Santa Fe Institute – Global Sustainability Summer School

Chuck Kutscher: Summary and Analysis

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Introduction

The purpose of this paper is to briefly summarize and then analyze a lecture delivered by Chuck Kutscher, principal engineer and manager of the Thermal Systems Group at the National Renewable Energy Laboratory in Golden, Colorado. The talk, "The Urgency of Climate Change and How to Address it with Renewable Energy and Energy Efficiency", was delivered at the Santa Fe Institute's Global Sustainability Summer School (GSSS) in July of 2009. Dr. Chuck Kutscher is a principal engineer and manager of the Thermal Systems Group at the National Renewable Energy Laboratory in Golden, Colorado, where he has worked for 28 years. He is editor of a new 200-page American Solar Energy Society report, "Tackling Climate Change in the U.S.", on which much of his talk was based.

Dr. Kutscher first establishes the reality of climate change and the undeniable scientific evidence that points to the warming of the earth's climate. He augments his empirical evidence with his personal perspective gained from scuba diving in now endangered and diminishing coral reefs. Dr. Kutscher views technological innovations in the energy sector as the key to drastically reducing greenhouse gas (GHG) emissions, particularly in the US.

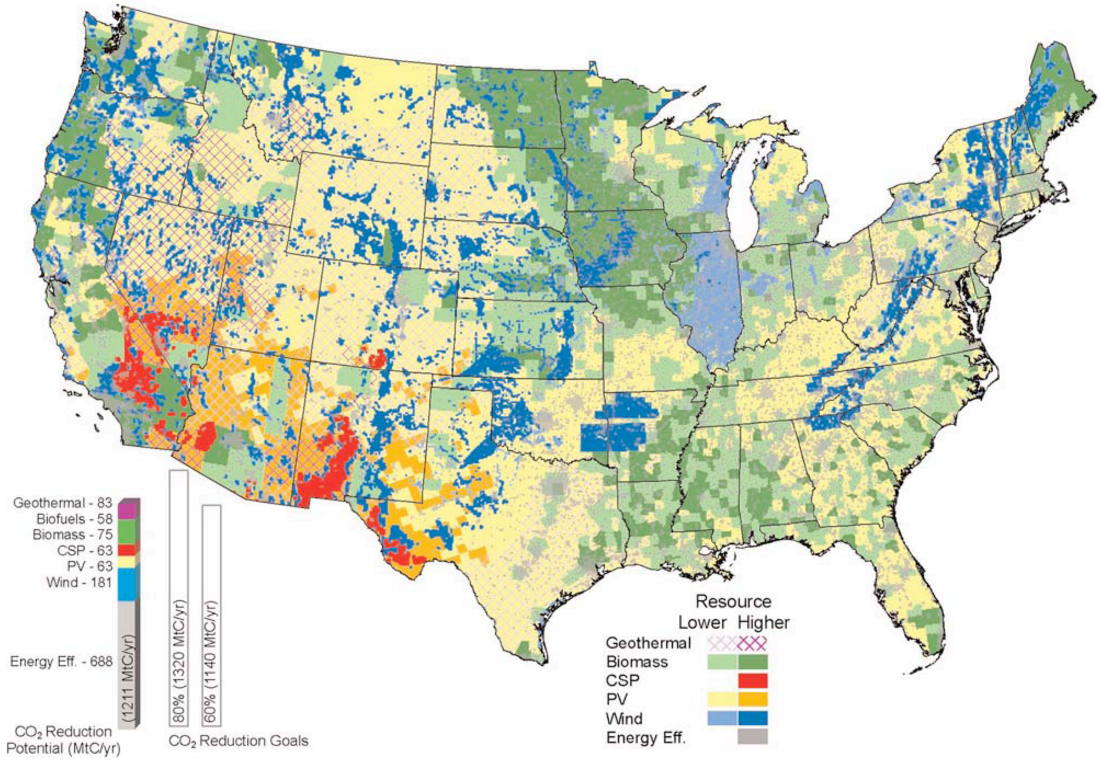
His analysis is based on reducing US GHG emissions by 60 – 80% by the year 2050. According to some climate models this reduction will limit sea level rise to one meter and species loss to 20% in the 21st century. If carbon is priced correctly, then the impetus to develop these technologies would emerge at the necessary levels. First, increased energy efficiency through improvements in the building, transportation, and industrial sectors would drastically reduce GHG emissions. Second, the remaining energy demand would be increasingly met by renewable energy options. Dr. Kutsher highlighted the availability of coal with carbon capture and storage as well as nuclear energy but considers these less desirable than renewable energy options.

In terms of renewable energy, the options are as follows:

1. concentrated solar power (CSP),
2. photovoltaics,
3. wind,
4. biomass and biofuels, and
5. geothermal.

