

## Wanning Workshop + Beijing Charts + Year-End Comments

29 December 2015

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I returned Christmas Eve from a workshop<sup>a</sup> in Wanning, China and talks at Peking University and Tsinghua University. The workshop was conceived after a trip to China last year (cf. [Sleepless in Ningbo](#)) to attend the Symposium on a New Type of Major Power Relationship at invitation of the Kissinger Institute on China and the United States. That symposium included trips to solar and windmill factories, but nuclear power seemed to be taken off the table despite the implausibility of phasing out coal use in China and India without the help of nuclear power. Thus I contacted nuclear energy experts Richard Lester (MIT) and Per Peterson (University of California at Berkeley) and my Chinese friends and fellow climate scientists, Junji Cao and Yunfeng Luo, with the aim of asking what role nuclear power might play in addressing air pollution and climate change. Junji was a marvelous workshop host, enlisting nuclear scientist Hongji Xu as a co-organizer. We will prepare a report with recommendations in the near future.

China's leaders have done a remarkable job in raising more people out of poverty than any case in Earth's history. Yet that progress is now threatened by the twin scourges of air pollution and climate change. Two of the days I was in Beijing were "red alert" days, with air pollution so bad that school was cancelled. Unlike my experience in Ningbo, I avoided an asthma attack with the help of a good face mask – any sleeplessness was only the result of an 11-hour time zone shift.

A crucial requirement for cleaning up the air and environment is abundant affordable electric power for all citizens, allowing replacement of many polluting activities. Chart 1 here is Chart 44 of my Tsinghua University presentation, which is available at [Beijing Charts](#). On the way to China I took part in a 'Scientific Reticence' session at the American Geophysical Union meeting.

### Advancing Nuclear Energy to Help Address Climate Change and Air Pollution

Climate change and air pollution combine to create a crisis that threatens to derail progress towards elimination of poverty. Growing demand for energy must be met in ways that provide clean air and abundant clean water and not leave young people a climate system running out of control. The urgency of expanding clean energy implies that nuclear power, presently the largest source of carbon-free energy and historically the clean-energy source capable of fastest scale-up, likely must play an important role in meeting needs for dispatchable electric power, carbon-neutral liquid fuels, and fresh water.

Enormous potential for innovation in modern nuclear reactors offer promise of obtaining clean energy competitive with or lower than fossil fuel costs while maintaining the highest standards for safe operation and efficient management and utilization of nuclear waste. Nuclear power will need to complement renewable energies, providing sufficient baseload electric power to help address the challenge of replacing energy presently obtained from fossil fuels.

China, because of the rapid pace required for its clean energy development, has the opportunity to lead the world in moving the nuclear innovation agenda forward in cooperation with other nations. Indeed, such cooperative progress seems to be an imperative for the well-being of young people and future generations of the entire world.

**Chart 1. Introductory statement at Wanning workshop (cf. Beijing Charts).**

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<sup>a</sup> Workshop on Advanced Nuclear Energy to Address Climate Change and Air Pollution, December 17-20, 2015.

Several blatant falsehoods about nuclear power were repeated in that session, including claims that (1) nuclear power has a large carbon footprint (it is actually as low as that of renewables, and it is even lower with advanced generation nuclear power), (2) nuclear power is a slow way to decarbonize (in fact all of the fastest decarbonizations in history occurred via nuclear power), (3) nuclear power gets inordinate subsidies (in fact renewable subsidies dwarf nuclear subsidies).

However, it is wrong to pit renewables against nuclear power. We need all hands on deck. Carbon-fee-and-dividend provides a way to avoid contentious discussion and allow competition. It is unfortunate for young people in the United States that the economic benefits of advanced generation nuclear will likely accrue elsewhere, given government policies seemingly designed to kill nuclear power.<sup>b</sup> I have felt the sting of a gross asymmetry in the renewable/nuclear energy discussion, as proponents of a role for nuclear power support renewable energies, but proponents of renewables unleash a torrent of criticism of anyone advocating a role for nuclear power.<sup>c</sup>

I limit this discussion with a final point: all energy sources impact the environment. The effects of old generation nuclear power can be greatly reduced with new technology. The impacts of renewable energies may not be acceptable to all environmentalists. Chart 2, for example, shows the renewables proposed by Jacobson et al. (2015).<sup>d</sup> Will each of the 50 states actually approve these installations? What about the new power lines criss-crossing the nation? Not included in this chart is the “water” portion of this proposed renewable power installation: it is equivalent to 50 Hoover dams, one for each state; although the proposition is to do this with a larger number of smaller dams, it is not clear that these dams would be welcomed by all environmentalists.



