Cutting Edge Energy Technology

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Contents

Innovations in Energy Technology

1831
British scientist Michael Faraday discovers the principle of electromagnetic induction using magnets and a loop of copper wire.

2001
In Taos, New Mexico, architect Michael E. Reynolds builds his first energy-efficient Earthship homes from recycled materials.

1999
The term *Internet of Things* is coined by British tech pioneer Kevin Ashton.

1954
Bell Laboratories creates the first photovoltaic solar cell to convert sunlight into electricity.

1800 1900 ••• 1990 2000

1928
The theory of antimatter is put forth by English physicist Paul Dirac.

1991
The first commercially available lithium-ion battery is marketed by Sony.

1998
The Canadian government legalizes the commercial growth of industrial hemp, a source of fiber used in bioenergy production.

New Ideas for Old Problems

The United States had about 123 million households in 2015. Of that number, a tiny fraction—around 250,000—was estimated to be off the grid. These homes did not get their electricity from the nationwide system of interconnected power plants, transformers, and high-voltage lines known as the power grid. Those living off the grid use solar panels, windmills, and other methods to light, cool, and heat their homes.

If businessman Elon Musk has his way, the number of people living off the grid will continue to grow every year. Musk is an inventor and engineer and the founder of several companies, including the electric car company Tesla Motors and the solar energy firm SolarCity. In 2015 Tesla began manufacturing a rechargeable solar storage battery (SSB) called the Powerwall. The Powerwall is designed to accept a charge from solar panels during the day to provide all the power a homeowner needs at night.

Musk has brought a lot of media attention to SSBs. However, they are just one of dozens of cutting edge technologies under development that are focused on making better use of resources and energy. Some, such as producing power from rotting food and animal waste, are older technologies that are being updated for the twenty-first century. Other concepts, like obtaining energy from antimatter, remain the stuff of science fiction. But every idea is on the table when it comes to next-generation energy technology. And there is little doubt that future generations will receive their power in ways barely imagined by scientists, researchers, and inventors working today.

Slowing Climate Change

Many alternative energy researchers are driven by environmental concerns. They are searching for ways to reduce demand for coal and natural gas—the fossil fuels commonly used to generate

Solar panels like the ones on the roof of the house shown here generate electricity using energy from the sun. A relatively recent invention known as a solar storage battery collects energy from the panels during the day and powers the house at night.

electricity. The combustion of fossil fuels produces carbon dioxide (CO_2) emissions. Rising levels of CO_2 and other heat-trapping gases in the atmosphere have warmed the earth, leading to a phenomenon known as climate change. The wide-ranging impacts of climate change, scientists say, include rising sea levels; melting snow and ice; more extreme heat events, fires, and drought; and more extreme storms, rainfall, and floods.

Microsoft founder Bill Gates is one of many people around the globe who believe that humanity must develop alternate forms of energy to slow climate change. Gates wants to see more money acid, such as sulfuric acid, to strip the graphene from graphite. However, researchers have discovered that graphene can be replaced with nonpolluting hemp fibers to make organic supercap nanosheets.

Hemp is a variety of the cannabis plant, which is biologically related to marijuana. Hemp has very low levels of THC, the psychoactive ingredient in marijuana. Whereas marijuana has 5 to 25 percent THC content, hemp only has about .3 percent. Although people cannot use hemp to get high, federal law in the United States prohibits farmers from growing hemp. In China, Canada, and the United Kingdom, hemp can be grown industrially for clothing and building materials. In the United States, hemp products, including rope, paper, cloth, oil, and food seeds, are legal to possess.

nanosheet

An extremely thin molecular structure that contains only a single layer of atoms.

David Mitlin, a professor at Clarkson University in New York, discovered that hemp nanosheets perform as well as graphene but are a thousand times cheaper to produce. Hemp nanosheet production does not require polluting acid, and hemp can be grown without herbicides and chemical fertilizers. Additionally, the nanosheets are made from the inner fibers of hemp, called bast, which is considered a waste product and is usually dumped in landfills. Mitlin's team took bast and recycled it into supercapacitors. According to Mitlin, "Fifty miles down the road from my house in Alberta [Canada] there was an agricultural hemp processing facility. And all that bast fiber—they don't know what to do with it. It's a waste product looking for a value-added application. People are almost paying you to take it away."[9] Mitlin plans to start a company to produce supercap nanosheets with the hemp waste.

