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BEFORE THE SENATE ENVIRONMENT AND PUBLIC WORKS COMMITTEE

HEARING ON THE SCIENCE OF GLOBAL CLIMATE CHANGE AND ISSUES RELATED TO REDUCING NET GREENHOUSE GAS EMISSIONS

MAY 2, 2001

Mr. Chairman and members of the committee, thank you for inviting me to summarize for you the findings of a recent study that examines the ability of energy-efficient and clean energy technologies to reduce U.S. greenhouse gas emissions.

I am Marilyn Brown, Director of the Energy Efficiency and Renewable Energy Program at the Oak Ridge National Laboratory in Oak Ridge, Tennessee, and I am one of the lead authors of the study completed late last year titled *Scenarios for a Clean Energy Future.*[1]

Introduction

The *Clean Energy Future* study is the most comprehensive assessment to date of technologies and market-based policies to address the energy-related challenges facing this nation. It involved the analysis of hundreds of energy-related technologies and 50 policies. The focus is the United States, and the time frame is the next 20 years. Thus, it is not a global or long-term study; rather, it is an assessment of what could be done here and now.

The study was commissioned by the U.S. Department of Energy and was co-funded by the U.S. Environmental Protection Agency. It was prepared by researchers from five DOE national laboratories: Argonne National Laboratory, Lawrence Berkeley National Laboratory, the National Renewable Energy Laboratory, Oak Ridge National Laboratory, and Pacific Northwest National Laboratory.

The *Clean Energy Future* study concludes that accelerating the development and deployment of energy-efficient and renewable energy technologies could significantly reduce air pollution and greenhouse gas emissions, oil dependence, and economic inefficiencies, at no net cost to the economy. The overall economic benefits of the technologies and policies that are modeled result in energy savings that equal or exceed the cost of implementing the policies and of investing in the technologies.

Barriers to Energy Efficiency and Clean Energy Policies

Like many other analyses, the *Clean Energy Future* study describes a large reservoir of highly cost-effective energy-efficient technologies that are available or could soon be available to U.S. consumers; yet many of these technologies remain unexploited. These technologies could save us money, make our power system more reliable, make our society less energy wasteful, and preserve our environment—so why aren't we using them? If energy-efficient technology is cost-effective, why isn't more of it hitting the markets? If individuals and businesses can make money from energy efficiency, why don't they just do it?

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[1] The report is posted on the World Wide Web at http://www.ornl.gov/ORNL/Energy_Eff/CEF.htm

Although some like to assert that markets are perfect, practical experience tells us otherwise. Energy markets, like many markets, are plagued by barriers that can impede the adoption of new products, even those that are beneficial and economical. These market failures and barriers include:

- Misplaced incentives (for instance, these often occur in apartment buildings where landlords pay the utility bills, giving tenants no incentive to conserve)

- Distorting fiscal and regulatory policies (for example, electricity rates that do not reflect the real-time cost of electricity production)

- Unpriced costs (such as the health problems associated with burning hydrocarbons: because energy prices do not include the full cost of environmental externalities, they understate the societal cost of energy), and

- Unpriced benefits (such as the public benefits associated with energy R&D: because the benefits of private-sector investments in R&D extend beyond any individual firm, investments are insufficient from a public perspective).

The existence of market barriers that inhibit investment in improved energy technologies is a primary driver for public policy intervention. In many cases, feasible, low-cost policies and programs can be put in place to eliminate or compensate for market imperfections and barriers, enabling markets to operate more efficiently for the benefit of the society.

Scope of the Study

Scenarios for a Clean Energy Future assesses promising energy technologies and a range of public policies that could reduce the barriers to their use. It does so by developing scenarios that characterize how the future might unfold under different sets of policies. Three primary scenarios are presented: a business-as-usual (BAU) forecast and two alternative policy cases that reflect increasing levels of public commitment and political resolve to solving the nation’s energy-related problems.

- The BAU forecast assumes that current energy policies and programs continue, resulting in a steady but modest pace of technological progress and improved efficiencies.