## What this would require

- 1,670 offshore wind farms the size of the 468 MW Cape Wind array (92 per coastal state)
- 2,400 Tehachapi-size wind farms (705 MW each) onshore (or about 50 per state)
- 27,000 megawatts of wave machines (zero exist today)
- 227 Gigawatts of concentrated solar plants (or 580 Ivanpah-sized plants at 392 MW each, or 10 plus per state) to produce energy, and an additional 136 GW (7 per state) just for storage
- 2,300 GW of central solar PV plant, or 1,200 times more central PV capacity than exists today
- Additional 469 GW of solar thermal storage, or roughly 1.5 times the capacity of US coal

**Chart 2. Renewable energies proposed for U.S. by Jacobson (chart courtesy of Armond Cohen).**

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<sup>b</sup> One example of many, “renewable portfolio standards” rather than “carbon-free-portfolio standards” – but it would be better to have neither, instead letting a rising carbon fee and the free market guide utility decisions.

<sup>c</sup> The torrent is led by “Big Green” environmental organizations, but as with climate change “deniers” there is a large unpaid well-meaning but not very well-informed public that descends, discouraging objective analysis.

<sup>d</sup> Jacobson, M.Z., Delucchi, M.A. et al.: 100% clean and renewable wind, water, and sunlight (WWS) all-sector energy roadmaps for the 50 United States, *Energy Environ. Sci.*, **8**, 2093-2117, 2015.



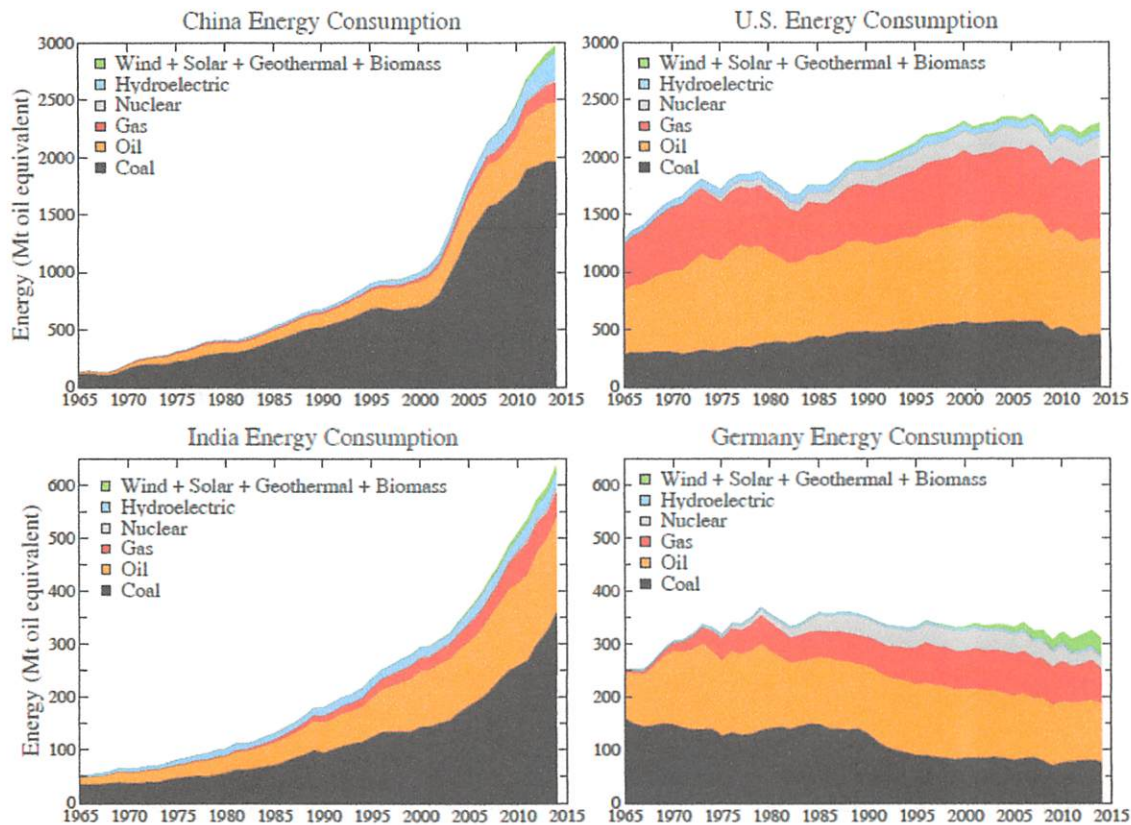


Fig. 1. Energy consumption in China, United States, India and Germany (data from BP<sup>1</sup>).

