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Introduction

1.1 The First Edition

Our planet's atmosphere has been the dumping ground for all sorts of gases for as long as human history. Its capacity is large, and when those using it as a dump were few there was no problem. There are now more than seven billion of us, and we have now reached the point where human activities have overloaded the atmospheric dump and the climate has begun to change. The United Nations population group projects that there will be 10.5 billion by 2100. Our collective decision is what to do about it. Do we do nothing and leave the problem to our grandchildren who will suffer the consequences of our inaction, or do we begin to deal with it? It is much easier to do things now rather than later, but it will cost us something.

To me the answer is clear: we should start to deal with it. This book describes the problem and the alternatives that exist to make a start on limiting the damage. This is not an academic book, even though I am a physics professor. It is written for the general public. True, it does contain some scientific details for those interested in them, but they are in technical notes at the ends of chapters; you can skip them if you like.

The title of the book, *Beyond Smoke and Mirrors*, can be taken two ways. One is what future energy sources might

replace coal and today's versions of solar power. The other is the real story behind the collection of sensible, senseless, and self-serving arguments that are being pushed by scientists, environmentalists, corporate executives, politicians, and world leaders. I mean the title both ways, and the book looks at the technical and policy options and what is really hiding behind the obscuring rhetorical smoke and mirrors. There are many ways to proceed and, unfortunately, there are more senseless arguments than sensible ones, and still more that are self-serving.

I divide those doing the most talking into the anti-greens, sometimes called the deniers; the greens; and the ultra-greens, sometimes called the exaggerators. As you might guess, I consider the greens to be the good guys. I classify myself among them.

There is a rapidly declining number of those denying that human activities are increasing the global temperature, but the species is not yet extinct and perhaps will never be. These are the anti-greens. Even they agree that the greenhouse effect is real, and that greenhouse gases in the atmosphere are the main element that controls the average temperature of the planet. Why they do not agree that changing the greenhouse gas concentration changes the temperature is beyond me.

The ultra-greens have declared an immediate planet-wide emergency where money is no object and where only solutions that match their programs are acceptable. They seem to have forgotten that the object is to cut greenhouse gas emission, not just to run the world on windmills and solar cells, which alone are insufficient to deal with the problem. By rejecting options that do not

match their prejudices they make the problem more difficult and more expensive to address.

According to the anthropologists our first humanoid ancestor appeared about four million years ago. During the very long time from then until now the world has been both hotter and colder; the Arctic oceans have been ice-free before, and at other times ice has covered large parts of the world. What makes climate change a major problem today is the speed of the changes combined with the fact that there will be about nine billion of us by the middle of this century and probably 10.5 billion by the end of the century. We were able to adapt to change in the past as the climate moved back and forth from hot to cold, but there were tens of thousands of years to each swing compared with only hundreds of years for the Earth to heat up this time. The slow pace of change gave the relatively small population back then time to move, and that is just what it did during the many temperature swings of the past, including the ice ages. The population now is too big to move *en masse*, so we had better do our best to limit the damage that we are causing.

Though there is now world agreement that there is a problem, there is no agreement on how to deal with it or even on what we should be trying to achieve. The European Union (EU), a collection of the richer countries, has a big program aimed at cutting greenhouse gas emissions. The richest country, the United States, has only recently acknowledged that human activity is the main cause of global warming, but has done very little so far to do anything about it. Russia thinks warming is good for it and has done nothing. The developing countries have said it is the rich countries that caused the

problem so they should fix it, and poor countries should not be asked to slow their economic development. However, they are growing so fast that according to projections, the developing world will add as much greenhouse gas to the atmosphere in this century as the industrialized nations will have contributed in the 300 years from 1800 to 2100. We all live on the same globe, the actions of one affect all, and this problem cannot be solved without all working together.

There are three parts to this book. Part I is on climate change itself and explains what we know, what we don't know, what the uncertainties are in predictions of the future, and how urgent is the need for action. The section discusses what can be learned from the past, how the future is predicted, the many models that are used, and what they predict. The models are not yet good enough to converge on a single number for the expected temperature increase because the science is not that perfect. Uncertainty is used by some as an excuse for inaction, but it should not be, because by continuing "business as usual" (BAU) the predictions for the end of the century range from terrible at the high end of the predicted increase (about 12 °F or 6 °C) to merely very bad at the low end (about 4 °F or 2 °C).

