SENERGI

Sustainable Energy & Infrastructure

Real-world research and innovation toward green energy and energy independence

Synergy — where the result of cooperative action is greater than the sum of individual efforts — is a concept Oregon State University has practiced for decades. Today, in the College of Engineering, that collaboration across OSU, Oregon and the nation is working on several fronts to address the challenges of sustainable energy. Already, research from our faculty, students and industry partners is yielding tangible results. And under the **Sustainable Energy and Infrastructure (SENERGI)** initiative, these synergies will grow even stronger and produce even greater outcomes.

The SENERGI initiative has three primary objectives:

1. Discover high-impact solutions

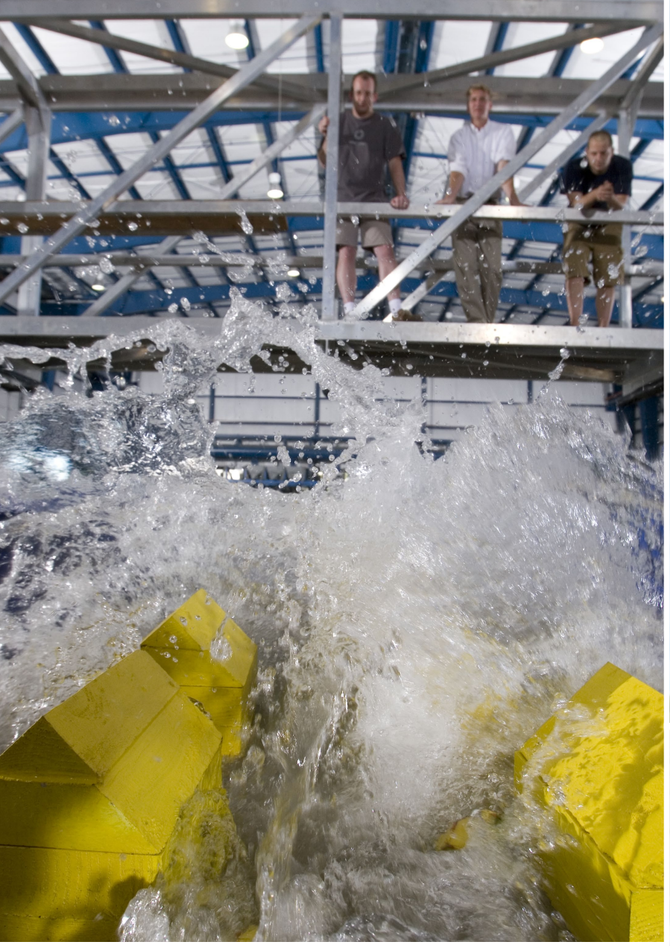
Already a national and international leader in sustainable energy research, OSU is exploring multiple pathways to energy independence. From harnessing the wind and waves to engineering highly efficient solar cells, to finding more efficient methods for biofuel production, to developing safe, cost-effective nuclear reactors, OSU researchers, industry partners and national laboratories are finding new ways to power the world.

2. Commercialize breakthroughs

More than just discovering sustainable energy solutions, OSU is putting them to work. Through industry partnerships, spinoff companies and technology licensing, we're turning energy innovations into reality. And that's not just good for the environment — it's good business. Creating new companies and expanding current ones means new jobs, new revenue streams and greater prosperity.

3. Develop engineering leadership

True to its land grant mission of applied knowledge, OSU is preparing the next generation of engineers. This includes incorporating the latest clean and renewable energy concepts into the curriculum, involving both undergraduate and graduate students in research projects and providing hands-on experience through internships with our industry partners.



Solving energy problems on multiple fronts

From a local, national and international perspective, the energy challenges we face are considerable. Not only are conventional energy sources dwindling in supply and escalating in cost, emerging economies have increased energy demand worldwide.

Besides the issues of supply and demand, there's the environmental impact. In the United States, transportation contributes to 40 percent of all carbon emissions. Power to light, heat and cool our homes and businesses adds another 40 percent.

Accordingly, the SENERGI initiative is addressing issues of supply and environmental impact simultaneously. Our research seeks to:

- Develop secure, sustainable and clean energy sources that are economically viable.
- Reduce carbon emissions.
- Reduce consumption through greater efficiency.
- Distribute and store energy from non-traditional sources.
- Adapt existing technologies to accommodate new energy alternatives.

Wave energy

Harnessing the power of the ocean

The energy potential of the world's oceans is astounding. Harnessing even one percent of sea energy could light up the world. It is a vast, largely untapped energy source that's clean, environmentally benign, cost-effective and perpetual.