Sugar-Filled Bio-Batteries

Nonpolluting organic substances are also being used to create electrolyte in biological batteries, or bio-batteries. These batteries produce electricity by mimicking the ways plants and animals

Cigarette-Butt Batteries

Cigarette butts are the most common form of litter—an estimated 1.7 billion pounds (771 million kg) of butts wind up as toxic litter every year. But in 2014 researchers at Seoul National University in South Korea discovered a way to convert used cigarette filters into supercapacitors that charge quicker and last longer than li-ion batteries. Cigarette filters are the part of the cigarette that people hold between their lips. They are made from a nonbiodegradable material called cellulose acetate. Researchers found they could convert cellulose acetate into carbon by heating it at 1,652°F (900°C) for two hours.

Carbon conducts electricity well, which makes it the most popular material for making supercapacitors. According to Korean scientists, the butt-based material was able to charge faster and hold a charge longer than other substances used in supercapacitors, including graphene. And whereas graphene is expensive to produce, used cigarette butts are free.

create energy. The key to producing bio-batteries is finding a way to utilize glucose. This common sugar fuels all living things, including plants, people, and animals. All parts of the human body, including the muscles, brain, heart, and other organs, need energy to function. The energy comes from food that is broken down into glucose by molecules in the stomach called enzymes. During the digestion process, the enzymes create energy to power the body. A bio-battery imitates the digestion process, using enzymes to produce electricity.

Research into bio-batteries is being conducted by biology professor Y.H. Percival Zhang at Virginia Tech. The bio-battery works with maltodextrin, a glucose substance derived from corn or wheat; it is commonly used in soda, candy, and processed foods. The battery passes maltodextrin through a pathway lined with enzymes that strip the sugar of its energy while generating electricity.

The sugar battery has about ten times the energy density of a li-ion battery, which means it can go much longer between doing is taking every aspect of your life and putting it into your own hands. A family of four could totally survive here without having to go to the store.[25]

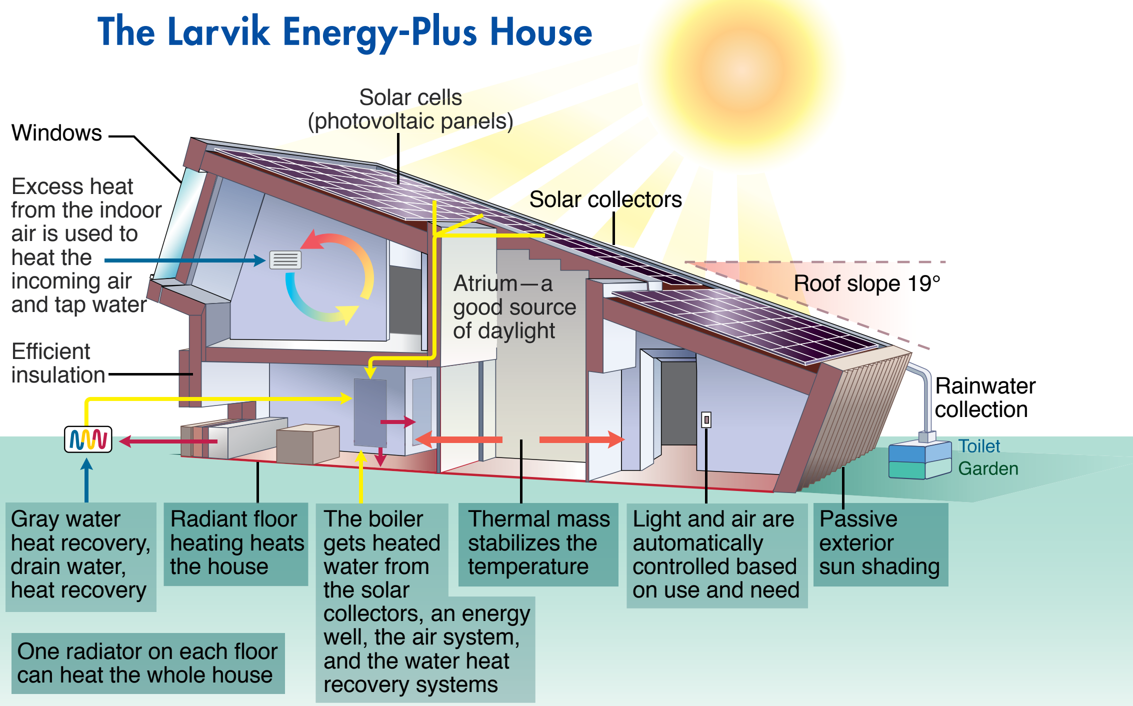
Since 2007 Reynolds has been exporting the Earthship designs to communities in countries throughout the world. The houses work in most any climate; currently they are found in Africa, Asia, Australia, New Zealand, Europe, the United States, and Central and South America.