Part II begins with what we need to do in controlling greenhouse gas emissions to limit the ultimate temperature rise. It is too late in this century to return the atmosphere to what it was like before the start of the industrial age. I include my estimate of the allowable upper limit on greenhouse gases, the amount beyond which the risk of sudden climate instability greatly increases.

Next is a review of what the economists say about the best way financially of controlling emissions. There are no economists that I know who are saying do nothing now. The argument is over how fast to go. The natural removal time for the major greenhouse gases is measured in centuries, so if we wait until things get bad we will have to live with the consequences for a long time, no matter how hard we try to fix things. The issue is the problem that we will leave to our grandchildren.

Part II goes on to look at the sources of anthropogenic (human-caused) greenhouse gas emissions and what we might do about them. Two broad categories dominate: the energy we use to power our civilization; and agriculture and land-use changes that have accompanied the increase in world population. I focus on energy use, which is responsible for 70% of greenhouse gas emissions. Agriculture and land-use changes contribute the other 30% of emissions, but their coupling to food production and the economies of the poor countries are not well understood. I leave this to others, except for biofuels which are part of the energy system.

I review what kinds of energy we use in the world economy and what each contributes to greenhouse gas emissions. The conclusion is the obvious one: fossil fuels are the culprit, and the only way to reduce their use while economic growth continues is by some combination of increased efficiency and a switch to sources of energy that do not emit greenhouse gases either by their nature or by our technology. In truth, we can continue our old ways of using fossil fuels for about another 50 years if we don't care about our grandchildren. Even with business as usual there are unlikely to be supply problems until the second half of the century, though there may be price problems.

There is no single technology that will solve all of our problems. We will have to proceed on many fronts simultaneously, starting with what we have in our technology arsenal now. All the options are reviewed, including capturing and storing away emissions from fossil fuels; efficiency; nuclear power; and all of those energy systems called the Renewables. Some are ready for the big time now, others need further development. All revolutionary technologies start in the laboratory, and we are also not investing enough in the development of the technologies of the future.

Energy supply is the area where one finds most of the senseless and self-serving calls to action. For example, it is not within the bounds of reality to eliminate all the fossil fuels from our electricity supply in the next 10 years. This one is senseless. Further, increasing the amount of corn-based ethanol in our gasoline does almost nothing to decrease emissions when emissions in ethanol production are included. This one is self-serving.

Part II concludes with an admittedly opinionated summary of the promise and the problems of various technologies (there are lots of both), as well as my personal scorecard showing winners, losers, and options for which the verdict is not yet in.

Part III concerns policy options. There are two dimensions that need discussion: what to do on a national or regional scale, and what to do on a world scale. I believe the best policies in market economies are those that allow the private sector to make the most profits by doing the right things rather than the wrong things. There is always a huge amount of brain power devoted to making money and it can and should be tapped. I call this "tilting the

playing field" so that things move in a desired direction. Of course, regulations are required too. The US auto industry, for example, had resisted efficiency improvements until regulations required them to act. I know this area well, having spent six years in the 1980s on the General Motors Science and Technology Advisory Board. I think the industry has finally understood what is needed and is developing the technologies required to meet the long-term goal of 54 miles per gallon for the average mileage of the light vehicle fleet.

The global problem is harder to deal with. It is particularly tough because while emissions have to be tackled on a global basis, the world has countries that range from rich to poor. Most emissions are coupled to energy use, and energy use is coupled to economic development: the poor want to get rich, the rich want to get richer, and the benefits coming from actions now are going to be seen only in the future. The very poorest use so little energy that even as they begin to climb the development ladder and use more, they will still make only a tiny contribution to emissions, and the world program can leave them alone until they have climbed several steps.

