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What Is Stopping the Renewable Energy Transformation and What Can the US Government Do?

WE NEED CHEAP, RELIABLE, SAFE RENEWABLE ENERGY

Across the world we all inhabit, the economic system that we depend on is based on the one-time use of fossil fuels and other material resources. Our planet's population has grown to over 7 billion people. We simply cannot continue using up materials and dumping the waste into a hole in the ground; we need to develop and deploy the technology to create a renewable resource-based economy. The future well-being of the United States, and of the planet as a whole, depends on the US government playing a more strategic and future-oriented role to bring about the transition to a renewable-resource-based economy.

We know that we must transition to renewable energy eventually, but with energy technology advancing every decade, why hasn't the transformation to a renewable economy happened yet? What is preventing a more fundamental shift in our energy production and use? There are three barriers to this transformation: (1) technologies that still need advancing; (2) infrastructure that is not designed for distributed generation; and (3) complicated political challenges that limit our ability to make the tough choices necessary for long-term energy policies.

The public sector is critical in the transition to a sustainable global economy. Smart sustainability policy and management can help the United States and other countries move past technological, market, and political barriers, and there are a range of federal policies that could lead us on the path toward a sustainable economy powered by clean energy.

THE ENERGY CHALLENGE

Energy is at the core of the sustainability challenge. Our use of energy and consumption of raw materials dwarfs the consumption rate of the early twentieth century. The modern economy is built on energy; most of the production, transportation, and everyday processes that we depend on daily are energy intensive. We need not only to make these processes more energy efficient, but to power them with renewable sources if we are to develop a long-term sustainable economy. Enhanced energy efficiency can help us reduce demand as we reach peak production capacity. However, the growing global population and increased energy use means that increasing energy efficiency will not be enough; we also need to develop renewable energy technologies to meet the growing global demand for energy.

The leading edge of the dialogue about the global sustainability crisis is climate policy. The goal of many climate activists has been to raise the costs of fossil fuels to represent their true costs (with carbon taxes, cap and trade, for example), but we should be focusing instead on renewable energy technology that lowers the price of sustainable energy. Taxing fossil fuels may be preferred by some economists, but this method is not politically feasible in the United States or in the developing world. While some nations may be capable of implementing rapid command and control reductions in fossil fuel use, energy is too central to modern economic life to expect that all large nations will do so. Unless the reductions are worldwide, they will be ineffective. And unless we end our dependence on fossil fuels altogether, we cannot develop a long-term sustainable economy.

The very real dangers of climate change are a warning that we need to begin the transition from fossil fuels to renewable energy. The trick is doing this while worldwide consumption of energy continues to grow at a ferocious pace. The other trick is to convince companies that have billions of dollars in sunk costs in the current energy system to stop lobbying against renewable energy and start investing in it.

Fossil fuel extraction damages the well-functioning ecosystems that human life depends on. Fossil fuel use emits greenhouse gases that cause climate change, and climate change disrupts human settlements, agriculture, and infrastructure. These disruptions are expensive, and so climate change provides a strong motivation to develop alternatives to fossil fuels. In addition, fossil fuels are finite, and though they will not run out in our lifetime, they will eventually become so scarce or risky to extract that they will be too expensive to use. This inevitable price increase is what will eventually move us off fossil fuels, but the sooner we discover a cheaper form of energy that is not finite and not buried underground, the better off we will all be. The United States needs lots of energy, and countries like India, China, and eventually countries across Africa will come to need even more. The motivation to develop new sources of energy is incredibly high.

If the entire world continues to use fossil fuels at the rate that we do today, the resulting scale of environmental destruction will almost certainly poison our land, water, and food supply. Moreover, fossil fuels will eventually lose the cost competition with renewables. The fuel itself may be subject to boom-and-bust cycles, but in the long run, supply will diminish and prices will rise. In addition, the capital, operation, and maintenance costs of mining and transporting fossil fuels will tend to grow, while the costs of renewable energy technology will tend to shrink. A technology that utilizes a cost-free base resource like the sun or wind could be subject to the same expense dynamics as computing power and communications.

