Strategies to Address Global Warming

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Is Sundance Kid a Criminal?

Jim Hansen

In my opinion, it is still feasible to solve the global warming problem before we pass tipping points that would guarantee disastrous irreversible climate change. But urgent strong actions are needed. These actions would have multiple benefits, providing a helpful economic stimulus, improving public health, and increasing energy independence and national security.

Assessment of strategic options for solving the problem requires knowledge of geophysical constraints and their implications. The geophysical facts practically dictate the general course of action. Fortunately, it is clear that the required course is technically feasible, and it would have great benefits to the public in developing and developed countries.

Unfortunately, knowledge and understanding of the situation are not widespread. In addition, there is a minority of people, termed fossil interests, who benefit from business-as-usual. These fossil interests have enormous influence on governments worldwide, far outside their fair role in democracies.

Failure to achieve the actions needed to stabilize global climate will result in great intergenerational injustice. The young and unborn in both developed and developing countries would bear full consequences of actions of prior generations. We need to help young people draw attention to this great injustice.

Climate Situation.

Our global climate is nearing tipping points. Changes are beginning to appear, and there is a potential for rapid changes with effects that would be irreversible – if we do not promptly slow fossil fuel emissions during the next few decades.

Tipping points are fed by amplifying feedbacks. As Arctic sea ice melts, the darker ocean absorbs more sunlight and speeds melting. As tundra melts, methane a strong greenhouse gas, is released, causing more warming. As species are pressured and exterminated by shifting climate zones, ecosystems can collapse, destroying more species.

We already have caused atmospheric carbon dioxide to increase from 280 to 387 ppm (parts per million). What science has revealed in the past few years is that the safe level of carbon dioxide in the long run is no more than 350 ppm. The optimum CO_2 level to support civilization may be less than 350 ppm, but more precise knowledge is not needed immediately for the purpose of establishing present policies.

The conclusion that CO_2 must be reduced to a level <350 ppm was startling at first, but obvious in retrospect. Earth's history shows that an atmospheric CO_2 amount of say 450 ppm eventually would yield dramatic changes, including sea level tens of meters higher than today. For reference, 450 ppm yields global warming about 2°C (3.6°F) above the preindustrial level. Such a level of atmospheric CO_2 and global warming imply that we would hand our children and grandchildren a condition that would run out of their control, a situation that should be unacceptable to humanity.

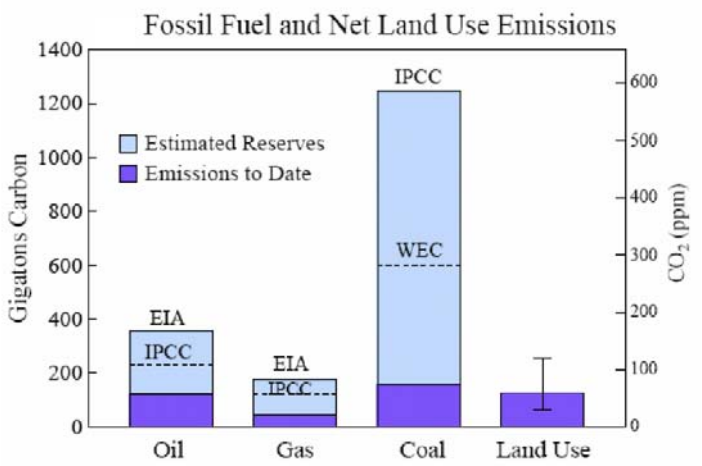

Figure 1. Fossil fuel and land-use CO_2 emissions, and potential fossil fuel emissions. Historical fossil fuel emissions are from the Carbon Dioxide Information Analysis Center [CDIAC, S34] and British Petroleum [BP, S35]. Lower limits on oil and gas reserves are from IPCC [S36] and higher limits are from the United States Energy Information Administration [EIA, 80]. Lower limit for coal reserves is from the World Energy Council [WEC, S37] and upper limit from IPCC [S36]. Land use estimate is from integrated emissions of Houghton/2 (Fig. S14) supplemented to include pre-1850 and post-2000 emissions; uncertainty bar is subjective. References are given by Hansen et al. (Open Atmos. Sci. J. 2, 217-231, 2008).

