Climate and Energy: Fundamental Facts, Responsibilities and Opportunities[a]

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Thank you for the opportunity to discuss climate and energy. Fundamental facts about climate and energy reveal a great responsibility that our government has not only to the American public today, but to future generations. The facts imply the need for specific actions to address this responsibility. The required policies would improve our economy and our security, while also dealing with current issues such as the advisability of the Keystone tar sands pipeline.

Science has exposed the fact that we cannot burn all fossil fuels without enormous growing costs that would be borne most heavily by young people. So far we have burned about 380 GtC (gigatons of carbon), the purple areas in Fig. 1. Preserving creation, a planet that continues to look like the one civilization developed on, requires that we limit total fossil fuel emissions to something close to 500 GtC.

The exact limit is debatable, but there is no scientific debate about the fact that we cannot burn all of the fossil fuels without unacceptable destruction of life and property. That means we must phase out coal emissions and leave most of the unconventional fossil fuels, including tar sands, in the ground.

Fossil fuel emissions need to be phased down as rapidly as practical. Appropriate policies will spur development of carbon-free energies until tipping points are reached and rapid energy transition occurs. Time required to replace existing energy infrastructure means that some overshoot of the 500 GtC emissions target is probably unavoidable, but prompt policy actions can keep the overshoot small. In that case, improved agricultural and forestry practices can help draw down the excess atmospheric carbon. The crucial requirement is that we not push the climate system so far into the danger zone that we leave young people with a planetary system spiraling out of their control.

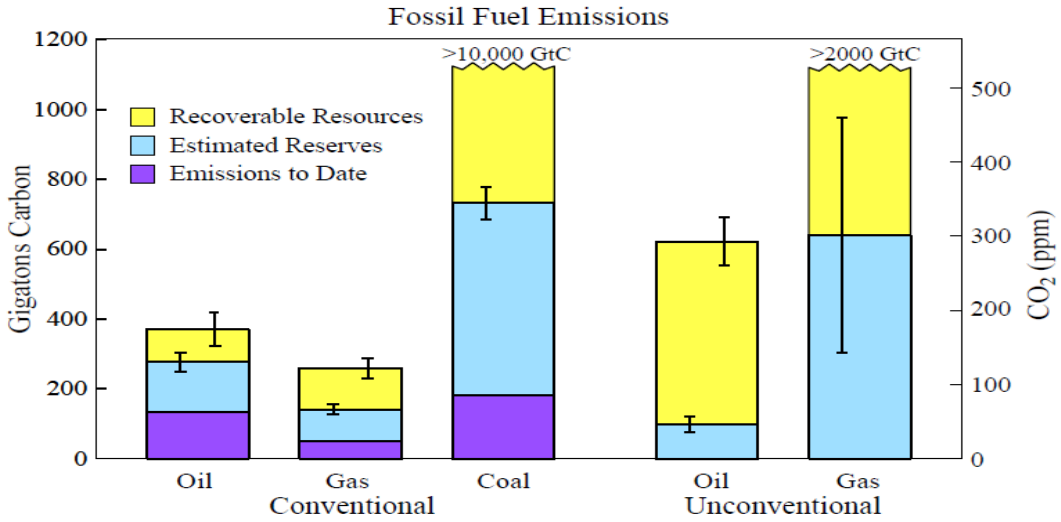

Fig. 1. Fossil fuel CO_2 emissions and carbon content.[1] Purple portions are fossil fuels already burned. Unconventional oil includes tar sands and tar shale. Unconventional gas includes hydraulic-fracturing. See reference 1 for further information, units and data sources.

