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Post Carbon Transitions, Visions and Challenges

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Energy Technology and the Challenge of a Low-Carbon Transition

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I commend our conference organizers for structuring our discussion around the word "transition." Transition denotes a process. The end state of the energy transition is still fuzzy, and the word itself suggests a journey that is never fully complete. Indeed, there will be carbon in our energy menu—not only long after 2050, but also long after the beginning of the next century. This long transition is not a matter of choice. It is a reality. The twin but only partially overlapping problems of global climate change and energy security motivate us to move forward rapidly, but the magnitude and difficulty of the task dictate that the transition will be lengthy and sometimes halting.

This transition is not ours to plan in detail and certainly not ours to complete. It is ours, instead, to place in motion. It is then for us and future generations to carry forward. Therefore, our most important function is to create, and then leave to others, the preconditions under which future generations can move the process to completion. Our role is to be good stewards of our opportunities so that others can build upon them. This view of our task is one I have termed "rolling stewardship"—with us tasked to create for the future the capability of being good stewards in their turn, so that they might also provide for those who follow.

The simple prescription for long-term success is to create the low-carbon and energy-efficient technologies and practices that can assure adequate energy services to meet human wants and to support sustainable economic growth into

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the future—and then to deploy those technologies and practices on a global basis. The goal is a sustainable energy system in which all populations can have lives such that the disparity in energy services available is not a source of political or social instability.

Defining this goal in terms of energy services is critical. "Energy services" encompass three aspects: First, energy supply; second, the set of human wants that require energy inputs; and finally, the effectiveness and efficiency by which the energy supplied is transformed into want satisfaction.

I leave to a later session a discussion of "sustainable lifestyles"—the shift in human wants that may affect the future quantities of energy required. I note, however, that for much of the population of the world—mostly in the developing countries but also the less well-off sub-populations within the developed world—energy services are even now inadequate to provide the basic necessities of satisfactory daily life—food, clothing, shelter, adequate medical care, and security in meeting these needs. The challenge of providing these is daunting enough, to which is further added the tasks of the transition we are about. And going beyond concern for our fellow man, international peace and domestic stability requires that the challenge of enabling at least basic sustenance for all be met, along with a reasonable hope for a better tomorrow.

The brute fact is that the energy transition will require enormous investment. Thus, this generation and several generations in the future have had thrust upon them an additional burden: to replace the cheap energy services based on oil, gas, coal (and the perception of a forgiving environment) with a new system. Further, the developing world is and will utilize a growing segment of global investment. Hence, success in providing for the future requires not only sustained economic growth but also a substantial increase in the amount and rate of saving to support that investment. Something will have to give. The likeliest (and arguably fairest) outcome will be a decline in the rate of growth in consumption of traditional goods and services among the more affluent of us. The stresses we will face in reducing consumption to bolster savings in order to make this investment leap require that we be very hard-minded and wise in our priorities and our actions in making this transition, and even then it will not be easy.

It is not my place, nor is within it my capacity, to suggest the specifics of future energy technologies. I can, however, suggest a framework for making the choices required. In doing so it is useful to distinguish the stages through which a technology develops from inception to deployment.

Science combined with a creative spark is the initiating force that can foster new technology. Sufficient public support for basic scientific progress, built upon a strong educational foundation, is the hope of the future. The most important aspect of this is STEM education—Science, Technology, Engineering and Mathematics—on which many in the United States think that we, at least, have been doing an inadequate job. Substantial increases in public investment in education and basic science—along with innovation and learning from other's success and failures—is necessary for success. On this all depends.

Out of this foundation will grow further questions and possible energy technology opportunities, most of which, unfortunately but inevitably, will prove empty. But a few will be worth pursuing. Research and development on energy production and consumption then can follow. The products of this activity, like basic science, also are partly in the nature of public goods, and like the education foundation on which they rest, will require governmental funding. Indeed, because education, basic research and R&D have the promise of global benefits, international funding and broad and deep communication and movement of ideas and research results across boundaries are desirable, however hard they are to accomplish in a politically and economically fragmented world. The primary task of such R&D is not to pick winners but to weed out losers from the ideas brought forth. Since R&D is the "cheap" stage of technological development, the broadest and deepest of portfolios are justified—with a concomitant rigor in dispatching losers to the dustbin.

