

Safe and fair: The daunting goals of the global energy system

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Towards a Sustainable Future: The Role of Long Term Investment

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I will make these points.

1. *Climate change is the consequence of prosperity.* The modern economy has enabled unprecedented wealth, which has been accompanied by an unprecedented rate of transformation of natural resources. Our planet, however, has a fixed size. As a result, for the first time in history, human beings are producing planetary-scale environmental change to a significant degree. The climate is only one example. Many of the world's fisheries have been depleted, and we have found most of the planet's low-cost oil. We almost failed to recognize the ozone hole over Antarctica.
2. *This new information about la condition humaine is profoundly unsettling.* It is as unwelcome as the news in Galileo's time that the earth was not the center of the universe, and the news in Darwin's time that human beings were not apart from the animal kingdom. On both of these earlier occasions, the news that scientists brought was fiercely resisted. We should not be surprised, therefore, at the current resistance to the news that through living well we can change the planet. Alas, the news this time is just as true as was the news from Galileo and Darwin.
3. *The climate problem provides a window into the general issue of planetary-scale disturbance.* By one metric, emissions of carbon dioxide resulting from burning fossil fuels and clearing forests for pasture have already raised the atmosphere's stock of carbon dioxide by 40% relative to the "pre-industrial" past (a millennium or more prior to 1800). Today, the rate of change is roughly a 5% increase every decade. By a second, less certain metric, the long-term average surface temperature of the earth will rise about 1 Celsius degree relative to its "preindustrial" value as a result of the carbon dioxide already emitted, and the average surface temperature is rising today at a rate of nearly 1 Celsius degree every half century.
4. *Climate change is a problem in risk management.* Climate science is only partially developed. The best and worst outcomes from climate change consistent

with known climate science are very different. We could be lucky, but we could also experience climate change that would be extremely disruptive. Risk management is familiar territory to bankers.

5. *The depletion of fossil fuels will almost surely occur far too late to prevent significant climate change.* Even if the era of low-cost oil ends a few decades from now, coal and “unconventional” oil and gas will remain abundant. The depletion of fossil fuels will not occur in the time frame of this century. Yet, in this century, we must cease using fossil fuels as we do now.
6. *The scale of the required transformation of the current global economy is profound.* First the engaged public believed that solving the climate problem was impossible, then that would be easy. But it is neither impossible nor easy; it is difficult. The globally averaged per capita emission rate for carbon dioxide is four tons per year. (A car driven 24,000 km/yr with a fuel economy of 5 liters/100km emits four tons per year. The American per capita average is 20 tons per year, and the European value is 10 tons per year.) But in order to sustain a new plateau of concentration in the atmosphere, the global emissions rate must fall to about 1 ton per year. It is not sufficient to limit emissions in the prosperous parts of the world and allow the less fortunate to catch up. Such an outcome would overwhelm the planet. The emissions of the future rich must eventually equal the emissions of today’s poor, not the other way around. This requires investments on a global scale starting soon. The first priority ought to be infrastructure that is being built now and will last a long time: the buildings of the new cities, urban infrastructure, and power plants.
7. *Pace is key.* Pace is the rate of change. How quickly should the global energy system be transformed – in two decades, or four, or over the course of this century, or over a still longer time period? This is a matter of judgment, not science. Change the system too quickly, and the consequences of dealing with climate change can become more disruptive than climate change itself. An example of moving too quickly: encouraging the global spread of nuclear power prior to establishing a stronger international management regime that prevents nuclear weapons proliferation. Change the system too slowly, and we risk spending large fractions of future global GDP on moving cities inland, relocating agriculture, redirecting water supplies, and migration.
8. *Price, plus.* Markets will direct investment more cleverly than individuals in many cases. There needs to be a rising price of carbon that the world can count on, and the price must ramp up to a value high enough to assure that low-carbon investments are elicited. It is a mistake to expect a low price to be adequate. For specificity, anticipate that the required ramp brings a price of \$100/tCO₂ in twenty years everywhere in the world. That price adds \$5 to the price of a standard cubic foot of natural gas, \$50 to the price of a barrel of oil, \$200 to the price of a ton of coal, and about \$80 to the price of a MWh of coal-fired electricity. But a ramp is not enough. There must be policy that deals with the

market failures that retard investments in energy efficiency. And there must be policy that enables new entrants.

9. *The developing world will decide what kind of planet we live on.* Already, more than half of the world's carbon dioxide emissions come from outside the OECD. For a while longer, the industrialized countries will lead. But over this century countries outside the OECD will dominate decisions related to natural resources and global environmental impact. A new kind of country will be especially important for several decades, where the lifestyles of a significant fraction of the population are identical to those of the prosperous people in the OECD, while many of the rest live in abject poverty. These are the R&P countries, with many Rich and many Poor. It will be difficult for the world's nations to find a way to deal with climate change that is both "fair" across nations and "safe" in terms of acceptable level of climate risk. Fortunately, the abject poverty of the world's poorest two billion people can be eradicated with negligible impact on climate change or oil markets.

10. *The new global economy can be based largely on technology already understood today, but all kinds of research and development will be required.* The first need is to scale up what we already know how to do. Most of the physical plant that will exist in 2060 has not yet been built. Building very different buildings and power plants will require pilot projects and full-scale demonstrations, extensive monitoring of successes and failures, and learning by doing. One should expect dramatic reductions in physical throughput; for example, electronic communication will substitute extensively for business travel. One should expect extensive deployment of technologies that capture carbon dioxide at power plants fueled by coal or natural gas and then place this carbon dioxide deep underground safely. The second need is to develop entirely new options, via broadly based research programs that build on the astonishing level of scientific understanding of materials and biological systems now achieved at the molecular level.