White Paper

Sustainability Plus: How Renewable Energy Helps Conserve, Move and Heat Water while Curtailing Emissions and Saving Money

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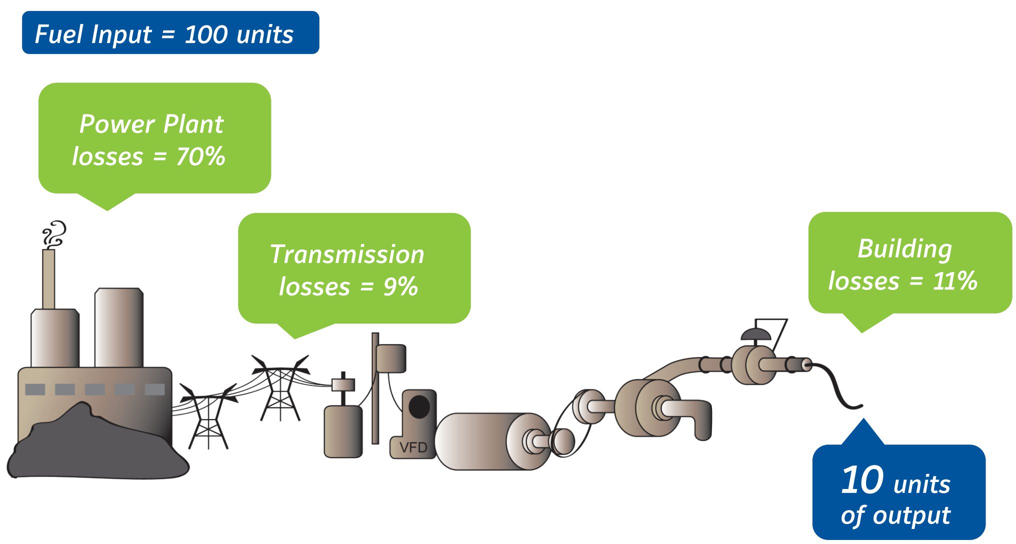
Sustainability Plus: How Renewable Energy Helps Conserve, Move and Heat Water while Saving Money and Curtailing Emissions

There is much more to renewable energy than saving fossil fuels and improving carbon emissions. Because water and energy are closely connected, technologies like wind and solar power, digester-gas-to-energy, and geothermal heating and cooling also help make optimal use of increasingly stressed water resources.

Just 10 percent of an iceberg appears above the water. Similarly, the electricity used in a building may represent just one-tenth of the energy actually released back at the utility power plant.

Why? From the time the power plant burns a pound of coal, to the time equipment in a building uses the electricity and pumps water to heat the space, nine-tenths of the coal's energy may be lost to normal inefficiencies – in the power plant, in utility transmission and distribution lines, and within the building itself. And in reverse, one unit of energy saved in a building means ten units do not need to be produced at the power plant.



That scenario is reason enough to consider deploying emission-free on-site renewable energy to displace fossil-fueled generation. And it doesn't even account for the effect of withdrawing vast amounts of water from a lake, river or well to cool the power plant turbines and supply makeup water to the boilers. Electricity production requires more than 40 percent of all daily freshwater withdrawals in the nation, according to the U.S. Department of Energy.

On the other hand, it takes substantial energy to manage water. The transportation, distribution and purification of water in the United States consumes about four percent of all electricity.[1] And an estimated 18 percent of water used in homes and businesses is heated, requiring still more energy.[2]

This close connection between energy and water – called the energy-water nexus – argues strongly for renewable energy. Technologies like wind, solar and geothermal help reduce demand on increasingly stressed water resources while also conserving fuels.

At the same time, renewables can replace some of the fossil-fuel energy needed to pump, treat and heat water. And water itself – in the form of wastewater – can become an energy source when the digester methane by-product from wastewater treatment is put to work.

Abundant possibilities

The effects of on-site renewable energy on water supplies are hard to overstate. The operation of wind turbines and solar panels produces no greenhouse gases and only requires water for periodic cleaning of wind turbine blades and washing of solar collector panels.

Coal accounts for 52 percent of U.S. electricity generation, and each kilowatt-hour generated requires withdrawal of 25 gallons of water. That means people may use as much water powering their homes as they use taking showers and watering their lawns.[3]

As for air emissions, the U.S. Department of Energy estimates that for every kilowatt-hour of green power produced, one less pound of the greenhouse gas carbon dioxide is released to the atmosphere.[4]

Opportunities to use renewables abound in facilities of almost all sizes and across the spectrum of businesses and industries. The most promising on-site renewable energy strategies that should be evaluated for a facility include:

- Using solar thermal systems to heat water for a wide variety of uses such as boiler preheating, swimming pools and domestic water uses.
- Using wind or solar photovoltaic power to generate electricity.
- Using geothermal energy to heat or cool a building and conserve water.

