological storage options, including (i) vast reservoir capacities sufficient to accommodate centuries-long U.S. production of fossil fuel CO2 at locations within pipeline distances to populated areas and CO2 sources along the U.S. west coast; (ii) sufficiently closed water-rock circulation pathways for the chemical reaction of CO2 with basalt to produce stable and nontoxic (Ca2 , Mg2 , Fe2)CO3 infilling minerals, and (iii) significant risk reduction for post-injection leakage by geological, gravitational, and hydrate-trapping mechanisms. CO2 sequestration in established sediment-covered basalt aquifers on the Juan de Fuca plate offer promising locations to securely accommodate more than a century of future U.S. emissions, warranting energized scientific research, technological assessment, and economic evaluation to establish a viable pilot injection program in the future.

Most coal fired power plants are located on rivers, for cooling water. These rivers constitute a natural biomass collection and transport network, for either currently existing biomass waste or biomass plantations located on the watershed that is drained by those rivers.

Carbonization of biomass into biochar can produce a fuel as energy dense, storage stable, and transportable as coal.

Most coal fired power plants in the U.S. are also located over deep saline aquifers, with hundreds of billions of tons of potential CO2 storage volume, for CO2 injected into these formations a couple of kilometers deep in the earth.

We need to continue with our mitigation efforts.

We need to launch a "carbon negative" active remediation effort in parallel with the mitigation effort.

We need to stop believing industry lies, and industry sponsored studies with industry sponsored assumptions, which lead to industry friendly political results.

11. *Len Ornstein* says:

September 6, 2009 at 12:18 pm

Bob Wallace:

If and when you get to read the papers, you'll find that I was referring to TROPICAL old growth forests. All your observations properly apply to temperate old growth forests – but NOT to tropical forests.

12. *ecostew* says:
September 6, 2009 at 12:34 pm

Len, What fraction of the coal-fired power plants exist in the tropics?

13. *Leland Palmer* says:
September 6, 2009 at 1:24 pm

Hi Len-

Still digesting your papers. Very interesting ideas, IMO.

It might work best with nuclear powered desalination and irrigation.

Wildfire prevention might be a problem.

Carbon storage in trees is certainly going to be a big part of our coming climate solution, but which part?

Everything should be on the table, nothing off the table, every idea considered according to its scientific and economic merits.

Thank you for your efforts, and I'll read your papers with interest.

14. *Jim Eager* says:
September 6, 2009 at 3:02 pm

Len, most tropical soils are nutrient depleated, as most of the available nutrients are locked in the biomass of said old growth tropical forests. Harvesting deadfall from those forests for fuel would permanently remove those nutrients. Who would you address that?

15. *Jim Eager* says:
September 6, 2009 at 3:03 pm

Oops, that should be:
How would you address that?

16. *Bob Wallace* says:
September 6, 2009 at 4:02 pm

Len – I don't feel like paying to read your input.

Why don't you spell things out here if you want to push your ideas on a public forum?

And please address the issue of getting downed trees out of tropical forests and onto the grid. I've been in tropical forests. A lot of dead stuff rots while standing and removing fallen sound wood would be difficult and expensive, not to say damaging to forests. That's why we typically farm trees rather than selectively cut.

17. *Leland Palmer* says:
September 6, 2009 at 4:27 pm

I wonder if Len's Sahara project could "bootstrap" itself, once a start was made, by the use of carbon negative biomass plus deep injection power schemes? Could sufficient power be generated to do the desalination and irrigation required? How about methane hydrate deposits? Could sufficient methane be harvested from dissociating hydrate deposits to be burned and the resulting CO2 deep injected to power the scheme?

I wonder what the state of Saharan deep saline aquifers are, and what the prospects for in situ mineral carbonation are, off the African coasts?

Advantages that I can see are huge tracts of unused land, and probable less concern for CCS leakage under an area that is currently almost unpopulated, and less regulatory difficulty, probably, in obtaining permits and the like.

Disadvantages might include a lack of existing coal fired power plants to be converted, lack of natural river transport networks for the biomass, and problems keeping such forests from drying out and becoming tinderboxes.