Fossil Fuels.

Human-made sources of atmospheric carbon dioxide are summarized in Figure 1. The dark portions of the bars are the portions of the fuels that have been burned with the carbon put into the atmosphere as carbon dioxide. The size of fossil fuel reserves (the fossil fuel not yet extracted from the ground) has significant uncertainty. An important point is that the size of recoverable reserves depends upon whether drilling is allowed in off-shore regions, public lands, polar regions, and the deepest ocean. Similarly, the amount of coal reserves that is practically minable is uncertain and depends upon the degree to which ever more destructive mining practices are allowed. Unconventional fossil fuels (tar sands, oil shale, methane hydrates), not shown in Figure 1, are similar to coal in their high carbon content. The unconventional fossil fuels have reserves that may be comparable in size to that shown for coal or even larger.

Despite uncertainties in reserve sizes, it is clear that if we burn all the fossil fuels, or even half of remaining reserves, we will send the planet toward the ice-free state with sea level about 250 feet higher than today. It would take time for complete ice sheet disintegration to occur, but a chaotic situation would be created with changes occurring out of control of future generations.

Oil may already be about half depleted, i.e., the world may be close to peak oil production (implying that the IPCC estimate of reserves is closer to the truth than the EIA estimate). In either case, common sense suggests that the largest oil pools will be exploited and the carbon dioxide, which is emitted mainly from tailpipes, will end up in the atmosphere. Gas, the least carbon intensive and cleanest burning fossil fuel, also surely will be exploited.

The obvious conclusion is that the only practical way to avoid climate catastrophe is to terminate emissions from the largest fossil fuel source: coal, the dirtiest of the fossil fuels. If coal emissions are phased out between 2010 and 2030, global fossil fuel emissions would begin to fall rapidly as shown in Figure 2. The rate of emissions (shown in billions of tons of carbon on the left and in percent of 2008 emissions on the right) depends upon how much oil and gas is

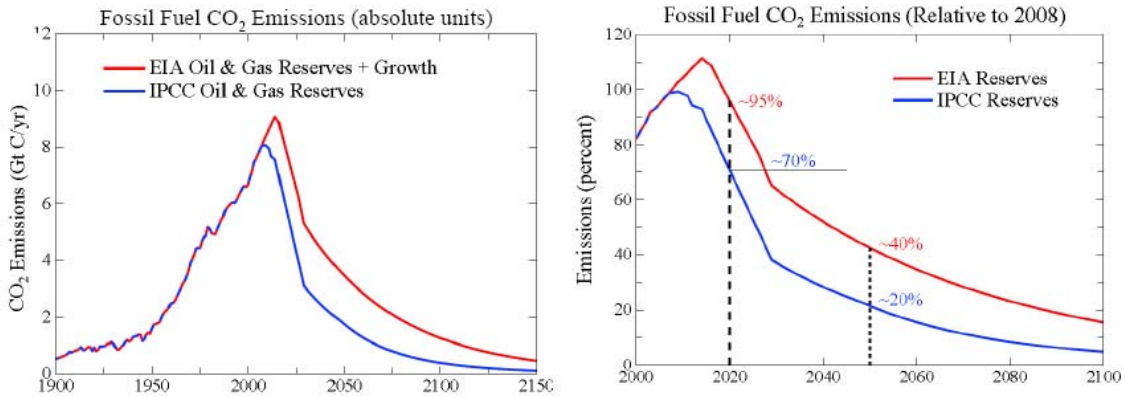

Figure 2. Fossil fuel CO_2 emissions if coal emissions are phased out linearly between 2010 and 2030 (i.e., they are reduced by half in 2020 and eliminated by 2030). Emissions are shown in billions of tons of carbon (Gt C/year) in the left graph, and as a percent of 2008 emissions on the right.

used. The (red) curve showing larger emissions is based on the assumption that the larger reserve estimates of EIA are valid and all of the CO_2 is emitted to the atmosphere.

