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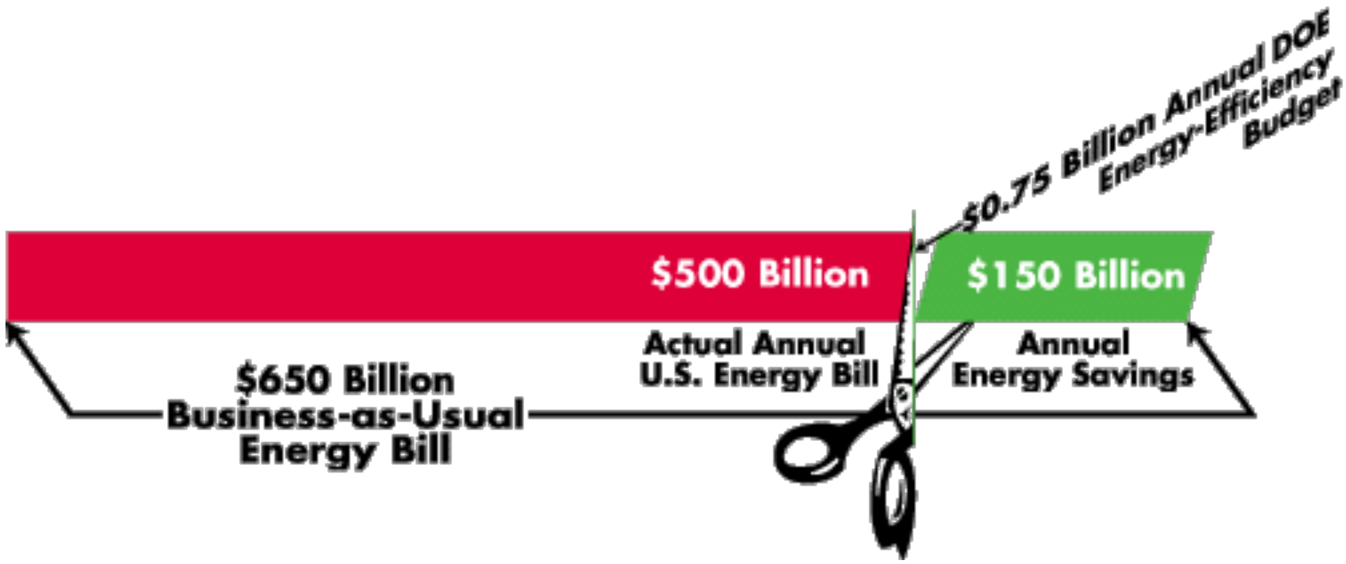
# Cutting Energy-Efficiency R&D: Penny-wise and Petro-foolish




Consumers save about $150 billion per year (about $600 per person) thanks to improvements in energy efficiency, policies that encourage efficiency, structural changes and lower energy prices. DOE's energy-efficiency programs cost about one-tenth of 1% of the annual U.S. energy bill.

While Congress moves to cut or eliminate a host of government energy-efficiency programs, little thought is being given to the billions of dollars of energy savings that will be forfeited by American homes and businesses. As oil imports eclipse levels that preceded the first energy crisis, as scientists discover yet more evidence of global climate change, as energy bills become a higher percentage of income for the poor, and as our competitor countries expand their energy R&D spending, we should look before we leap into slashing tomorrow's programs in the name of "efficiency."

## Government R&D Makes Markets More Vibrant

Improving energy efficiency was our economy's single most cost-effective response to the energy crises of the 1970s. Price- and policy-induced gains averaging about 25% in all sectors are today saving energy users a staggering $150 billion each year. Low-income households benefit; so do high-tech industries. Yet there remains a huge untapped potential to curb our ravenous $500-billion-a-year energy appetite ($2,000 for each American). The hard truth is that we are consistently less efficient than our global competitors, the rate of efficiency improvement has stalled, and energy demand-for the first time since OPEC became a household word-is rising.

The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy spearheads the nation's efforts. Its world-class R&D infrastructure and unique technical resources are designed to improve energy efficiency and indoor environmental quality in U.S. buildings, to make our transportation systems less dependent on imported oil, and to enhance energy productivity in industry. The DOE strategy combines technology push and market pull, in partnership with private-sector providers of energy-efficient goods and services. It focuses on developing basic materials and software, solving engineering problems, helping industry and policymakers understand the market's functioning, supporting utility demand-side management programs, and crafting mandatory standards to improve efficiency where other measures fail.

