American Presidential Choices: An Opinion Based On Climate Science

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I am a political Independent, fed up with both of our major parties. I have begun writing a piece in which I argue the case for a third party, not in 2016, but soon thereafter, if, as seems likely, the threat of a downward spiral in the economic prospects for young people becomes more apparent. Thus I intended to say nothing about the current election cycle.

However, an important issue about alternative energies has come up in the current campaigns. We would not need to get into the discussion if we had an across-the-board rising carbon fee. But in the absence of a rising carbon fee, we must pay close attention to energy infrastructure.

I can clarify the issue via the "ask" in our lawsuit against the U.S. government. Young people want the Court to require the government to produce a plan that approximately stabilizes climate. To first order, that requires restoring Earth's energy balance. As long as more energy is coming in than going out, Earth will continue to warm (see my Ted talk).

If other climate forcings remain unchanged, CO_2 must be reduced to about 350 ppm to restore planetary energy balance.[1] That is a huge "ask." It is technically possible, but it requires rapid phase-out of fossil fuel emissions complemented by policies that draw down atmospheric CO_2. If we change energy policies soon (including an underlying rising carbon fee; cap-and-trade is too ineffectual), that drawdown can be accomplished via natural or quasi-natural means.

We showed[2] that, if the net of other forcings is constant, restoring energy balance would require reducing fossil fuel emissions about 6% per year, as well as major reforestation and improved agricultural practices, so as to store about 100 GtC in the biosphere and soil.

The U.S. government is likely to respond with something like: "well, that is implausible, so we should be allowed to continue with our half-baked ineffectual policies" (they may use different adjectives). A common-sense answer to this cop-out is that, even if we fail to achieve 6%/year reductions, coming as close as practical to that goal improves chances of avoiding unacceptable consequences such as many-meter sea level rise. Moreover, there are two ways to relax the 6%/year requirement: (1) exceed the 100 GtC biosphere/soil CO_2 drawdown, (2) achieve a net reduction of non-CO_2 GHG forcings. The second of these has implications for the United States Presidential campaign. However, let me first make a comment on the first of these.

The portion of fossil fuel CO_2 emissions appearing in the air continues to hover at about 50%, as it has averaged for the past 25 years (Fig. 1), compared with the 60% during 1960-1990. This implies a huge increase in uptake of CO_2 by the biosphere/soil, which differs from what had long been anticipated. The assumption was that, if CO_2 emissions accelerated, as they have, the airborne fraction would likely increase, in part because the surface layers of the ocean (the biggest CO_2 sink) would tend to become relatively saturated with CO_2.

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[1] Hansen, J., M. Sato, P. Kharecha, D. Beerling, R. Berner, V. Masson-Delmotte, M. Pagani, M. Raymo, D.L. Royer, and J.C. Zachos, 2008: Target atmospheric CO_2: Where should humanity aim? *Open Atmos. Sci. J.*, **2**, 217-231.

[2] Hansen, J., P. Kharecha, M. Sato, V. Masson-Delmotte, F. Ackerman, D. Beerling, P.J. Hearty, O. Hoegh-Guldberg, S.-L. Hsu, C. Parmesan, J. Rockstrom, E.J. Rohling, J. Sachs, P. Smith, K. Steffen, L. Van Susteren, K. von Schuckmann, and J.C. Zachos, 2013: Assessing "dangerous climate change": Required reduction of carbon emissions to protect young people, future generations and nature. *PLOS ONE*, **8**, e81648, doi:10.1371/journal.pone.0081648.

