



35 Years of Innovation: The National Renewable Energy Laboratory Leads the Way to a Clean Energy Future

For 35 years, the National Renewable Energy Laboratory, the U.S. Department of Energy's premier national laboratory for renewable energy and energy efficiency research and development, has delivered knowledge and innovations that have enabled the emergence of a U.S. clean energy industry. From its start in 1977 to today, NREL has pushed the boundaries of what's possible. NREL...

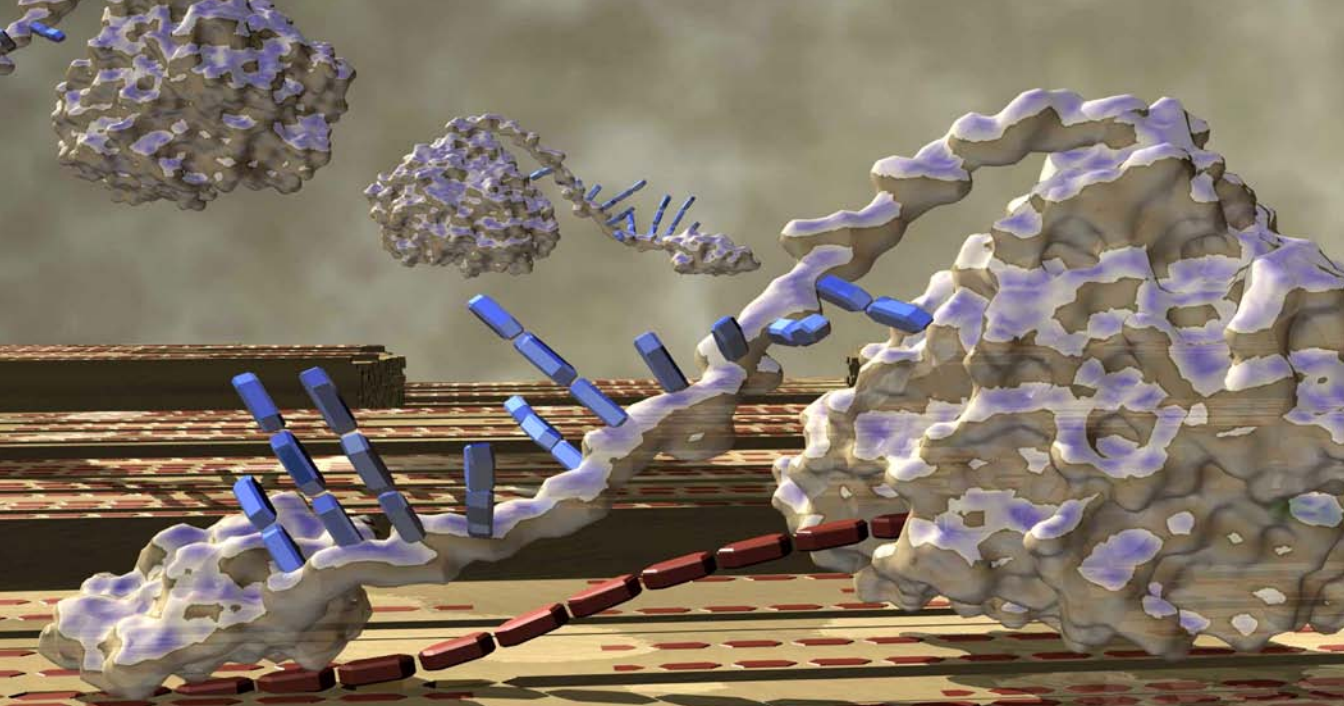
**NREL is a national laboratory of the U.S. Department of Energy,
Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.**



Builds batteries backwards for high performance

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NREL researchers build batteries in reverse order, burying the fragile lithium metal anodes that typically rest on the top of the battery, where cracks can develop and lead to rapid failure. The “buried anode” technology triples the performance of today’s lithium-ion batteries at half the cost and should lower the overall price tag of plug-in vehicles.



