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World's Greatest Crime against Humanity and Nature

As I peer through Beijing's impenetrable smog I feel nauseous. I have long been troubled by the injustice of human-made climate change to our children and grandchildren, which may soon constitute a tragedy of epic proportions. Now I stare in the face of another tragedy.

Air pollution from coal kills over 1,000,000 people per year in China. Life expectancy in North China is reduced at least five years, and those living suffer many health effects. One scientist told me that he was using his savings to send his child out of the country, to grow for a while in clean air.

What makes me sick is the realization that climate change and air pollution were both preventable. Thus they are true human-made tragedies. And I know that we in the West bear a moral burden.

We scientists have special responsibility. We had knowledge 25 years ago that should have allowed climate change and air pollution to be manageable problems, not tragedies. However, we failed to communicate the implications well enough with political leaders and we did not achieve effective action. We must try harder now, because it is still possible to minimize the climate change effects and it is possible to solve the air pollution problem.

If we burn all fossil fuels, the carbon dioxide added to the air will have enormous effects. Sea level will rise many meters, submerging thousands of coastal cities. Hundreds of millions of refugees will be driven from coastal regions and island nations. A large fraction of the world's species will be exterminated by shifting climate zones that amplify other human-made stresses. Summer heat waves, droughts and fires will be more extreme. Rain, when and where it occurs, will be heavier and floods will be more devastating. Storms will be stronger.

Scientists informed political leaders decades ago that carbon-free energies must be phased in to replace fossil fuels. Carbon-free energies include hydropower, renewable energies such as the sun and wind, and nuclear power. However, hydropower is limited. Renewable energies are intermittent and their energy source is diffuse. Nuclear energy is so concentrated that nuclear fuel the size of a ping-pong ball contains all the energy a person uses in a 100-year lifetime with a Western life style, but nuclear energy creates nuclear waste and the danger of a possible accident.

All these energies are needed in countries such as China and India, and all the energy technologies can be improved. Today's nuclear reactors, "slow" reactors that utilize less than 1% of the nuclear fuel, can be made passively safe, so they shut down in an emergency such as an earthquake and cool themselves without outside power. "Fast" reactors, which utilize more than 99% of the nuclear fuel and can "burn" nuclear waste, will be needed several decades in the future as easily available uranium is used up. Nuclear reactors can also be made more resistant to weapons proliferation than today's reactors. This is important because nuclear power is here to stay, existing in more than 30 nations.

Uranium sieved from the ocean can power all of the world's nuclear plants for billions of years, once fast reactors are operational. Thus we can stop mining uranium on land in the future, if we choose. At night, when electricity demand is low, future nuclear plants can be used to make hydrogen and other liquid fuels. These fuels can be used for future vehicles, supplementing electric vehicles.

Nuclear scientists were ready in 1976 to build a demonstration fast nuclear power plant. However, the project was stopped by President Jimmy Carter in his first State-of-the-Union message. Research continued at a low level until 1993 when President Bill Clinton delivered an intended *coup de grace*, declaring “We are eliminating programs that are no longer needed, such as nuclear power research and development.” Clinton was caving in to a quasi-religious anti-nuke minority in the Democratic Party, whose unrealistic “belief” was that diffuse renewable energies could satisfy all energy needs.

R&D on advanced technologies, including thorium reactors with the potential to ameliorate remaining concerns about nuclear power, was stifled, seemingly because it was too promising. Powerful anti-nuclear forces had their way with the Democratic Party. “Green” organizations had indoctrinated themselves in anti-nuclear fervor, and their intransigence blinded them to the fact that they were nearly eliminating the one option for abundant clean electricity with inexhaustible fuel and a small planetary footprint.

The enormity of anti-nuclear policy decisions would be difficult to exaggerate. It meant China and other developing nations would have no choice but to burn massive coal amounts, if they wished to raise their living standards. It meant our children and grandchildren faced near certainty of large climate change.

None of the developing nations and none of our descendants had any voice in the decision.

I cannot blame President Clinton. We scientists should have made clearer that there is a limited “carbon budget” for the world, i.e., a limit on the amount of fossil fuels that could be burned without assuring disastrous future consequences. We should have made clear that diffuse renewables cannot satisfy energy needs of countries such as China and India. It seems we failed to make that clear enough.

The United States, as the leader in nuclear R&D, had an opportunity not only to help find a carbon-free path for itself, but also to aid countries such as China and India. Indeed, such aid was an obligation. The United States had already used its share of the “carbon budget” and was beginning to eat into China’s.

Perhaps our leaders, and certainly the public, did not really understand the implications of decisions made more than two decades ago. But there can no longer be such excuse. If we do not now do what is still possible to minimize climate change and eliminate air pollution, will it not be a crime against future generations and nature? Will it not be a crime of one people against another?

A core American value, which spurred our decision to fight for nationhood, was the belief that all people have the right to development. Thomas Jefferson called it a right to “pursuit of happiness.” Can we take that right away from other people by burning their share of the world’s carbon budget, and then not help them find a viable alternative?

Before describing what we should do, 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 when 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 American 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.

Such progress is crucial. Recent events have been spiraling down so rapidly that I find it hard to sleep. Ex-President Clinton campaigns for a huge pipeline to carry Canadian tar sands, which would light a fuse to the dirtiest energy source on Earth, opening the way for unconventional fossil fuels that should be left in the ground. Dogged insistence by environmental groups that intermittent renewable energies are the only alternative to fossil fuels assures massive expansion of hydraulic-fracturing and helps lock-in long-term dependence on gas for electricity and carbon-intensive crude oil for vehicles.

Yet my greatest frustration is with our own inability as scientists to clearly communicate the energy story. We could rapidly phase down fossil fuel emissions via a simple rising fee on carbon collected from fossil fuel companies, with funds distributed uniformly to the public, spurring efficiency and carbon-free energies, thus discharging our responsibility to future generations, other cultures, and other life on Earth. Instead, our governments subsidize fossil fuels and facilitate more-and-more invasive mining practices.

Secretary of State John Kerry has offered to keep China informed of what we are doing about climate in the United States. If that is the best we can do, if we do not help China obtain the abundant, affordable carbon-free energy needed to raise living standards while leaving room on the planet for other species, I believe that our own children, and the world as a whole, are likely to look back on us as having been guilty of the world's greatest crime against humanity and nature.

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