ENERGY

End-Use Efficiency

Concerns over the environmental and societal impacts of fossil fuel burning and nuclear power, and questions of energy security mean that identifying viable energy alternatives is a widespread concern affecting everyone, not just those interested in river restoration or hydropower dam construction. About 2,400 hydropower dams generate roughly ten percent of the nation's electricity. While many of those dams will continue to operate profitably, some dams no longer produce enough power to justify their benefits. By taking a look at the longer-term alternatives presented below, we can begin to consider options that eliminate the ecological concerns raised by hydropower dams and other traditional energy sources. The utilization of one or a combination of the following alternatives can help a community or government eliminate the need for an existing or proposed dam:

- End-use efficiency
- Emerging technologies

END-USE EFFICIENCY

It has long been recognized that programs designed to reduce energy needs represent an environmentally beneficial and, in many cases, cost-effective alternative to seeking new or eliminating existing sources of power. Such programs can motivate people to be more careful about the way they use energy, offer financial assistance in making homes and businesses more energy efficient (for example, by improving insulation or by installing high-efficiency appliances), or find ways to shift energy usage from on-peak to off-peak periods. Together, these types of measures have come to be known as demand-side management or (more recently) end-use efficiency.

End-use efficiency represents an opportunity to reduce the need for electrical generation and consequently the need for obsolete or new hydropower dams.[1] Energy efficiency measures can reduce pollution and greenhouse gas emissions, save money and create jobs. Many efficiency measures and technologies are cost-effective at today's electricity prices, and the use of full-cost environmental and social accounting of electricity supply options makes them even more so. According to the Rocky Mountain Institute, up to 75 percent of the electricity used in the United States today could be saved with cost-effective energy efficiency measures.[2]

Since 1973, the United States has acquired more than four times as much new energy from end use efficiency as from all expansions of domestic energy supplies put together. The energy savings already achieved have cut Americans' energy bills by more than $200 billion a year, compared to what they would collectively be spending if they used energy at the same rate as in 1973.[3] Most hydropower dams in existence today produce very little power; 80 percent of FERC-regulated dams produce less than 50 MW of power, which is enough electricity to power approximately 50,000 homes.[4] In fact, it has been said that the energy produced by Edwards Dam that was removed from the Kennebec River in Maine could have been met by replacing 75,000 standard light bulbs with energy efficient bulbs.[5] The current and potential energy savings combined with the low output of many hydropower projects lessens the need for existing and potential hydropower dams.

1. World Commission on Dams. *Dams and Development: A New Framework for Decision-Making.* London: Earthscan Publications Ltd, Nov. 2000.
2. Rocky Mountain Institute, *Efficiency is Still the Best Bet*, ‹www.rmi.org/sitepages/pid510.php› (22 Oct 2001).
3. Pottinger, Lori. *River Keepers Handbook: A Guide to Protecting Rivers and Catchments in Southern Africa.* Berkeley: International Rivers Network, 1999.
4. World Commission on Dams, *Dams and Water Global Statistics*, ‹www.dams.org/global/namerica.htm› (3 October 2001).
5. McPhee, John. *The Founding Fish*. New York: Farrar, Strauss and Giroux, 2002.

Despite the demonstrated effectiveness and promise of implementing these measures, actual investments in energy efficiency and the savings from them continue to be small, and have declined in recent years.[6]

In the late 1980s, new regulatory tools were designed to create incentives for utilities to invest in demand side management strategies. Complex mechanisms for cost recovery, lost revenue recovery and shareholder incentives were implemented, and, as a consequence, many utilities began investing heavily in energy efficiency as a means to balance supply and demand. With the advent of retail competition, however, these mechanisms became increasingly obsolete. Indeed, the mere threat that utilities might eventually have to face competition caused their demand side management spending to plummet nearly as fast as it rose.[7]

End-use efficiency programs may include a number of strategies, including the following:

- Offering financing for energy efficient homes and buildings in the form of energy efficient mortgages;
- Offering rebates to consumers for purchasing efficient equipment and to manufacturers for designing and producing it;
- Setting energy efficiency standards;
- Implementing consumer education programs about conservation and efficiency measures available to them;

7. Raphals, Philip. *Restructured Rivers: Hydropower in the Era of Competitive Markets.* Berkeley: International Rivers Network, May 2001.
8. Pottinger, Lori. *River Keepers Handbook: A Guide to Protecting Rivers and Catchments in Southern Africa.* Berkeley: International Rivers Network, 1999.