Len's original idea seems to be to use the trees as carbon storage, and I think that might not be such a good idea. What if the irrigation system breaks down, due to war, or global warming itself? A lot of that standing carbon might end up burning in wildfires.

I guess the contention is that, once established, such forests might be self-sustaining, as in the Amazon basin. this seems possible, but might be risky.

Certainly, the Sahara is a "blank slate" and is available land, for concentrating solar power or whatever use, if humanity can become united in fighting this fight.

I think it's important to carefully evaluate such ideas, and not "throw the baby out with the bathwater" by rejecting them too quickly.

I believe that if we can get the fossil fuel corporation propaganda out of our heads, and make full use of the resources of the earth, we can solve this runaway global warming problem, and even have a good time doing it.

But, we can't do it by adding more factors to a situation already explosively degenerating into an out of control situation, IMO, by adding geoengineering schemes to a situation already beyond our comprehension.

We need to take the carbon added to the system by the industrial revolution back out of the system, in one way or another, IMO. One thing we know is that the climate system we were given, before the addition of 300 billion tons of fossil carbon by the industrial revolution, was stable. If we get back to that situation, chances are that the climate system would become stable again. This seems like our best shot at avoiding catastrophe- take the carbon out of the system and allow the climate system to heal itself.

Len's ideas are one possible way to do that, and such ideas deserve careful consideration, IMO.

In the lab where I work, analytical problems are often solved a piece at a time. Combining one piece of the solution with another can often lead to a synergistic solution. We need to find such a synergistic solution ASAP, and not reject any pieces of the puzzle prematurely.

ecostew says:
September 6, 2009 at 4:58 pm

To start with – grow trees where they grow best naturally!

19. *Leland Palmer* says:
September 6, 2009 at 5:37 pm

Hi ecostew-

Well, you could be right.

Certainly, starting with the heavily forested Mississippi/Ohio watershed, with it's existing coal fired power plants which could be converted, its huge resources of forests and agricultural biomass "waste", and it's natural river transport network (not to mention a huge railway and road network) seems easier and quicker than creating artificial forests in the Sahara.

We owe it to the earth to "do the math", though, and not reject ideas out of hand "by the light of reason".

And the Sahara is a "blank slate", and potentially a huge carbon sink, if we can figure out how to turn these factors to our advantage.

It's an intriguing idea.

I think it is a "longshot" too, though, so far.

20. *ecostew* says:
September 6, 2009 at 5:54 pm

The Sahara exists due to climatic conditions and it will take a huge amount of energy and water to do the experiment. It's best to manage forests where they grow best, which doesn't mean that one shouldn't push back on desertification.

21. *David B. Benson* says:
September 6, 2009 at 6:25 pm

Jim Eager & *Bob Wallace* — As close to the felled tree as possible, densify via torrification or another pyrolysis process. Transport, via river/canal/lake/ocean as much as possible, to a wood burner to produce elctricity. Return the ash, containing the nutrients, to the forest. The feasiblity depends almost entirely upon transportation costs. A coal burner in South Carolina is being relicensed as a wood burner; there is enough otherwise unused wood nearby that this competes with Appalachian coal.

ecostew & *Leland Palmer* — Thousands of years ago much of the Sahara was an open woodland savannah. All that is needed to do that again is water. The place to start is to the south, the Sahel. All the countries with Sahel savannah would very much like to plant a wide belt of treees to ward off the encroaching desert in the north. With the proper choice of tree peciess, no irrigation is required. Indeed the local labor force would be happy, I believe, to do the work. But these countries are too poor to start the massive tree nurseries required. They have appealed to the EU, I think, but so far nothing has been done.

As for leaving/taking the trees which eventually die, that is many years in the future; additional research meantime will make clear to appropriate ratios in each locality.

22. *ecostew* says:
September 6, 2009 at 7:38 pm

David,
Actually you restated my point nicely. One must remember use of trees (biomass) for electricity carries with it an energy density issue (also an air emissions issue), as you point out and, which also means that you can only get so much biomass to electricity in the big picture of a secure energy supply and also, why making biofuels rather than electricity at this point is a non-starter based on EROEI.