Strategies specific to water and wastewater utilities include:

- Using digester methane to generate electricity and heat.
- Using wind or solar power to generate the electricity needed at water and wastewater facilities.

Furthermore, simple conservation measures can significantly reduce water consumption and the energy usage that follows. For example, by installing water efficient faucets and toilets, a building saves water and requires less heated water so energy is saved.

Renewable technologies are more financially attractive than ever, as higher-volume production drives down the cost of equipment, government incentives reduce up-front capital costs, and tools like performance contracting and tax lien financing improve cash flow on projects and enable guarantees of energy cost savings.

Toward the sun

Solar energy continues to grow rapidly. The most recent survey from Solar Energy Industries of America (SEIA) shows that grid-connected photovoltaic (PV) capacity increased 58 percent in 2008, while solar water heating capacity increased 40 percent. Total capacity grew by 1,265 MW, up from 1,159 MW in new installations in 2007. That boosted total installed capacity by 16 percent to 9,183 MW.[5]

At the same time, solar energy is becoming more cost-competitive. Costs declined by about 30 percent during 2009 from price pressures related to the economic recession, increased global manufacturing capacity, and excess volume caused by changes in some international incentive programs.[6]

Converting methane to energy is especially beneficial because it destroys a greenhouse gas that is 25 times more potent than carbon dioxide.

Solar thermal remains the most cost-effective and possibly the most versatile solar technology.

PV systems tend to get the most attention, as they enable owners to supplement utility power for their facilities or export power to the grid. However, solar thermal remains the most cost-effective and possibly the most versatile solar technology.

Solar thermal systems have applications for water heating in a variety of settings. Water heating accounts for an average of 11.5 percent of the energy used in a typical commercial building.[7] Heavy hot water load applications include commercial laundries, hotels, hospitals, universities, schools, and water-intensive industries like food processing.

Several states generously incentivize solar thermal systems. For example, in early 2010, California regulators approved a $350 million program to subsidize installation of solar water heating systems, reserving up to 80 percent of that for multi-family and commercial buildings. The program allocates $180 million in utility-provided incentives to replace gas water heaters and the rest to replace electric heaters. The goal is to replace slightly more than 556,000 therms of natural gas and 150 megawatts of electric capacity over the program's eight-year life.[8]

A key to growth in solar thermal energy is to integrate the technology with building HVAC systems so that it can also be used for purposes like reheating chilled water during summer and preheating fresh air entering buildings during winter.

Solar thermal systems are also being used for solar cooling, in which hot water is used to power absorption chillers. At the Fort Bliss (TX) Army base, a solar thermal installation will supply a single-effect absorption chiller, operating in tandem with an electric chiller that will run when the sun is not shining. The base also has six solar water heating systems and a solar-heated swimming pool.

On the PV side, installations are steadily expanding in size. The 29 Palms Marine Base in California hosts one of the world's largest non-utility solar power plants, spanning eight acres with more than 1 MW of capacity. It provides supplemental power during peak-load periods and fulfills about seven percent of the base's annual electricity needs.

Many water utilities in California, New York, New Jersey and other states are installing PV systems at their wastewater treatment facilities, using land typically reserved for stormwater and overflow.

Tapping the earth

An excellent but less recognized source of renewable energy is the Earth itself. At depths of about six feet or more, soil and groundwater temperatures are stable between 45 and 58 degrees F. Ground-source heat pumps use the earth as a heat source in winter and as a heat sink in summer.

A geothermal heat pump system captures heat from soil or groundwater more easily than a conventional heat pump can from frigid air outside. Conversely, in summer, the relatively cool soil or groundwater absorbs waste heat more readily than warm outdoor air.

The U.S. EPA has identified geothermal energy as the most energy-efficient and cost-effective space conditioning available. Geothermal heat pumps can reduce energy costs by 25 to 40 percent over conventional systems. They eliminate cooling towers and so save thousands of gallons of water those towers would lose to evaporation.

A geothermal heat pump is part of a net-zero-energy building that houses Integrated Design Associates Inc., an electrical and lighting design consultancy in San Jose, CA. Water flows through pipes laid under an open landscape area and passes into the building, where a heat exchanger collects heat from the water in winter and uses the cooling effect of the water in summer.