- The Moderate scenario is defined by an array of market-based policies including a 50% increase in cost-shared federal energy R&D, expanded voluntary programs, and tax credits for efficient appliances, vehicles, and non-hydro renewable electricity.

- The Advanced scenario is defined by more aggressive policies including a doubling of federal energy R&D; voluntary agreements to promote energy efficiency in vehicles and industrial processes; appliance efficiency standards; renewable portfolio standards; and a domestic carbon cap and trading system.

The impacts of these policies are examined using various assessment methods and modeling tools. A modified version of the Energy Information Administration’s National Energy Modeling System is then used to quantitatively integrate the impacts of each scenario’s policies.

Results

The BAU scenario forecasts that U.S. energy consumption will increase from nearly 100 quadrillion Btu (quads) in 2000 to 110 quads in 2010 and 119 quads in 2020. Carbon dioxide emissions are forecast to increase at a comparable rate, to 1,770 million metric tons of carbon (MtC) in 2010 and 1,920 MtC in 2020 (see Figure 1). While there is necessarily great uncertainty associated with any specific forecast, all indications are that, without change, the United States is on a path toward increasing energy consumption and carbon emissions well into the foreseeable future.

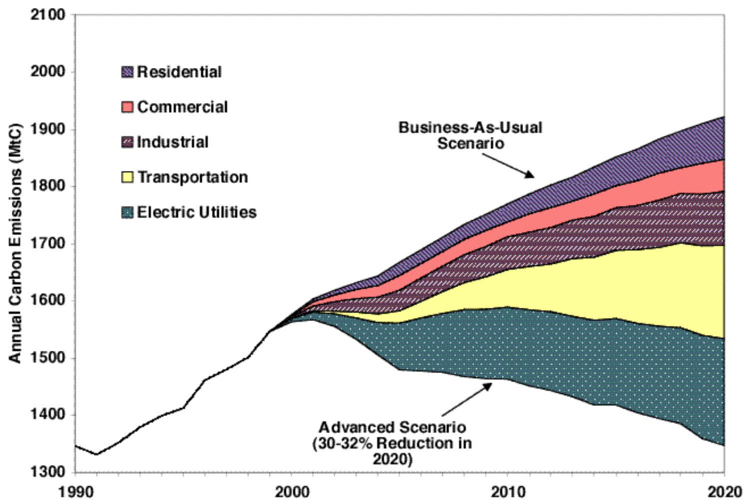

Figure 1. Carbon emission reductions, by end-use sector, in the Advanced scenario.

Under the Advanced scenario, the United States consumes 23 quads (20%) less energy in 2020 than is predicted under the BAU forecast. That savings amounts to almost 25% of our current energy use, and it is enough to meet the current energy needs of all the citizens, businesses, and industries located in the top three energy-consuming states–Texas, California, and Ohio. Other key findings of the Advanced scenario include the following:

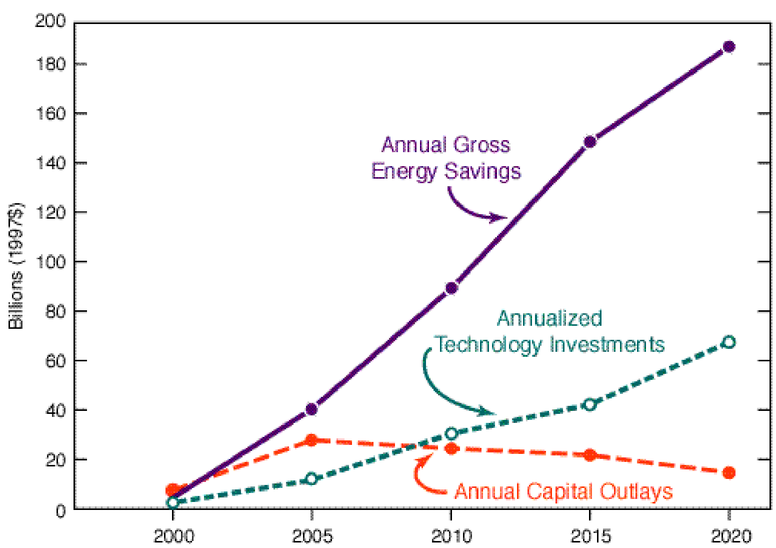

Figure 2. Annual energy bill savings and incremental technology investments of the Advanced Scenario: 2000 through 2020.