Past DOE efforts have already paid for themselves many times over, creating multi-billion-dollar markets for new products and services. For example, consumers save $1,000 for every dollar spent by DOE on its appliance standards program. And delivering energy efficiency creates more jobs than producing raw energy.

The market has by and large welcomed DOE's involvement. Building and appliance standards (the latter of which were signed into law by President Reagan) were arrived at through a remarkable consensus of manufacturers and trade organizations. Computerized design tools are embraced by architects and engineers who lack the ability to develop their own. The heating, ventilating, and air conditioning industry has expressed strong support for continued federal research on indoor air quality. Under the Partnership for a New Generation of Vehicles (PNGV), the big three auto makers will make Japanese cars look like gas-guzzlers-if Congress lets them.

DOE's programs do not interfere with the functioning of markets; they make these markets more vibrant. The work is far from done. Promising projects now on the lab bench include better, CFC-free insulation; advanced gas heat pumps; the super-efficient S-lamp; "smart" windows whose properties adjust with changes in light and thermal conditions; a new generation of standards that harvest savings made possible by emerging technologies; and multimedia design tools that vastly expand the ability of architects and engineers to apply new technologies. Other efforts focus on improving efficiency in basic industries such as steel and paper. PNGV is a bold effort to produce a midsize car three times as efficient as those sold today, with no sacrifice in cost, performance, or safety.

The building industry also looks to DOE for cost-effective and energy-efficient solutions to ventilation and indoor air-quality problems. DOE has responded with new technologies for better duct systems, inexpensive pollutant-monitoring devices, and designs for energy-efficient, radon-resistant homes. While saving money on energy bills, we could simultaneously address the hidden costs associated with the infamous "sick building syndrome," respiratory illnesses, lung cancer, asthma, many allergies, carbon mo$NO_x$ide poisonings, and other health problems.

These are worthy goals. Indoor air-quality problems are one of the most common causes of litigation in the buildings industry today. Around 20,000 deaths, and ten times as many illnesses, are attributed to indoor air pollution in the U.S. each year.

## Efficiency R&D in the Balance

Despite the prospective benefits, many of DOE's promising research programs could be eliminated or substantially reduced by a Congress that hastily dubs them "corporate welfare." In addition, several programs that promote the market deployment of energy-efficient technologies may be significantly downsized-among them the Weatherization Assistance Program for low-income households. Why is government involvement necessary? There are clear market failures that make industry reluctant to embark on certain kinds of R&D. Although private companies are often the source of innovation, they have short time horizons and shrinking research budgets. Small companies are at a particular competitive disadvantage and can benefit from the nonproprietary knowledge base, specialized resources, and risk-sharing available to them through DOE. Efficiency R&D funded by states and the utility industry is rapidly waning, making federal R&D more important than ever.

DOE has demonstrated an ability to unify disparate actors in the fragmented buildings industry. As an example, the recently formed National Fenestration

Rating Council (NFRC) established for the first time a coordinated group of glass, frame, and window manufacturers to agree on a common yardstick for quantifying and labeling the energy performance of windows. The labeling system helps utilities, code officials, ESCOs, and others in need of an objective and standardized efficiency measurement for windows.

DOE's programs leverage substantial private R&D cofunding. More important, industry eventually makes vastly greater investments in manufacturing and marketing the new technologies. On the demand side of the equation, DOE's market-conditioning programs address a host of informational, economic, and institutional barriers that keep consumers from purchasing efficient products. Government funding is not a handout; it's a catalyst for market creation. DOE also helps the government put its own house in order and to lead by example. In keeping with the theme of reducing the cost of government, federal managers are using the products of their own R&D to trim the government's $11-billion annual energy bill. This not only saves taxpayers money, but creates considerable demand for energy-efficiency goods and services provided by private companies. Take for example the energy management program in DOE's own 14,000 buildings around the country. Eliminating this activity-as proposed by both Houses of Congress-will only cost the taxpayers money: $5 for each $1 ostensibly "saved" through budget cuts.

Today, funding for DOE's efficiency programs represents a mere one-tenth of one percent of the U.S. energy bill (only $3 per capita). By trimming these programs further, government would divest itself of a proven tool for meeting its responsibility to ensure energy security, a livable environment, jobs, economic competitiveness, and prosperity for its citizens.

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Based on an article entitled "Cutting Government Programs to Save Energy Overlooks Benefits" by the authors in the Los Angeles Times, Business Section, September 10, 1995, p. D2.