All these factors are stimulating a worldwide technological race to replace fossil fuels and lower the price of sustainable energy. The price of computing power and phone calls has come down as utilization and technology has increased. Renewable energy should be subject to the same price dynamics. We need to develop a form of energy that is cheaper, less capital intensive, more reliable, decentralized, and less polluting than fossil fuels in order to drive them out of the marketplace. No technological challenge is more important for the future of our civilization.

Progress to Date

According to the US Department of Energy's National Renewable Energy Laboratory (NREL), renewable electricity generation from technologies that are commercially available today, in combination with a more flexible electric system, are more than adequate to supply 80 percent of total US electricity generation in 2050 while meeting electricity demand on an hourly basis in every region of the country. However, we must continue efforts to lower the costs of renewables, increase reliability, expand transmission, and improve grid integration (NREL 2013, 8).

While different energy technologies are more applicable in certain regions due to topographic limits, environmental, and other land-use constraints, the NREL still found potential for at least one renewable energy source in almost every state. It also found that renewable energy showed the potential to generate more than 100 times the country's total electricity consumption in 2011 (NREL 2013, 7). At the global level, renewable energy use has already increased dramatically in recent years. Between 2000 and 2011, installed global renewable electricity grew by 72 percent, accounting for 22 percent of all global electricity generation in 2011. According to the NREL, global renewable capacity is expected to triple by 2035, supplying close to one-third of electricity worldwide, fueled by the increasing cost competitiveness of wind and solar technologies and by the deployment of renewables in emerging markets (2013, 6–7).

With effective public policy, renewable energy technology can advance enough to become a low-cost alternative to fossil fuel use sooner than we think possible.

THE MAIN BARRIERS TO ADVANCING RENEWABLE ENERGY

There are a number of barriers to advancing renewable energy, which are related to technology, distributed generation infrastructure, and political challenges. The National Research Council summarizes the main barriers as “cost-competitiveness of the existing technologies relative to most other sources of electricity (with no costs assigned to carbon emissions or other currently unpriced externalities), the lack of sufficient transmission capacity to move electricity generated from renewable resources to distant demand centers, and the lack of sustained policies” (2010, 4).

If the United States is to catch up with other countries that are pursuing renewable energy, “it must overcome obstacles like a fragmented, outdated energy grid poorly suited to renewable energy; a historic reliance on plentiful and cheap supplies of fossil fuels, especially coal; powerful oil and coal industries that often oppose incentives for renewable development; and energy policy that is heavily influenced by individual states” (Rosenthal 2010). These issues limit our ability to make tough choices necessary for long-term energy policies, but smart sustainability policy and management can help us move past these barriers and toward a sustainable economy powered by clean energy. The following describes these three main barriers and why they have hindered our progress towards widespread use of renewable energy in the United States.

Technologies Still Need Advancing

As technology has developed over the past several centuries, our lives have changed. For example, medical technology has allowed us to live longer and healthier lives, and families can now be planned. Agricultural technology, waste, water, and transportation technology

make it possible for us to live in cities and build a brain-based economy and a culture focused on learning, entertainment, and social interaction. The automobile opened up the suburbs and air conditioning stimulated the move to the south and southwest. Ironically, the Internet's rapid-fire technology and the spread of smartphones are fueling attraction to the city's dynamic social and cultural environment and are causing many young people to de-suburbanize and re-urbanize instead.

Much of the economic growth of the past hundred years directly results from development in applied technologies such as refrigeration, transportation, computers, cell phones, the Internet, and a host of breakthroughs in medicine. We need something similar for renewable energy. The same resources once spent on shrinking computers for placement on missiles and spacecraft must be devoted to developing low-cost, non-fossil-fuel-based energy. The US energy system is characterized by large-scale, capital intensive, centralized facilities: we need to develop a small, low-cost solar cell and battery for storing electricity once it is generated. When home-generated renewable energy is cheaper and more reliable than the grid, why would anyone have any reason to burn fossil fuels? Ultimately, each home and business should be capable of generating, storing, and sharing energy. After Hurricane Sandy in 2012, many suburbanites in the Northeast bought electric generators and gasoline tanks to keep their homes powered during and after storms. A solar energy system in the home, with an advanced storage battery, would be a more convenient and cleaner way to do the same job.