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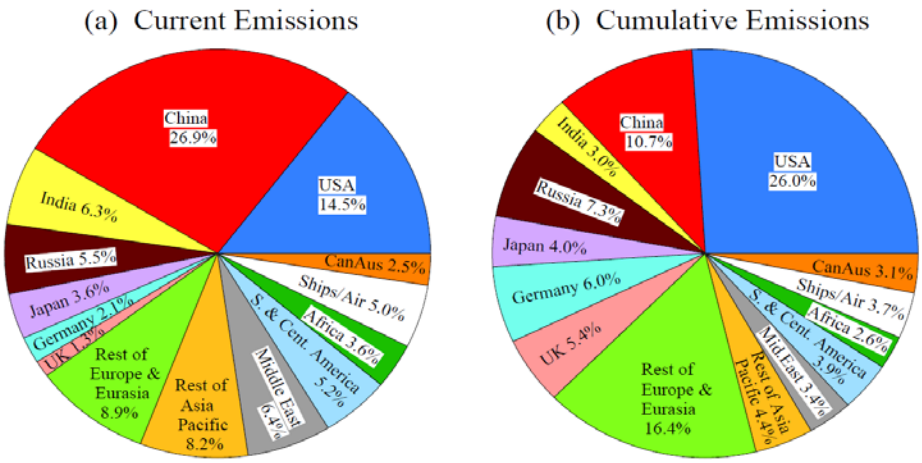

Fig. 2. (a) Fossil fuel CO_2 2012 emissions and (b) cumulative 1751-2012 emissions.[2]

China's fossil fuel emissions today far exceed those by the United States (see Fig. 2a) and China's emissions are continuing to increase rapidly, mostly from coal burning. However, climate change is driven by the cumulative emissions (Fig. 2b)[3], as the CO_2 (carbon dioxide) from fossil fuels remains in the climate system of the order of 100,000 years. The United States is, by far, the nation most responsible for excess CO_2 in the air today (Fig. 2b), a conclusion that is all the more true on a per capita basis.

The United States burned not only its share of the global carbon budget, but a large part of the budget belonging to China, India and other countries. While it can be argued that the United States has a right to burn its own resources, we have no right to unlimited use of the global atmosphere as a waste dump. The capacity of that dump is limited. We have filled much of that dump, leaving little room for other nations. If other nations follow our example, the consequences, without question, will be catastrophic for all.

This situation does not call for hand-wringing and despair. Other nations do not wish to fill the air with waste. However, they have the right to develop, to aspire to a better life. Thomas Jefferson posited "pursuit of happiness", after life and liberty, as one of the most fundamental human rights, the human rights that Americans decided to fight for. That specific right implies a right to develop. Development requires energy. We used fossil fuel energy to develop our nation and raise our standard of living. If the rest of the world follows our example we will all be losers.

Let's be clear. The task before us is not easy. Developing countries need energy to lift their people out of poverty, just as developed countries did. Affordable energy is important as a matter of justice, but also to bring global population under control. As countries develop and poverty declines, so do birth rates, which is important so that we leave room on the planet for all the other species whose eco-services we depend upon. Developed countries have a responsibility to work with the developing world, because we burned much of their share of the global carbon budget.

Developed nations, including the United States, also have a need for abundant clean, affordable energy. Clean energy is needed to phase out fossil fuels and to provide energy for producing liquid fuels, for desalinizing water, for recycling metals. Yes, we can be more efficient in our energy use, but energy needs are not going away. Obtaining an adequate continuing supply of clean energy is a great challenge.

The energy challenge is also a great opportunity. We have the potential to meet the challenge. We have the potential for innovations. Our free enterprise system, fed by the greatest university system in the world, creates the potential for rapid progress. However, we must have policies that provide the incentives required for this potential to be realized, not policies that hamstring it.