23. *David B. Benson* says:
September 6, 2009 at 8:14 pm

ecostew (22) — Thank you. As for air emissions, much easier to contorl from a wood burner than a coal burner. As for biofuels, in some locations biodiesel from Jatropha is being started in a big way for reasons of energy security. Boviously ethanol from maize is a loser on several grounds, but ethanol from sugarcane is again done in Brazil and India to provide energy security.

However, it is certainly the case that biomass cannot be the sole solution to the world's erergy "desires". See the last portion of
http://www.eoearth.org/article/Global_human_appropriation_of_net_primary_production_(HANPP)

24. *Bob Wallace* says:
September 6, 2009 at 8:23 pm

If we get some sort of cap and trade in place then there would be funding for increasing the amount of biomass produced on marginal lands, be it desert or simply played out farmland.

A very efficient expenditure of funds would be to pay poor farmers a basic living wage to grow selected crops that would improve the soil and capture carbon. We've identified several varieties of nut bearing trees which will grown in poor soil, require little water, and produce nuts which can be used for biofuel. Harvesting will probably labor intensive, but in those areas where life is very tenuous people don't object putting in a good day's work for decent pay. Once the trees are played out they can be turned to biochar and incorporated into the soil.

There are crops such as switchgrass which will also grow in pool soil, need little water, and improve the soil/sequester carbon via their extensive root systems. The tops can be harvested for conversion to ethanol.

There are lots of ways that a small amount of the C&T money could be used to cut our fossil fuel use, sequester carbon, and improve the lives of some of the poorest of us. As well, spread us out a little, cut down the number of people who are swelling the poorest parts of our cities.

25. *ecostew* says:
September 6, 2009 at 8:36 pm

While restoration of marginal lands is great and can assist with carbon storage, marginal lands will not any time soon contribute to energy security without huge inputs of fertilizer, water, etc.

26. *Len Ornstein* says:
September 6, 2009 at 10:06 pm

Bob Wallace:

You don't have to pay to read those papers. Both are "open access" at the Springer website. We payed $3,000 a piece in order for them to immediately be free to everybody!

Getting the trees out IS addressed – e.g., using Boeing's Skyhook, neutrally-buoyant lighter-than-air-ships, designed with logging in mind – and referenced in the bibliography.

Most of the caveats you might think of are addressed in the texts – such as replacing each harvested tree with its equivalent of wood ash, to avoid mineral depletion.

27. *ecostew* says:
September 6, 2009 at 10:20 pm

Len, You have not addressed the sustainability/EROEI issues raised!

28. *Bob Wallace* says:
September 7, 2009 at 12:02 am

ecostew – Switchgrass is one plant that can be grown in a lot of very marginal areas with little fertilizer and needs little water. It's a native grass also know as "prairie tallgrass" and grew from Southern Canada south to Mexico without fertilizer or irrigation.

At most, it might need some help getting established, but should be self-sustaining. It's a perennial with a 10+ year life span.

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The Croton tree produces a nut that is 27% oil. It doesn't need irrigation once established. And there are others.

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There's some interesting recently developed irrigation tubing which allows plants to be watered with salt or highly contaminated water. The tubing material allows water to seep through under quite low pressure and traps the salt, etc. inside. Periodically the tubes need to be flushed. The flushed material can be collected in evaporation ponds and disposed of when dry.

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We're developing food plants that will grow in brackish/salty water, which should be very important in places such as Bangladesh where the ground water is beginning to be contaminated by rising sea levels.

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By carefully choosing the right plant for the location it should be possible to greatly increase plant cover over a lot of land that is now standing largely bare. If we can pull a little fuel off those plants and create some jobs for poor people it would seem to be a win-win.
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Len – thanks, I'll go back and look again. I didn't notice the free to read option, only the purchase option.

29. *Leland Palmer* says:
September 7, 2009 at 3:55 am

With regard to EROEI for biomass, I think those problems have been overstated.