- By 2020, **U.S. CO_2 emissions have been reduced to 1990 levels** [avoiding 565 MtC compared with the BAU forecast]. By 2010, carbon emissions are approximately 300 MtC less than in the BAU case.

- Clean energy technologies and policies could **shave $122 billion off the U.S. energy bill in**

2020 ($189 billion in gross energy savings minus $67 billion in carbon permit costs)**.** These savings far outweigh any costs of implementation. (See Figure 2.)

- Under the Advanced scenario, voluntary agreements to increase the fuel efficiency of cars and light trucks, combined with other measures, could **cut U.S. oil consumption** by 5 million barrels per day. This would result in an estimated $23B reduction in transfer of wealth from U.S. oil consumers to world oil exporters, in the year 2020, and reducing the cost to the U.S. economy of a future oil price shock such as we are presently experiencing..

- Improving the energy efficiency of U.S. buildings and industry through voluntary programs, tax credits, efficiency standards, and other measures **could reduce electricity demand by 22% relative to the BAU forecast**—all at a negative net cost.

Two policies that are key to the energy and emissions savings in the Advanced scenario are increased resources for R&D in energy efficiency and clean energy, and a domestic carbon trading system.

- The Advanced scenario assumes that the federal government doubles its spending for cost-shared energy R&D, resulting in an overall increase of $2.8 billion per year (half federal appropriations and half private-sector cost sharing).

- A carbon trading system sets limits on the quantities of carbon emissions that can be released annually. Companies that produce emissions can comply with the cap by either reducing their emissions or purchasing emissions permits from other companies. The federal government would collect revenues from the emissions permits and transfer them to taxpayers. The goal of this policy is to change the relative price of carbon-based fuels without lowering personal incomes.

A Sampling of Technology Opportunities

The foundation of a clean energy future is efficient, clean energy technologies and sources. These technologies deliver the reductions in energy consumption, energy costs, and polluting emissions envisioned in the report. But what evidence do we have that these new technologies are real possibilities, not just wishful thinking? Consider the outcome of a major R&D effort that began in the late 1970s to improve the efficiency of household refrigerators, as one example.

Between 1977 and 1982, DOE invested approximately $5 million in R&D to make home refrigerators more energy-efficient. Working in a public/private partnership with compressor and appliance manufacturers, DOE and two federal laboratories identified ways of improving the performance of refrigerator compressors, motors, insulation, and controls, and they provided test data for use in the setting of national standards. These technology investments, in conjunction with the

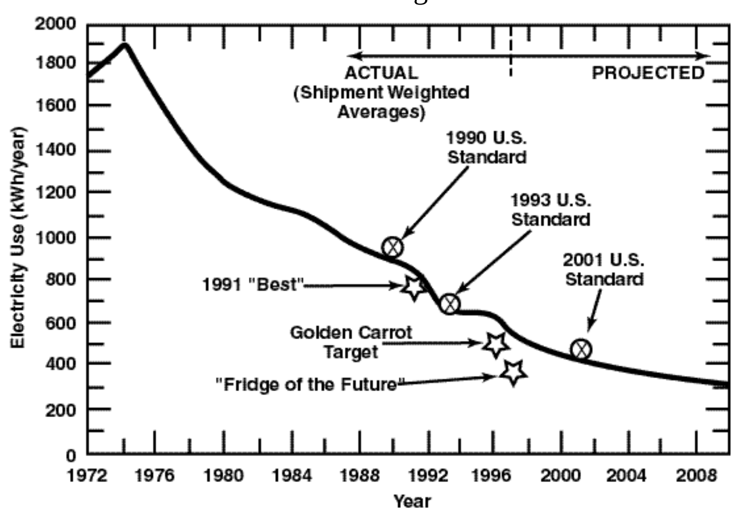

Figure 3. Average electricity use of household refrigerator/freezers by year of purchase.

issuance of appliance standards, cut the energy use of the average new refrigerator in half by the year 1990 and saved U.S. consumers $9 billion in energy costs from 1981 to 1990 (1999 dollars) (see Figure 3).