- Implementing programs like the EPA Energy Star program, in which products, homes and other buildings are identified and promoted if they meet energy-efficiency standards; and
- Improving efficiency on the supply-side, such as reducing losses through distribution systems.[8]

Advantages

Programs around the world have demonstrated that efficiency measures can significantly decrease electricity demand, thereby reducing the need for hydroelectric dams and other generation sources. In most cases, these demand reductions can be achieved at less cost than constructing new power sources, and provide more jobs in the long run.

Disadvantages

The principal drawback of depending on efficiency to decrease energy demand is the perceived incremental and diffuse nature of an approach that depends on changing the behavior of many individuals, or on retrofitting many relatively small devices. These characteristics can prove challenging for energy planners who prefer more quantifiable and predicable approaches.

Costs

Many simple strategies implemented by consumers are very low cost, such as $5-$15 for a compact fluorescent light bulb. Larger programs that provide incentives to consumers for replacing inefficient large appliances can cost millions – up front. In most cases, however, the cost of the measure is paid back many times over its lifetime. Replacing an old refrigerator with a newer, energy-efficient model may cost $700 to $1,500 up front but could save as much as $180 a year on a homeowner's energy bill.

Case Study, End-Use Efficiency

Energy conservation in the Northwest has saved enough energy to power two cities the size of Seattle during the last 22 years, and the potential exists to acquire more conservation savings by 2025, according to the Northwest Power Planning Council. The council put forth a plan that will save the equivalent of 5,800 MW of electricity through energy efficiency and conservation by the year 2025 (by comparison, the nation's largest hydropower dam – Grand Coulee – produces 6,800 MW). This figure includes 2,600 MW the region has already conserved since Congress passed the Northwest Power Act in 1980. The power act directs the council to prioritize low-cost conservation before it encourages the development of generation plants.

Building codes that promote energy-efficient design, weatherizing the home, and compact florescent lights are among the developments that have helped to reduce electricity demand since the council's first 20-year power plan in 1983. In laying out a power plan for the next 20 years, council analysts say the region should be able conserve 3,200 MW. The region has defied long-term projections with its end-use efficiency programs. In the 1970s, power planners projected a Northwest energy shortfall, prompting many of the region's utilities to embark on an ill-fated nuclear power program. Deep shortages never panned out, however, due largely to conservation.

For more information on this Pacific Northwest energy efficiency case, see the Northwest Power Planning Council at www.nwcouncil.org.

8. Pottinger, Lori. *River Keepers Handbook: A Guide to Protecting Rivers and Catchments in Southern Africa.* Berkeley: International Rivers Network, 1999.

Case Study, End-Use Efficiency

Before the deregulation of the energy sector, California was long a leader in increasing energy efficiency, spending at its peak in 1993 as much as $416 million per year on utility efficiency programs. Thanks to this strong effort, California's demand grew at about one percent per year over a decade, which is half the rate of the rest of the country.

Since 1975, a combination of state energy efficiency standards for buildings and appliances and utility energy efficiency programs dramatically reduced energy consumption in California – enough to heat and power the entire state for over two years. In 1998 alone, the savings from building and appliance standards totaled $1.4 billion, with utility programs adding a similar amount. The displaced energy from both standards and programs was roughly the equivalent of ten 1000-MW power plants. The combined impact of all the efficiency programs in California in one year is equal to 15 percent of the total statewide electricity consumption. Had efficiency programs been continued at mid-'90s levels, the state could have saved an additional 1,100 MW – enough to avoid some of the problems during the state's 2001 energy crisis.

