Pathways to Energy Transition: Technology, Economics, Behavior and Ethics

Introduction

My charge today is to talk about pathways for reducing greenhouse gas emissions. I would like first to establish a broader rationale for doing so. Reducing emissions means cutting back on fossil fuels; to the extent that we continue their use, we must manage their greenhouse gas emissions. The central theme of this effort, then, is a comprehensive energy transition. This transition will change the global economy and the lives of its six billion inhabitants in ways that are comparable to those wrought by the industrial revolution of two centuries ago. There are multiple reasons for forging this transition, and it will serve us well to keep all of these reasons in mind as we debate various policy and technical solutions. I would like to highlight three of these reasons for your consideration: economic, energy security, and environmental.

The economic rationale has two elements: first, fossil fuels are limited in supply, and as demand grows, they will, all of them, become more costly. We are experiencing this today in the form of higher prices for gasoline and diesel, natural gas, and coal. These prices manifest themselves throughout our economy. To the extent that we reduce our reliance on fossil fuels, we will reduce our exposure to continued price inflation. We can also preserve these limited fossil resources for the best uses to which they can be applied. In addition to fueling our cars and providing electric power, fossil fuels are critical building blocks for many important products—from pharmaceuticals to a variety of materials. As these fuels become scarcer, we will need to choose wisely between competing uses. The second economic element concerns the growth that the search for alternatives to fossil based energy resources can stimulate. Make no mistake, this vast energy

transition will have costs, but it can also drive innovation, investment and economic growth.

Energy security has received a great deal of attention in political circles, and, candidly, not all of it has been helpful. I believe it has become a simplistically dangerous slogan. We live unavoidably within the confines of a global economy, and it is untenable that we could erect walls around our parochial interests to somehow isolate the country from this larger context. We can diversify our energy supply and enhance our security, by reducing demand for imported fossil fuels, and replacing it with energy efficiency, renewables and domestically produced substitutes.

The environmental rational has multiple aspects. Global warming is the one that has occupied most of the recent debate and has captured—for the moment—the public's attention; but it is not the only one. Cutting fossil fuels use will reduce emissions of all conventional air pollutants along with greenhouse gases. Doing so will yield significant health and ecosystem benefits in the short run. Many alternative technologies can also reduce the use of water compared to fossil counterparts. Finally, perennial biomass can be produced for fuel feedstocks in ways that improve wildlife habitat and reduce polluted runoff. In short, there is a suite of environmental benefits to be reaped from the energy transition.

It is critical that all of these rationales be borne in mind as we debate solutions; forgetting any one of them will weaken our arguments, and potentially point us in the wrong direction.

As we think about how we move forward as a country and as a global community, I would like to reflect briefly on an analogous moment in American history.

Three months into his term as President, Jimmy Carter spoke to the nation about the energy crisis. Here is how he opened that now infamous address:

"Tonight I want to have an unpleasant talk with you about a problem unprecedented in our history. With the exception of preventing war, this is the greatest challenge our country will face during our lifetimes. The energy crisis has not yet overwhelmed us, but it will if we do not act quickly.

It is a problem we will not solve in the next few years, and it is likely to get progressively worse through the rest of this century.

We must not be selfish or timid if we hope to have a decent world for our children and grandchildren.

We simply must balance our demand for energy with our rapidly shrinking resources. By acting now, we can control our future instead of letting the future control us.

Two days from now, I will present my energy proposals to the Congress. Its members will be my partners and they have already given me a great deal of valuable advice. Many of these proposals will be unpopular. Some will cause you to put up with inconveniences and to make sacrifices.

The most important thing about these proposals is that the alternative may be a national catastrophe. Further delay can affect our strength and our power as a nation.

Our decision about energy will test the character of the American people and the ability of the President and the Congress to govern. This difficult effort will be the "moral equivalent of war" -- except that we will be uniting our efforts to build and not destroy."

When the President declared that the struggle to change America's energy consumption was the "moral equivalent of war" he was borrowing language from William James, the 19th century New England psychologist and philosopher.

