The Challenge of Sustainability

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[transcript]

Most prominent in my thoughts these days is of course energy and how we can address some of the challenges that it poses. But I thought tonight, to kick off the discussions that will take place tomorrow; I would broaden the discussion out a bit to include sustainability more generally. This is a new talk. This is some new material. I have not tried it out in public before so you will forgive me if it's not quite as cogent as some other talks I have given. On the other hand, I think it is interesting and provocative enough that it should get a good discussion going after my remarks.

I would like to offer two theses. The first is that global development and population growth will place unprecedented stresses on resources. I call this the big S sustainability problem.

There is a second issue and that is that these same factors will have a profound influence on this country's domestic and global circumstances. I call that the little S sustainability problem. I believe that navigating these changes will be the major task for this country in the next several decades.

I will offer first a little bit of review with the global drivers. I will then talk about sustainability for energy, food, and water, look at some commonalities, some differences, and then close with some remarks on the little S sustainability.

So far if you look at consumption patterns over the last 40 or 50 years, consumption of almost everything increases universally and monotonically as development proceeds. I most often illustrate this by looking at energy where you see that nobody uses less energy as they get richer. That is a theorem. The same is true if you look at other consumptions –- meat, for example. Consumption of meat goes up as GDP goes up per capita.

The general pattern is that the developed world has a large but slowly growing consumption per capita while the developing world has a small but rapidly rising consumption per capita as the GDPs go up. Also, they have many more people to do the consuming.

Beyond that development trend we also have the population trend. The world right now is a little bit more than half way through an unprecedented quadrupling of the world's population in a century. If you go back to 1950 there were just under 2.4 billion people in the world. By 2050 we can confidently project that there will be just a little over 9 billion people in the world. Most of that

growth takes place in Asia and in the Middle East. The countries in the developed world are pretty much static in terms of their population.

Now if we try to take those two trends and examine in physicists' style (back of the envelope rough calculations), we can try to make some projection as to what consumption is going to look like in the next 50 years. An important fact is that the US is 4 percent of the world's people, 300 million plus or minus a bit, actually plus a little bit. And nevertheless we account for about 20 percent of the consumption of just about everything. In some cases it is 15 percent. In other cases it is 25 percent, but in round numbers it is 20 percent whether it is oil consumption, gas consumption, nuclear power-produced cars, et cetera. And of course we are about 23 percent of the world's GDP.

You can do a little bit of math. In the limiting case let's take the whole world right now, seven billion people and let them consume at the rate that the US consumes per capita. When you do that, consumption turns out to be five times current amount. If you inflate the current seven billion people to nine billion by the middle of the century, you get six times the current amount of consumption.

You might say: well the US is notoriously

profligate in its consumption. Let's look at the European Union as a benchmark; if you do that the numbers come down by only 30 percent. Instead of six times by mid-century you will have four times by mid-century. Again, in theoretical physicists' style, those numbers seem to be rather compelling and pretty firm.

Four times the current draw on the world's resources is probably not something we can support. What is going to happen? Well, one is that we will learn technically how to decouple development and consumption. Nobody has learned how to do that yet in my understanding. What we really need to do is learn how to conserve. Not efficiency, but conservation. They are different, as the economists know -- conservation needs to be enabled by policy and technology.

A second thing we can do is find new or substitute resources for those that we are consuming. And then another thing we can do is to reset expectations and restrain development.

Those three alternatives are not exclusive and no doubt some mix of all of them will happen in the next 40 years. I wouldn't advocate any one particular path and of course the results will depend upon a mix of economy, policy, and technology development.

Let me focus for a minute on energy and then I

will turn to water and food. Energy demand is projected to rise by roughly 40 percent by 2030 and not quite double by the middle of this century, under business as usual projections. The world gets most of its energy today from fossil fuels: 80 percent come from coal, oil, and gas.

If you look at current trends under plausible projections, that dominance of fossil fuels will continue certainly through 2030, and the world as a whole. The reason for that is that there are plenty of fossil fuels available. They are relatively easy to use. They are convenient and as I mentioned they are plentiful.

If you look at coal, today we have more than 150 years' worth of coal at current consumption rates in the US. For oil we have formally about 40 years of oil in the world, but like any natural resource there is a cost curve and as the cheaper resources get depleted the more expensive ones will come into play.

Right now if you count the conventional and nonconventional oil resources, we have about four trillion barrels in the ground that we know are recoverable at prices economic today. The world will need a trillion barrels out to 2030. We have plenty of oil in the ground.

The same is true for gas. You may have read in the papers recently about new technologies to access shale gas developed by the oil and gas industry that have vastly

expanded the reserves of gas available to us.

There are plenty of fossil fuels. If so, what is the problem? Well, really there are two problems for the globe. One is that for oil, demand and supply are not geographically co-located. There is an increase in concentration of the easy oil reserves in a few countries, distant lands whose actions are uncertain, whose stability is uncertain, and who are certainly not allowing for a free market these days. That leads to the challenge of energy security, which is mostly about oil for this country and, in Europe, about both oil and gas.

The other problem we have with energy is the greenhouse gas challenge. Conventional use of fossil fuels is filling the atmosphere with carbon dioxide, which will not go away for many centuries. Most of the emissions of carbon dioxide come from stationary sources of heat and power and from deforestation land use.

In order to stabilize atmospheric concentrations at prudent levels we will need to halve our emissions by the middle of the century in the face of a doubling of energy demand, and we will need to reduce emissions by a factor of four by the end of this century.