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# News From the D.C. Office

## New Work With Motor Systems

The Energy Analyis Program has recently started a project for the DOE Office of Industrial Technologies Motor Challenge Program. This project, to be carried out in the Washington D.C. office, extends the office's work to an exciting new area of electric motor system efficiency.

Motor systems consume about 70 percent of the electric energy used in the U.S. industrial sector. Emphasis on motor efficiency in recent years has led to passage of efficiency standards, to become effective in 1997, for most common types of motors. This is extremely important because the cost of energy consumed by a motor during its useful life typically far exceeds its acquisition cost. Frequently, significant system-level opportunities for energy savings are overlooked as well.

An electric motor system is defined as a combination of electrically-driven equipment and associated hardware that converts electrical energy to mechanical or fluid power. Components of motor systems can include controls, adjustable-speed drives, pumps, air compressors, fans and blowers, and mechanical devices such as belts, gears, and bearings. Ancillary equipment such as dryers, dampers, heat exchangers, air cleaners, and filters, as well as distribution lines (ducts and pipes), can also be part of the motor system.

The Office of Industrial Technologies estimates that improvements in motor efficiency represent 18% of total potential energy savings for motor systems. The remaining savings opportunities are in the motor-mechanical subsystem (41%), process optimization (33%), and electrical distribution correction (8%). While these estimates pertain to the industrial sector, they also have significance for commercial building motor systems, which typically include system components such as fans, blowers, pumps, and distribution lines.

Through a series of conferences and round tables with industrial customers, distributors, and manufacturers, the Motor Challenge program has identified substantial gaps in the type, quality, and knowledge of system performance information available to industrial customers. This information has given the program a major market transformation opportunity through educating both high-volume and small buyers on the benefits of purchasing highly efficient motor systems.

Our work with Motor Challenge is designed to address these information gaps and assist buyers through the development of a series of tools for industrial end-users to be released in late 1996 and early 1997.

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This work is supported by DOE's Office of Industrial Technologies.