While some renewable energy advocates believe that available technology could be used to transition from fossil fuels, I still believe that new technology is needed. In 2010, the National Research Council concurred stating that: "The future evolution of costs for generation of electricity from renewable resources will depend on continued technological progress and breakthroughs." (National Research Council (2010, 7) Large-scale implementation of smart-grid technology could accelerate the trend to renewable energy and expand the

renewable market rapidly. Breakthroughs in nanotechnology have the potential to shrink the size of solar cells, making it possible to have more inexpensive installations of solar arrays. For example, in January 2014, researchers from Harvard University published a study in the journal *Nature*, describing development of a battery that can store a couple of days of electricity from wind farms and other sources of power in an economic way (Bullis 2014). A low-cost solar receptor and battery could become as common as a cell phone.

However, we simply are not there yet. We haven't had the breakthroughs that would enable these advanced technologies to be widely distributed. Doing so would require heavy investment in science and engineering research and education, but that investment is likely to generate additional and unpredictable economic benefits in the future.

The Need for Modern Distributed Generation Infrastructure

In many places across the United States, during certain times of the year, energy use puts an enormous strain on energy generation facilities (New York City in August, for example). Traditional electrical systems are “centralized,” where electricity is generated at a large-scale power plant and then transmitted to customers. Alternatively, distributed generation is the generation of electricity from sources that are at or near the point of consumption, which can reduce the amount of energy lost in transmitting electricity and reduce the size and number of power lines needed (NREL 2012). Distributed generation can provide greater local energy independence and reliability, and is often combined with load management and energy storage systems to improve the quality of electric supply. Decentralized, distributed generation of energy is also less vulnerable to catastrophic, large-scale disruption (Umberger 2012, 191). During Hurricane Sandy in New York City, a large housing cooperative in the Bronx was able to stay powered due to its combined heat and power (CHP) plant—a type of clean distributed generation—that enabled it to work independent

of the grid that failed in other parts of the city during and after the storm (Pentland 2012).

However, utilities have little incentive to promote distributed generation, and there are a number of technical barriers to getting each individual site coordinated with respect to power, voltage, consistency (non-intermittent generation), and other factors, as well as a number of information barriers for customers (Universal Interconnection Technology 2002). There are also several spatial and temporal constraints to integrating independently generated electricity with the grid in a way that ensures a reliable supply of electricity throughout the system (National Research Council 2010, 3).

We need to decentralize production and increase the resiliency of the energy distribution system. Current systems need greater capacity and major upgrades to basic infrastructure. We need a transmission process that is more efficient and open to decentralized transmission. We need a smart grid that can incorporate data across the transmission system; we need a grid that optimizes delivery, efficiency, and conservation. We need advances in storage technologies so localized energy can be used whenever it's needed. According to Kate Galbraith, "cheap, large-scale energy storage is considered the holy grail of renewable power because it would allow wind and solar farms to provide constant energy to the electric grid" (2014). Better storage will allow for increased flexibility of energy use, allowing the use of energy on peak, and can facilitate increased use of transmission lines that connect the resource to the grid (National Research Council 2010, 12).

When we think about advances in renewable energy technology, we must not focus solely on the solar cells and wind turbines that will produce the energy. We need to think about technical advances in infrastructure that enable these types of production to be used on a mass scale. One of the main obstacles to decentralized renewable energy is the varied set of rules governing access to the power grid by states and utility territories. Barriers range from the challenge of raising capital to formulating a legal structure that allows for local

ownership to battling against utilities that are hostile toward local generation because of the threat to their own market share (Farrell 2013). Elisabeth Rosenthal (2010) observed in the *New York Times* that

widely diverse permitting procedures in different states and the fact that many private companies control local fragments of the grid make it hard to move power over long distances, for example, from windy Iowa to users in Atlanta. The American Society of Civil Engineers gave the United States' grid a "D+," commenting that it is "in urgent need of modernization."

We need to get over these technological, market, and regulatory barriers. To help us get there, we must develop a massive public-private partnership between governments, academia, and private industry to develop smart grid, distributed generation technology.