Lead by electrical engineers Annette von Jouanne and Ted Brekken, OSU researchers are refining a direct-drive buoy, which uses a spiral of copper wire secured inside a buoy. The coil surrounds a magnetic shaft, which is stationary and tethered to the ocean floor. As the buoy rises and falls on the waves, the coil moves up and down relative to the shaft, inducing voltage as it passes through the magnetic field.

One buoy can generate an average of 100 kilowatts of power. A network of about 500 such buoys could power downtown Portland.

Successful testing of prototype buoys in rugged ocean conditions has led to a spinoff company, Columbia Power Technologies, which is commercializing the design.

Research on wave energy is a collaborative effort between the Northwest National Marine Energy Center, directed by mechanical engineer Bob Paasch, and the colleges of Engineering, Oceanic and Atmospheric Sciences, Agricultural Sciences and Science, along with Sea Grant, the Cooperative Institute for Marine Resources Studies, the Marine Mammal Institute, the Hatfield Marine Science Center the University of Washington, and the National Renewable Energy Lab.

Wind energy

Thinking smaller and thinking ahead

OSU has been working on wind energy since the 1970s, and that extensive research has yielded breakthroughs on two fronts:

Mention wind power, and most people think of the giant turbines dotting rural hillsides. Not mechanical engineering professor Stel Walker. As a consultant to California-based AeroVironment, Walker helped design a micro wind turbine that can be mounted in rows along the edges of building rooftops. That means wind power can be generated in urban and suburban settings, not just from rural wind farms of towering turbines.

On the second front, OSU's Energy Resources Research Laboratory is working with the Bonneville Power Administration (BPA) on wind-forecasting models to determine the most productive locations for wind farms.

Forecasting models are also useful in research to capture excess energy generated during peak wind events and releasing the stored energy onto the power grid at times when wind speeds are low.

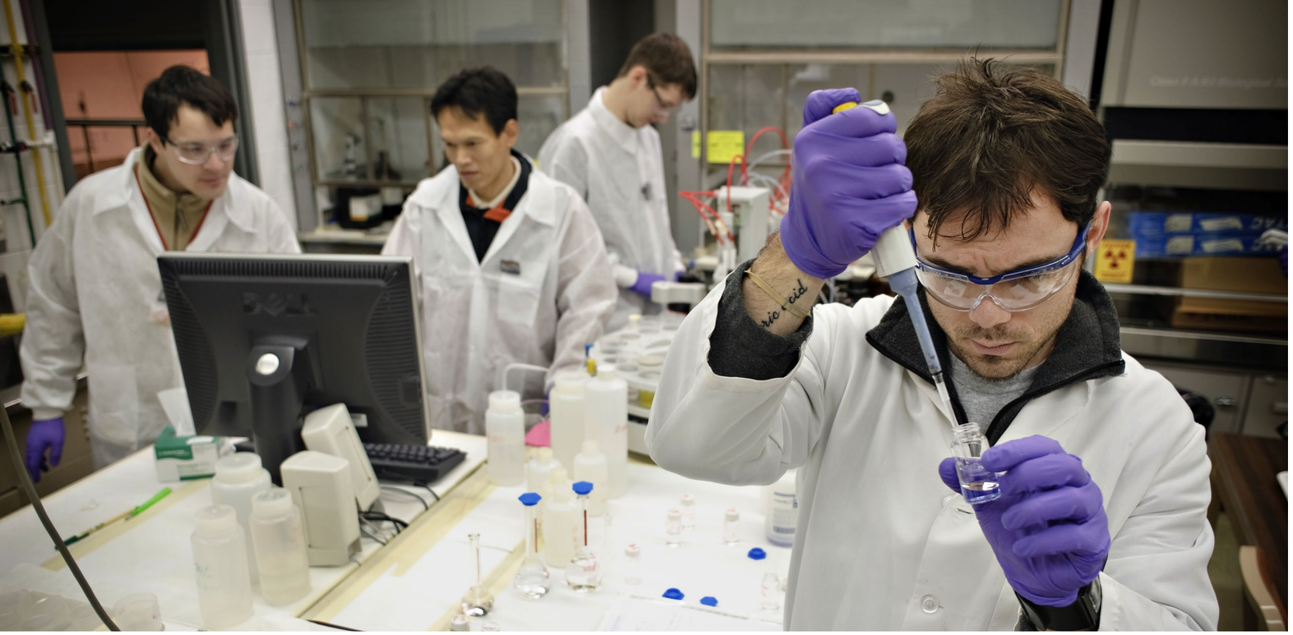
In addition to AeroVironment and the BPA, other partners include Massachusetts-based Second Wind Inc. in Massachusetts and the Oregon Built Environment and Sustainable Technologies (BEST) center.