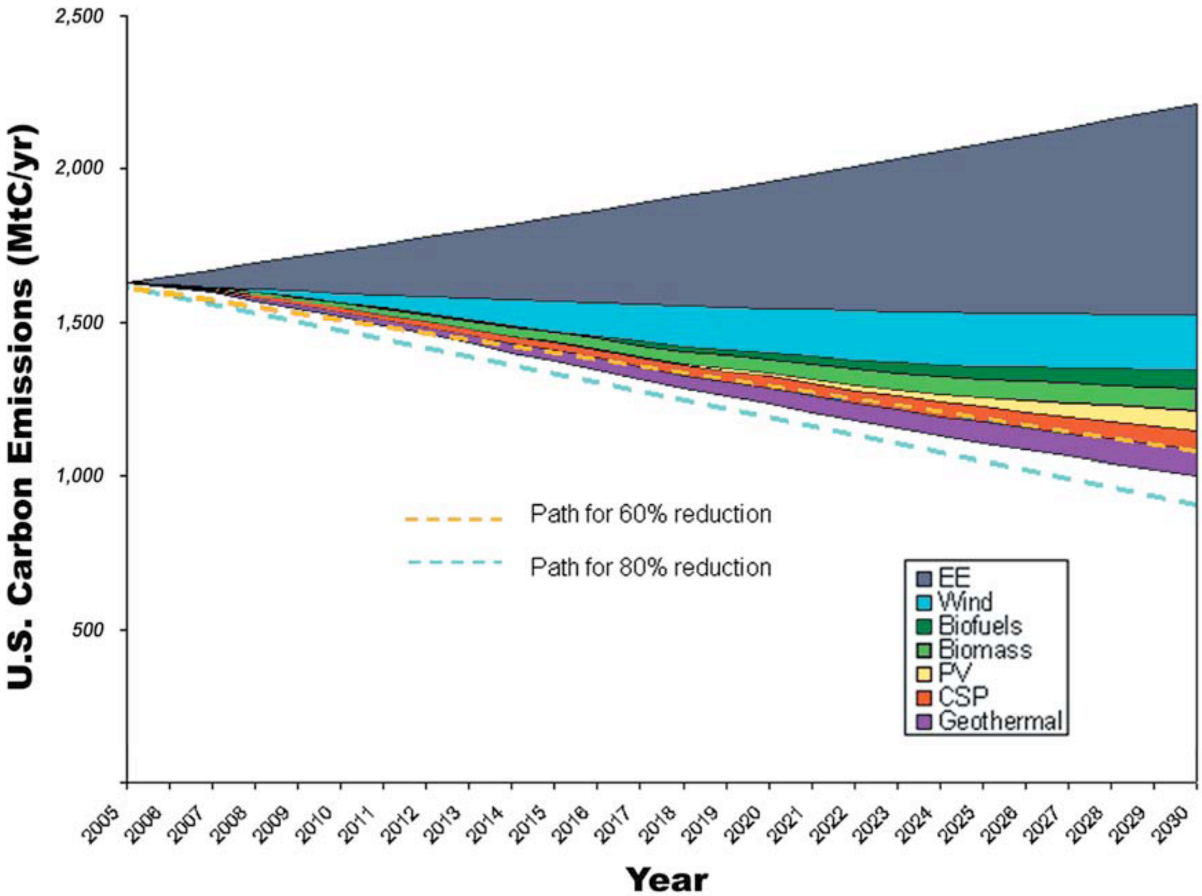
Figure 1 is a US map illustrating the potential contributions by energy efficiency and renewable energy by 2030. CSP and wind are based on deployment scenarios; other renewables indicate resource locations.[i]

Figure 1



According to this map, energy efficiency and renewable energy have the potential to reduce US GHG emissions by 60%, with an 80% reduction just out of reach. Figure 2 highlights carbon reductions in 2030 from energy efficiency and renewable technologies and paths to achieve reductions of 60% and 80% below today's emissions value by 2050.[ii]

Figure 2



Analysis

Assumptions

Dr. Kutscher bases success on reaching 60 – 80% reductions in US emissions of greenhouse gases. Two significant assumptions are embedded in this statement. First, it defines the level of climate change society deems acceptable, in this case one meter of sea level rise and 20% species lose. Some stakeholders in the climate debate may take issue with that assertion and claim that it either allows for too little or too much damage.

Second, the statement asserts a narrow range of technological changes is necessary to reach the goal, when there are a large suite of solutions available in terms of technology, behavior change, policies, etc. His analysis also does not take into account the changes that will need to be made by other countries. The question of what level of reduction is needed to reach an acceptable level of climate change is highly controversial.

Feasibility

Dr. Kutscher's analysis provides an optimistic view to the climate problem: given the appropriate pricing of carbon and advancements in technology and commitment, it is possible for the US to reduce GHG emissions to an acceptable level. This view is somewhat contradictory to the opinions expressed early in the GSSS by Donald Paul, Research Professor of Engineering, Earth Sciences, and Policy, Planning, and Development at the University of Southern California. Dr. Paul asserts that energy system is fundamentally complex and advancements are dependant not only on whether a certain technology has been developed but also economics, business, politics, and society.

New developments in the energy system must integrate with the existing supply and demand infrastructure. Replacing or changing this infrastructure can be cost prohibitive with many of these technologies, making their integration extremely difficult. Furthermore, since the cost to produce different types of technology is initially high and then decreases rapidly with time, it may perhaps be foolhardy for a government or business to invest immediately in groundbreaking renewable energy technology that may be much cheaper in only five or so years. Thus, to immediately pursue this kind of investment comes as a high opportunity cost and would not necessarily be dictated solely by the price of carbon.