Energy-Plus Houses

Self-sufficient housing is one of a variety of ideas being pursued by green builders. Another is known as an energy-plus house. This is a house that produces more power than it needs. The surplus electricity is often enough to charge an electric car in the garage while also feeding power into the electric grid. One of the most advanced energy-plus experimental homes is located in Larvik, Norway. It was built by Norway's Research Centre on Zero Emission Buildings.

The Larvik energy-plus home is both beautiful and spacious—at 2,152 square feet (200 sq m) in size. The house is also a miniature power plant that produces twice as much energy as it consumes. Moreover, the energy-plus home is a portrait in simplicity. Whereas some high-tech energy-plus homes rely on computer sensors and fans to regulate the temperature, the Larvik home was built to take advantage of natural changes in wind and sunlight. For example, the roof is oddly tilted at a nineteen-degree angle. This design allows the rooftop solar panels to harvest the maximum amount of sunlight throughout the year. And the angled roof provides a natural updraft, which allows warm air to flow out of the building during Norway's long summer days. The Larvik home uses naturally generated heat in extremely efficient ways. The house is heated in the winter with energy from geothermal wells, or hot springs, which are located nearby. Excess indoor heat is channeled into the water heater, which provides hot tap water and also heats an outdoor swimming pool.

The Larvik Energy-Plus House



Source: E-Architect, "2EB Pilot House in Larvik," September 21, 2015. www.neat-living.com.

The energy-plus house was built using sustainable construction techniques. This means the project is 100 percent carbon neutral; no excess CO_2 was generated during its construction. The home's renewable energy generation helped offset the fossil fuels used to construct the building and to manufacture its solar panels, recycled steel frame, and appliances.

The lessons learned from building the Larvik pilot house are being put to use elsewhere in Norway. In 2015 a new development of eight hundred energy-plus homes was completed in Bergen. The homes are creating one problem, however: they produce so much power that the local utility company must devise an efficient way to feed the excess electricity into the grid.

Concrete from Hemp

Builders who wish to follow carbon-neutral construction principles are searching for alternatives to one of the most common

Source Notes

Introduction: New Ideas for Old Problems

1. Quoted in Christopher Adams and John Thornhill, "Gates to Double Investment in Renewable Energy Projects," *Financial Times*, June 25, 2015. www.ft.com.
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4. Adam Boesel, Green Microgym, 2015. www.thegreenmicrogymbelmont.com.
5. Quoted in Rebecca Burns-Callander, "This Is the Next Generation of Renewable Energy Technologies," *Telegraph,* December 13, 2014. www.telegraph.co.uk.
6. Quoted in Australian Broadcasting Corporation News, "WA Wave Energy Project Turned On to Power Naval Base at Garden Island," February 17, 2015. www.abc.net.au.

Chapter Two: Battery Breakthroughs

7. Quoted in ScienceDaily, "New Design Points a Path to the 'Ultimate' Battery," October 29, 2015. www.sciencedaily.com.
8. Quoted in ScienceDaily, "Ultra-Fast Charging Batteries That Can Be 70% Recharged in Just Two Minutes," October 13, 2014. www.sciencedaily.com.
9. Quoted in James Morgan, "Hemp Fibres 'Better than Graphene,'" BBC News, August 13, 2014. www.bbc.com.
10. Quoted in John Lieberman, "Batteries That Run on Sugar Could Be in Gadgets in Just 3 Years," International Science Times, January 21, 2014. www.isciencetimes.com.

For Further Research

Books

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Sylvia Engdahl, ed., *Energy Alternatives.* Farmington Hills, MI: Greenhaven, 2015.

Robert Green, *How Renewable Energy Is Changing Society.* San Diego: ReferencePoint, 2015.

Elizabeth Rusch, *The Next Wave: The Quest to Harness the Power of the Oceans.* New York: HMH, 2014.

Bryan Stone and Carmella Van Vleet, *Explore Electricity! With 25 Great Projects*. White River Junction, VT: Nomad, 2014.

Websites

Earthship (http://earthship.com). Earthships are extremely sustainable buildings made from old tires, earth, and other recycled materials. The company's website features photos of many homes and information about Earthships constructed all over the world, from New Mexico to New Zealand.

ExtremeTech (www.extremetech.com). This site covers the latest developments in technology in fields including computing, medical tech, gaming, space, and energy. The writers explain new developments in science in plain language and provide links to articles that cover similar topics.

Future Technology (www.alternative-energy-news.info/technology/future-energy). This website covers the latest developments in the alternative energy field, from hydrogen-powered trams to solar collectors that work at night. Articles cover next-generation concepts under development and those already in place around the world.

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Note: Boldface page numbers indicate illustrations.