A radiant floor system with cross-linked counter-flow tubing uses the water to convey heating and cooling to the space.

Waste-to-energy

Wastewater treatment plants can fulfill a large share of their energy requirements by using methane from anaerobic digestion, the process that breaks down and stabilizes sludge (called biosolids).

There are about 16,000 wastewater treatment plants in the United States, and more than 3,500 use anaerobic digestion, yet only two percent use digester gas to produce electricity. Digester gas usually contains more than 60 percent methane and can contain as much as 95 percent. When properly collected and purified, this gas provides high-quality fuel.

Converting methane to energy is especially beneficial because it destroys a greenhouse gas that is 25 times more potent than carbon dioxide. Treatment plants can burn the methane in boilers to provide heat for the digestion process, building spaces, and domestic water.

To maximize the potential of biogas, plants install combined heat and power systems, using methane to fuel reciprocating engine-generators that produce electricity, and capturing heat from engine coolant and exhaust for plant heat loads.

At the Back River Wastewater Treatment plant in Baltimore, MD, digester methane fuels three 12-cylinder gas engines with a combined 3 MW capacity, producing more than 2.4 MWh of electricity per year, along with steam for process heating. The project reduces the plant's energy bill by $1.4 million per year, while eliminating emissions of 12.9 pounds of carbon dioxide.

Forward-looking treatment plants have investigated innovative methane-to-energy systems. With help from a U.S. EPA grant, King County, WA, conducted a two-year demonstration project on a fuel cell generating system at its South Treatment Plant. The project tested fuel cell technology and its promise of high energy conversion efficiency with lower air emissions.[9]

The Sanitation Districts of Los Angeles County installed a digester-gas-fueled 250 kW microturbine at its Lancaster Water Reclamation Plant.[10] While microturbines require extensive fuel treatment, they offer high efficiency and simplicity of operation and can be modularized for easy system expansion as gas volume increases.

Back River Wastewater Treatment Plant in Baltimore, MD

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Capturing wind

Wind power, first used years ago in simple mechanical water pumping systems on farms, is fast gaining momentum for large- and small-scale electricity generation.

The U.S. wind energy industry broke records in 2008 by installing 8,358 MW of new capacity, enough to serve more than two million homes. That increased the nation's wind power capacity by 50 percent. The projects completed in 2008 avoided nearly 44 million tons of carbon emissions, the equivalent of taking more than seven million cars off the road for a year.[11]

While utility-scale wind farms account for the bulk of new wind power installations, smaller installations consisting of one or two turbines located near the load they are powering continue to show promise. Wind turbines create power for such energy-intensive applications as municipal water and wastewater treatment.

Wind power also can be used to charge batteries for buildings not connected to the utility grid, or to supply some or all of the electricity for businesses, schools, colleges, prisons, or military bases. In general, the technology provides the best return on investment in areas with high utility electricity prices and a strong, consistent wind resource.

On average, applying water-efficient designs and products leads to about 15 percent less water use, 10 percent less energy use, and 12 percent lower operating costs.[12]

Education is key

The cleanest energy source of all is "negawatts" – energy saved through conservation. That includes savings achieved by retrofitting water- and energy-efficient equipment, and by changing behavior patterns. Here again, the connection between water and energy is clear.

On average, applying water-efficient designs and products leads to about 15 percent less water use, 10 percent less energy use, and 12 percent lower operating costs.[12]

Meanwhile, an American household can waste, on average, 11,000 gallons of water every year from running toilets, dripping faucets, and other leaks.[13] If all United States households installed water-efficient appliances, the country would save more than 3 trillion gallons of water and more than $18 billion per year.[14]

Similar or greater efficiency gains are possible in business settings, from commercial and industrial facilities to hospitals, schools, universities, public housing facilities, government office buildings, correctional facilities, and military bases.

Organizations can also contribute to water and energy savings by encouraging people to conserve water at work and at home.

Conservatively, if a city encouraged one million people to turn off the water while brushing their teeth twice a day, the city's utility would eliminate the treatment, pumping and distribution of 800 million gallons of water per year, enough to meet the needs of two million families of four. That would also mean an average savings of $88,000 in electricity and a reduction in greenhouse gas emissions equivalent to burning 1,250 barrels of oil.

Financing renewables

Naturally, renewable energy systems and most efficiency measures require investments. Governments at many levels offer a variety of incentives to lessen the up-front and life-cycle costs.