# PowerDOE: A Visual Energy Analysis Tool

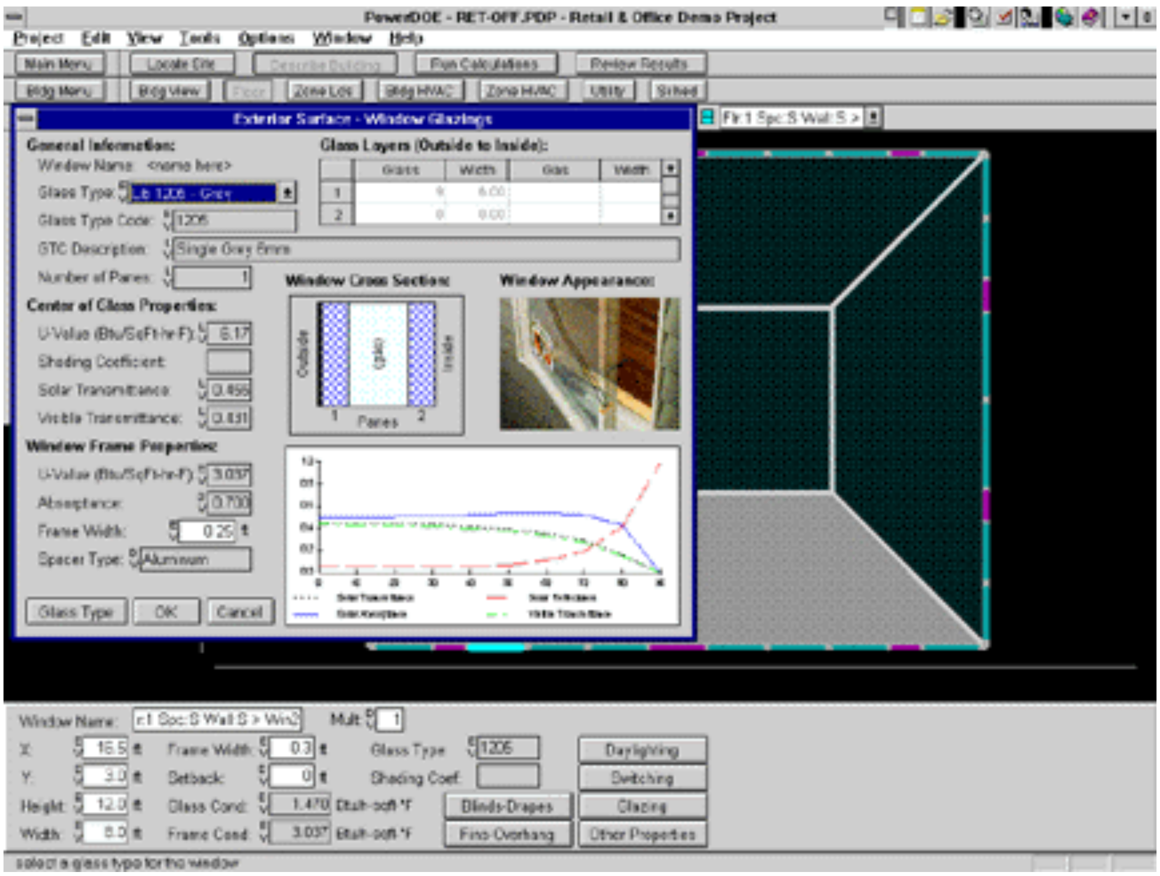


Figure 1: Building zone loads screen with exterior windows screen.

PowerDOE is a new PC-based tool for simulating building energy performance. To be released in April 1996, it combines the full capabilities of the DOE-2.1E building simulation program with an easy-to-use, flexible Windows graphical user interface. PowerDOE's development began in 1992 as a collaborative effort of Lawrence Berkeley National Laboratory and the Electric Power Research Institute.[1] The project's objective is to create a state-of-the-art program that will become a widely used and accepted tool for building simulation, energy analysis and design. PowerDOE is designed to serve a wide range of users, including building performance analysts, HVAC designers, architects, and electric and gas utility personnel and contractors.

## PowerDOE Structure

PowerDOE has a modular structure that allows sections of the program to be accessed externally or connected with other analysis tools. For example, its Review Results module can be used as a stand-alone application for post-processing DOE-2 results. The PowerDOE structure allows third party developers to use these modules-including Describe Building, Floor Plan, Zone Loads, Building Equipment, HVAC, and Central Plant-and the PowerDOE simulation engine in their applications. PowerDOE will also be linked to the Building Design Advisor, a multimedia-based, integrated building design support tool being developed separately at LBNL.

Unlike DOE-2's batch-mode operation, PowerDOE provides an interactive connection between the data input phase and the simulation, allowing the user to perform certain calculations prior to running the entire simulation.

For example, the user interface calls the simulation engine to perform the zone-by-zone peak-load calculations necessary for default HVAC equipment sizing. In this way, as the user passes from the architectural input phase to the HVAC description phase, all loads and the resulting default equipment sizing are visible and all are changeable prior to the energy use analysis.

The program requires a 386- or 486-based PC with a math coprocessor, VGA graphics card, color VGA monitor and 12 megabytes of memory. A SuperVGA (800x600) or a VGA (with 256 or more colors) video card and monitor are suggested for optimal display of the application's graphics. Windows version 3.1 or higher is required.