James argued that, although he believed war was immoral, society needed a ***moral*** substitute for it. According to James, wars united people in common cause, inspired them to put aside self-interest for a greater good, and diminished class distinction. President

Carter was arguing that we needed to unite as a county to effect change; we would experience short-term pain and sacrifice but enjoy long-term benefits.

President Carter's speech was filled with language we just don't hear much any more. Bad news. Pain. Sacrifice. And although he worked with Congress—and succeeded to some extent—to restructure American energy policies, the oil shortage and attendant cost run-ups were short-lived, and the country slipped back into complacency.

Three decades later, we find ourselves in a similar situation, and we must ask whether the we are now ready to engage in that "moral equivalent of war" that President Carter urged. If not what are our chances of success? If so, how can we be effectively motivated and led?

Achieving a global energy transition has been likened to turning a giant super-tanker. If we had started in 1977, we would be 31 years into the task; roughly comparable—according to the current scientific consensus— to the time we have left to avert climate destabilization. But, we didn't—and during the intervening time, the supertanker has gained momentum and grown larger. And, to push the nautical metaphor a little further, the ship's steerage—or ability to maneuver—is decreasing.

Now let me finally turn to discussing pathways for turning the supertanker. To date, much of the discussion in this vein has focused on two steps in the pathway—the technical and the economic. What are the technical innovations that will allow us to reduce the carbon footprint of the global economy? How much will they cost and who will pay?

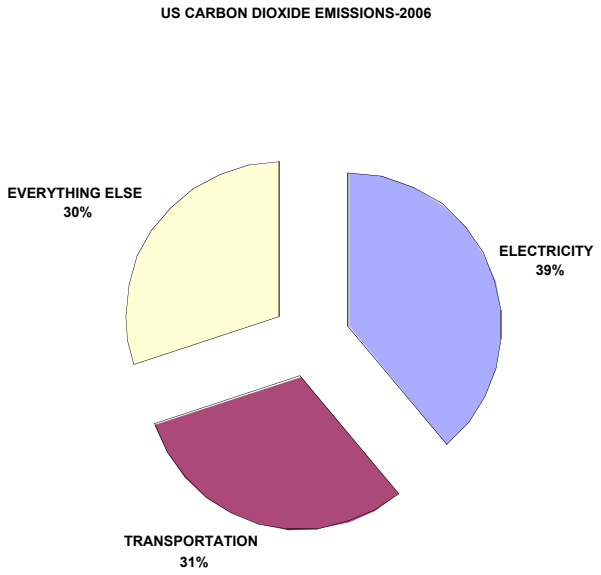
But I would submit to you that our challenges are not only technical or economic. We have much of the technology on hand

to change our energy consumption habits. Our challenges are not solely economic, either. Many of the technologies that we can deploy are only marginally more expensive than their high-carbon alternatives. Some of them actually are cheaper. Success depends also on two other steps in the path, and these have received much less attention: the behavioral and the ethical. We continue to ignore these elements at our peril.

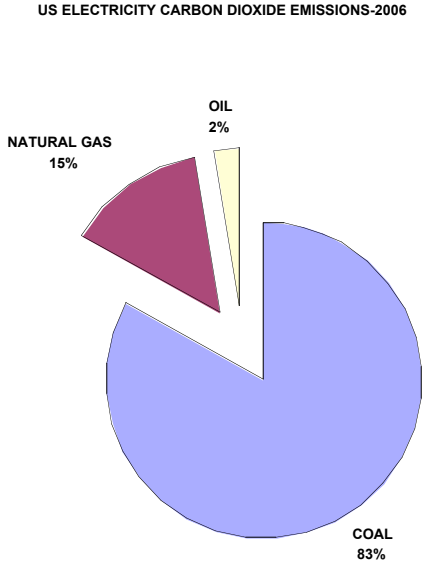
Let's start with the technical and economic aspects and move on later to the behavioral and ethical.