These emission scenarios have been converted to atmospheric CO_2 amounts using a simplified version of the Bern carbon cycle model, as described by Hansen *et al.* (Target atmospheric CO_2: Where should humanity aim?, *Open Atmos. Sci. J.* **2**, 217-231, 2008). Figure 3 shows that atmospheric CO_2 would peak at only ~400 ppm in ~2025, if the IPCC oil and gas reserves are accurate and if coal emissions are phased out uniformly over the period 2010-2030. If, however, the EIA oil and gas reserves are accurate (and if coal emissions are phased out), atmospheric CO_2 will peak early in the second half of this century and atmospheric CO_2 will be about 30 ppm higher than with the IPCC reserve estimates.

The EIA reserve estimates may be realistic if we choose to go after every last drop of oil by drilling off-shore, on public lands, in the Arctic National Wildlife Reserve, and in the deepest oceans, for example. With these larger reserves exploited, future generations, including our grandchildren, likely will be forced to seek ways to extract that extra 30 ppm of CO_2 from the atmosphere. In the referenced paper we discuss the costs of air capture and disposal of CO_2, estimating a cost of about $200 per ton of carbon. Thus the cost of removing 30 ppm would be

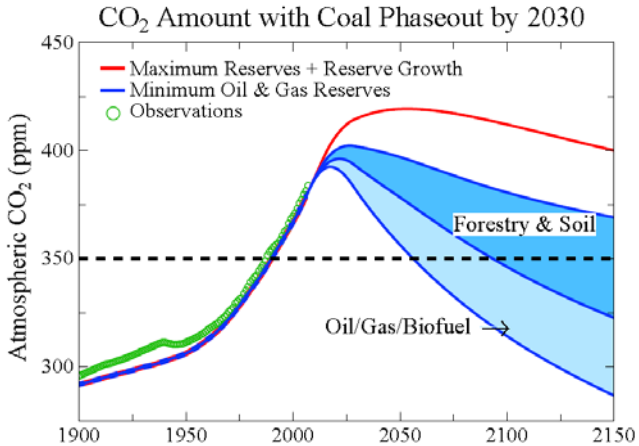

Figure 3. Atmospheric CO_2 based on the emission scenarios in Figure 2, i.e., assuming that coal emissions are phased out over 2010-2030. With IPCC oil and gas reserve estimates CO_2 falls to about 370 ppm by 2150. Atmospheric CO_2 can be reduced faster via reforestation and improved soil carbon management.

about $12 trillion dollars, a burden that would be passed to our descendants. In the final section below (Is the Sundance Kid a criminal?) I discuss the matter of going after every last drop of oil before moving to the energy era beyond fossil fuels.

The primary implication, however, concerns coal. The reason that CO_2 peaks at only 400-425 ppm in these scenarios is the assumption that coal emissions will be phased out linearly between 2010 and 2030. Such a scenario is technically possible, but only with policies that lead to availability of appropriate alternative technologies and incentives for using them.

Constraining Fossil Fuel Emissions: Fee & Dividend versus Cap & Trade.

Fossil fuel use, except for brief periods during economic recessions, has been increasing for more than a century, because it is our primary source of energy. The fundamental reason that we do not switch to cleaner energies is that fossil fuels remain the cheapest energy source, as long as they do not have to pay for their costs to society. We already should have been making fossil fuels pay for the damage they cause to human health and the environment. But now that we understand the climate implications of fossil fuel use, and recognizing that it is necessary to move beyond fossil fuels at some point anyhow, it is essential that we put a price on carbon emissions to make that transition occur sooner, in an economically efficient way.

There are two competing ways to achieve the needed price on carbon emissions.

The first approach is via a direct carbon fee applied uniformly to all oil, gas and coal at the source, that is at the first sale at the mine or port of entry. In my opinion all of the money collected in this fee and dividend approach should be returned to the public on a monthly basis as an electronic deposit in their bank account or applied to their debit card.