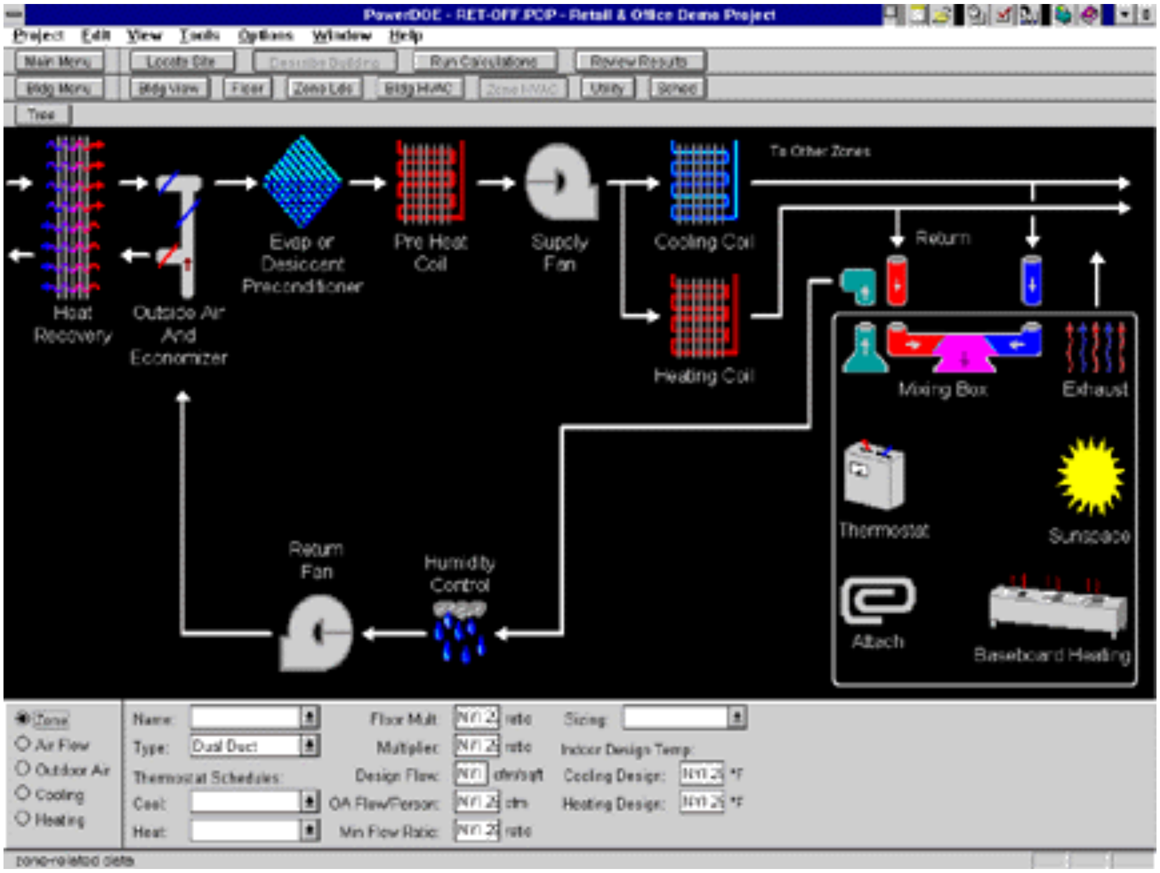


Figure 2: HVAC system screen.

## User Interface

The PowerDOE user interface takes a number of unique approaches to describe buildings accurately. PowerDOE organizes architectural and HVAC elements in a hierarchy that is intuitive and familiar to designers and analysts. Building areas are grouped into floor plans, with each floor composed of conditioned and unconditioned zones plus any plenums. HVAC equipment is grouped by air- and water-flow paths that supply the heating, cooling, and ventilation requirements of the building areas. Electricity and fuel supply are grouped into hypothetical meters that both reflect the actual building circuits and submetering, and provide end-use consumption and demand estimates.

## PowerDOE Library

PowerDOE includes a library of generic, parameterized prototype buildings and building components that can be altered to create new libraries. The user can select a prototype by building type (e.g., office, residence, hospital), size (large medium, small), vintage (pre 1970s, 1970s, 1980s, 1990s), and location. The prototype can then be altered globally to conform to the desired design. Global parameters include building size, area, number of floors, shape, usage breakdown by area percent (entry, office, kitchen), and HVAC configuration.

The initial release of PowerDOE will be available in April 1996. Subsequent releases will include more new features and improvements. Contact the Simulation Research Group for more information on PowerDOE's features and information on obtaining the software.

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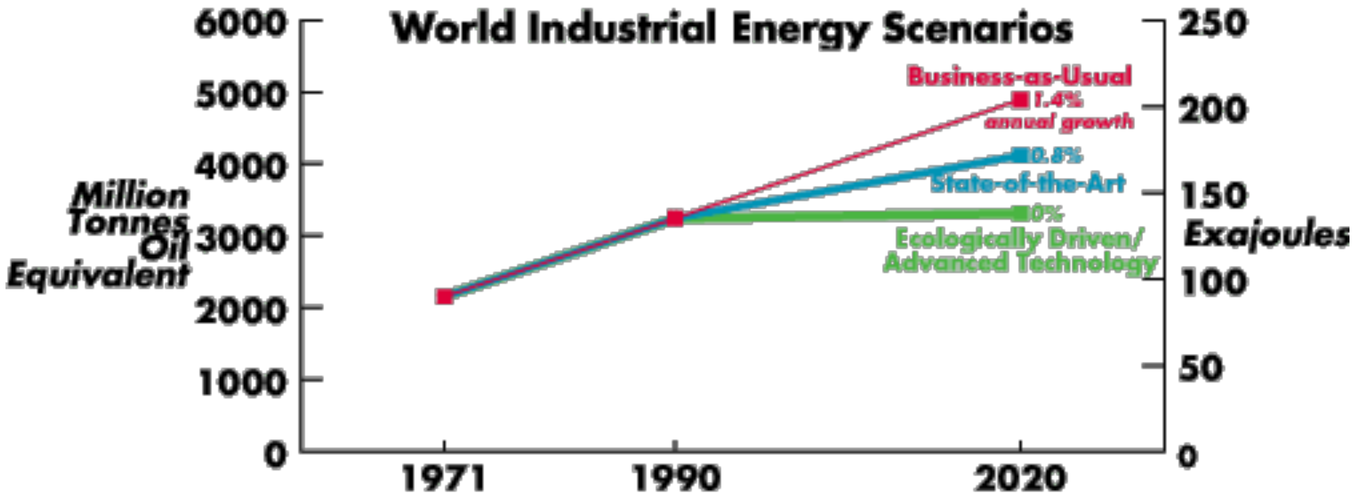
# A Report to the World Energy Council