In order to talk about solution pathways, we need first to know where to reduce carbon emissions.

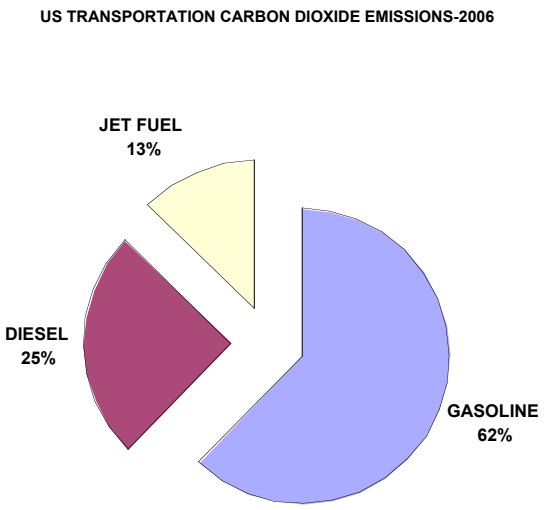
Willie Sutton was a notorious criminal who is alleged to have answered a reporter's question about why he robbed banks by saying "because that's where the money is." So, with respect to US greenhouse gas emissions, where is the money?



More than 60 percent of these emissions are concentrated in two sectors: electric utilities with 39 percent and transportation at 31 percent.



Electric power is dominated by emissions from the combustion of coal, responsible for 83 percent of that sector's CO_2 emissions.



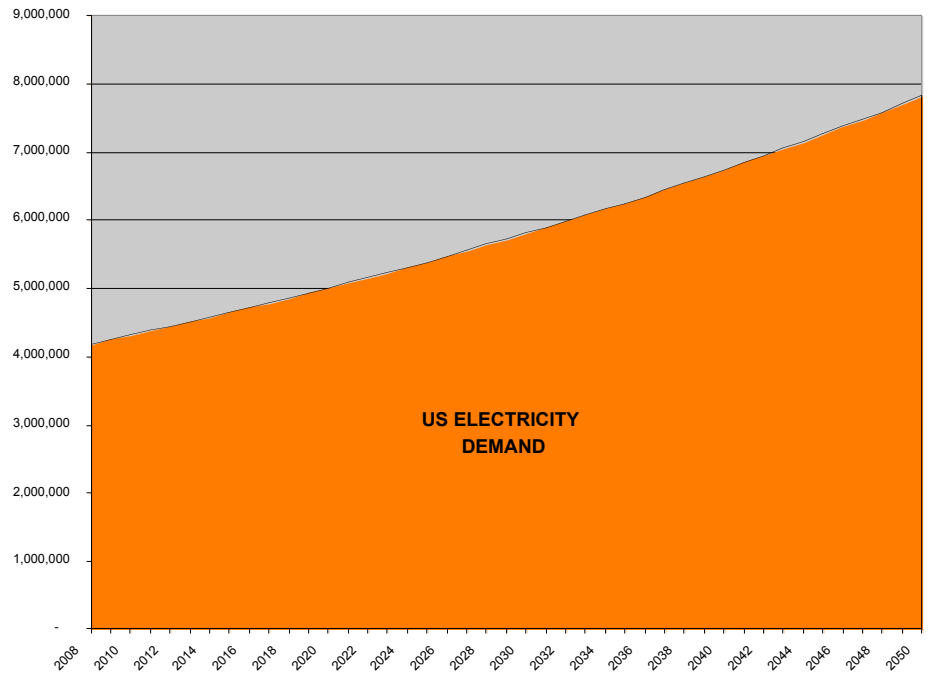
Transport emissions are dominated by gasoline, with 62 percent of the total CO_2 emitted. The bulk of this is emitted by cars and light trucks.

The lesson is plain: emissions from coal burning power plants and the millions of autos and light trucks must be at the center of any strategy to transform our energy system.