These energy goals require significant changes in the way in which the world produces and uses energy. We don’t have a lot of time, really, to do that and so we need

to identify the most cost-effective, material, and timely solutions. What I can tell you is that anyone who has studied the problem carefully knows that at least for the U.S., there are about seven or eight things we need to do in transportation, heat and power in order to deal with these challenges. I am pleased to say that steps are being taken to address almost all of those right now within the DOE and the U.S. government, and I am happy in the question period if anybody wants to go further into what those steps are, I will talk about it.

As we work to try to transform the energy system, it is sobering to realize that energy innovation is really different from other spheres in which we have seen great innovation in the last several decades. It is very different from IT. It is very different than biomed. That is because energy technologies change slowly. They change on decadal time scales. If you look at, for example, how the U.S. gets its energy, things don't change much from one decade to another. They do change. They change in response to policy, economics, technologies, but they don't change all that rapidly because of the scale of the energy system, because of the longevity of the assets, because energy involves many competing interests and they don't always agree with one another, and because we already have pretty good ways of providing heat, light, and mobility,

which set benchmarks for what any new technology is supposed to be able to do. Anyone who tells you they are going to revolutionize the energy system in 10 or 20 years just doesn't understand scale.

Because energy innovation is different, I think we need to change the way in which we do energy innovation in this country by bringing together much more closely the basic research, the development, and the deployment. Some of the energy innovation hubs that you may have read about that the department is pursuing or will be pursuing next year are meant to address challenges like that. ARPA-E is another mechanism by which we are trying to do energy innovation differently.

That is a little bit about energy. I want to talk now about water and food and their sustainabilities. Again, sustainability with a big S. Actually I was on a panel with a water expert two or three months ago. I got to go first and I did the energy scene. When I finished and he started, he said, "I can just about sit down now because everything you said about energy pretty much applies to water as well."

The demand for water will increase with development and population. We will need it for agriculture. We need it for energy. Water is a very important part of energy, as I will mention in a moment.

In developed countries the household use of water per capita is six times what it is in developing countries. Of course that availability is going to be exacerbated by climate change. On the other hand, there is plenty of water around. The problem is the water quality, its geographical distribution, and the depletion of stored water, for example, in the form of aquifers or snow and glaciers. However, unlike oil and gas, water is not a global commodity yet. We don't build large transcontinental pipelines to move water around. There is no water market. Traditionally, it is a local quantity.

Food sustainability: food demand goes up with development. Not only does the amount of food change as development goes up, but the quality demanded goes up as well. Also, meat gets substituted for crops as people get richer. Can we grow enough food? I think so. When I look at what is happening in biology and biotech, I think it is hard not to imagine advances that will echo what has already been accomplished in the green revolution over the last 50 years.

Energy, food, and water are of course intertwined with one another. Water is used for power production, as I mentioned. Cooling towers both in coal, nuclear, and natural gas plants use substantial amounts of water. It takes power to move water around. In California, water-

related energy use consumes 19 percent of the state's electricity just moving water around. Thirty percent of the natural gas used in California every year also goes to moving water.

There is of course the tension between food and biofuels and biomass. We need energy and water for agriculture. We have the competition between agriculture and other land uses leading to deforestation and climate change, and the impact of climate change on agriculture and water. There is a complex nexus here that remains to be sorted out.

Let's look at commonalities among those sustainabilities. First of all, conservation and efficiency are the first thing you write down whenever you talk about one of those. However, it is important to be aware of the rebound effect, first noted by Jevons, that increasingly efficiency over technology does not necessarily lead to reduced use.

The second among all these problems is that the trends are slow to develop and take a long time to fix. When you look at the time scales in politics, and especially in democracies, that is a little bit disheartening.

The third is that these are hard problems. They intertwine technical, economic, policy, and social factors.

Finally, if we are going to navigate them, we need to educate the populous and decision makers about what is and what isn't the problem and how we can address it.

Let me then spend a couple of minutes just on the little S sustainability discussion. If you just look at the numbers, you realize that the rest of the world is more numerous than we are, growing faster, younger, developing faster, and newer in the sense of they are building their infrastructure now. And of course they are just as smart in the rest of the world.

With a global world with a free flow of people, goods, resources, and capital, it is not obvious to me that the privileged position that the US has enjoyed can be sustained. I think we are going to see, or indeed already are seeing, shifts in US economic, cultural, and geopolitical heft on the global scene.

Maybe we are already starting to see that. If you look at manufacturing jobs in the U.S. since 2000, we have lost 30 percent of them. That is six million jobs. It is of course been exacerbated by the recent economic troubles, but this trend started already just about a decade ago.

Another harbinger perhaps is infrastructure. The infrastructure in the US has been built over the last century. We haven't been doing much of that lately whereas

the developing world is building its infrastructure now and consequently it is newer. If you look at what China is doing in its power grid, it is far beyond what we are aspiring to here in the U.S.

The U.S. infrastructure needs to be rebuilt. Unfortunately I think most of the skills and capabilities to do that are now better represented abroad than they are in the U.S. because it hasn't been a national task for a while.

How do we respond? I don't know. The US has some natural advantages. The rule of law, the innovation system, free flow of capital, and higher education are among the strengths that we have, but it's not obvious that that is enough to me.

What is going to happen in the end? I don't know. It is obviously not up to any one of us. It will be determined by policy modulated by technology development and the economic environment. But I think the important point about both the big S and the little S is that we begin a frank conversation about where we are headed, and about the implications of the decisions that we make. We need academia with its special ability to combine disciplines and speak with a credible voice. We need government to make the right policy and funding decisions, and we need industry to execute. All of these entities are

going to have to play together if we are going to navigate the next couple of decades. I would perhaps throw down a challenge to this group to start to think about and discuss these issues and come up with some wisdom, which we can then go out and spread to other folks.