## LBNL's Energy Analysis Program delivers a key energy efficiency study to WEC




On October 8-13, the 16th Congress of the World Energy Council, entitled "Energy for Our Common World: What Will the Future Ask of Us?", was held in Tokyo, Japan. The Congress brought together more than 5,000 key policy makers, industrial representatives, and researchers to discuss the sustainable production and use of energy.

At the Congress, Mark Levine, Head of the Center's Energy Analysis Program, presented findings from a two-year collaborative research effort on energy efficiency in industry and buildings that involved participants from 10 countries. The research culminated in a 500-page report, "Energy Efficiency Improvement Utilising High Technology: An Assessment of Energy Use in Industry and Buildings." The report, written by Mark Levine, Nathan Martin, and Lynn Price of LBNL and Ernst Worrell of Utrecht University, analyzes energy use in industry and buildings drawing examples from 23 commissioned case studies of energy-efficient technologies in these two sectors. Lee Schipper and Jayant Sathaye of EAP's International Energy Studies Group contributed to the companion report on transportation produced by Norway's Statoil.

The industry and buildings report, which was well received in Tokyo, analyzed global historical trends in energy use and efficiency in five energy-intensive industrial sectors (Iron and Steel, Pulp and Paper, Chemicals, Petroleum Refining, and Building Materials) and in residential and commercial buildings. Together, the top five energy-intensive sectors account for about 45% of total industrial energy use. Some of the most dramatic energy-efficiency improvements in these energy-intensive sectors were the result of advances in manufacturing processes and equipment improvements. For example, the increased use of scrap or recycled material in the steel and paper industries has greatly reduced the energy required to produce an additional unit of output. In buildings, equipment improvements such as high-efficiency lighting and appliances have also reduced unit energy consumption. Considerable potential (on the order of 1 to 2% annually) still exists for efficiency improvement in these sectors.

These efficiency potentials were evaluated in light of expected global changes in the demand for industrial products and buildings services and were incorporated into three scenarios to estimate future energy use. Industrial energy use is expected to grow by 1.4% annually through 2020 under a business-as-usual scenario (see figure). This growth can be slowed to about 0.8% per year through replacement of existing stock with the current most efficient technologies available. In a world in which an ecological imperative leads to rapid and widespread use of advanced technology, industrial energy use in 2020 can remain at the 1990 level despite growth in global industrial output ranging from 0.8% to 2.7% per year, depending upon the sector. In all three of these scenarios, energy demand growth for buildings is about 1% per year higher than for industry. As a result, the buildings sector is likely to use more commercial energy than all of industry within a quarter of a century unless energy-use patterns change unexpectedly.

The most striking finding was the tremendous growth in energy demand that is taking place in developing countries. Energy use for buildings has tripled since 1971, while industrial energy has more than doubled. Given the continued development of infrastructure and buildings in developing countries, demand is expected to increase rapidly. In China, for example, cement production (for roads and buildings) has doubled since 1988, making it the world's largest cement producer.

Given these findings, the report noted three essential requirements for an energy-efficient future: (1) aggressive energy-efficiency policies, that promote adoption of cost-effective technologies; (2) major programs to transfer knowledge, technology, and policy tools to the developing world and the restructured economies of Eastern Europe and the former Soviet Union; and (3) continued efforts to pursue research and development in technologies and practices to increase energy efficiency in industrial processes and buildings. For further information concerning the details of this report, contact Mark Levine, Nathan Martin, or Lynn Price. An abridged edition of the report is also available on the World Wide Web.