In 1997, a DOE–industry cooperative R&D effort developed a prototype “fridge of the future” that used nearly half as much energy again, as refrigerators then on the market and surpassed the 2001 efficiency standard for refrigerators. These developments in combination with the 2001 U.S. standard will save consumers billions of dollars each year.

With these advances, we are approaching the technical limits of home refrigerator/freezer technology. However, in other cooling applications, opportunities abound. For example, in Senator Reid’s state of Nevada, a natural gas-powered absorption chiller will be installed this summer in the Clark County Government Center for performance testing. This novel technology promises dramatic improvements in efficiency and emissions over chillers now on the market, and it uses no ozone-depleting refrigerants. These, and other building efficiency opportunities are highlighted in the *Clean Energy Future* study, including lower-cost compact fluorescent lamps, light-emitting diodes (LEDs) to replace incandescent traffic lights, heat pump water heaters, and switch mode power supplies to reduce standby losses.

Numerous opportunities exist in the industrial sector, as well. Just this week, Delphi Automotive Systems is hosting an event in Saginaw, Michigan, to celebrate the success of nickel aluminide trays used in its steel carburizing heat-treating furnaces. Nickel aluminide alloys, developed through a DOE–industry R&D partnership, are extraordinarily strong, hard, and heat-resistant. Their use in fixtures for high-temperature manufacturing can cut energy use by 5 to 10% by making it feasible to operate furnaces at higher temperatures and with fewer shutdowns. Nearly 100 such emerging technologies for improving industrial energy efficiency are modeled in the *Clean Energy Future* study. These include, for example, near net shape casting technologies for reducing the cost of producing iron and steel, and improved black liquor gasification that could make kraft pulp mills net electricity exporters.

In the realm of the here and now, improvements to industrial utility systems (steam, compressed air, motors, and pumps, etc.) offer tremendous energy-saving opportunities. Industrial motor systems, for example, use 25% of all the electricity consumed in the United States. In the Advanced scenario they are a source of considerable energy savings, based on the presumption of expanded technical assistance and voluntary programs. For instance, this scenario doubles the funding for DOE’s “Best Practices” program, which encourages the use of energy-efficient motor, steam, and process heating systems. In just the 5 most recently completed projects, annual energy savings of 131 trillion Btu were realized with an annual cost savings of $17 million, and an average payback on investment of 1.2 years. Full implementation of proven, cost-effective energy-efficient technologies could save 11 to 18% of the power used in motor-driven industrial systems, saving billions of dollars annually.

In transportation, the *Clean Energy Future* study underscores the availability of a collection of fuel-economy improvements to gasoline-powered vehicles that could be rapidly accelerated into the market through a combination of R&D, incentives, and voluntary agreements between government and automakers. These technologies include a range of engine technology improvements (such as advanced valve-timing and lift controls, friction reductions, direct-injection, and 4- and 5-valve designs) as well as gasoline-hybrid technology and lightweight materials substitution, especially aluminum and plastics. Altogether the Advanced scenario policies and technologies improve the fuel economy of gasoline-powered passenger cars from 28 to 44 miles per gallon by the year 2020.

Over the course of these same two decades, the *Clean Energy Future* study indicates that other propulsion systems and alternative fuels for passenger vehicles could be propelled into the market with an aggressive slate of polities. These include fuel cells, which account for 2.2 million of the passenger cars and light trucks sold in the Advanced scenario in 2020, and turbocharged direct injection diesels, which account for 2.6 million of light duty vehicles sold in 2020. Expanded R&D is critical to achieving the technology breakthroughs necessary for such growth in market shares of these novel, fuel-saving systems.