According to a study by the RAND Corporation, improvements in energy efficiency since 1977 caused the state's economy to be three percent larger in 1995 than it would have been otherwise, and resulted in savings of between $875 and $1300 per capita. In addition, the efficiency improvements resulted in a 40 percent reduction in air emissions, compared to what would have resulted if energy intensity had remained at 1977 levels and the mix of energy uses remained constant (i.e., energy intensive industry continued to dominate the economy).

The above case study is excerpted from a report by the Energy Foundation. To see the entire report: www.ef.org/california

Where you can go for help

- Natural Resources Defense Council: www.nrdc.org/air/energy/genergy.asp.
- Sierra Club: www.sierraclub.org/energy.
- Alliance to Save Energy: www.ase.org.
- Energy Efficiency and Renewable Energy Network, U.S. Department of Energy: www.eren.doe.gov.
- American Council for an Energy Efficient Economy: www.aceee.org.

While end-use efficiency has huge potential throughout the United States and the world, new sources of energy supply are often still required. Renewable portfolio standards (RPS), in which the government issues tradable credits to retail electricity companies for electricity produced from new renewable resources, promote the development and use of sources that are less damaging than dams, fossil fuels or nuclear power. In order to meet RPS requirements, each company must hold a given amount of credits each year. In 2002, twelve states had enacted their own RPS programs and the U.S. Senate passed a federal RPS. The Senate RPS required that major electric companies gradually increase sales of renewable energy sources to 10 percent by 2020, although this provision has met stiff opposition in the House and is far from becoming law.[9] Qualifying renewable resources must be new, so existing hydropower plants are not included. However, provision was made for inclusion of "incremental hydropower," which is defined as adding hydropower capacity to existing hydropower generation facilities.

However, definitions of "renewable" vary among different incarnations of the RPS. Some programs define "incremental hydropower" as renewable, others grant credit to "small" dams (e.g. less than 30 MW), while others exclude dams from the list of qualifying renewable resources. The retail electricity price impacts of RPS are projected to be small because the price of buying renewable credits and building the required infrastructure is projected to be relatively small when compared with total electricity costs.[10] Finding sources that are less damaging than dams is highly site specific and variable. Options include wind power, solar power, fuel cells and microturbines, geothermal power, biogas, ocean power,[11] and others. Discussed below are three of the most promising and economically viable technologies, including:

- Wind power
- Solar power
- Fuel cells and microturbines

9. Union of Concerned Scientists, *Fact Sheet: The Senate Renewable Electricity (Portfolio) Standard*, September 2002, ‹www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=838› (10 Sept. 2002).

10. Energy Information Administration, *Analysis of a 10-percent Renewable Portfolio Standard*, May 2003, ‹www.eia.doe.gov/oiaf/servicerpt/rps2/pdf/sroiaf(2003)01.pdf› (June 2003).

11. Pottinger, Lori. *River Keepers Handbook: A Guide to Protecting Rivers and Catchments in Southern Africa.* Berkeley: International Rivers Network, 1999.

WIND POWER

Wind power is the world's fastest growing energy source, with an average annual growth rate in the 1990s of 24 percent. It is likely to continue to grow at a breakneck rate through this decade as costs continue to drop and pressure grows to cut greenhouse gas emissions. In some areas, wind power is already cost competitive with fossil fuels. Wind power now contributes directly to the economies of 46 states, and often provides job opportunities in poor farming communities.[12] According to the American Wind Energy Association (AWEA), total installed wind power in the United States stood at 4,685 MW as of January 2003. However, growth in the United States was still slower than elsewhere around the world. AWEA estimates that wind projects are capable of providing six percent of the nation's electricity by 2020. Right now wind makes up about half of one percent of the U.S. energy mix. AWEA says government support is crucial for wind energy development, especially through incentives like the production tax credit (PTC).

DAVID BARENBERG, RENEWABLE NORTHWEST PROJECT

21ST CENTURY WIND TURBINES

Wind power has benefited from a 1.8 cent per kWh credit since 1992, but Congress failed to extend the credit when it expired under law in 2001. The PTC was renewed in March 2002 when Congress passed the current economic stimulus bill but has since expired. Several pending bills in Congress aim to extend the law for several years.