Analyzes biomass at high speed

A high-speed pipeline at NREL analyzes 1,000 samples of biomass at a time to find which ones, when combined with the right enzyme, most eagerly give up their sugars to be converted into biofuel. NREL's high-throughput pipeline screens both the feedstock and the enzymes that digest them to find the best combinations.



Tests behemoth wind turbines

The largest wind turbine manufacturers in the world conduct lifetime endurance tests at NREL to gauge 30 years' worth of wear to drive trains and gearboxes — all in a matter of months. NREL's powerful dynamometer runs at torque levels up to 9.6 million inch-pounds to simulate the effects of various wind conditions on the giant turbines, each of which can power hundreds of homes. Validation of their reliability can lead to less expensive energy.



Brings wind power to cold, remote areas

NREL's North Wind 100/20 Wind Turbine brings energy to 50 homes at a time in towns and villages in remote areas that must otherwise import diesel fuel—when it's available. The 100/20 Turbine is cheaper and lasts longer than diesel generators, and it doesn't require a gearbox or heated oil, making it ideal for extreme cold conditions and remote locations.

Creates hydrogen out of wind

NREL, in collaboration with Xcel Energy, demonstrates an efficient way to make hydrogen out of wind. The Wind 2H2 project passes the electricity generated by wind turbines through water to split it into hydrogen and oxygen. The hydrogen can then be stored and used during peak demand hours to generate electricity.

Provides architects with a tool to assess energy efficiency

Architects quickly sketch computerized 3-D drawings of buildings and their energy-efficient features using NREL's OpenStudio software. OpenStudio allows architects to take a virtual X-ray of a building's energy use, making it easier to design a building with fewer carbon emissions — which means lower utility bills and a healthier environment.



Shows the Army how to go green

NREL's scorecard for the Net Zero Installation Energy program is pushing military bases to achieve net zero status. Fifty-three Army installations are shooting for Net Zero Energy, Net Zero Water, or Net Zero Waste. They reach these goals by installing solar panels or wind turbines, maximizing efficiency, and turning trash into energy.



Sends its solar cells to Mars

NREL-designed highly efficient, multi-junction solar cells fly aboard Earth-orbiting satellites and Mars rover. NREL's inverted metamorphic multi-junction solar cell is a natural candidate for powering spacecraft and onboard instruments in the post-shuttle era because it is lightweight and flexible and needs no bulky mechanical controls.

Boosts the generation capacity of geothermal plants

The Geysers, the world's largest geothermal plant, now generates 17 percent more energy thanks to an ingenious geometric framework designed at NREL. The extra surface area on NREL's Advanced Direct-Contact Condenser means better interaction between cooling liquid and steam, and thus greater geothermal generation.



Teams with builders to design super-efficient homes and schools

NREL helps cities and school districts go deep green. Sacramento home builders use NREL's design for a solar-powered home that has an 88 percent smaller than average carbon footprint. And New Orleans is building 40 new schools and renovating 38 others based on NREL blueprints that promise 30 percent better efficiency.



Invents a design for radically cleaner, cheaper air conditioning

Future summers could be much more comfortable — and easier on the wallet — thanks to NREL's Desiccant Enhanced Evaporative air conditioner (DEVap). DEVap uses up to 80 percent less total energy than traditional air conditioners. It works by removing moisture from the air using desiccants and heat and then combining that with advanced evaporative technologies.

Animates the way plants decay

NREL's three-dimensional animation of Cel7A, nature's primary enzyme for decaying plants, is making it easier for scientists to figure out how to re-engineer it to produce sugars — and thereby make alternate fuels — even faster. The goal is to double its output to two units of sugar per second.

Drives down the cost and boosts the performance of hybrid and electric vehicles

NREL's jet impingement cooling technology reduces thermal resistance to help lower the costs of hybrid and electric vehicles. Here's how it works: a heat exchanger directs liquid cooling to the underside of a vehicle's electronic power devices. The direct cooling and the copper-ceramic surfaces allow for much smaller power modules and thus lighter, less expensive, and more energy-efficient cars.