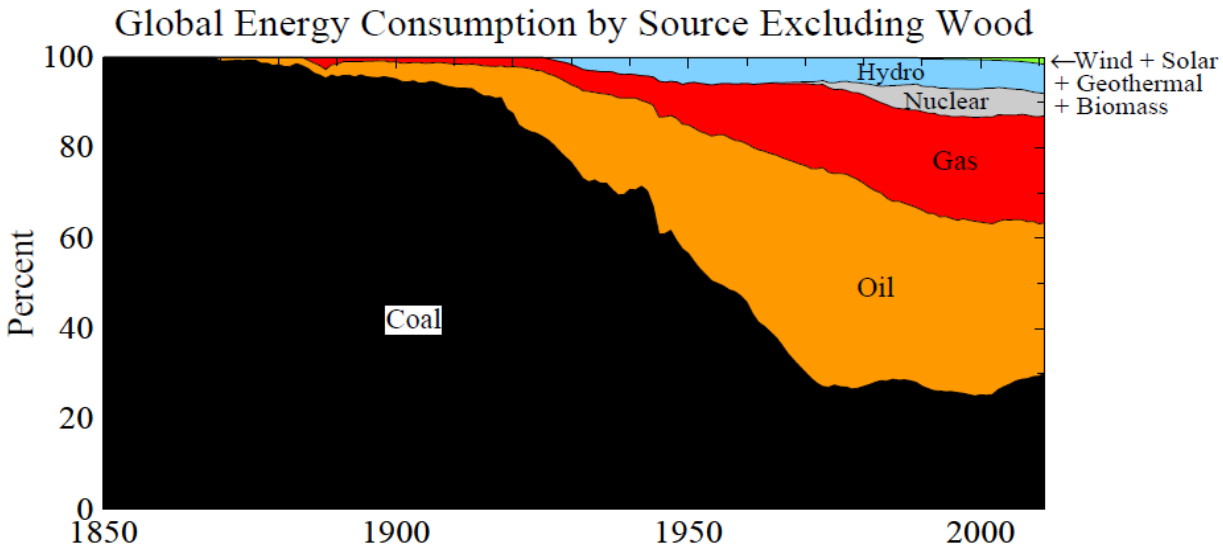

Fig. 3. World energy consumption for indicated fuels, excluding wood.

The needed policies are easier to define if we first examine two more charts. The fuels that provide global energy are shown in Fig. 3. Fossil fuels provide more than 85% of global energy. Coal use has surged in the past decade, surging in absolute terms even more than in the percentage shown in Fig. 3. Most of the growth is in developing countries, with 60% of the increased CO_2 emissions from China.

Non-hydro renewable energies provide only about 3% of global energy and 3% of U.S. energy. Thus total installed renewables, installed over a period of a few decades, offset only one year's growth of global energy use. Renewables are nowhere near covering the growth of energy requirements.

I am sorry that we scientists have not done an adequate job of communicating energy facts. A note and a draft op-ed discussing the energy situation in simple direct language is available[4].

My final chart (Fig. 4) shows the energy intensity and carbon intensity for several nations and for the world. There are two ways we can reduce our carbon emissions while still having the global economic growth that is needed to phase out poverty. One way is to reduce our energy intensity, i.e., use less energy to produce our products. Energy intensity is declining slowly in most nations, and with appropriate policies we can make it decline faster.

The crucial urgent factor is the carbon intensity, the amount of carbon released to the atmosphere per unit energy. We must reduce carbon intensity to near zero to stabilize climate.

There is one nation that has come close: Sweden. Sweden decarbonized its electricity, mainly via the combination of hydropower and nuclear power. With one additional step Sweden can be at or near the low carbon intensity needed to stabilize climate. The main remaining need is to produce liquid fuels for transportation from electricity or perhaps a breakthrough in battery technology.

Fossil fuels are the dominant energy source globally because they are, or appear to be, the cheapest energy. They are not actually cheapest, but they appear cheapest to the consumer because they are not required to pay their costs to society. They do not pay for the human health effects of air pollution and water pollution. They do not pay for growing climate effects.

The policy that is needed is a gradually increasing across-the-board carbon fee collected on oil, gas and coal at the first domestic sale, at the domestic mine or port of entry. It is very simple to collect from a small number of sources. 100% of the funds should be distributed to the public, equal amounts to all legal residents, electronically to their bank account or debit card.