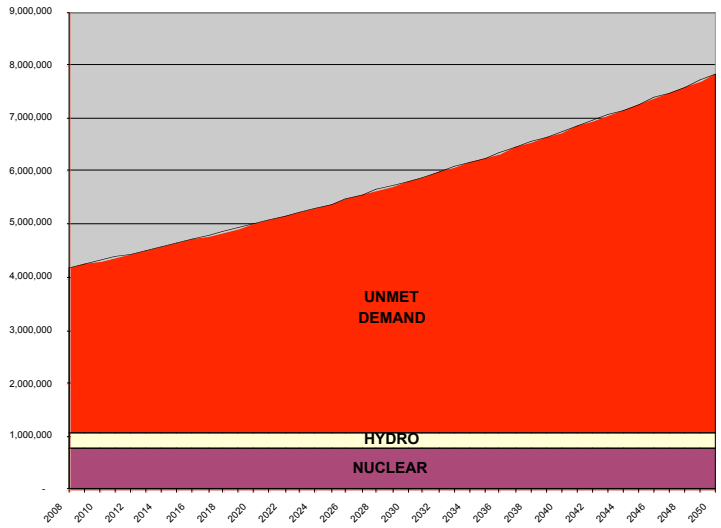
The solution in both electricity and transportation is three parted: first, reduce demand by increasing efficiency, and next, develop new non-fossil sources of supply, and finally manage the carbon emissions from remaining fossil sources.

I would like to illustrate some possible pathways in these sectors by presenting some simple scenarios. Just to be clear, a scenario is not a forecast of what *will* happen, but an illustration of what could happen given certain assumptions. The purpose of these scenarios

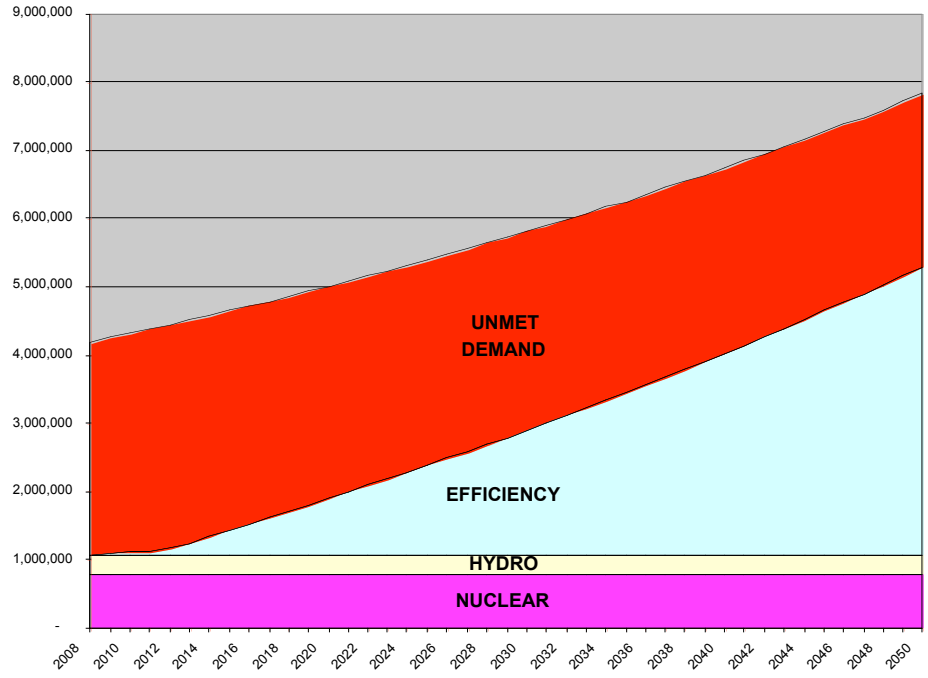
is to show how we might achieve a 60-80 percent reduction in carbon dioxide emissions by 2050. You will see that for both electricity and transportation, we start with a demand forecast—an assumption about how demand for electricity and transport will change in the future. In both cases, these demand forecasts are based on data developed by the US Energy Information Administration.