Designs better blades for wind turbines

NREL helps herald the era of huge, multi-megawatt wind turbines by inventing a series of specialized airfoils designed to withstand strong winds and dirt while operating at maximum efficiency at varying pitch and speeds. The improvements are key to increasing the nation's use of wind energy.



Makes the case for renewable energy on islands

NREL works with island nations to craft policies and infrastructure for a future fueled by the sun, wind, waves, seaweed, and lava. For example, NREL's Energy Development in Island Nations project is working on a plan to connect several Caribbean islands with geothermal energy via underground cable.

Creates a glassless mirror to concentrate the sun

NREL, with partner SkyFuel, invents a glassless mirror made of super-thin layers of silver and other reflective materials. The product is lightweight, weatherproof, and much cheaper to produce than other mirrors used to concentrate the power of the sun for utility-scale electricity production.

Develops a low-cost way to convert raw biomass into ethanol

Teaming with DuPont, NREL is using a hungry bacterium to produce 250,000 gallons of ethanol a year at a large plant in Tennessee. The unique, low-cost pretreatment process converts raw biomass — corn stover, agriculture waste, and non-food crops — to ethanol at high yields. *Zymomonas mobilis* should hasten the conversion of feedstock to fuel at industrial scale and help lower the nation's dependence on foreign oil.



Walks the talk with its own LEED

The Science and Technology Facility at NREL is the first federal lab to achieve LEED Platinum status. A showcase for energy efficiency, the facility provides a 41 percent reduction in energy cost compared to a standard laboratory building.

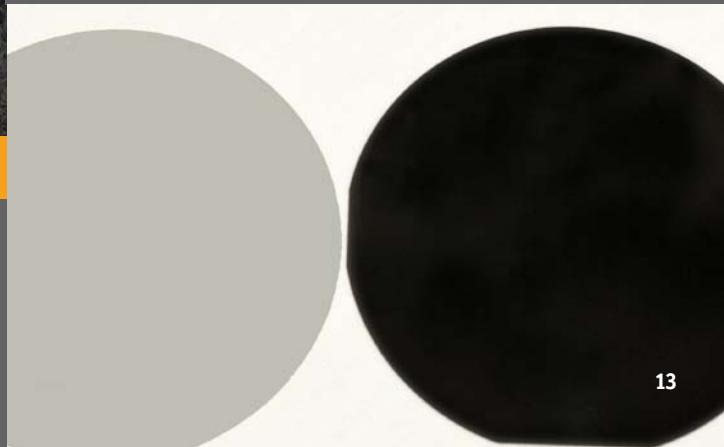


Platinum laboratory

And with energy-saving architectural features such as daylighting, evaporative cooling, and efficient motors, fans, windows, and lighting, it has become the standard for future federal lab buildings.

Turns silicon black for superior light absorbance

Tiny flecks of gold suspended in a solution etch a trillion holes into a CD-sized silicon wafer, turning it black and ensuring that almost none of the sun's light reflects back as wasted energy. NREL's Black Silicon Nanocatalytic Wet-Chemical Etch is a low-cost process that can etch the sub-micron-sized holes in a few minutes at room temperature. Less reflection means lower-cost solar modules for rooftops and utilities.



Builds an exemplary energy-efficient office building

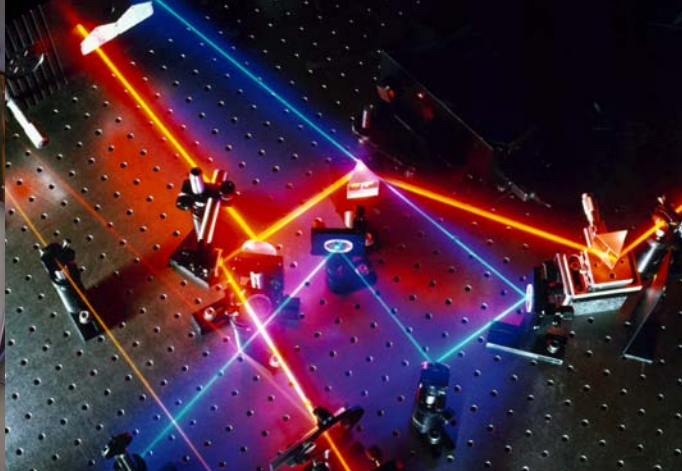
NREL's ultra-high-efficiency Research Support Facility (RSF) is a model for new office building construction and a living laboratory for a sustainable energy future. Employing energy-saving technologies such as daylighting, rooftop photovoltaics, and a mega-efficient data center, the RSF uses 50 percent less energy than required by current commercial code and consumes only the amount of energy generated by renewable power on and near the building.