Transporting biomass is more energy intensive than transporting biochar, for example. Transforming biomass into biochar is an exothermic process, which generates combustible gases during this carbonization process, as well, and can be done close to the source of the biomass. Some energy content is lost during the transformation, but most of the carbon remains in the biochar. The resulting biochar is as energy dense and transportable as coal.

Dewatering could be done by solar energy, in a sunny climate, and help improve on EROEI. Dewatering can also be done with waste heat from the carbonization process.

If the biomass was harvested at a higher elevation than the power plant, gravity can assist in its transport. When transporting biomass down rivers by barge, the role of gravity is obvious. The same effect, of gravity assisted transport, though, could be accomplished by running an electric railway, equipped with regenerative braking on the down slopes, in a continuous loop. The heavier, fully loaded trains going downhill could harvest gravitational potential energy via regenerative braking, and use that energy to power the lighter, empty trains going back up to higher elevations.

Another example of gravity assisted biomass transport could be biochar log pipelines made with coal log pipeline technology.

http://www.nrel.gov/docs/fy00osti/26740.pdf

The difference is that biochar is much, much cleaner than coal and the water used in these pipelines should be quite clean, and certainly be suitable for irrigation, due to the large content of activated charcoal in biochar. Really huge amounts of biochar could be transported by such pipelines. Water could be taken from higher elevations, used in these biochar log pipelines, and then used for irrigation at its destination, probably without any remediation of the water.

With regard to biomass not being able to power our entire society, well, there is enough biomass to power our entire society, IMO. But it doesn't have to power our entire society, to be very, very useful.

Due to the synergistic effects of carbon negative energy production, which simultaneously sequesters carbon, displaces fossil fuel use, generates electricity for use in electric cars, could assist in fire protecting forests, and could carbonize urban and biomass waste and prevent the production of methane from its decay, we could reach carbon neutrality with far less than total conversion to biomass/biochar, IMO.

But carbon neutrality is not enough, IMO. We need to either shut down or convert every coal fired power plant in the U.S. to enhanced efficiency carbon negative power plants, that run on biochar and store their CO2, to have a prayer of stopping runaway global warming, IMO. And the rest of the world needs to do the same.

30. *ecostew* says:
September 7, 2009 at 7:38 am

Based on EROEIs, liquid biomass biofuels to ICEs is much less efficient and more environmentally degrading than biomass electricity to EV/PEV.

31. *ecostew* says:
September 7, 2009 at 8:45 am

Although biomass to electricity is far more efficient the biomass to biofuels, this is text from a recent article:

Science 17 July 2009:
Vol. 325. no. 5938, pp. 270 – 271
DOI: 10.1126/science.1177970

Policy Forum
Energy:
Beneficial Biofuels—The Food, Energy, and Environment Trilemma
David Tilman, Robert Socolow, Jonathan A. Foley, Jason Hill, Eric Larson, Lee Lynd, Stephen Pacala, John Reilly, Tim Searchinger, Chris Somerville, Robert Williams

"Biofuels should receive policy support as substitutes for fossil energy only when they make a positive impact on four important objectives: energy security, greenhouse-gas emissions, biodiversity, and the sustainability of the food supply. Performance-based policies are needed that provide incentives proportional to the benefits delivered. Legislation that is vague could allow significant portions of the biofuels industry to develop along counterproductive pathways. Complementary policies must directly target related goals, such as land- and water-efficient food production, reduced agricultural greenhouse-gas emissions, and the prevention of habitat loss from land-clearing. The recent biofuels policy dialogue in the United States is troubling. It has become increasingly polarized, and political influence seems to be trumping science. The best available science, continually updated, should be used to evaluate the extent to which various biofuels achieve their multiple objectives, and policy should reward achievement. Three steps should be taken: meaningful science-based environmental safeguards should be adopted, a robust biofuels industry should be enabled, and those who have invested in first-generation biofuels should have a viable path forward. In support of such policy, rigorous accounting rules will need to be developed that measure the impacts of biofuels on the efficiency of the global food system, greenhouse-gas emissions, soil fertility, water and air quality, and biodiversity. Accounting rules should consider the full life cycle of biofuels production, transformation, and combustion. Unless new technologies and life-styles are adopted globally over the coming decades, the massive projected increases in global energy and food consumption will greatly elevate atmospheric greenhouse-gas levels from fossil fuel combustion, land-clearing, and livestock production and will create immense biodiversity loss from habitat destruction and climate change."