Electricity demand is expected to continue to grow at about 1.5 percent per year throughout the first half of the century. This means that electricity usage will nearly double by 2050. Here is a progression of low-carbon ways to meet this demand.

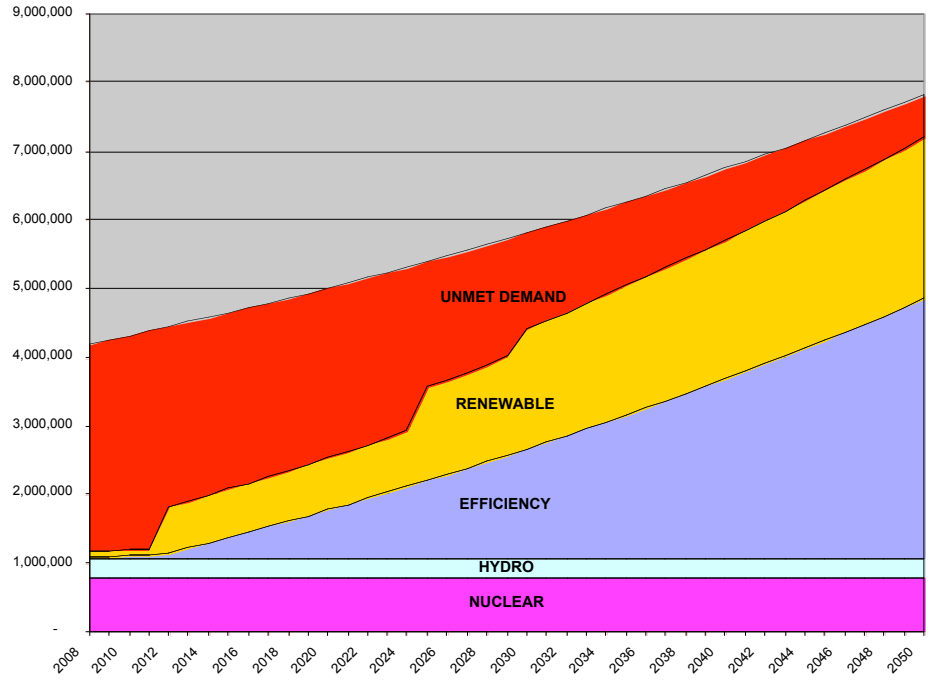


First, let's assume that the nuclear power plants and hydroelectric dams we now have continue to operate throughout the period.