But the developing countries in the rapid-growth phase – China and India, for instance – cannot be entirely left out of the action agenda as they were in the Kyoto Protocol of 1997. China has already passed the United States as the largest emitter of greenhouse gases, and the developing nations collectively are expected to surpass the industrialized ones in 5 to 10 years. There can be no effective program for the long term without all nations coming under a greenhouse control umbrella once they reach some emission threshold. It will no longer do for the developing

nations to ask the industrialized nations alone to fix the problem, because they can't. As I wrote earlier, in business-as-usual projections (continuing with the same mix of fuels as the world economy grows), the developing nations as a whole will emit nearly as much greenhouse gas from 2000 to 2100 as the industrialized nations will have done in the three centuries between 1800 and 2100. There is no solution to the global warming problem without the participation of the developing world. Policies have to reflect reality, and the richer counties will have to take the lead. There is no excuse for the United States to stand aside as it has done since 1997. The first Kyoto Protocol expires in 2012, and any new agreement has to include some graduated way to include all but the very poorest nations.

In 1968 Garrett Hardin, then a professor of ecology at the University of California, Santa Barbara, published an enormously influential article, "The Tragedy of the Commons" [1]. The metaphor of the title referred to how overgrazing occurred on common pasture land in medieval England. It did no good for only one person to limit his sheep grazing because his contribution was so small. Only if all worked together to limit grazing could the common pasture be preserved. Hardin's "Commons" today is the Earth's atmosphere.

We can preserve our atmospheric commons. What we know, how we know it, what the uncertainties are, and what we should be doing are the subjects of this book.

1.2 The Second Edition

The original manuscript of the first edition was delivered to my editor, Matt Lloyd, at the beginning of 2009, and

was in the bookstores in April of 2010, roughly 10 years after I had moved from physics to energy as my main work. Its contents back then reflected my 2008 understanding of the issues and the technology that might be used to confront them, and aimed to tell the reader what we knew, how we knew it, what the uncertainties were, and what we might do about the climate problem. Five years have passed, and although almost everything is still basically correct, a tune-up is in order to tell what advances and what retreats have been made in all the areas in the past five years, and what has been happening on the policy front.

There is also a need to take a view broader than just climate change when thinking about and planning an energy future that takes into account the aspirations of the developing world and the national security interests of all. Just telling a poor nation that they have to do something about climate change is not enough to get action if that action will keep them poor for a longer time; more about this later.

On the climate front, there is a new report [2] from Working Group I of the Intergovernmental Panel on Climate Change (IPCC). It is highly technical, and the analysis strengthens the case that climate change is real and that we are responsible. I am not sure that it means much to the non-expert to have the experts say that the probability that human activity is the cause of the temperature rise in the past 200 years has gone from very likely to extremely likely. More meaningful might be the conversion of an old friend at Berkeley from climate-change skeptic to believer. After the hacking of the emails from the University of East Anglia in England a few years

ago ("Climategate," as it was called), the language in some of those emails led some to conclude that the temperature results had been manipulated. My friend raised the money to do an independent analysis, put together an extremely sophisticated group of statisticians, and did a complete reanalysis of all the temperature data, getting the same results as the IPCC. He is now a believer; call this epiphany by statistics.

Some green technologies have shown greater promise since 2008, while others, particularly biofuels, have failed to live up to their early promise. Wind and solar electricity have proved to be effective at small scale, but hard to use at large scale because of their variability, which is not balanced by large-scale, affordable energy storage that can be used to smooth the fluctuations.

The Fukushima nuclear accident in 2011 has led some countries to move away from nuclear energy while others are going full-speed ahead.

In the United States, the shale-gas revolution has so lowered the cost of natural gas as to make it an effective transitional fuel to help move along a necessary change in our energy usage while lowering the cost of electricity and reducing greenhouse gas emissions. The potential supply of shale gas in other regions is still uncertain, but it may well be that there is much more waiting to be exploited which would have worldwide impact.

There are still big problems on the policy front. The Kyoto Protocol – which was supposed to place legally binding obligations on the developed countries to reduce emissions – has been a failure. In my opinion it was a silly idea in the first place because there was never a mechanism to enforce its so-called legally binding commitment.