Complicated Political Challenges Limit Long-Term Energy Policy

Energy is a part of everyday life in ways that only become clear to most of us when we are denied energy during a blackout. Think of a world without cars, jets, and trains. Think of food distribution without trucks and food storage without refrigeration. Then think of what the absence of energy would do to the electronic security systems in our prisons or the operation of water filtration and sewage treatment facilities. Think of how much energy is used by fire, police, and ambulance services—not to mention health care facilities. To most of us, life without energy and life off the grid is unimaginable. Our reliance on energy and the seductiveness of energy-based technology is contagious. Billions of people in the developing world see what the developed world has and want it. The increased visibility of the developed world's lifestyle is in part due to the Internet and to the use of over 7 billion cell phones worldwide.

This energy dependence creates political pressure for energy development. It comes from those of us in the developed world

addicted to all this stuff and determined to keep it, and people in the developing world who desire modern technology. Taking away these energy technologies from those who have it and denying them to those who want it would destabilize world politics in fundamental and frightening ways.

Energy efficiency is not controversial, but accelerating the use of renewable energy requires concerted government action, which requires political support. Renewable energy projects are typically smaller, more complex, and riskier than traditional energy investments—and therefore often require government-supplied incentives. Fossil fuel companies and their allies have considerable economic and political power, and have projected that power with a propaganda war against renewable energy (Rosenthal 2010). While fossil fuels receive substantial government tax expenditures, public and media attention is nevertheless focused on subsidies and failures of renewable energy support, such as Solyndra's bankruptcy.

The fossil fuel industry has caused much of the political division on climate change through aggressive action to promote doubt about climate science. The industry, typically through conservative think tanks, has funded opposing scientific opinions, economic reports, and public relations campaigns. The result has been an amazing and fact-free debate about climate policy in the United States Congress. According to Emily Atkin,

politicians tasked with making crucial decisions on national energy policy and air pollution have a propensity for ignoring the science. Approximately 56 percent, or at least 130 members, of the current Republican caucus in the House of Representatives deny the basic tenets of climate science. Sixty-six percent, or at least 30 members, of the Senate Republican caucus also deny the reality of climate change (Atkin 2014).

Conservative Congress members have been unwilling to engage in a discussion of the challenges of sustainability. Influential lobbyists push for a debate about the validity of climate science, which focuses attention away from policy discussions, and the media exacerbates the issue by giving credence to climate science deniers in order to be “fair and balanced.”

We need a Congress willing to engage in the policy process around energy. What we have instead is an interest-group-dominated battle over subsidies and ideological warfare over drilling vs. protecting the environment. We are living through an era of deep, although not unprecedented, partisanship in Washington. Congressional gridlock has become an assumption, and most Americans have little faith that the federal government can do much of anything. In fact, no new piece of major environmental legislation has been enacted since the 1990 amendments to the Clean Air Act—25 years ago. It is impossible to deny the growing partisan divide that has profoundly influenced policy and seems to grow more polarized every year. While climate science has become more definitive and environmental destruction more obvious, environmental sustainability has been defined as a partisan political issue.

Unfortunately, politics and policy is never simple, rational, neat, and effective. It’s messy, incremental, and difficult. You might be attracted to nuclear power, but try to overcome the politics of siting and waste disposal. You might be an elected official attracted to setting a price on carbon, but try selling your constituents on the idea of rising energy prices. Those steps might be taken, but they are difficult and unlikely. It would be much easier to sell an effort to research and develop a decentralized, inexpensive form of renewable energy. Let renewable energy knock fossil fuels out of the market. But first, it needs to get onto the political agenda. With the current “do-nothing Congress,” that seems like a steep uphill battle for proponents of a renewable energy economy. The political battle to define the energy issue will continue.

In the case of energy development in the United States, a number of other values add to its importance and ultimate political potency. One value is the emphasis we place on free enterprise and private property. In the American value system, “if I own land and want to dig a gas well on it, I should be allowed to do that”; “a man’s home is his castle.” Of course, one impact of adhering to this value without limits is that the free use of one person’s land can damage another’s land. More important, damage could be extended to collective goods such as groundwater resources.