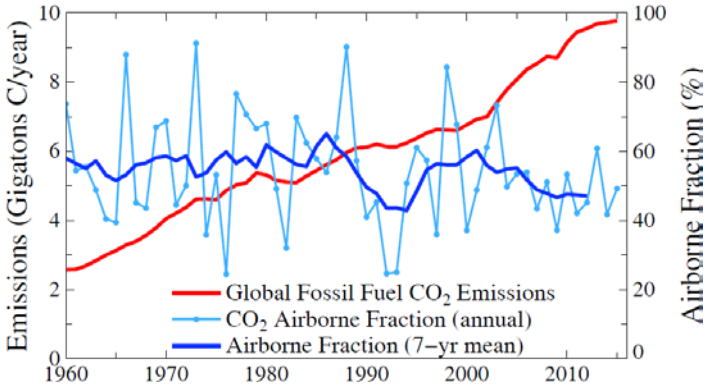

Fig. 1. Fossil fuel CO_2 emissions (left scale) and airborne fraction, i.e., the ratio of observed atmospheric CO_2 increase to fossil fuel CO_2 emissions. Update of Fig. 3 in Hansen et al. (2013).[3]

Why has nature sucked up more CO_2 than expected? We suggested[3] that increased drawdown may be largely due to human fertilization of the biosphere, via excessive application of fugitive nitrogen fertilizers and the effect of excessive atmospheric CO_2. Depending on what the correct explanation is, this good news on the carbon cycle could mean that it may be possible to achieve drawdown of somewhat more than 100 GtC via global improvements in agricultural and forestry practices, including reforestation and better soil management. These practices can be spurred via appropriate incentives in United Nations programs for climate adaptation and mitigation.

This moderate good news on the carbon cycle is offset by bad news on atmospheric methane (Fig. 2). Methane amount was stable from 1999 to 2006, but growth resumed in the past decade and accelerated more sharply in the past two years. Although the reasons for resumed methane growth remain to be accurately quantified, the largest methane source is fossil fuel mining and leakage, and the United States seems to be the greatest contributor.[4] The timing and location of renewed methane growth suggest hydraulic fracturing ("fracking") of shale formations as the primary cause of methane growth. There are two momentous implications of this development.

First, the hope of using a methane decrease to remove part of Earth's energy imbalance[5] is shattered, at least for a substantial period. Methane atmospheric lifetime is 10-12 years, so if the methane sources are reduced the methane climate forcing would fall rapidly. Present human-made methane forcing, including its indirect effects on other greenhouse gases, is 0.8-1 W/m^2. Although there are multiple sources of methane, including agriculture and landfills, in addition to fossil fuels, if a serious effort to phase out fossil fuels were undertaken it should be possible to reduce the methane forcing by about half. Such a reduction would go a long way toward removing the planetary energy imbalance.[6] Thus it is a huge setback if the "fracking" miracle is allowed to proceed, as it indefinitely postpones a decrease of methane forcing.

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[3] Hansen, J., P. Kharecha, and M. Sato, 2013: Climate forcing growth rates: Doubling down on our Faustian bargain. *Environ. Res. Lett.*, **8**, 011006, doi:10.1088/1748-9326/8/1/011006.

[4] Turner, A.J., Jacob, D.J., Benmergui, J., Wofsy, S.C., Maasakkers, J.D., Butz, A., Hasekemp, O., and Biraud, S.C., 2016: A large increase in U.S. methane emissions over the past decade inferred from satellite data and surface observations. *Geophys. Res. Lett.*, **43**, doi:10.1002/2016GL067987.

[5] Hansen, J., M. Sato, R. Ruedy, A. Lacis, and V. Oinas, 2000: Global warming in the twenty-first century: An alternative scenario. *Proc. Natl. Acad. Sci.*, **97**, 9875-9880, doi:10.1073/pnas.170278997.

[6] Note that this way of quantifying methane's role, via its current global climate forcing and the methane lifetime, is more informative than the esoteric and misleading "global warming potential" approach.