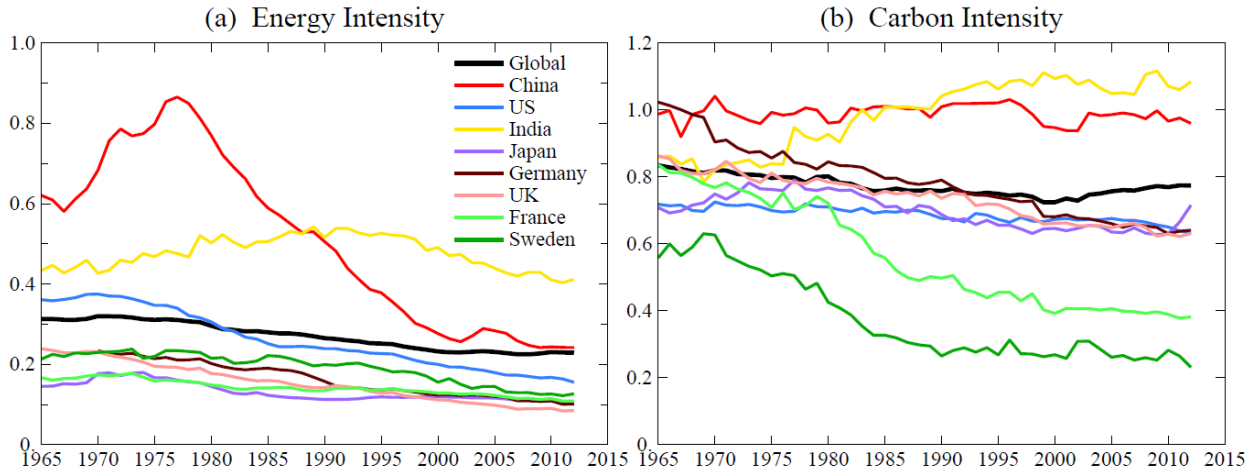

Fig. 4. (a) Energy intensity, defined as energy consumption (Gt of oil equivalent) divided by real gross domestic product (trillions of 2005 U.S. $), and (b) carbon intensity, defined as fossil fuel carbon emissions (GtC) divided by energy consumption (Gt of oil equivalent).

Thus the person who does better than average in limiting his fossil fuel use will make money. There will be an incentive for individuals to move to low-carbon and no-carbon energies, and an incentive for entrepreneurs to develop those products. Energy choices are left to the individual and the market place. Not one dime to the government. It's a conservative plan that would work wonders. In 10 years, if the fee rises $10 per ton of CO_2 per year, U.S. emissions will be reduced by 20-30% according to economic simulations by the Carbon Tax Center.[c]

The annual reduction of oil use alone, after 10 years, would be more than three times the volume of oil carried by the proposed Keystone XL pipeline, rendering the pipeline superfluous. By eliminating the need for the pipeline, the danger of oil spillage on American soil is also eliminated. With this approach we would move over a period of years to true energy independence, as the economic incentive from a rising carbon fee would spur our entrepreneurs to develop alternative energy carriers, including liquid fuels from abundant no-carbon electricity. The no-carbon electricity can be provided by renewables or nuclear power or some combination as the market decides or as the public chooses.

In addition to a carbon fee-and-dividend, we in the United States have a moral obligation and a great opportunity to work with China to help assure that their drive to develop energy does not release so much CO_2 as to cause climate change out of humanity's control. It is an obligation, because we burned much of their share of the global carbon budget. It is an opportunity, because it will provide us the chance to get back on top of the nuclear technology world. For the sake of the whole world, as well as for our own sake, it is important that the United States provide leadership to assure that nuclear technologies are as safe as possible and resistant to weapons proliferation.

The alternative is that we leave the field to Russia. Russia is more than happy to fill the void. Indeed, China has already agreed to purchase nuclear technology from Russia, including fast reactors with potential for recycling of nuclear material. The United States still has the best technology capabilities, but that lead is rapidly shrinking and will be gone in the near future if we continue to languish.

[c] This fee is progressive. Sixty percent of the people, especially low income people who do not travel around the world a lot, will receive more in the dividend than they pay in increased prices. But to stay on the positive side of the balance sheet, they must pay attention to what they buy.

Before describing what we should do in such cooperation, I must say what we should not do. It is inappropriate and an insult to go to China and tell them to work harder on renewables and energy efficiency. China is already doing more in these regards than we are in the West. For example, where possible, codes for new buildings in China require use of geothermal heat and other renewables, and efficiency standards are ratcheted up as soon as improved technologies appear.

We also should not expect China to use renewable energy for base-load electricity. We just completed a solar power plant, Ivanpah, near the Nevada-California border on public land provided free. Ivanpah cost $2.2B and it covers five square miles (about 13 square kilometers). With a generous estimate of 0.25 for the plant's capacity factor (the ratio of average power to peak power when the sun is highest and the sky is clear), Ivanpah will generate 0.82 TWhours of electricity per year. The power is intermittent because Ivanpah does not have energy storage, which would make the plant far more expensive.