Ultimately, our lifestyles are an expression of our values. Those values find expression in our use of energy and in the location of our cities and homes by the water. Efforts to change those values directly will tend to fail. While crises and catastrophe might change attitudes and behavior for a time, political propaganda that calls the science fake can also influence public opinion. People doubt environmental science because they fear that if it is correct they will need to sacrifice their comfortable way of life. As long as the issue is framed as a stark trade-off, people will resist its premises. It is a political nonstarter to argue that we must turn off the lights and get out of our cars or we will all be flooded out by sea-level rise. Instead, political leaders need to reframe the issue highlighting our economy and our way of life’s dependence on a sustainable planet.

GOVERNMENT’S ROLE IN THE TRANSITION TO A CLEANER ECONOMY

The key to this transition is intelligent sustainability policy and management. Government can take a number of actions to lead us in this direction. The public sector has a critical role to play in the transition from a fossil fuel-based economy to one based on renewable energy. This includes six central public functions:

1. The first government sustainability function is to fund basic scientific research. The development of new technology is essential to this transition, and most corpora-

tions cannot fund basic science. Even in applied work, unless the payoff is rapid, private companies cannot justify the use of resources for this work.

2. The second government function is to fund sustainable infrastructure. This has long been a responsibility of government, and even in this anti-governmental era in the United States, it is a critical role that only government can play.
3. The third government function is to use the tax structure to provide incentives to direct private capital toward investment in the renewable energy economy. The goal here is to provide a positive environment to reinforce corporate sustainability.
4. The fourth government sustainability function is to use regulatory rules and enforcement to prevent unsustainable economic activities. Companies cannot be permitted to obtain short-term private profit at the expense of long-term public clean-up costs.
5. The fifth function is technology transfer to the developing world. We must ensure that clean technology used in the United States and other developed nations is also used in the developing world.
6. The sixth government sustainability function is to develop sets of sophisticated partnerships between government, industry, and nonprofits to foster the necessary advancements we need to usher in an era of sustainable energy for all.

Funding Basic Science

The private sector is clearly best at making and marketing renewable energy resources, and it will play an important role in commercializing government-funded research; however, it will not fund the necessary research and development on its own. Supporting scien-

tific research is a fundamental role of government similar to national security, emergency response, infrastructure, and criminal justice. It is about the quest for the fundamental knowledge that has allowed us to improve our standard of living and holds the promise of a sustainable planet.

America's research universities remain the best in the world, funded by peer-reviewed, competitive government grant programs that have great potential to develop a way to get off of dependence on fossil fuels. Government could reallocate a chunk of its federal research budget to focus on basic and applied solar energy research, or a well-managed, clear, focused, and skillfully communicated renewable energy research project. Michael Levi, a senior fellow for energy and the environment at the Council on Foreign Relations, has noted that "government support for long-term technological development, particularly through R&D, will be essential too, if policies that 'pull' the right technology into the market are to become more affordable over time" (Levi et al. 2011). A concentrated effort to focus our scientific and engineering brainpower on this critical issue would provide a visible, tangible, and coherent climate mitigation strategy.

According to Donald Sadoway, a professor of materials chemistry at the Massachusetts Institute of Technology, "in the last 10 to 15 years, the total amount of money that goes into really cutting-edge energy-related research is far too low" (Galbraith 2014). The work of our scientists and engineers could not be more important. Basic and applied scientific research can uncover new policy options, lead to cost savings in unexpected ways, and can help make sense of sometimes conflicting data or information. The government must continue and expand its investment in this area.

Providing Incentives to Steer Private Capital

Subsidies, taxes, and tax credits along with other market-based tools can be used to promote or discourage certain behaviors, which can help lower the risk associated with clean technology development. Government must creatively balance carrots and sticks to encourage

private firms to use resources efficiently and minimize negative externalities. Communities, households, and businesses must be encouraged through the tax code to become energy generators. There is of course a precedent for such a massive government intervention in the private market place: home ownership. In 1940, 43.6 percent of all American households owned their own homes. By 1960 that had reached 61.9 percent (US Census Bureau 2011). This was made possible by making mortgage interest and property tax deductible and by government-backed mortgage insurance.