The pilot phase follows, and again has substantial public good components that in some cases will justify incremental public funding in partnership with private interests. Those interests should have personnel and substantial capital investment in the project so as to assure that learning and innovation can flow forward to the next stage, if warranted. Further, because private investment is at risk, powerful incentives for efficiency and for timely termination of failures are in place—enhancing the capital available for other efforts. With the incentives provided by participation of private interests, it is more likely that those prospects carried forward would be judged by two necessary criteria: potential technical success and sufficient potential contribution to justify the investment required to bring them to either further consideration or to prompt abandonment. Learning and innovation becomes an important aspect at this point as problems faced are solved, or not. The spillover effects of this learning mean that even a failed project may make a contribution to those proceeding elsewhere, which again illustrates the partial public good aspect of work at this stage.

The demonstration stage again brings escalating investment cost, much longer time frames, and substantial risk. Criteria for moving into this stage mirror those before—but with a much larger bet on the line in both directions. On the one hand, the investment required may be so large as to call for sharing the risk through public investment or by collaboration among private firms. On the other hand, much of the prospective return will be in the form of intellectual capital and experience, and sharing it diminishes the potential for a bonanza return. Each situation will vary, but the premise should be to guarantee secure intellectual property rights for those making the decisions and the investment unless the situation requires their explicit modification to proceed. Given the size, complexity, and public and private benefits from technologies that foster the transition, institutional innovation to accomplish these goals is potentially important.

The deployment stage for many major technologies will absorb massive amounts of capital and long time horizons. This is especially true for most supply technologies and for consumption systems such electricity generation, transportation, and the like. The capital absorbed in deployment must come from alternative investment and from consumption. This means that making wise decisions here is extremely important if the globe is to meet both its energy and its other needs. Preemptive lock-in of a second-best technology not only can foreclose a better alternative, but also will lower the real incomes of the population.

It is at this point that the confounding factors of global climate change and energy security enter the picture. The social costs and risks they impose mean that relying totally on market forces for the appropriate pace of the transition would likely lead to a diminished future. Appropriate social intervention to increase the rate of the transition is required if we are indeed to be good stewards for those who follow us—and in the matter of energy security, perhaps even for ourselves. Designing that intervention presents two problems. The first is to incorporate maximum efficiency, and that means taking account of the role of incentives. The second is just as important: that is, to determine how much we choose to invest collectively in speeding the transition. Too little and we risk excessive damage and loss in the future from climate change. Too much, and we starve our ability to provide adequately for the other human wants that we and succeeding generations desire and need. Unfortunately, there are few reliable guideposts in making this cruel balance, and even if there were, where that balance would be struck will certainly be affected by the present and prospective situations in which individuals, countries, and populations expect to find themselves.

Reasoned agreement seems likely, however, that full funding of the early stages of promising technologies, including basic science, is clearly desirable. Second, taking any actions toward decarbonization that are cost effective and meet a broad cost-benefit test, taking into account prospective relative prices of energy, would likely provide a higher-than-expected payoff if the plausible return from energy security or climate change were taken into account. Third, technologies that both enhance the security of supplies and address the low-carbon transition provide both joint benefits and risk reduction across a larger span of possible harms, and hence are doubly desirable. Finally, the potential for risk from both climate change and energy disruptions argues that a "portfolio" approach to future national and global welfare would include investment in the energy transition beyond a "business as usual" level.

The view outlined above on the role of energy technology in the prospective energy transition suggests the following conclusions:

1. We don't know enough yet to make major bets on the energy technologies that will accomplish the transition from carbon.

2. A major goal of this generation should be to enhance the basic education and science that will be the foundation for that transition.

3. Priority in the investment in energy technologies should go to creating a portfolio of potential solutions—that is, at the R&D, pilot, and demonstration stages, and not in the deployment stage unless and until the

technology is both proven and cost-effective when an appropriate risk reduction benefit is factored in. We cannot afford the cost of expensive and/or ineffective “feel good” actions, or the danger of technology lock-in of minor improvements.

4. Creating this portfolio will require a system in which public funds are invested and private interests are motivated. The goal is an adequate level of activity in these early stages to reflect the urgency that global climate change and energy security adds to the transition path.

5. Incentives for efficiency in this process are critical; the marriage of private and public goods, national and international actors, politics, and economics pose enormous coordination, management, and decision problems in moving forward.

6. The energy transition will draw resources away from both consumption and from other investment. The bad news is that over the next generations the world will be poorer than it would have been had the transition not been required. The good news is that wisdom in action can partially mitigate the loss.

7. The consequent decline in world effective economic growth will create international and national stress that will require difficult adjustments to weather.

8. Finally, the difficulty and length of this transition to a low-carbon future suggests that it alone will not, and cannot, substantially reduce the potential threats posed by climate change and energy insecurity. Neither the ability nor the will are sufficient. An effective response to these potential threats will require substantial investment in adaptation as a response to both threats, and serious research on alternatives such as geoengineering with respect to climate change.