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32. *Len Ornstein* says:
September 7, 2009 at 11:09 am

ecostew:

Energy return on energy invested (EROEI) is explicitly treated in both papers.

In the Irrigated Sahara project, the yearly EROEI largely depends on what kind of energy source is used for pumping (desalination and water distribution) which is discussed. It ALSO goes down linearly as the amount of irrigation required diminishes as a result of induced rainfall. And the value of an ultimately 'forever' sustainable harvest also increases the long-term energy return VERY substantially.

In Substituting Wood for Coal, it largely depends on how far the wood must be transported (but is a small fraction of the value of the wood as fuel). But even if the wood is just safely stored (rather than burned in power plants), the cost of the net sequestration of the 1.5 to 5 GtC/yr is tiny compared to the cost of that amount of CCS from coal-burning power plants!

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33. *Leland Palmer* says:
September 7, 2009 at 1:00 pm

Hi ecostew-

> In support of such policy, rigorous accounting rules will need to be developed that measure the impacts of biofuels on the efficiency of the global food system, greenhouse-gas emissions, soil fertility, water and air quality, and biodiversity. Accounting rules should consider the full life cycle of biofuels production, transformation, and combustion.

But hopefully the accounting rules and environmental permitting process will not be so stringent that it blocks beneficial new development.

This is an emergency, and we might have to give up some loss of soil fertility, for example, to turn the corner on this runaway global warming problem, and "dodge the bullet" from the coming decade or two of radical, self-sustaining and accelerating climate change.

It's important to not hold biofuels and biomass systems to an impossibly high standard of meeting multiple criteria, with new projects subject to "moving target" multiple rounds of criticism.

No such process is currently implemented for fossil fuels, for example, and this seems to be a double standard- a double standard that fossil fuel companies and those academics in fossil fuel supported programs are likely to want maintained.

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34. *David B. Benson* says:
September 7, 2009 at 7:00 pm

Len Ornstein — Yes, by all means green the Sahara, but don't forget the Sahel as well. Incidently, the RO and pumping energy needs are largely interruptable, so wind power with maybe some solar could handle those energy needs.

If you are going to do that, go the whole hog: use some of the land to grow algae to make biomethane to compete in the world-wide natural gas market. Some of the biomethane could be used locally for the RO and pumping via combined cycle gas turbines.

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35. *Len Ornstein* says:
September 7, 2009 at 7:36 pm

David B. Bensin:

Incidentally, the GCM simulations in our paper shows that the rainfall over the Sahel is also usefully increased by irrigating the Sahara forest – as a free bonus;-)

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36. *Leland Palmer* says:
September 9, 2009 at 3:39 am

Methane hydrate alert:

http://walrus.wr.usgs.gov/globalhydrate/poster.pdf

There appear to be some deposits of methane hydrate off the coast of Africa.

If these are substantial deposits, and they start to dissociate, they could provide more than enough methane to power Len's Sahara project, I think.

Combining hydrate remediation with carbon sequestration in Saharan forests seems like a good, synergistic

idea, which would simultaneously help limit ocean acidification, limit methane release to the atmosphere, and help store carbon in the forests.

The CO2 resulting from burning the hydrate methane should be deep injected, probably, into porous basalt strata below the ocean floor for in situ mineral carbonation. The electricity generated from burning the hydrates could be used to power the desalination units and pumps for groundwater to get the forests started.

Perhaps a lot of the resulting carbon, from the trees, could be turned into biochar and used as a soil amendment, to help build soil fertility.

37. *Leland Palmer* says:
September 9, 2009 at 10:11 am

On the other hand, about Len's idea, Chris Field says that tropical forests could release hundreds of billions of tons of carbon by 2100 by burning.

These would be irrigated tropical forests, in the Sahara, though.