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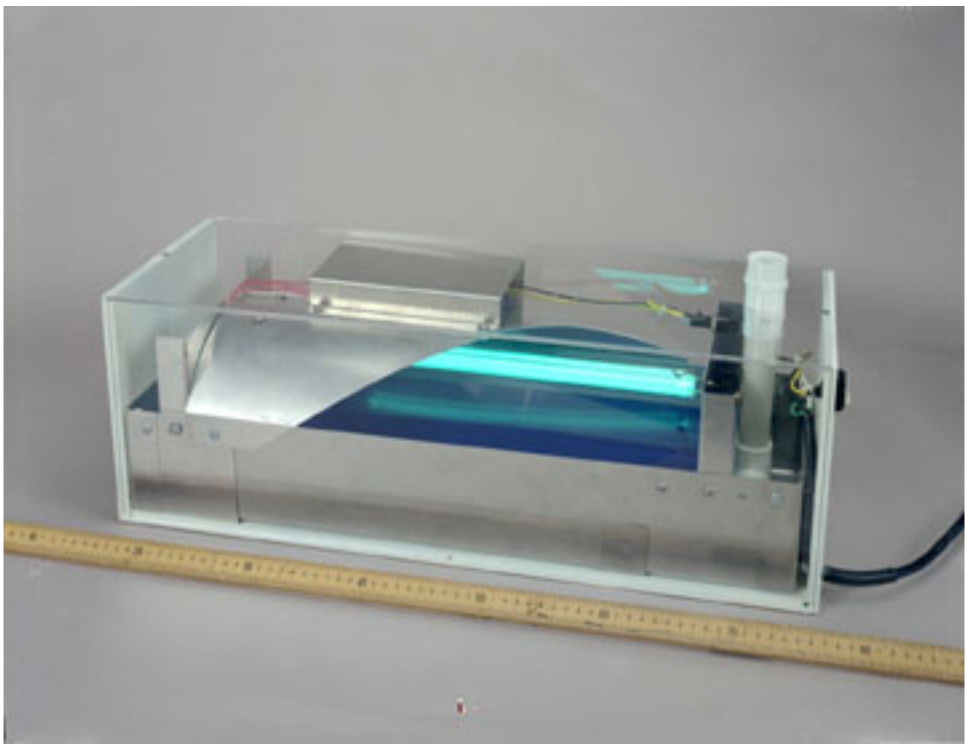
# UV Waterworks: Reliable, Inexpensive Water Disinfection for the World



The UV Waterworks water-disinfection unit, with a plastic cover and cutaway reflector revealing its interior.

In the developing world, waterborne diseases such as cholera, typhoid fever, gastroenteritis, dysentery, and infectious hepatitis worldwide kill more than 400 children every hour and result in the loss of billions of hours of worker productivity each year. Municipal tap water is uncommon in many developing-country households, and two out of three people in the world must fetch water from outside their homes. In India, water-purity issues are particularly important during the monsoon season when heavy rainfall washes raw sewage and other contaminated material from the fields into the wells and surface water. Disinfecting water by boiling it over cookstoves increases the burden on those collecting the fuelwood, mostly women and children, and also stresses the biomass resource. Gathering wood occupies time that might be spent productively in other activities.

To address this significant public health and energy problem, an effort is underway at the Center's Indoor Environment Program to introduce a water-purification system using ultraviolet light to rural villages in India, Mexico, and South Africa. The goal of this project is to design and field-test a water-purification device for developing countries that is durable, easy to use, and inexpensive and can be constructed and maintained locally. It has resulted in the development of a prototype device called UV Waterworks.

We began our research early in the summer of 1993 and increased our efforts considerably in August 1993, when an outbreak of cholera was reported in India, Thailand, and Bangladesh. A year later, the cholera epidemic continued to be a problem in India-approximately 2,200 people died from cholera in the state of Bihar, between the months of May and August 1994. Other waterborne diseases also pose a serious health threat to Indian communities. In the state of Orissa alone, approximately 300 infants die every day as a result of waterborne gastrointestinal diseases.

We estimate that UV Waterworks can disinfect drinking water for 2¢ per ton of water, including the cost of electricity and consumables and the annualized capital cost of the unit. Its first cost is about $300, and, using only 40 watts of electricity, it provides four gallons of disinfected drinking water per minute. The disinfection process is highly energy-efficient and uses approximately 20,000 times less primary energy than the standard alternative-boiling water over a cookstove.

By our calculation, one unit serving a typical developing-nation community of 1,000 people for 15 years will avert 15 deaths of children below age 5 and avoid the stunted growth of 150 children. Under aggravated conditions, (e.g., epidemics) life savings and health benefits will be much larger. Because women are primarily responsible for collecting fuelwood, fetching water, and bearing and caring for children, the UV disinfection system could greatly improve women's quality of life by reducing their workloads as well as the number of children they lose to waterborne diseases.