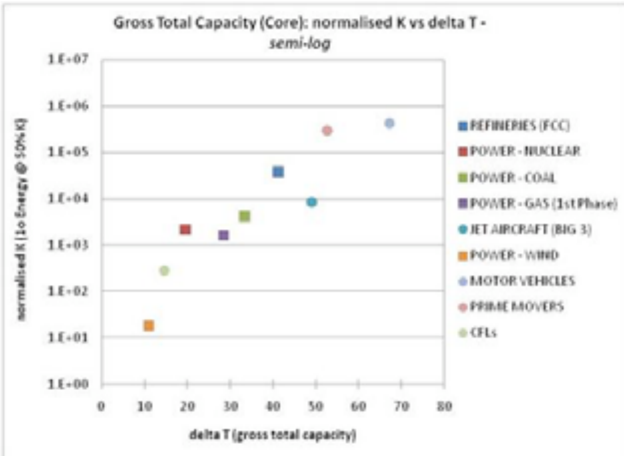
Human nature and history may also be against such a rapid adoption of new technology. Arnulf Grübler, Professor in the Field of Energy and Technology at the Yale School of Forestry and

Environmental Studies, illustrated during GSSS the time lag between invention and innovation. According to Dr. Grübler the innovation life cycle is as follows:

1. Invention: new knowledge, research
2. Innovation: new application of knowledge, research and development
3. Niche markets: exploration of application possibility and debugging through supplier-user interaction
4. Diffusion: standardization, cost reductions via learning curve and scale effects, globalization of markets

The technologies that Dr. Kutscher have proposed are at varying locations on the first three steps; none of them have made it to the level of diffusion which is necessary to reap the benefits of the technology. Many variables will influence the rate of diffusion of a new technology, including the size of the system within which it operates. The larger a system is, the longer it takes to be changed. Since the energy system is enormous, according to this theory it will take a long time to change. This is has been verified empirically by the Figure 3 which illustrates the historical relationship between the extent and rate of industry scaling is consistent across technologies.[iii] Additional research present by Dr. Grübler also indicates that contrary to popular belief, the rate of technological change is not accelerating and thus the transformation of the energy system will be subject to the same boundaries of time and diffusion.

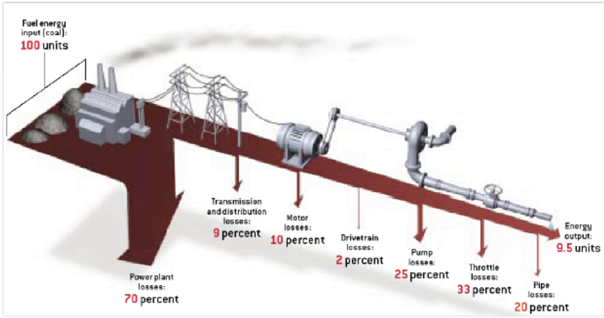
Figure 3



Upstream Focus

Assuming that technology is the key to preventing disastrous climate change, there is much debate as to where the advancements in technology should be focused. Dr. Kutscher's analysis pays special attention to the upstream section of the energy system – energy production. Amory Lovins, Cofounder, Chairman, and Chief Scientist of the Rocky Mountain Institute, presented an alternate point of view during GSSS. Dr. Lovins has developed proposals for innovative new technologies that use mass quantities of energy. For instance, Dr. Lovins presented several innovations that would drastically reduce gas consumption in cars. If these changes were to be put in place, they would eliminate the need for the energy in the first place. Figure 4 illustrates this connection.

Figure 4



Starting downstream saves ten times as much fuel as at the power plant, and it makes upstream equipment smaller, simpler, and cheaper.[iv]

Technology Focus

Others would take a completely different view than both Dr. Kutscher and Dr. Lovins and focus on behavioral changes rather than technological solutions. Dennis Meadows, President of the Laboratory for Interactive Learning Emeritus Professor of Systems Policy and Social Science Research and the University of New Hampshire, used simple and interactive simulations during GSSS to illustrate the importance of human interaction and relationship with technology in reaching a more sustainable world.

Conclusion

Despite differences of opinions in ways to combat climate change, all presenters at GSSS agreed with Dr. Kutscher's view that climate change is dire, change must be immediate, and technology will play an important role. The path that will be taken is highly dependent upon political and economic circumstances as well as the will of US citizens to lobby for their preferred outcomes. More debate, research, testing, and application is needed until it becomes clear what the US' response to climate change will be.

[i] American Solar Energy Society. "Tackling Climate Change in the US." 2007, p. 36.
[ii] Ibid p. 33
[iii] Grüble, Arnulf. "Climate Change: Rates of Change and Constraints for Adaptation and Mitigation Measures." Global Sustainability Summer School. Santa Fe: Santa Fe Institute, 2009, p. 4.
[iv] Lovins, Amory. "Winning the Oil Endgame." Global Sustainability Summer School. Santa Fe: Santa Fe Institute, 2009, p. 68.