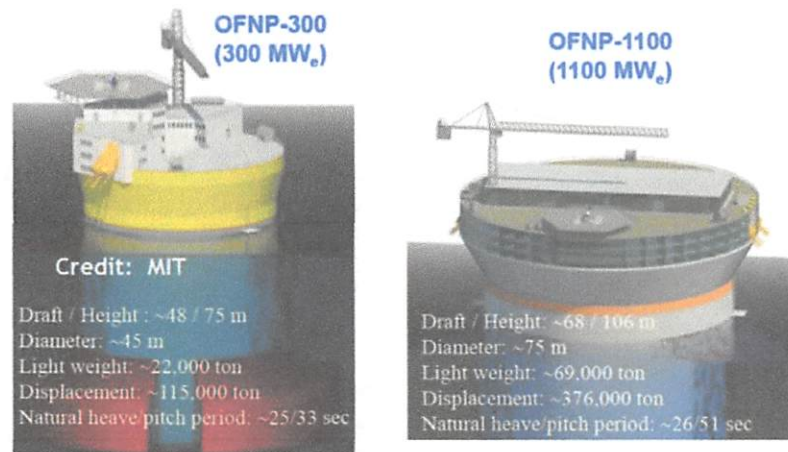
I briefly note here a few topics that I will address one-by-one in future communications.

**Paris.** Shameless preplanned back-slapping accompanied a Paris climate accord that guaranteed nothing except continued high fossil fuel emissions. Low oil and gas prices afforded a golden opportunity to introduce a rising carbon fee, the only practical way to achieve honest pricing of fossil fuels. However, such a simple honest approach without any giveaways to special interests was dismissed as being too complex to be considered. Instead continued low fossil fuel prices will spur construction of more fossil fuel infrastructure with lock-in of high future emissions.

The major economic powers, including the United States, China and the European Union, need to define a feasible path to carbon-free energy. However, the U.S. is hamstrung by extremist political factions: the far right proclaiming that climate change is a hoax and extreme liberals asserting that we are on the verge of getting all energy from renewables. The European Union is under the thumb of Germany, which has dispatched Angela Merkel on a global crusade to sell a no-nuclear-power cap-and-trade scheme designed by and for Germany. Yet, despite world-leading engineering capabilities, a large balance-of-trade surplus, and a willingness to pay high electricity prices, Germany has made little progress in reducing fossil fuel emissions (Fig. 1). [The reduction in coal use in the early 1990s was due to German unification with closing of inefficient East German coal plants (earlier data being the sum for West and East Germany). The small decline in recent decades is due at least in part to export of manufacturing.]

China may be the best hope for the rapid progress needed to save the future of young people, given the U.S. and Europe situations, despite the fact that China is responsible for only 10% of cumulative fossil fuel emissions that cause climate change (U.S. and Europe are each responsible for >25%). On a per capita basis the gap is even larger (see Fig. 2 in [my prior Communication](#)).

## Shipyard construction of deep-water, floating plants has potential to greatly reduce construction cost/time



UCB Nuclear Engineering

Potential advanced reactor benefits and challenges

Natural period must be < tsunami wave period (plant rides tsunami) and > peak storm wave period (minimized oscillations in storms)

**Chart 3. Schematic of shipyard-constructed nuclear power plants, P. Peterson, Wanning workshop.**

Concepts for “disruptive” technologies, potentially providing abundant continuous electric power as cheap or cheaper than coal, and safer, are given in Charts 3 and 4. Such innovations are likely to be developed in China because of its urgent need for clean energy, but once implications are clear there may be pressure to fix barriers that hinder nuclear power development in the West.

**Near-Term Publications.** Two substantial papers that occupied us most of the year are in final stages of journal review/revision. They address the issues that I believe are the most important ones determining “dangerous” climate change. The essence of the paper on ice melt/sea level was published in the “discussion” version of the paper, but the revised paper is reorganized and easier to read. I hope to be able to make both of these papers available within several weeks.