Advantages

Wind power is non-polluting, easy to install in increments that match demand, and can blend with other land uses such as farming or grazing, thereby minimizing the amount of land consumed by power generation. It is competitively priced, and does not pose a fuel-price-escalation risk. It also creates more jobs per unit of energy produced than other forms of energy, according to AWEA. Furthermore, according to the EWEA and Greenpeace, the potential penetration of wind power into the total national energy grid is about 20 percent.[13] Depending on the location of a wind farm in relation to a hydropower dam, the potential to replace an existing or delay a new hydropower may exist.

Disadvantages

The major drawback to wind power is its intermittency – at even the best sites the wind blows at different speeds, and sometimes not at all. While it has been said that the Mid-West could produce enough wind energy to power the entire country, the problem lies in delivering the power to the eastern and western seaboards. Transmission lines may not exist in rural areas where

12. American Wind Energy Association, *Wind Energy and Economic Development: Building Sustainable Jobs and Communities*, ‹www.windonthewires.org/windFactsJobs.cfm› (2003).

13. Marsh, P. "Wind Power Systems Poised to Triple Over Next Five Years," *Financial Times*, 23 January 2001.

farms would need to be sited and would take three to five years to install even a regional network. Relying on a variety of wind farm sites to power the grid can help minimize the problem.[14] Another drawback is that local opposition occasionally arises due to concerns such as noise, property values and hazards to bird populations. Location and portability also play a role in the ability of a wind farm to replace hydropower output given the characteristically different geographic needs (plains versus steeper grade) of wind farms and hydropower dams.

Costs

The cost of energy from wind projects fell by 80 percent between the early 1980s and late 1990s. Real, level costs are now about three to six cents per kW without any tax credits. This is competitive with many new coal or natural gas facilities. Costs for individual projects depend on financing, transmission infrastructure, and wind quality. The most cost-effective wind farms usually have at least 35 turbines and a total capacity of 25 MW or more.[15] Average cost to construct a 25 MW wind farm can range $25 to $35 million.[16,17]

14. American Wind Energy Association. *Global Wind Energy Market Report*, 2001, ‹www.awea.org/faq/global2000.html› (June 2003).
15. Reliable Northwest Project, *Wind Technology*, ‹www.rnp.org/RenewTech/tech_wind.html› (19 March 2003).
16. Renewable Northwest Project, *Vansycle Ridge Wind Farm*, ‹www.rnp.org/Projects/vansycle.html› (16 March 2004).
17. Energy Information Administration, *Renewable Energy Annual*, 1997, ‹www.eia.doe.gov/cneaf/solar.renewables/renewable.energy.annual/backgrnd/chap10h.htm› (16 March 2004).

Case Study, Wind Power

In order to meet growing energy demands, the city of Austin, Texas created the GreenChoice program in 1999 after the city council decided that five percent of their electricity must come from renewable

Case Study (cont.)

sources (Renewable Portfolio Standards). To meet the RPS, the city chose to offer customers wind power as their renewable source. The program gave customers the option of replacing the standard fuel charge on electric bills with the GreenChoice charge (about one cent/kWh higher rate) or to buy the renewable electricity in fixed blocks for a fixed price. The GreenChoice charge is fixed at the sign-on rate for ten years, making the plan ultimately cheaper as fuel prices rise. To date, more than 6,000 residential customers and more than 150 businesses and government agencies have signed up for GreenChoice. In fact, business customers have committed to purchasing a majority (85 percent) of the renewable power available. Austin Energy expanded their production, such that Austin's King Mountain wind farm is becoming one of the nation's largest wind development projects. By increasing its wind power purchases and by using renewable energy sources, Austin Energy will meet 53 percent of its projected load growth between 2000-2003 through savings from its energy-efficiency programs.[18]

To view the entire GreenChoice case study, visit www.greenpowergovs.org/wind/Austin%20case%20study.html.