In contrast, Westinghouse is nearing completion of two AP-1000 nuclear plants in China. These nuclear facilities each require about 0.5 square miles (about 1.3 square kilometers). With a capacity factor of 0.9, typical of nuclear power plants, the output of each plant will be 8.8 TWhours per year. It would require more than 10 Ivanpahs to yield as much electricity and an area of more than 50 square miles (128 square kilometers), area that China does not have to spare. The AP-1000 cost in China is about $3.5B per plant

What the United States should do is cooperate with China and assist in its nuclear development. The AP-1000 is a fine nuclear power plant, incorporating several important safety improvements over existing plants in the United States, which already have an excellent safety record. There has been only one serious accident among 100 reactors, at Three Mile Island in Pennsylvania, and it did not kill anyone. However, further advances in nuclear plants beyond AP-1000 are possible and the large demand in China allows rapid progress and building at a scale that can drive down unit cost.

China has initiated nuclear R&D programs, including cooperation with U.S. universities and firms. Cooperation with our universities and the private sector could be expanded rapidly, and areas of relevant excellence persist in some Department of Energy Laboratories despite inadequate levels of support. Training of nuclear engineers and operators in the U.S. could help assure safe operations during a challenging period of rapid expansion. Benefits of cooperation in technology development can eventually circle back to United States industry and utility sectors as cost effective power plants are perfected.

In assessing the potential for the U.S to eventually benefit from a cooperative program of nuclear technology development, it is apparent that reforms are required in our Nuclear Regulatory Commission. There is widespread agreement that the NRC has done a good job of regulating. They have capable technical staff, and they do a good job as resident inspectors at nuclear plants, in incident reporting, and in keeping the nuclear plant operators on their toes.

It is a different matter, however, with regard to the nuclear reactor permitting process. The heavily lawyer-laden permitting process results in paper-work requirements and delays that stretch into years and billions of dollars of cost growth. Nuclear power proponents make a strong case that this situation is in part a consequence of pressure from anti-nuke "greens" who aim to delay nuclear construction and make nuclear power so expensive that it will fade away. Whatever the balance of causes, this problem needs to be fixed or the U.S. will suffer serious economic disadvantages and decline in comparison to rising economic powers such as China.

Summary. Issues such as the Keystone pipeline (and the reliability of Russian energy exports) should be viewed in a broader context of energy and climate. Basic facts include:

(1) The carbon budget for the planet has been nearly used up, implying that the world as a whole needs to phase off fossil fuel energy as rapidly as practical.

(2) Current skyrocketing of global emissions is primarily a consequence of rapidly developing countries, especially China.

(3) The West, especially the U.S., has burned more than its fair share of the allowable global carbon budget, implying a responsibility to help developing countries find a low carbon pathway to development.

(4) Non-hydro renewables provide only a tiny fraction of global energy and do not appear capable of satisfying the large energy requirements of developing nations such as China and India.

These facts suggest the following policy recommendations:

(1) A carbon fee-and-dividend system that places a flat across-the-board rising fee on the carbon content of fuels with the funds distributed 100% to legal residents. This approach provides a strong incentive for energy efficiency as well as development of carbon-free energies. A flat across-the-board rising carbon fee provides the basis for an international agreement that could begin to phase down global carbon emissions. Such an approach would require initial agreement only among a few major nations such as the United States and China. Border duties would be placed on products from nations without an equivalent carbon fee to avoid handicapping domestic manufacturers, and the carbon fee on products exported to non-participating nations would be rebated to domestic manufacturers.

(2) The United States should cooperate with China to aid its transition to low-carbon and no-carbon energy sources, including the development and deployment of improved nuclear power technology. It is to everyone's disadvantage if China continues down a path of heavy carbon emissions, including, for example, extensive development of coal gasification. There is a strong complementarity of the contributions that the two nations could bring to such cooperation and there could be enormous benefits, not only to the two nations, but to the world.

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