We need similar policy creativity to increase the percentage of people generating energy from renewable sources and investing in energy efficiency. The tax code can be used to provide private firms with incentives to invest capital in the new and speculative technologies. Subsidies, which are already characteristic of energy exploration and production policy, can be revisited to encourage the adoption of clean and smart technologies (UNEP 2008, 2).

Infrastructure Investments

The private sector may see no immediate benefit in investing in energy efficiency measures and other sustainable infrastructure, and so government must build the infrastructure of the twenty-first century just as it built railways, ports, and bridges: the infrastructure of the past. As we work to transition to a sustainable economy and begin the long process of reversing the causes of climate change, we will also need to adapt to the impact of the climate changes already underway—changes such as hurricanes that can bring down power lines, intense rainstorms that can inundate soil and cause rivers to overflow their banks, blizzards that can damage our roads and buildings, and droughts that can cause fires and famines. As these events are predicted to happen with greater frequency and intensity, government will have to build more resilient infrastructure. A modern energy transmission system and smart grid, and even research facilities, are key here. This infrastructure needs to be centered on renewable, high-tech, distributed energy systems.

We are already moving toward a new age of decentralized energy technology. Large-scale implementation of smart grid technology would make it possible to accelerate this trend. This indicates a latent market that could expand rapidly following a major technological advance in solar generation or energy storage technology. The proper infrastructure to take advantage of these breakthroughs needs to be put in place by government.

Set and Enforce Regulations

While short-term benefits can be obtained by ignoring environmental conditions, our polluted land, air, and water must eventually be cleaned if we are to remain healthy. Companies cannot be permitted to obtain short-term private profit at the expense of long-term public clean-up costs. Our more complex economy and the increased use of toxics in production require rules that keep pace with economic, demographic, and technological change. Rules must prevent damage to the environment, but also must ensure that energy efficiency, recycling, and water efficiency are integrated into our structures, institutions, and daily routines.

In the United States we have learned that protecting the environment requires laws, rules, and regulations. Valuable and vulnerable natural resources and public health must be protected from those that ignore or neglect the negative impacts of their actions. Incentives to stimulate responsible behavior are not always sufficient. Sometimes we need the rule of law to draw a line in the sand to distinguish right from wrong. In addition to making our environment less toxic, environmental regulations reduce the cost of health care attributed to environmental-induced illness and stimulate technological innovation.

Environmental regulations follow the same logic as traditional limits on the free market. Economic regulation and rules on fraud and protection of private property limit free enterprise. Businesses know they must operate within a system of law. That system both constrains and protects them. The regulatory process is a bargain-

ing process where rules are proposed and adjusted to minimize costs while maximizing benefits. All environmental rules go through a process of give and take. Some disputes are settled by changes in rules as political leaders respond to industry demands. Some are settled in the courts when the Environmental Protection Agency (EPA) cannot find a way to get environmental groups and industry to compromise.

Regulations applied with firmness and care provide incentives for organizations to innovate and develop new ways of operating. Energy efficiency standards have created incentives for innovative engineers to build appliances that deliver higher levels of performance while using less energy. Start-up companies are launched to meet these new requirements and established giants such as General Electric reinvent themselves to compete under new rules. Industry opposition to technology-forcing environmental rules is nothing new. The food, water, and air that sustain human life must be protected—only government rules and enforcement can ensure that those critical resources are maintained in a sustainable way.

Technology Transfer

In 1980, according to the US Energy Information Agency, North America consumed about 33 percent of the world's petroleum and Asia only 16 percent. In 2010, it consumed 27 percent of the daily supply of oil and Asia consumed 29 percent (US EIA 2012). Less developed countries are moving rapidly to catch up with the economies of more developed countries, and are bringing on line massive amounts of energy facilities. If the United States and other developed countries lower greenhouse gas emissions while developing nations increase emissions, the climate will continue to be degraded. Developing nations need to be given incentives to use new energy sources instead of building coal-fired power plants; these plants could get very inexpensive as they are replaced by cleaner sources of energy in the developed world. A variety of financial tools could be used to lower the cost of new technology for export to the developing world (Jacobs et al. 2009, 2). Technology transfer can include resources, but also expertise, knowledge, and training.