The fee needs to increase gradually and be large enough to affect purchasing decisions. By the time the fee reaches a level of $115 per ton of CO_2 it will add $1 per gallon to the price of gasoline. Given United States fossil fuel use of 2007, $115 per ton of CO_2 would yield $670 billion, enough to provide a dividend (rebate) for each legal adult resident of almost $3000 per year. With half a share per child for a maximum of two children per family, the rebate would be $9000 per year for a family with two or more children. The carbon fee would provide a strong incentive to replace inefficient infrastructure. It would spur the economy. It would spur innovation.

In this fee and rebate approach, a tipping point would be reached as energy efficiency and carbon-free energies become cheaper than fossil fuels. We would then transition rapidly to the era beyond fossil fuels, leaving most remaining coal in the ground, and avoid the need to go to extreme environments to find every drop of oil. We must move beyond fossil fuels anyhow. Why not do it sooner, for the benefit of our children?

The fee rate would need to increase in time, but when gas hits $4 per gallon again most of that $4 will stay in the United States, as dividends. Our vehicles will not need as many gallons. We will be well on the way to energy independence.

The alternative approach is Cap & Trade, or perhaps more honestly Tax & Trade, because a ‘cap’ increases the price of energy, as a tax or fee does.

Other characteristics of the “cap” approach: (1) unpredictable price volatility, (2) it makes millionaires on Wall Street and other trading floors at public expense, (3) it is an invitation to blackmail by utilities that threaten “blackout coming” to gain increased emission permits, (4) it has overhead costs and complexities, inviting lobbyists and delaying implementation.

The biggest problem with this second approach is that it will not solve the problem. It may slow emissions, but because of the long lifetime of atmospheric CO_2, slowing the emissions does little good. As long as fossil fuels are the cheapest form of energy they will be used eventually. There is no hope that cap and trade can get us back to 350 ppm CO_2.

Political Leadership.

Political meetings may produce lofty goals for reduced carbon dioxide emissions by some future date. But these are of practically no significance, if the goals and the actions of the nations are inconsistent with geophysical constraints.

For example, I spoke with a German Minister. We found that we were in good agreement with the startling conclusion that we are already moving into dangerous levels of atmospheric CO_2. Yet Germany plans to build more coal-fired power plants. His rationalization was that they could "tighten the carbon cap" on cap and trade. I pointed out that, if coal emissions continued, that cap would somehow have to force Russia to leave its oil in the ground. I asked how he would convince Russia to do that. He had no answer.

The overwhelming practical requirement, for the sake of future generations, humanity itself, and the other species on the planet, is phase-out of coal emissions over the next 20 years. Also we cannot heavily exploit unconventional fossil fuels such as tar shale and tar sands, and we should not be pursuing every last drop of oil on the planet.

The correct fundamental approach is a rising price on carbon emissions, as needed to achieve these objectives. The Waxman-Markey bill fails the test in the same way as the German plans: it builds in approval of new coal-fired power plants! There is no need for these plants except to enrich utility and coal special interests – they are included only because the monstrous 1400-page absurdity was hatched in Washington after energetic insemination by special interests.

Fee-and-rebate, in contrast, spurs innovation and works hand-in-glove with increased building, appliance, and vehicle efficiency standards. A rising carbon fee is the best enforcement mechanism for building standards, and it provides an incentive to move to ever higher energy efficiencies and carbon-free energy sources. A tipping point soon would be reached, with rapid phase-over to future post-fossil energy sources. Tar shale would be dead and there would be no need to go to the extremes of Earth to find the last drop of oil.

Some environmental leaders have said that I am naïve to think that there is an alternative to cap-and-trade, and they suggest that I should stick to climate modeling. Their contention is that it is better to pass any bill now and improve it later. Their belief that they, as opposed to the fossil interests, have more effect on the bill's eventual shape seems to be the pinnacle of naïveté.

The proper course of action is clear, from the science and common sense. The geophysical boundary conditions dictate a course that causes coal emissions to be phased out expeditiously, although not necessarily coal use. There should be an immediate halt to construction of coal-fired power plants that do not capture all emissions, including carbon dioxide. Mountaintop removal, with its blasphemous environmental damage, should be banned – it provides only seven percent of United States coal, less than our exports.

