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Research and Energy Efficiency: Selected Success Stories

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Research and Energy Efficiency: Selected Success Stories

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ABSTRACT

Energy use and energy technology play critical roles in the U. S. economy and modern society. The Department of Energy (DOE) conducts civilian energy research and development (R&D) programs for the purpose of identifying promising technologies that promote energy security, energy efficiency, and renewable energy use. DOE-sponsored research ranges from basic investigation of phenomena all the way through development of applied technology in partnership with industry. DOE's research programs are conducted in support of national strategic energy objectives, however austere financial times have dictated that R&D programs be measured in terms of cost vs. benefit. In some cases it is difficult to measure the return on investment for the basic "curiosity-driven" research, however many applied technology development programs have resulted in measurable commercial successes. The DOE has published summaries of their most successful applied technology energy R&D programs. In this paper, we will discuss five examples from the Building Technologies area of the DOE Energy Efficiency program. Each story will describe the technology, discuss the level of federal funding, and discuss the returns in terms of energy savings, cost savings, or national economic impacts.

Energy Efficiency

In an effort to reduce the nation's vulnerability to disruptions in our energy supply, the DOE sponsors research in energy efficiency and the development of alternative energy sources. Although energy efficiency may not appear as glamorous as renewable energy sources, such as solar or wind power, it does follow the old adage of "a penny saved is a penny earned." The installation of energy efficiency technology reduces the country's energy usage, and thereby mitigates our susceptibility to potential energy supply disruptions.

There are numerous examples of energy efficiency technologies, where initial development was sponsored by DOE, and now private-sector implementation has resulted in measurable energy savings. In the lighting area, electronic ballasts for fluorescent lamps are saving 15-30% over magnetic ballast technology. Low emissivity windows are achieving 35% savings over double pane windows in both residential and commercial applications. Savings like these have been documented in an attempt to raise the awareness of the value of energy efficiency measures, while also supporting the efficacy of the nation's energy R&D investments.

Fluorescent Lamp Electronic Ballasts

Fluorescent lighting using the electronic ballast consumes 15-30 percent less electricity per unit of light output than the magnetic alternative

(depending on the technology replaced and the type of lamp used). The current state-of-the-art electronic ballast technology was developed by the DOE, in the late 1970s.

Through 1996, over 140 million electronic ballasts have been sold. In 1996, this industry's sales totaled $260 million (over and above the market value of an identical number of magnetic ballasts), accounting for 31 percent of total ballast sales. Electronic ballasts are expected to replace magnetic ballasts in 75 percent of applications by 2015.

The electronic ballast not only improves the lighting quality of fluorescent lamps, but has saved consumers $1.5 billion in energy costs through 1996. For comparison, DOE's investment in the electronic ballast research program totaled only $3 *million*. (1975 dollars) It is this type of payback that justifies our research investment, and contributes to our nation's energy security.

Advanced Energy-Efficient Windows

A DOE research and development partnership between industry and a DOE National Laboratory culminated in the development of an advanced energy-efficient window technology that uses low-emissivity coatings to block heat loss, achieving a 35% energy savings, compared to standard double-pane windows. Prior to the Department's R&D investment, no U.S. manufacturer had invested in this technology. Today, every major glass and window manufacturer offers low-emissivity products.

Approximately 2.4 billion square feet of low-emissivity windows have been sold through 1996. This new industry's marginal sales totaled $625 million in 1996 (compared to ordinary window sales), accounting for 35% of total residential window sales and 18% of nonresidential sales. Low-emissivity windows are expected to replace ordinary windows in 80% of applications by 2015.

Cumulative consumer energy savings through 1996 attributable to using low-emissivity windows are $2.5 billion. Although DOE was only a partner in sponsoring the research, the cited energy cost savings were leveraged and catalyzed by a DOE investment of just $3 *million* through the early 1980s.

The advances made in the low-emissivity window provide the foundation upon which further improvements can be built. DOE is actively involved in cost-shared R&D with industry to develop the so-called "smart window", a window whose properties can be adjusted electronically to respond selectively to changing environmental conditions. Smart windows will save energy and lower operating costs, will allow smaller cooling systems to be installed, and will improve comfort in buildings.

Computerized Analytical Tool for Energy Efficient Building Design

Energy efficiency measures can be designed into the construction of new buildings, and into the renovation of existing structures. DOE research has resulted in the development of a powerful analytical software tool, DOE-2, which can be used to reduce energy use in buildings. DOE-2 calculates hourly building energy use and cost from information on the building's construction, climate, operation, heating, ventilating and air conditioning (HVAC) systems, and utility rate schedule. Architects and engineers using such a tool are able to implement energy-efficieny measures with far greater ease and precision.