18. International Council for Local Environmental Initiatives, *Case Study: Austin, Texas; Local Government Renewables Portfolio Standard*, ‹www.greenpowergovs.org/wind/Austin%20case%20study.html› (11 June 2002).

Where you can go for help

- American Wind Energy Association: www.awea.org.
- National Association of State Energy Officials: www.naseo.org/energy_sectors/wind/default.htm.
- U.S. Dept. of Energy, wind page: www.eere.energy. gov/wind.
- National Renewable Energy Lab: www.nrel.gov/wind.

Solar Power

Two types of technologies dominate the solar power industry at this time: solar photovoltaics (PVs), the panels that turn sunlight directly into electricity; and solar thermal, which involves focusing reflected sunlight on boilers that produce steam to turn electric generators.

PVs are the world's second fastest growing source of power, but some of the largest solar generating facilities use solar thermal technology. The use of PVs around the world grew by an annual average of 17 percent a year through the 1990s, although solar generation is still only a minuscule fraction of the world's electrical supply.

SACRAMENTO MUNICIPAL UTILITY DISTRICT

ONE OF THE SACRAMENTO MUNICIPAL UTILITY DISTRICT'S "BORROWED" SOLAR ROOFTOPS.

Advantages

Solar power has incredible potential; it has been estimated that 100 square miles of open space covered with efficient solar panels in a location such as Nevada could generate all the electrical power needs of the United States.[19] It is an emissions-free energy source that can be incorporated easily into existing or planned structures. Depending on the location of the dam and the amount of power it produces, PVs have the potential either by themselves or in combination with other alternatives to alleviate the need for an existing or proposed hydropower dam.

Disadvantages

Like wind, solar power is intermittent – it cannot generate at night and production is cut during overcast days. Because battery technology is still relatively inefficient and expensive, it is not feasible to store large amounts of power.

Costs

In remote homes or industries, relying on solar power can be as little as one-tenth the cost of grid power because it can be fully cost competitive. In grid-connected homes and industries, solar power can be two to five times the cost of grid power.[20] According to BP Solar, the world's biggest manufacturer of solar cells, the cost of making PVs fell from $30 a watt in 1990 to seven dollars a watt a decade later. But the costs of PVs are still high, and will have to fall another 50-75 percent to be fully competitive with fossil fuels for grid-connected power. BP believes that this will take another five to ten years.[21] However, many states such as California offer rebates for home PV systems, which brings the technology within range of standard grid power.[22,23,]

19. Murphy, Pat, "Solar Power: the great untapped energy source." *National renewable Energy Laboratory*,2000, ‹www.enn.com/enn-features-archive/2000/06/06072000/solarpower_12849.asp› (16 June 2003).

20. Solarbuzz.com, *Solarbuzz.com Online*, ‹www.solarbuzz.com/StatsCosts.htm› (21 January 2003).

21. McCully, Patrick. *Silenced Rivers: The Ecology and Politics of Large Dams.* Berkeley: Zed Books, 2001.

22. See California Energy Commission website link to their "Buy Down" program.

23. Windmill Tours, *Windmill Tours Online*, ‹www.windmilltours.com› (26

Case Study, Solar Power

The Dangling Rope Marina on Lake Powell in Utah began the operation of 384 solar panels on August 30, 1997 in an effort to decrease the pollution of the desert air. The electricity that runs the gas pumps for the 250,000 boaters that visit the remote reservoir each year now comes from the sun rather than diesel fuel. According to the EPA, this is the largest solar power generating facility within a national park and the second-largest standalone solar facility in the nation. The project cost $1.5 million and is projected to save $2.3 million over the projected 20-year lifespan of the solar panels. Furthermore, the solar power will reduce 540 tons of carbon dioxide, 27,000 pounds of nitrogen oxides, and 5,183 pounds of carbon monoxide emissions annually.

To learn more about the Dangling Rope Marina visit the EPA at www.epa.gov/globalwarming/greenhouse/greenhouse1/utah.html.