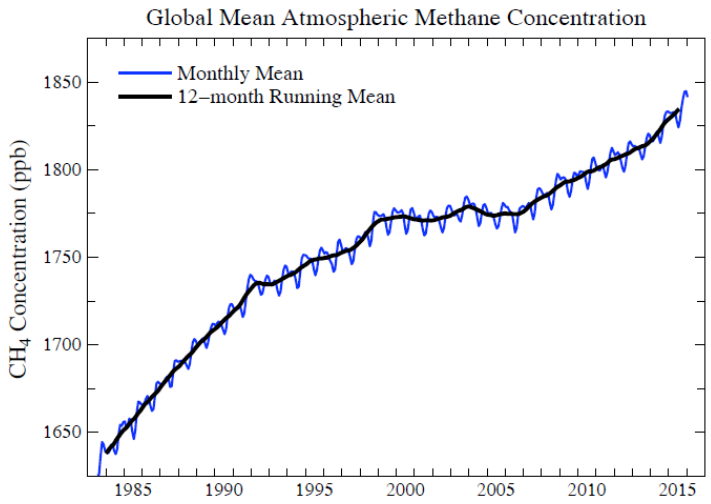

Fig. 2. Global atmospheric methane (data from NOAA Earth System Monitoring Laboratory).

Second, the re-acceleration of methane growth and the increased volume of the available natural gas reservoir that result from "fracking" contribute to a fundamental change in the trend of the total greenhouse gas (GHG) climate forcing growth rate (Fig. 3). The annual growth of total GHG climate forcing declined by 30% between 1987 and 2000, but now it is back to 90% of its peak value. Resurgence in total forcing growth coincides with methane resurgence, but CO_2 also contributes to the change. It had appeared in 2000 that, with a rising price on carbon, it might be conceivable to follow a course such as the Alternative Scenario (Fig. 3), which would yield a maximum global warming of about 1.5°C. Fig. 3 shows that the global GHG growth rate is now far above the 1.5°C scenario and diverging from it.

So is it even conceivable that this growth trend can be reversed; can we get back on a downward trend for the GHG climate forcing growth rate? The answer is: we have no choice, we must get back on track or young people are in deep doo-doo, inheriting a situation out of their control. Furthermore, it is possible, but it requires (1) a negative climate forcing trend from methane, and (2) phase-out of fossil fuel CO_2 emissions via an across-the-board rising carbon fee.

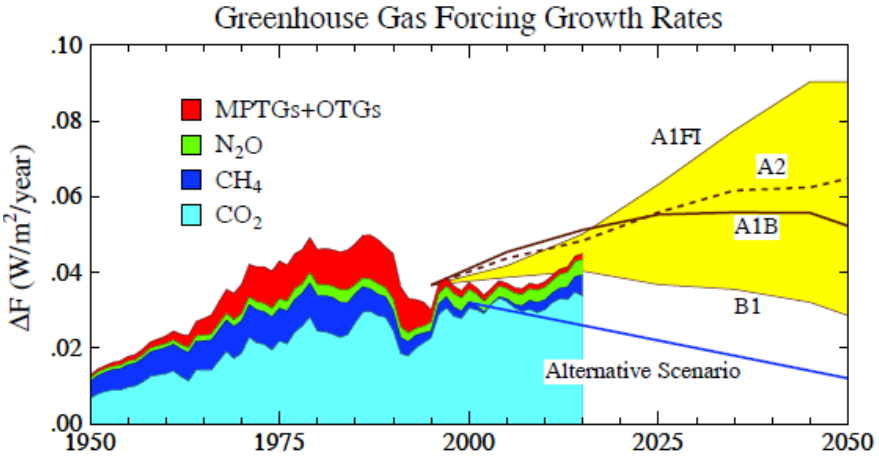

Fig. 3. Five-year mean of growth rate of GHG climate forcing; final two points are 3- and 1-year means[7].

[7] Hansen, J., and M. Sato, 2004: Greenhouse gas growth rates. *Proc. Natl. Acad. Sci.*, **101**, 16109-16114.

There seem to be two practical implications.

First, we need to forgo the fruits of the "fracking" revolution. The signature of U.S. fracking on global methane is only too clear, including the added acceleration of the past two years in which 55,000 additional fracking wells were drilled.[8] The U.S. fossil fuel industry will object, but the industry was well aware of fossil fuel climate impacts and was free to put R&D investments into other energy sources as opposed to fossil fuels alone. If the U.S. allows fracking to proceed unabated, surely other nations will follow and global warming cannot be contained.