The truth is, the climate course set by Waxman-Markey is a disaster course. It is an exceedingly inefficient way to get a small reduction of emissions. It is less than worthless, because it would delay by at least a decade or two the possibility of getting on a path that is fundamentally sound from economic and climate preservation standpoints.

Officials in the Obama administration privately admit that the science demands much more rapid emission cuts than Waxman-Markey would yield, but they say that their hands are tied by a recalcitrant Congress. Is that so? Has President Obama provided direction or guidelines for what he expects from Congress?

This is a problem that demands strong leadership. The only special interest that should be calling the tune is the public's special interest. Mountaintop removal should be banned. We should move rapidly to terminate coal use except where all emissions are captured.

The truth is that the climate problem cannot be solved without taking on special interests, specifically the coal industry. That is possible. The coal industry is but a fraction of what it once was; alternative industries will be far more beneficial to the nation and provide better jobs. President Franklin Roosevelt, for the general good, took on more powerful special interests. Margaret Thatcher showed that the coal industry is not omnipotent. This does not mean that coal workers should be abandoned – on the contrary, it would be straightforward to have programs in the affected states that provide support and opportunities for all of today's coal workers.

President Obama is our best hope, perhaps the only hope, of achieving real change in the near term. But we have to level with him. President Obama recently came out with a full-throated endorsement of Waxman-Markey. Was he properly advised about its contents? Perhaps so, but he chose to overrule the advice? His Science Adviser, John Holdren, has said that he cannot discuss what he has said to the President.

Al Gore probably has the strongest voice that the President would listen to, so assessment on that front is useful. Last year Al called for rewiring America within 10 years – a national electric grid with renewable energies and energy efficiency replacing 100 percent of coal use. Now he supports Waxman-Markey, which locks in negligible movement in that direction – indeed, the progress in that direction might be greater without Waxman-Markey, and surely would be greater with a rising carbon price. Perhaps "100% carbon-free in 10 years" was only meant as an idealistic goal to be abandoned. But the climate problem demands an <u>actual</u> solution – we must move rapidly toward carbon-free electric energy. Such a result can never be achieved by a top-down, 1400-page, special-interest-driven, coal-fired, prescription.

The route to success is a rising carbon price, with rebate of the money to the public. That is what is needed to allow energy efficiency, renewables, and other carbon-free energy to compete most efficiently against fossil fuels. The rate at which the carbon price increases can be debated. Also it could be argued that some of the money collected should go to energy R&D rather than rebate – I favor 100 percent rebate because of the economic stimulus it provides and because the size of the rebate would make most people supporters of a rising carbon price. [I have received notes from conservatives who say that they would support a carbon price, rather than Waxman-Markey, but they want me to drop the uniform rebate, which they say is income redistribution. That may be so, but it seems to me that the amount of carbon "tax" that would be paid by wealthy people, even if they have multiple houses and cars, is still small to them – indeed, the fact that personal energy costs are modest is the reason we still need efficiency standards in addition to a rising carbon price.]

<u>India, China and Nuclear Power</u>.

The fact that China has passed the United States in current CO_2 emissions should not cause us to forget that of the excess 107 ppm of CO_2 in the air today, the United States is responsible for three times more than China, so 10 times as much on a per capita basis. Compared to India, we are 25 times more responsible. What is the connection to nuclear power?

In all countries first priority should be energy efficiency, which has tremendous potential. After that comes renewable energies and improved low-loss smart electric grids. Everybody hopes that will be enough, but I cannot find real world energy experts who believe that is likely in the foreseeable future, even in the United States. This is all the more true in India and China, which are even more dependent on coal and have faster growing energy demands.

The current fleet of (2^{nd} generation) nuclear power plants is aging. The 3^{rd} generation plants that are likely to gain construction approval soon have some significant improvements over the 2^{nd} generation, using less than 1 percent of the nuclear fuel, leaving the rest in long-

lived (>10,000 years) wastes. If that were the end of the story, I would not have any enthusiasm for nuclear power. However, it is clear that 4th generation nuclear power can be ready in the medium-term, within about 20 years. Some people argue that it could be much sooner – however, the time required for its implementation is of little importance.