Case Study, Solar Power

The city of Sacramento, California has established a strong solar power program. The Sacramento Municipal Utility District (SMUD) purchases, installs, owns and operates two to four kW residential rooftop PV systems on the "borrowed" rooftops of willing customers. Since the beginning of the PV Pioneer program, more than 550 PV systems have been installed.[24] They operate two 1-MW photovoltaic generating plants, PV1 and PV2, the largest of their kind in the United States. Operating in a 20-acre field near the closed Rancho Seco Nuclear Generating Plant, PV1 and PV2 produce enough energy in the summer to power over 700 homes.[25]

For more information on SMUD programs, visit www.forth.com/Content/Stories/SMUD.htm.

24. SMUD, *Solar PV Pioneer Programs*, 2002, ‹www.smud.org/pv/index.html› (18 June 2003).
25. Sprung, Gary, *Solar Power Generation with Express*, February 2001, ‹www.forth.com/Content/Stories/SMUD.htm› (18 June 2003).

Case Study, Solar Power

In November of 2001, voters in San Francisco, California approved a $100 million revenue bond for renewable energy and energy efficiency. The measure pays for itself entirely from energy savings at no cost to taxpayers. This bond aimed to increase use of solar energy, leading to lower solar energy costs and increased demand. Because solar energy is initially expensive, the bond delegated $50 million for solar projects, while delegating the rest of the money to wind projects and energy efficient technologies. The energy efficiency projects have extremely short payback periods, and wind energy is already commercially viable and affordable. When these projects are bundled together, the costs for solar are effectively lowered, as is San Francisco's emissions of greenhouse gases. San Francisco's success has established a model for funding the nation's transition to solar and renewable energy and away from hydropower and fossil fuels.[26]

For more information on the San Francisco case study, visit "Vote Solar" at www.votesolar.org/index.html.

26. Vote Solar, *Vote Solar*, ‹www.votesolar.org› (18 June 2003).

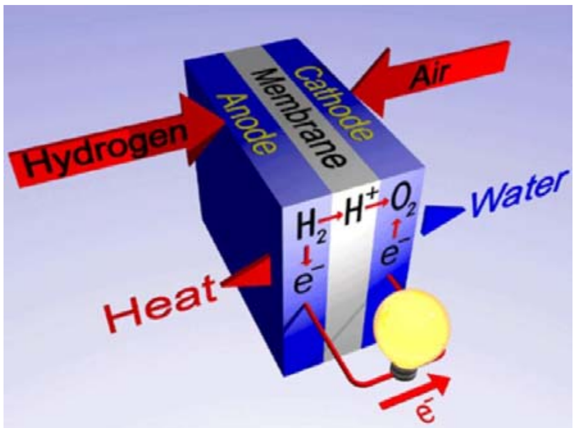
Where you can go for help

- American Solar Energy Society: www.ases.org.
- Solar Energy Industries Association: www.seia.org.

FUEL CELLS AND MICROTURBINES

Fuel cells and microturbine engines are highly efficient, small-scale technologies at the forefront of a movement toward distributed generation, which reduces the dependency on grid power and thus hydropower and fossil fuels. They are completely distinct technologies that are each at different phases of their development; however, they do share similarities in terms of scale and application.

FUEL CELL TODAY



FUEL CELL

With microturbines and fuel cells, individual apartment buildings, hotels, residential care facilities, small factories, supermarkets, and office blocks can generate their own electricity, heat and cooling. "Cogeneration," or combined heat and power, is the most efficient application for microturbines, fuel cells, and other heat-producing electricity generating methods. In a cogeneration system, heat produced in generating electricity that would normally be wasted is used to heat water and/or buildings.