A convenient source of information on these programs is the Database of State Incentives for Renewables and Energy Efficiency (http://www.dsireusa.org). This database is a comprehensive source of information on federal, state, local and utility incentives and policies that promote renewable energy and energy efficiency. Established in 1995 and funded by the U.S. Department of Energy, DSIRE is an ongoing project of the North Carolina Solar Center and the Interstate Renewable Energy Council.

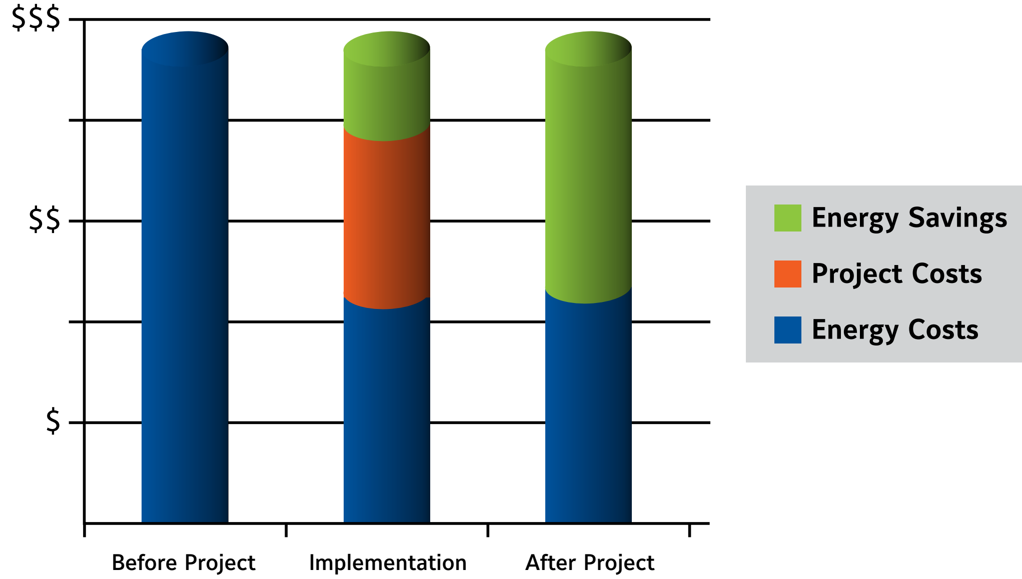
Incentives include Renewable Energy Credits (RECs), also known as Green Tags, or Tradable Renewable Certificates. Each REC typically represents proof that one MWh of electricity was generated from a renewable source. RECs can be sold and traded, and owners can claim to have purchased renewable energy. As the program develops, carbon credits may also provide opportunities for financing of solar thermal systems.

In states with Renewable Portfolio Standards that require a certain percentage of electrical energy to be generated from renewable sources, utilities can buy RECs as one way of increasing their renewable holdings. As of early 2010, 29 states plus Washington, D.C. had Renewable Portfolio Standards.

In addition, innovative financing tools can make investments in renewables more attractive. Alternatives include tax lien financing and performance contracting.

Tax lien financing – also called Property-Assessed Clean Energy (PACE) Bonds – is a newer mechanism with potential to accelerate renewable energy development in the private sector. Here, owners borrow from a municipal financing district created exclusively for small renewable energy projects and energy-efficiency retrofits, repaying the money over a 20-year term through a special assessment on the property tax bill. As of early 2010, 16 states had passed legislation to enable tax lien financing.[15]

In performance contracting, an organization engages an energy service company (ESCO) to install the renewable technologies, often along with other energy-efficiency enhancements. The ESCO guarantees the customer a specified amount of savings over a contract period, such as 10 to 15 years, and those savings are used to pay off the project cost, usually funded by a third party lender.



Performance Contracting Funding Model

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Closing the circle

The benefits of renewable energy go well beyond conserving fossil fuels. Wind, solar and geothermal energy also help conserve precious water. Digester-gas-to-energy uses a waste by-product as an innovative fuel while reducing harmful greenhouse gases.

Sandia National Laboratories observes, "Electricity and water are at the heart of the U.S. economy and way of life. National defense, food production, human health, manufacturing, recreation, tourism, and the daily functioning of households all rely on a clean and affordable supply of one or both of them.

"Understanding the complex relationship between water and electricity and developing technologies to keep that relationship healthy is an important key to a sustainable and secure future for the United States."[16]

That healthy relationship most certainly includes all forms of renewable energy technology.

Resources

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