The reason that 4th generation nuclear power is a game-changer is that it can solve two of the biggest problems that have beset nuclear power. 4th generation uses almost all of the energy in the uranium (or thorium), thus decreasing fuel requirements by two orders of magnitude. It practically removes concern about fuel supply or energy used in mining – we already have fuel enough for centuries. Best of all, 4th generation reactors can "burn" nuclear waste, thus turning the biggest headache into an asset. The much smaller volume of waste from 4th generation reactors has lifetime of a few centuries, rather than tens of thousands of years. The fact that 4th generation reactors will be able to use the waste from 3rd generation plants changes the nuclear story fundamentally – making the combination of 3rd and 4th generation plants a much more attractive energy option than 3rd generation by itself would have been.

Of course, nuclear power poses dangers, but that is going to be true in any case – nuclear power is not going to disappear from the planet. The United States will be far safer if it takes a leadership role in helping assure international standards and controls on the nuclear industry.

The reason that I bring up this topic again, especially in connection with India and China, is continued over-emphasis on "clean coal", i.e., carbon capture and sequestration. That technology should be given a chance, but it is doubtful, even if it worked, that India and China will be willing to go to the enormous costs of implementation. On the other hand, they are choking in air pollution. Standardized, replicable nuclear power stations seem a more plausible bet than "clean coal".

I always make clear that energy efficiency and renewable energy should have first priority, and if they can do everything, great. But we would be foolish to take that as a presumption or to remove options for our descendants. It was a mistake to terminate the R&D on 4th generation nuclear power at Argonne Laboratory in 1994, but we still have the best expertise in the world. They deserve much more support, and we should be working in full cooperation with China, India, and other countries.

Civil Resistance: Is the Sundance Kid a Criminal?

Another truth that has become apparent: our climate/environment leaders are not people located in Washington. The leaders are members of the public who understand the situation and have the courage to act on it. I met a couple of them recently:

Tim DeChristopher, the University of Utah student, who, realizing that it makes no sense to be going after the last drop of oil on pristine public lands, outbid the oil companies for drilling rights. He has been charged with two felonies (because he had no money to pay for the drilling rights) and is threatened with 10 years in prison (he is facing about $100,000. in legal costs -- you can contribute to his defense at http://www.peacefuluprising.org/).

You can see a rationale for Tim's defense in the above charts. The efforts of fossil interests to go after every last drop of oil may leave his generation with a $12 trillion cleanup bill – that's just for restoring the air (removing 30 ppm of CO_2), without consideration of payment for damage due to rising seas – and what is the price of species exterminated?

Larry Gibson, the Mountain Man near Coal River Mountain who refuses to let Massey Energy blow up the mountain where he lives and his relatives are buried. In my last post http://www.columbia.edu/~jeh1/mailings/2009/20090625_CoalRiverMountain.pdf

I mentioned Gibson, a target of drive-by shootings. These are the people with real courage – it made me nervous just to ride in Gibson's pickup in hostile territory. Larry and I both have pleaded not guilty to charges of obstruction during the protest on 23 June and are requesting a trial.

On the subject of civil resistance (Mahatma Gandhi explains why civil resistance, as opposed to civil disobedience, is a better philosophy; "The Essential Gandhi", L. Fischer, Vintage Classics), a recent note from Damian Carrington of the Guardian and Observer reads:

Given your involvement in the Kingsnorth trial, I thought you would be interested to know the result of the trial of the 29 people that stopped a coal train going to Drax. They were found guilty of the main charge after the judge ruled out the necessity defence. We have covered the trial extensively (unlike our competitors) and you can if you wish read more here: http://www.guardian.co.uk/environment/activism
Their closing statement is quite something.
http://www.guardian.co.uk/environment/2009/jul/02/drax-protesters-defence-sum-up
I would very much like to include your reaction to the verdict. Could you send me a line or two?

I responded that they are right to keep the focus on the necessity defence. Civil resistance is not easy, but if governments continue to abdicate their responsibility to citizens, in favor of special interests, it seems essential. Strength comes from realization of rightness of course, and should be increased, not diminished, by temporary setbacks.