A fuel cell is an electrochemical device that combines hydrogen with oxygen via a chemical reaction. A fuel cell produces electricity, heat, and water (a byproduct) without combustion. Because hydrogen can be produced by electrolysis of water, fuel cells are theoretically an almost totally clean and renewable source of electricity. However, since the electrolysis of hydrogen requires electricity, in the short and medium term most non-vehicle fuel cells utilize natural gas to fuel hydrogen production. When used to generate combined heat and power, or when running on hydrogen produced without the use of fossil fuels, fuel cells can reduce carbon dioxide emissions by 40 to 100 percent compared with conventional power plants or engines. In early 2000 there were nearly 50 MW of fuel cell demonstrations under way or planned in Japan, the United States, and Europe.

The microturbine engine, a downsized version of jet-engine-based gas turbines now common in electrical generation, is a commercially viable technology. A 30 kW microturbine is about the size of a refrigerator and generates enough energy to power a small business. Microturbines are mostly powered by natural gas, but can also be powered with other fuels including biomass, the most abundant fuel source in rural areas of developing countries. Advantages over traditional combustion engines include fewer moving parts, compact size, lighter weight, greater efficiency, lower emissions, lower electricity costs, and opportunities to utilize waste fuels. They have the potential to be located on sites with space limitations. Waste heat recovery used with microturbine engines can achieve efficiencies greater than 80 percent. This compares with efficiencies of 45 percent for the newest coal-burning technology and of around 60 percent for state-of-the-art combined-cycle gas turbines.

Advantages

The primary benefit of fuel cells is that they have the potential to be virtually pollution-free. With cogeneration, microturbines can offer efficiencies over 80 percent compared to many older hydropower dams, which may operate at only 60 percent efficiency. Once these technologies become commercially available and are able to saturate the market, they will have the potential to lessen the need for a hydropower dam, particularly when used in combination with other alternatives.

Disadvantages

At this point, fuel cells are still experimental (though microturbines are commercially available), and are likely to remain costly for a number of years after they appear on the market. Fuel cells and microturbines are currently dependent primarily on natural gas, which produces greenhouse gas emissions. While fuel cells have the potential to be emissions free, the combustion engine of a microturbine, though more efficient than conventional energy production methods, will always require a non-renewable fuel source. In addition to these disadvantages, the difficulties in translating these alternatives to large-scale projects inhibit their ability to truly replace a hydropower facility.

Costs

Today, the most widely marketed fuel cells cost about $4,500 per kilowatt; by contrast, a diesel generator costs $800 to $1,500 per kilowatt and a natural gas turbine can be even less. High capital cost is also a deterrent to wide scale adoption of cogeneration. While it is possible to purchase and install a 60kW microturbine for less than $100,000, integrating a microturbine into a large facility can double or even triple the cost of the installation and raise the project complexity by an order of magnitude.

Case Study, Fuel Cells and Microturbines

In the mid-1990s, the U.S. Department of Defense (DoD) launched a Fuel Cell Demonstration Program that involved the installation and operation of 200 kW phosphoric acid fuel cell power plants at 30 government locations across the United States. The goal of this program was to determine how fuel cells could fit into the DoD's future energy strategy and to stimulate the fuel cell industry. By January 1, 2000, the demonstration showed the fuel cell power plants generated 91,720 MWh of electricity, and decreased electrical and thermal costs by $3.6 million. The power plant installed at Edwards Air Force Base in California created a net savings of $96,000, which included $122,000 in electrical savings, $3,000 in thermal savings, and $29,000 in natural gas costs.[27]

To learn more about the Fuel Cell Demonstration Program case study visit www.dodfuelcell.com/IQPCpaper.pdf or the DoD Fuel Cell Demonstration website at www.dodfuelcell.com.

27. Binder, M.J., F.H. Holcomb, and W.R. Taylor, *Cogeneration Case Studies of the DoD Fuel Cell Demonstration Program*, ‹www.dodfuelcell.com/IQPCpaper.pdf› (11 June 2002).

Where you can go for help

- Fuel Cells 2000: www.fuelcells.org.
- Scientific America article "Beyond Batteries" December 23, 1996: www.sciam.com/article.cfm?articleID=000103AE-74A1-1C76-9B81809EC588EF21&pageNumber=2&catID=4 .
- Technical magazines include: Energy Policy, Power Engineering and Renewable Energy World.