## How it Works

The technology uses ultraviolet (UV) light to kill waterborne pathogens (bacteria, viruses, and molds) in the local water supply. UV light is classified by three wavelength ranges.[*] UV-C light is "germicidal"; that is, it destroys bacteria, viruses, and other pathogens by inactivating their DNA and thus their ability to reproduce. Light with a wavelength of 254 nm gives the highest germicidal efficacy in the UV range. Because this is the wavelength at which a low-pressure mercury vapor lamp emits roughly 90% of its light, the standard fluorescent lamp technology can be used in the system.

The glass tubes of the fluorescent lamps that light our offices and kitchens are coated with a phosphor that absorbs UV light and gives off visible light. The lamp used in the UV disinfection system is similar to a standard fluorescent lamp, but the lamp tube is not coated with a phosphor and is made of a special glass that is transparent to UV light. This "germicidal" variety of lamp is already manufactured by many large companies that make standard fluorescent lamps. Consequently, lamps, ballasts, and starters for the UV disinfection system can be bought off the shelf, with the full benefits of mature volume production (at low cost and free of technical bugs).

The $300 one-time capital cost of UV Waterworks includes materials, fittings, and labor. The life of the metal unit is expected to be approximately 15 years; the UV lamp requires replacement in alternate years. Assuming the system operates for 12 hours per day and the price of electricity is 8¢/kWh, the annual electricity cost of operating a UV system is expected to be approximately $14.

Based on these assumptions regarding cost and system life span and a 12% discount rate the total annualized cost of the UV system is approximately $70 per year. This includes the annualized cost of the 35-watt UV lamp, the ballast, the metal chamber, and the cost of electricity. It is assumed that the villagers provide their own hand pump for groundwater or storage tanks and sand filter; the raw materials for these components are readily available and inexpensive. If the system operates for 12 hours per day, 4,000 tonnes (4 million liters) of water can be disinfected every year. Using a per- capita drinking water requirement of 10 liters per day, a single system can provide enough water for approximately 1000 villagers. Accordingly, using a UV system to ensure potable water for a rural community of this size year-round costs about 5¢ per villager per year.

LBNL's Technology Transfer Office has received licensing inquiries from dozens of interested businesses. To encourage wide dissemination, we are now seeking funding support for extended field trials to identify and incorporate any user-requested design improvements and document the device's performance in the field.

*[UV-C from 100 nanometers (nm) to 280 nm; UV-B from 280 nm to 315 nm; and UV-A from 315 nm to 400 nm.]

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# A-Team Report

## Measurement and Verification: The Accounting System for Energy-Efficiency Engineering

Measurement and verification is the accounting system for energy-efficiency engineering. With two full-time employees working on M&V issues as well as subcontracts with experts in specific techniques, the Applications Team is helping advance M&V practices. Its current activities include field monitoring projects, M&V management of a large General Services Administration retrofit project, and playing a lead role in developing standard protocols. The major clients for this work includes DOE (the In-House Energy Management Program, Federal Energy Management Program, the Office of Building Technologies), GSA, the Federal Aviation Administration, and the National Park Service.

The M&V field work serves several purposes. Monitoring can be used during the audit process to identify and quantify energy conservation opportunities and to help create baselines for energy savings performance contracts (ESPCs). M&V is essential in establishing the basis of payment for ESPCs.

The goals of recent A-Team projects were to create baselines of electricity and gas usage at the Presidio in San Francisco and an FAA air traffic control center and to complete a survey of energy use at the U.S. embassy in New Delhi.

Overall M&V management is the task at GSA's Phillip Burton Federal Building in downtown San Francisco. This far-reaching project will showcase the first installation of a BACNET-compatible Energy Management and Control System. M&V will be used to quantify the effectiveness of the retrofits and the BACNET protocols.

Finally, the A-Team is leading the development of two protocols that will standardize the language and procedures of M&V. The National Energy Monitoring and Verification Protocol (NEMVP) will be the first national M&V protocol developed as a consensus document. A related federal M&V

document is specifically tailored to meet the needs of federal agencies and is compatible with the NEMVP document. Both documents will be released in late fall 1996. In addition, the A-Team is contributing to the efforts led by the American Society of Heating, Refrigeration and Air Conditioning Engineers to develop an M&V standard, ASHRAE GPC 14P, "Measurement of Energy and Demand Savings."

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