**Legal Actions.** As noted in earlier Communications we are involved in several legal cases whose overall purpose is to use the judicial branch of our government, which should be less subject to influence of the fossil fuel industry, as a means to move the executive and legislative branches to action on climate change. Courts were essential for securing civil rights.

## An Example of Technology

### Thorium-Powered Molten Salt Reactor

Operates at Atmospheric Pressure

Factory or Shipyard Construction

Uses Most Nuclear Fuel, Not <1%

Reduced Waste, Shorter Half-Life

Passively Safe Operation

Not Well-Suited for Weapons Material

**Chart 4. An example of a nuclear technology that is ripe for development.**



The most important case is the one against the federal government, for which I submitted my [testimony](#) several months ago. The presentation of the case is now firmly based on fundamental rights guaranteed by the Constitution for “equal protection of the law” and “due process”. The case has the potential to provide a historic turning point in the fight for justice for young people.

**Solicitation and the last word.** I understand that some donors are not happy about discussion of nuclear power. That topic occupies only a small fraction of our work. I highlight it here because of just returning from the workshop and the great amount of disinformation on the topic. We cannot aim to tell people what they want to hear, rather we must aim for objective analyses, providing the public as much information as possible including policy options.

Fortunately, a gift we received from the Durst family a year ago, with 1:3 matching from the Grantham Foundation, and other contributions will cover the costs of our present 3.5 person Columbia University program for 2016. However, we need funding for our non-profit 501/C3 Climate Science, Awareness and Solutions, Inc. (CSAS Inc.). CSAS Inc. is used to pay costs of the legal actions (mainly for a brilliant young lawyer, Dan Galpern, who drafts my testimonies), computer costs for modeling and research, and travel. In 2015 I made a donation of \$25K from CSAS Inc. to Our Children’s Trust, which we are working closely with on the federal case, and we hope to continue to support them in 2016, but funds in CSAS Inc. are largely depleted.

Betsy Taylor is President of CSAS, Inc., I am the Chief Executive Officer, Bill McKibben and Larry Travis are Board Members, Jim Miller is a newly elected Board Member this month, and Jay Halfon is the Secretary and Treasurer. Jim Miller has been very helpful over the past 1-2 years in helping find support for the Columbia University program, in discussions with policymakers about fee-and-dividend, and recently he has encouraged us to explicitly work into our legal cases the concept of “irreparable harm”, which has been effective in prior legal cases.

Donations to CSAS, Inc. should be sent to Jay Halfon, 45 West 36<sup>th</sup> Street Floor 6, New York, NY 10018, attn. Geoff Boehm. Of course we welcome support of our Columbia University program, Climate Science, Awareness and Solutions, which would allow me to spend less time fund raising in 2016 and make the program more effective. Donations to the Columbia program should be sent to Gregory Fienhold, The Earth Institute, Hogan Hall, Room 108 2910 Broadway, MC 3277 New York, NY 10025 or made online at <http://csas.ei.columbia.edu/support/>.

I give the old year’s last word to my oldest grandson, Connor. Three years ago, as an 8-year old, unbeknowst to me, he was in the back row of an audience listening to my talk on human-caused climate change. At the end, when Anniek noticed tears running down his cheeks, she ran to him and said “Don’t worry, Connor, adults are working on the problem. They will solve it.”

Sometimes it is not so easy to fool young people. Connor’s recent thoughts (Chart 5), as an 11-year old, do a remarkably good job of capturing the crucial “delayed response” aspect of climate change. And he seems to understand the bottom line.

## Connor's Thoughts

If we keep doing what we are doing now then the environment will be ruined when the people who are kids now are grownups.

And **unless we can figure out how to make a time machine that actually works**, there will be no way to go back in time to fix it.

It's not fair that the grown ups now are ruining the atmosphere for the grownup in the future.

Grown ups now are scared of nuclear power but they should be scared of what will happen if they keep doing what they're doing now because we know the ways to use nuclear power safe and **we know that using fossil fuels is not safe. It is very dangerous.**

Chart 5. Thoughts of 11-year-old grandson on climate change and energy.

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<sup>1</sup> Additional graphs, for CO<sub>2</sub> emissions, are available at <http://www.columbia.edu/~mhs119/CO2Emissions/> with longer periods covered using data of Boden et al. (Oak Ridge National Laboratory) with British Petroleum data concatenated for recent years.