Creates a manikin to test and improve air conditioning in cars

NREL researchers design a life-sized manikin called ADAM (Advanced Automotive Manikin) that sweats and shivers, reacting like a human would to the sweltering or freezing temperatures inside a car. Auto manufacturers turn to ADAM to try to lower air-conditioning fuel use, which accounts for about 7 billion gallons of U.S. fuel use each year.



Makes a vivid green light from a bright idea

NREL researchers reverse the process of making advanced solar cells to create a brilliant green light-emitting diode (LED). Generating a true green with an LED had been a missing ingredient in producing LEDs that shine a brilliant white light, last many years, and use a fraction of the energy today's light bulbs need.



Captures photons in quantum dots

NREL scientists demonstrate that a solar cell can yield more electrons per second than the number of photons that hit it per second – a promising step toward the goal of solar cells becoming cost-competitive for both electricity and transportation fuel. The NREL cell that yielded more electrons out than photons in (114%) employed quantum dots, which can harvest excess energy in their tiny diameters and lift cells to a more optimal energy state.



Engineers enzymes that convert biomass to ethanol faster — and cheaper

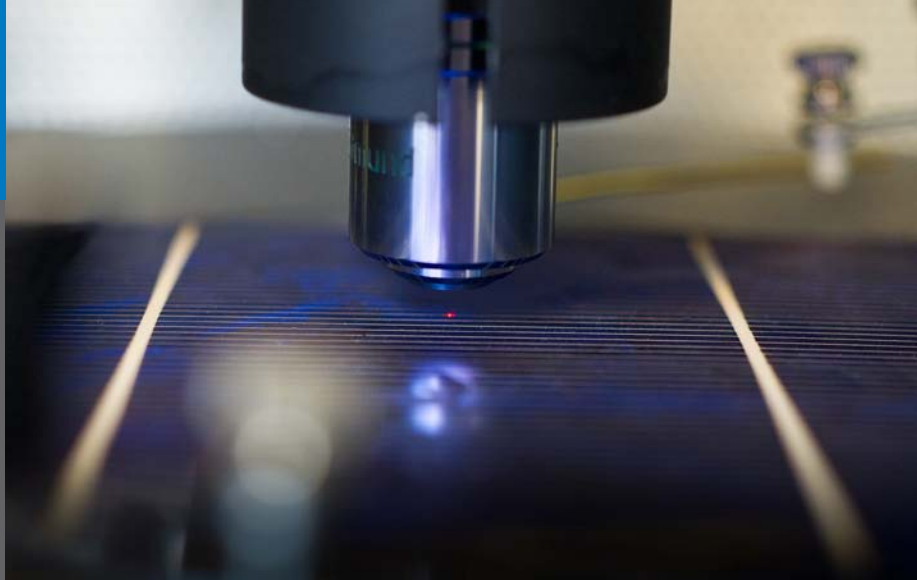
With partners Novozymes and Genencor, NREL engineers three cellulase enzymes that more quickly attack non-food biomass and turn it into sugars ready to be processed into ethanol. The breakthrough helps lower enzyme costs from \$4 a gallon to about 12 cents a gallon, a giant leap toward making biomass-based fuel cost-competitive with gasoline.

Makes two electrons for the price of one

NREL demonstrates a process called singlet fission, creating the first designed molecular system that essentially gets two electrons from each photon. More precisely, the design produces two one-spin particles from each zero-spin particle. The breakthrough could lead to a 35 percent increase in the amount of electricity a solar cell can generate – and huge drops in photovoltaic manufacturing and installation costs.