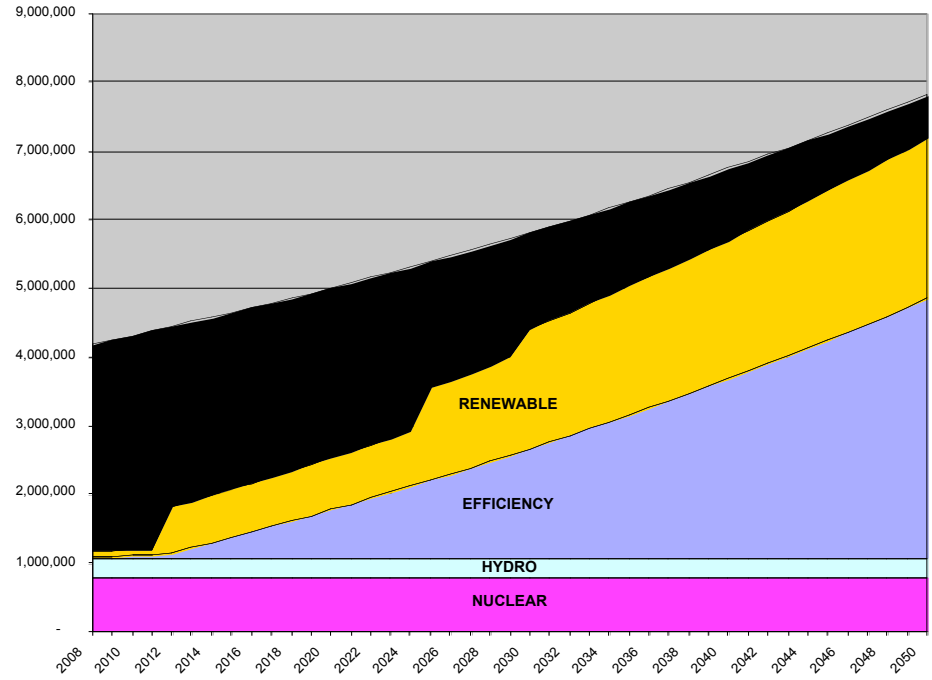


Second, let's assume that we successfully achieve the energy efficiency targets established by the Midwestern Governors

Association last year. This would mean that actual demand for electricity drops a bit each year beginning in 2012, and that by 2050 most our demand for electricity is provided through efficiency.



Third, lets assume that we also achieve the MGA agreements on renewable electricity—25 percent of total supply by 2025, and 30 percent by 2030. There is still a portion of future demand that is unmet, even with substantial reliance on efficiency and renewable energy.



This unmet demand would most likely be supplied by fossil power. Without techniques to capture and dispose of the carbon dioxide emissions from this remaining increment of fossil power, we could not reach and maintain an 80 percent reduction below 1990 levels for the electricity sector.

Slide 14: same as slide 13 but with demand held constant at 2012 levels.

If we do not meet the energy efficiency goals—and these are very ambitious goals to be sure—but we manage to hold electricity demand constant at 2012 levels, the unmet demand that would need to be met through fossil generation is even larger, underscoring the urgent necessity of developing techniques for capturing and disposing of carbon dioxide.

Slide 15 and 16

The next two slides present the percentage of the electricity supply provided from each supply source over time. The first assumes the

more aggressive efficiency goals and the second that we only manage to hold demand constant. In both cases we see the role played by fossil fuels diminishing, and the role played by renewable energy growing; in both cases there is still a portion provided by fossil fuel.

These slides point out two important lessons: First, reduced demand—through increased efficiency—and technological innovation point the way to a solution for the electricity sector: Second, we need all the options available to achieve an 80 percent reduction. Now let's turn to transportation.

Slide 17: Forecasted VMT 2005-2050

Here is the forecast for vehicle miles traveled-or VMT-for 2005-2050 according to the US Energy Information Administration. VMT is predicted to grow rather dramatically throughout the period, essentially doubling by mid-century.

Slide 18: Forecasted gasoline consumption

This slide translates the forecasted VMT into gasoline consumption. Because of expected increases in efficiency—from an average of about 20 MPG in 2005 to about 43 MPG at the end of the period—total gasoline consumption grows more slowly than VMT, but it still grows.

Slide 19: Contribution from advanced biofuels

Here is the potential contribution from cellulosic biofuels, which the USDA and DOE estimate could provide about 1/3 of current gasoline consumption in a sustainable fashion. If these biofuels are produced in a carbon neutral fashion, we can expect about a 30 percent reduction in emissions, short of our 60-80 percent goal. We will need some additional tools to accomplish this.

Slide 20: VMT reduction

This next slide shows a possible trajectory of controlled VMT growth, allowing it to peak around 2030, and then gradually implementing VMT reduction measures—such as car pooling, telecommuting and mass transit—which gradually reduce VMT so that by 2050, we are slightly below present levels.

Slide 21: MPG improvement strategy

Here we see the impact of a slightly more aggressive strategy for improving vehicle efficiency, reaching about 50 MPG in 2050 instead of the forecasted 43. We know today that it is possible to design autos and light trucks to achieve 50 MPG, and this is only a modest improvement over the predicted 43.

Slide 22: Combined effect

Finally, this slide portrays the combination of reducing VMT with improvements in vehicle efficiency. By holding the VMT about equal to our present levels and by driving more efficient cars and truck, by mid-century we can reduce the demand for conventional petroleum to almost nothing, and do better than our 60-80 percent goal.

What can we learn from these scenarios?