Public-Private Partnerships

We need a sophisticated partnership between government, industry, and nonprofits to transition to a sustainable economy. Such partnerships exist at all levels of government and were vital in building much of the major infrastructure in the United States—our transcontinental railroad, interstate highway system, air traffic control system, ports, and shipping terminals. Similarly, the technology breakthroughs that require the transition to a sustainable economy will be developed by emerging partnerships between an active government, vibrant research establishment, and a fully engaged private sector. The ideological bias favoring one sector over another is destructive. Each sector—public, private, and nonprofit—plays a different role and performs different functions (Cohen 2001). A partnership between all three will be the most effective way to transition to a sustainable economy.

CONCLUSIONS

The planet's population growth to 7 billion people has had an unprecedented effect on our land, water, and air. Sustaining that many people requires massive amounts of energy and resources. We need to learn a great deal more to guide our actions so that the way we live does not destroy the planet we live on. Some of those actions require the development and deployment of new technologies and modifications in the way we use existing technologies, which in turn will require changes in our behavior. The changes need not be painful or negative—and let's keep in mind that today, behavior change is constant. The influence of technology on our behavior is growing—think about how much of one's day now involves looking at screens, reading, and responding. These are new behaviors.

Our goal should be to have the new technology of renewable energy drive out the old technology of fossil fuels. It's been done before: tapes replaced records, CDs replaced tapes, and MP3s replaced CDs. Cars replaced horses and cell phones replaced landlines—and someday, the electric car will replace the internal combustion engine.

Our policy focus should be on inventing new technologies through government-funded research and development and then commercializing those technologies through private enterprise. Government can help direct capital toward the commercialization of new technologies, and can use its vast purchasing power to help speed the implementation of these new technologies. While some fossil fuel companies and energy utilities might resist, the new companies that build these new technologies will provide a powerful counterweight to the political power of these declining businesses. It is also possible that the better run fossil fuel companies will become modern energy companies and move into the renewable energy business for real, not just in their green-washing commercials.

There is little question that an improved, lower-cost, and renewable energy base is a necessity for this nation's future prosperity. A recent report by the Pew Charitable Trusts noted that many are seeking clean, secure, and affordable sources of power and are finding conventional sources unpredictable in price and harmful in terms of pollutants. It also noted that while the United States has invented many clean energy technologies, there is not enough investment relative to the size of its economy and history in the field (Pew Charitable Trusts 2012, 5, 7). There is also little question that the nation's fossil fuel companies and electric utilities will fight to prevent a system of lower-cost, decentralized renewable energy. Fortunately for America, we are now part of a global economy. This new technology will be developed by a multinational public-private partnership. The economic forces that dominate America's political process will not be able to prevent this change from taking place.

While no one can predict the future, these facts will motivate human ingenuity to develop better alternatives. Someone is going to be the Bill Gates or Steve Jobs of renewable energy and find a way to bring this form of energy to the marketplace. Lower-cost, less destructive forms of energy are desperately needed, and will likely be developed. To help speed the process, we need an energy policy that acknowledges the centrality of energy to modern life and focuses

scientific and corporate attention on developing and diffusing fossil-fuel-free energy.

Our energy goals are massive, important, and difficult, and they require government leadership, resources, and authority. We need to reduce our addiction to fossil fuels, but energy is too important to our way of life to just go cold turkey. We must replace our addiction to one form of energy with another form. The private sector cannot solve the energy problem alone and will not develop solutions fast enough to preserve our ecosystems. Building a sustainable economy and transforming our energy system requires that government take the lead, fund the required basic research, regulate private firms, build infrastructure, and reward sustainable practices. It must work with all of us to develop a vision of a sustainable economy and then must invest the resources needed to achieve that vision. The move to a sustainable economy requires that we generate far more energy tomorrow than we generate today. We do not yet know how to do that safely and effectively, but we need to learn, because solving the energy problem can solve problems of water, food, climate change, and ecosystem destruction.

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