Turns solar cells upside down to achieve record efficiencies

NREL researchers set a world record of 40.8 percent solar cell efficiency by creating a new process that grows the cell from the top layer down. The inverted metamorphic multi-junction solar cell's layers are slightly mismatched, which allows more sunlight to be absorbed. And when the cell is completed, the thick, rigid substrate is removed, eliminating 94 percent of its weight.



Analyzes the quality of solar cells 1,000 times faster

NREL and industrial partner Tau Science Corp. demonstrate how to use 26 quickly blinking LED lamps — set at different frequencies — to assess the quality of each solar cell as it advances through the assembly line. The Flash QE device operates 1,000 times faster than similar devices to assess how each cell responds to blue and red light. That lets manufacturers group the cells to capture more photons at sunrise, midday, and sunset.



Applies the inkjet printing process to solar cells

NREL's patented technology deposits thin films on metal, glass, plastic, foil, or other building materials the same way ink is deposited by inkjet printers. Solar modules produced this way can be integrated directly into a building's structure, virtually turning entire buildings into clean energy power plants.

Makes energy information more accessible than ever

NREL's public website OpenEI.org uses linked open data to gather local, national, and international energy information useful to consumers, utilities, and professionals. Also publicly available is NREL's Solar Advisor Model, a free, user-friendly tool that examines detailed performance, costs, and financing to determine the overall economic value of existing or proposed solar projects across all markets.

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Demonstrates the merit of multi-junction solar cells

NREL shows that two thin-film materials sandwiched together can absorb enough light to compete with thicker, more expensive, single-layer solar cells. The breakthrough ushers in an era of multi-junction cells, proving that the layered cells not only use a fraction of the precious electronic materials used by the bulkier flat-plate cells, but also generate more electricity over the course of a day.



Accelerates the weathering process to test new products

NREL's Ultra-Accelerated Weathering System gauges in just a few weeks how well an outdoor product will hold up to years or even decades of sunlight. The one-of-a-kind testing device uses mirrors with 96 layers of alternating high- and low-refractive material to shine the equivalent of 50 suns of ultraviolet light onto a product, while only letting in the equivalent of one sun's visible and near-infrared rays.

Designs robots that build and test solar cells

Stainless steel robots fabricate, analyze, and improve solar cells faster and with more precision than ever at NREL's Process Development and Integration Laboratory (PDIL). Industry engineers use the PDIL to learn how to fix glitches and get maximum efficiency out of their cells, improvements that translate to lower costs for homeowners and utilities.

Measures the fuel potential of trees

Foresters and researchers are analyzing trees where they stand to determine their best use — veneer, paper, lumber, biomass for fuels — thanks to a portable device developed at NREL. Real-Time Biomass Analysis uses a laser and spectrometer to quickly and inexpensively determine the chemical composition and mechanical properties of trees, a crucial step toward boosting the biomass-as-fuel industry and lowering oil imports.



Multiplies the power of photovoltaics

NREL concentrates sunlight up to 500 times its usual intensity by coupling highly efficient multi-junction solar cells with inexpensive lenses in the utility-scale Amonix 7700 Concentrated Photovoltaic Solar Power Generator. The technology's unprecedented efficiency allows for reduced cost and land use — both crucial for solar electricity to reach cost parity with fossil fuels.



Tracks the sun with split-second precision

NREL rewrites an algorithm to precisely follow the sun down to the leap second, from 2001 B.C.E. to 6000 C.E. The algorithm and software help solar manufacturers to build more precise trackers, orchards to keep their apples spotless, and filmmakers to keep shadows off movie stars.

Engineers a smarter window

NREL researchers are metaphorically putting sunglasses on buildings with a new generation of highly insulated “dynamic windows” that change color to modulate interior temperatures and lighting. If broadly installed, windows like these could save about 5 percent of the nation’s total energy budget.

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National Renewable Energy Laboratory

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