First, a combination of efficiency improvements, new technologies, and improved use of fossil fuels can reduce carbon dioxide 60-80 percent below 1990 levels.

Second, these options can save us money in the long run. Efficient buildings use less energy, efficient cars burn less fuel—and as we

discussed at the outset of this presentation, all fossil fuels are becoming costlier and are likely to remain so.

Third, new technologies offer the potential to stimulate economic health. Advanced biofuel production can help drive a vital farm economy; expanded deployment of renewable resources can add dollars to the state and regional economy, money not spent on fossil fuels is freed up for other purposes.

From a more local perspective, these scenarios point to a number of specific opportunities:

- North Dakota can take advantage of its abundant wind resource, its significant lignite reserves, and its leadership in carbon capture and disposal to develop a vast low carbon electricity industry;
- North Dakota can become a leader in production of perennial biomass for producing cellulosic ethanol;
- Because of this, North Dakota has an interest and should play a role shaping the regional and national debate on global warming and energy policy to take advantage of these great assets.

Let me move on to behavior and ethics.

We already have efficient technologies for new buildings that can cut energy use in half, and pay themselves back within five years, but most architects do not incorporate them. We have industrial technologies that pay themselves back in less than year, but most industries do not employ them. Reducing the amount we drive can save on gasoline, but most of us are stuck alone in our cars, commuting to and from work. The solutions to these problems are not technological but behavioral. And if we ignore the important job of understanding how to change these behaviors, we will almost certainly fail to achieve our goals. We need to focus as

intently on identifying and changing behavior as we do on new technologies.

There is also an important ethical component to this equation as well. I calculated the carbon footprint for my family (5 of us, in total), and the biggest slice wasn't from our electricity, our natural gas or our gasoline. The biggest slice is from the energy that is embodied in all the stuff we buy—this is the invisible part of the energy crisis. Everything we consume—food, clothing, housing, transportation, electronics—takes energy to produce. And the more we consume, the more energy is required. In addition to considering our direct uses of energy, we need to be aware of and consider the indirect uses as well. And, especially in America, we need to reflect on how our consumer society affects our ability to change energy consumption patters, and on the model it provides for the rest of the world.

Technology, economics, behavior and ethics—we must keep them all in view as we plan for the energy transition.

Let me end on a theological note.

Sometimes ancient categories can be very helpful as we consider modern dilemmas. I have lately been reflecting on two of the seven deadly sins, their contrary virtues, and how they impinge on our chances of success to turn the global energy supertanker.

First, pride, the most dangerous of the deadly sins. When I ponder the enormity of the energy transition challenge and the many interests that must be balanced as we seek solutions, I worry about the sin of pride. Putting ourselves first—as individuals, states or nations—will be an impediment to progress. As we muddle through, I would like to counsel a heavy dose of humility—pride's contrary virtue. Humility to recognize the size of the task we have

taken on, to hear with compassion the perspectives of neighbors both near and far, and to consider and reconsider our assumptions.

Second, sloth. In a modern context, it's easy to see sloth as being glued to the tube with a beer and a bag of chips. But, the latin for sloth-*acedia*-is really about inaction, about despair. Sloth is nearly as dangerous as pride, and it's easy to fall into despair and inactivity when confronted with big challenges. Sloth's contrary virtue is diligence, and we will do well to remember this when we find ourselves daunted by the task. Diligence is what we all need to do our part to forge this transition, we can help each other to remain diligent; we can demand diligence of our leaders. The energy transition cannot occur with easy fixes, and it will not be over quickly. But with diligent focus, we still have time to move society forward in an orderly and equitable fashion, and avoid the potentially chaotic alternative.

Pessimism is a perfectly understandable response when weighing our chances against winning the paired battles of climate change and global energy transition. But I think hope is a better one. Efficient, equitable use of our world's limited resources, pathways that provide economic opportunity, new technologies that benefit both the developed and the developing world—these are all causes for hope. And if we engage collectively, diligently, and optimistically, this hope will not disappoint.

Thank you.