Over 8 billion square feet of building floor area has been evaluated using DOE-2 through 1996. The value of DOE-2 design services delivered by U.S. private firms totaled $115 million in 1996. Today, approximately 15% of new commercial building floor area is designed with DOE-2, and the use of DOE-2 is expected to reach half of all buildings by 2015.

DOE-2 users surveyed report achieving an additional 22% energy savings, on average, thanks to the tool. This translates into about $0.33/ft^2 of building floor area. The use of the tool has saved building owners and tenants an estimated $12.5 billion in energy costs through

1996. For comparison, DOE's investment in the DOE-2 program totals $17 *million* through 1996.

High-Efficiency Refrigerator/Freezer Compressor

From 1978 through 1980, the Department of Energy, through a DOE National Laboratory, sponsored a contract with Columbus Products Company to develop a high-efficiency compressor for household refrigerators. DOE's investment of $8.3 million over this period ($15 million in $1996) supported the development of a new compressor that achieved a 44% improvement over the existing refrigerator compressor technology of that time. Refrigerator energy use declined from about 1,300 kilowatt hours per year in 1980 to about 900 kilowatt hours per year in 1990. The availability of high-efficiency compressors accounted for at least half of the drop in refrigerator energy use. Use of the improved compressors will save consumers a significant amount in energy costs throughout the life of these refrigerators. Considering only those refrigerators purchased through 1990, these high-efficiency compressors will save consumers at least $24 billion ($1996) in refrigerator life cycle energy costs.

Flame Retention Head Oil Burner

In the early 1970s, concern with oil supply and price volatility promoted interest in raising the efficiency of oil use. At this time, DOE sponsored research on the *Flame Retention Head Oil Burner*. This device, invented by others, offered a measurable improvement in oil use efficiency, yet it had languished for 9 years with no appreciable market penetration. This lack of market interest is remarkable during a period in which heating oil prices nearly quadrupled.

From 1977 to 1981, field tests were conducted by the Oil Heat Research and Development Program at a DOE National Laboratory. Results from this research established the validity of the energy conservation benefits of this technology. A second Department effort published the findings in a consumer-oriented information booklet. Due to DOE's critical investment during this period, totaling $8.8 million ($16.6 million in $1996), the retention head burner steadily achieved a growing market share and now accounts for over three quarters of the market for new and replacement oil burners. Before DOE's involvement in validating, testing and promoting this energy-saving technology, the Flame Retention Head Oil Burner had been largely ignored by the market and industry. Net consumer energy cost savings to date, from bringing this innovation to the marketplace, total more than $5 billion, (more than $8 billion in $1996). Using conservative estimates, assuming that DOE's involvement accelerated market acceptance by only 3 years, the Department's investment in this technology accounted for over $1 billion of these savings.

Energy Security

When discussing R&D investments by government agencies, most taxpayers want to see the "social good" that is achieved by performing the research. To make the public aware of the benefits achieved by its research, the DOE has published cost benefit analyses for selected R&D programs. The cost savings achieved provide excellent justification for performing the research in the context of alternative government investments. However, the true value of the the R&D, or "social good," is really best expressed in terms of the effect on our nation's energy security. The oil supply disruptions in the early 1970s demonstrated this nation's dependence on energy as a commodity. During the gas shortage of 1973, and to a lesser degree in 1980 and 1991, our transportation sector was crippled. When gas lines were over a mile long, our citizens were not concerned with cost savings, they wanted gas (and they wanted it in a hurry). Americans love their cars, and they do not like the idea of being susceptible to energy supply disruptions. It is in this context that the relevance of DOE investments in energy efficiency technology becomes apparent.

If we can acknowledge the impact of energy

efficiency in terms of reduced domestic energy use, and thereby reduced vulnerability to supply disruptions, then our R&D investments are truly justified. Renewable sources of energy are becoming commercially available, and market forces will determine how we, as a nation, exploit their benefits. However, regardless of the energy source, renewable or not, the efficient use of energy will always result in savings that will benefit our nation, and ultimately the world.

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Biography

Patricia Welesko Garland received her B.S. degree in Chemical Engineering from Carnegie-Mellon University in 1983 and an M.S. degree in Chemical Engineering from the University of Tennessee in 1995. Patricia is a technical staff member in the Energy Division at the Oak Ridge National Laboratory. She currently works on assignment in Washington, D.C. Patricia is a member of ASHRAE, AIChE, and a life member of SWE.

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