Second, fossil fuel CO_2 emissions must begin to decline rapidly, which can happen only via an agreement of the major powers, notably China and the U.S., for a rising carbon fee. This fee would become near-global via border duties on products of non-participating nations. Although that approach is coercive, it is essential and is in the best interests of all, including developing countries. It is needed to move the world off the fossil fuel track onto a clean energy track. Developing countries will have leverage required to assure financial and technical assistance, because their cooperation is essential to achieve globally (and locally) needed changes in agricultural and forestry practices that improve carbon sequestration and increase soil fertility.

What is the relevance to American political campaigns? We must first discuss one more matter.

There will be two major contributors to phase-out of fossil fuels: (1) renewable energy + energy storage, including hydropower and other "batteries", and (2) improved nuclear power that deals with several issues, including standard reactor designs that are produced largely in factories or shipyards at a price competitive with fossil fuels. Neither (1) nor (2) is available today, except for nations with abundant hydropower, but both are likely to be available within 1-2 decades.

The balance among (1) and (2) will vary from country to country, but it is crucial that the public understand that nuclear power will be part of the global solution. China and India, the #1 and #3 CO_2 emitters today, are determined to develop nuclear power for clean electricity, and they will do so regardless of whether the U.S. continues to withhold technical information or, instead, concludes that we had better cooperate in improving the technology as rapidly as possible.

It is also noteworthy that Russia offers nuclear power plants for sale, including "fast" reactors, to almost any nation. We cannot make the world safer by abandoning responsibility to develop the safest technologies possible. We also must continue the historical leadership that the U.S. has provided in international organizations that safeguard nuclear technology and materials.

Finally, the relevance of climate and energy science to political campaigns: (1) "Fracking" should be opposed; it is analogous to mountaintop removal and tar sands, producing local pollution while making the global climate problem practically unsolvable, (2) existing nuclear power plants in the U.S., which are operating safely under supervision of the Nuclear Regulatory Commission and have saved an enormous number of lives and avoided large carbon emissions,[9] should continue to be used until one or both of the options discussed above (renewable energy + energy storage and improved nuclear power) are available. The practical alternatives today to maintaining existing nuclear power are gas alone or gas supplementing subsidized intermittent renewable energies, in either case locking in gas and probably "fracking" for at least half a

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[8] Fracking by the Numbers, Frontier Group, Environment America, Ridlington, E., Norman, K., Richardson, R., 2016.

[9] Kharecha, P.A., and J.E. Hansen, 2013: Prevented mortality and greenhouse gas emissions from historical and projected nuclear power. *Environ. Sci. Technol.*, **47**, 4889-4895, doi:10.1021/es3051197.

century, thus assuring that the climate problem is practically unsolvable. If the U.S. keeps fracking, so will the world.

I have not checked statements of the political candidates, but it will be interesting and important to see their responses to questions on these topics. In the primaries there is a tendency in both parties to push candidates to the extremes. On the liberal side that means oppose fracking and nuclear power; it will be interesting to see if any candidate is responsibly "Presidential". On the conservative side, it seems that nobody has the courage to oppose climate change denial; thus it seems that any of these candidates will go whole hog in burning more fossil fuels.

So I am not recommending any candidate after all. The only thing I would say is that we had better make maximum effort to help the winner understand the climate/energy story this time. As my oldest grandson said, unless we can make a time machine that actually works we will not get a "do over." I had zero success in informing the current resident of the White House.[10] Maybe next time I will try parachuting in for a visit. No, on second thought, given the new securities, that might be a coruscating finale. I had better tend my orchard.

BTW, one other thing: it seems to me that scientists who have taken the trouble to understand the energy story should make their opinions clear to the public. I have the impression that there is a reluctance to speak out by those scientists who conclude that nuclear power needs to play a role in solving the climate problem. Everyone knows that if you yearn for applause and want to hobnob with Hollywood liberals you should agree that all we need is the sun and the wind for energy. Meanwhile, they drive to the airport in electric cars powered by gas and coal and fly off to Timbuktu. I'm not criticizing Hollywood liberals – many of them are generous and dedicated environmentalists. However, as long as all they are told is what they want to hear, we will have a hard time getting the public to understand the energy situation.

[10] November 27, 2015: Isolation of 1600 Pennsylvania Avenue: Part I