In the electricity sector, combined heat and power is singled out in the Advanced scenario as a highly promising distributed energy resource. By locating power-producing equipment near industrial plants that require electricity, it is possible to also put the waste heat from the power generation to use in the industrial process. This enables the efficiency of the U.S. electric grid–which has ranged between 28 and 33% over the past four decades, to be dramatically increased. Through policies such as expanded research, tax credits, and interconnection standards, combined heat and power technologies in the Advanced scenario reduce U.S. energy consumption by nearly 2.5 quads in the year 2020.

The expanded research budget portrayed in the Advanced scenario also drives down the cost and improves the performance of natural gas combined cycled plants and non-hydro renewable power. In combination with other incentives for low-carbon power, these policies grow the non-hydro renewable contribution to 10% of electricity production in 2020, with the bulk of the increment coming from wind power. Research on turbines that operate in less-windy regimes promises even more opportunities for wind power. Economic turbines in less windy regimes means that wind power can be used closer to eastern loads without the need for large transmission investments. Natural gas grows to one-third of power generation, just surpassing coal's contribution. In addition to lowering the nation's carbon emissions, a revised fuel portfolio such as this would significantly reduce local air pollution.

Conclusion

Energy conservation does not have the rugged, dramatic appeal of oil drilling or coal mining. It does not wow us with massive dams, dramatic cooling towers, or tall smokestacks. But energy conservation makes a tremendous amount of energy available. In fact, over the past 25 years, energy efficiency has become the number one domestic source of energy available for use by U.S. consumers. In 1999, almost a quarter of the energy we used was energy that would have been lost to waste without the energy-efficiency technologies that have been developed and implemented since the Arab oil embargo of 1973-74. A Btu saved is a Btu available to power our homes, industries, and cities. Energy efficiency is a clean energy source, producing no emissions or runoff. It improves our balance of payments, and we need not go to war periodically to defend it.

Clearly, following current approaches to energy policy in this nation will bring substantial increases in carbon and other polluting emissions over the next 20 years. The BAU case in *Scenarios for a Clean Energy Future* projects carbon emissions 31% and 43% above 1990 levels by 2010 and 2020, respectively. Virtually any future based on continuing current trends would include large increases in carbon emissions. The inescapable conclusion is that, absent major shifts in policy and the economy, the United States will be ever further from stabilizing its carbon emissions.

The *Clean Energy Future* study identifies a set of policy pathways that could speed the introduction of cost-effective, efficient, clean energy technologies into the marketplace. These technologies are good for business, good for consumers, good for the economy, and good for the environment. To secure these benefits, the nation needs to move forward on many fronts—on policies to remove market barriers, R&D to accelerate technology advancements, and programs to facilitate deployment of the new technologies. These, in combination with the political leadership that the world expects of the United States, are all necessary ingredients of a clean energy future

Thank you for this opportunity to talk with you today. I would be happy to answer any questions.

Biographical Sketch

Marilyn Brown is the Director of Oak Ridge National Laboratory's Energy Efficiency and Renewable Energy Program. During her 18 years at ORNL, she has researched the design and impacts of policies and programs aimed at accelerating the development and deployment of sustainable energy technologies. She currently manages a $110 million/year program of research to develop and assess advanced energy efficiency and renewable energy technologies. Prior to coming to ORNL in 1984, she was a tenured Associate Professor in the Department of Geography at the University of Illinois at Urbana-Champaign, where she taught graduate and undergraduate seminars on technological change, resource geography, and statistical analysis. She has received two NSF grants and funding from numerous other sources to support her research on the diffusion of energy innovations. She has a Ph.D. in geography from the Ohio State University where she was a University Fellow, a Masters Degree in resource planning from the University of Massachusetts, and a BA in political science (with a minor in mathematics) from Rutgers University. She has authored more than 140 publications and has received awards for her research from the American Council for an Energy-Efficient Economy, the Association of American Geographers, the Technology Transfer Society, and the Association of Women in Science. Dr. Brown sits on the boards of several energy and environmental organizations and journals.