If the carbon was deep injected as CO2, though, especially if it was deep injected off the African coasts into basalt strata for in situ mineral carbonation, it would be stable. And any carbon stored would be carbon taken out of the climate system, and would tend to help stabilize the climate system.

Perhaps Len's plan makes sense only if the carbon is stored in a stable form, by deep injection or mineral carbonation, and is more likely to succeed in the near term, with long term feasibility depending on climate change itself, how rapid and severe it becomes? So maybe we have a window of opportunity for Saharan forests, which is rapidly closing?

Maybe instead of growing trees where they grow naturally, we should grow trees where the models predict they will be capable of growing under severe global warming scenarios.

I would have said that was in the Canada and Siberia, until the bark beetle infestation. Once again, the Mississippi/Ohio basin might be a good place to put biomass plantations, and the Amazon Basin, which also looks to have potential hydrate deposits close to the coast of South America. The diversity of the Amazon flora might make it resistant to insect infestations.

In the short term, we need to concentrate on harvesting the beetle killed trees, IMO, and get as much carbon from these trees as possible underground, in converted, carbon negative coal fired power plants.

38. *Len Ornstein* says:
September 9, 2009 at 11:23 pm

Leland Palmer:

The bio-sequestration projected for the Sahara and Outback forests is about 8 GtC/yr – 'forever' – if eco-neutral conservation harvest is practiced as the forests mature. That, by itself, would almost stop AGW 'cold'! So with added conservation practices that pay for themselves, "severe global warming scenarios" could be permanently avoided.

39. *Leland Palmer* says:
September 13, 2009 at 10:15 am

Hi Len-

Sorry about the delay in replying, got busy on the job.

I think your scheme is worth a shot.

There aren't that many ways of "putting the genie back in the bottle" and we shouldn't neglect this one.

I think you should consider ways of making the carbon storage as permanent as possible. Then, if the worst case scenario occurs, you have still managed to take a lot of carbon out of the system.

I've been thinking about a high carbon concrete aggregate, for example, that takes charcoal, and ruins it forever for use as a fuel by adding a geopolymer to it. This results in a hard rock-like substance that is suitable for concrete aggregate, but not suitable as a fuel, and that will hopefully have the long term stability necessary. Difficulties include locating a sufficient source of alkali to create the geopolymer.

I think your scheme is worth trying, especially if coupled with methane hydrate remediation and power generation, from the continental shelves around north Africa, and in-situ mineral carbonation of the resulting CO2 in basalt deposits off the north African coasts.

Nobody can predict the future, and we don't have that many opportunities to win the whole ball game.

Maybe you all should look at fire resistant species. Eucalyptus supposedly use fire as a weapon against other species, and are some of the top biomass producing species – and might be a bad idea for Saharan forests.

Thank you for your ideas and efforts, and all of your hard work.

Good luck on your scheme.

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40. *Leland Palmer* says:
September 13, 2009 at 11:15 am

Here a link to a new paper that seems to indicate that methane can erupt upward from methane hydrate deposits in plumes, from the base of the hydrate stability zone, bypass the gas hydrate stability zone and be released into the ocean and atmosphere. This paper seems to indicate that methane release from hydrates can be up to one million times faster than was previously thought likely:

http://www.eurekalert.org/pub_releases/2009-09/miot-mgl090209.php

It appears that the continental shelves are going to start evolving massive amounts of methane, and that this methane will erupt in plumes adding to ocean acidification, unless we drill down through the gas hydrate deposits and harvest the methane, for power generation and deep injection of the CO2. So we're going to have massive amounts of methane to deal with, and more than enough energy from these methane releases to power your Saharan forest scheme, I think.

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41. *Jubal* says:
September 14, 2009 at 8:53 pm

We need every tool we can get. I for one am a huge propoent of biochar. I'd sugest anyone interested visit http://www.outbackbiochar.com for biochar information, biochar research and the latest biochar news. This wonderfully informative site has gardening tips with biochar, recent studies published all over the world and informative biochar articles. In addition you can purchase biochar for your home garden from Outback Biochar.

Thank you in advance for your support and remember, if we all work together we can make real progress on climate change!