Students in focus EUNICE NASWALI

SOLVING ENERGY PROBLEMS BACK HOME

Eunice Naswali understands the need for clean, reliable energy. In her native Uganda, most of its electricity comes from hydropower. But during the dry season, there's not enough water flow to meet electrical demand, leading to widespread power outages. Nor does Uganda have the infrastructure to get electricity to remote parts of the country.

Through her internship at Vestas, the world's largest manufacturer of wind turbines whose North American headquarters are in Portland, Naswali is gaining practical knowledge and experience in wind energy. After completing her undergraduate degree — and with plans for graduate school after that — Naswali hopes to return to Uganda and take what she's learned about wind power and other renewable energy sources to bring more reliable electric power to her homeland.



Nuclear energy

Improving efficiency, safety and economics

Nuclear power — which can produce great quantities of energy without emitting carbon dioxide — is being revisited as a viable option, with OSU research at the forefront. New developments in high-temperature gas-cooled reactors, modular reactors, passive safety features and spent fuel recycling will make the next-generation of nuclear power plants safer and cleaner, as well as more efficient, economical, portable and flexible.

OSU nuclear engineers José Reyes and Brian Woods are co-inventors of a small-scale nuclear power plant. Their design includes a modular nuclear reactor core and passive-safety features that rely on natural forces like gravity, evaporation and condensation.

A spinoff company, NuScale Power, is now in the pre-application phase of the certification process. Once approved, these nuclear reactors will be built on an assembly line and transported via truck, railcar or barge to wherever they're needed. Each power plant can produce 45 megawatts of power — enough for about 45,000 homes.

Other research, led by radiochemist Alena Paulenova, is investigating ways to reprocess and recycle spent fuel. About 97 percent of the spent uranium and plutonium can be recycled into fresh fuel, leaving only 3 percent as toxic waste. Recycling spent fuel also saves up to 30 percent of the natural uranium that would otherwise be needed.

OSU is also helping China develop a badly needed nuclear infrastructure to reduce its reliance on pollution-spewing coal. In partnership with Westinghouse, OSU trained a team of elite scientists from Shanghai and Beijing in the operation of the 1,000-megawatt light-water reactor Westinghouse is building in China. The reactor features passive shutdown technologies that were extensively tested at OSU's Radiation Center.

Solar energy

Making solar more efficient and more viable

In their breakthrough research developing transparent electronics, electrical engineer John Wager, chemist Doug Keszler, physicist Jane Tate and a team of graduate students weren't thinking of solar energy. But that's become one of the first industrial applications for the technology.

These next-generation solar energy devices, manufactured by Xtreme Energetics, Inc., of Livermore, Calif. under license from OSU and Hewlett-Packard, replace mechanical tracking methods with an optical approach to tracking and focusing sunlight. This approach, along with a flat design that can be used on rooftop panels or central utilities, is expected to convert sunlight to electricity at twice the efficiency and half the cost of traditional solar panels.

Other areas of solar energy research and collaboration include Azuray Technologies, a company founded by OSU faculty, which is developing a more efficient way of converting the direct current produced by solar panels to the alternating current that's used in American homes and offices. Oregon BEST —which connects Oregon businesses with a shared network of university labs to commercialize breakthroughs in green building and renewable energy research — has worked with OSU researchers to create liquid fuel solar cells using micro-channel, thermo-chemical receivers, a technology that could be up to four times more cost-efficient than existing designs.

Additional solar energy partnerships include the Oregon Support Network for Research and Innovation in Solar Energy, the Oregon Process Innovation Center, the Microproducts Breakthrough Institute (MBI) and the Oregon Nanoscience and Microtechnologies Institute (ONAMI), a joint venture between government, industry and research institutions focused on moving nanoscience and microtechnology innovations from basic research through to commercialization. Industry partners include SolarWorld, Schott Solar, Sharp Solar, Suntech, Trina Solar, Solaicx, Sanyo Solar and PV Powered.

Biofuel energy

Developing new kinds of power plants

Researchers in both the colleges of Engineering and Agricultural Sciences are investigating new crops, enzymes and advanced fuel processing technologies. Currently, two companies are working on commercializing this research.

MTek Energy Solutions, in collaboration with OSU and ONAMI, has developed a prototype microreactor that combines vegetable oil, alcohol and a catalyst to produce biodiesel fuel. The process is efficient, fast and portable.

Trillium FiberFuels is creating process technology and equipment to produce ethanol out of the two main agricultural residues from straw: wheat and ryegrass. Trillium's isomerization process can increase the ethanol yield by 30 percent or more.

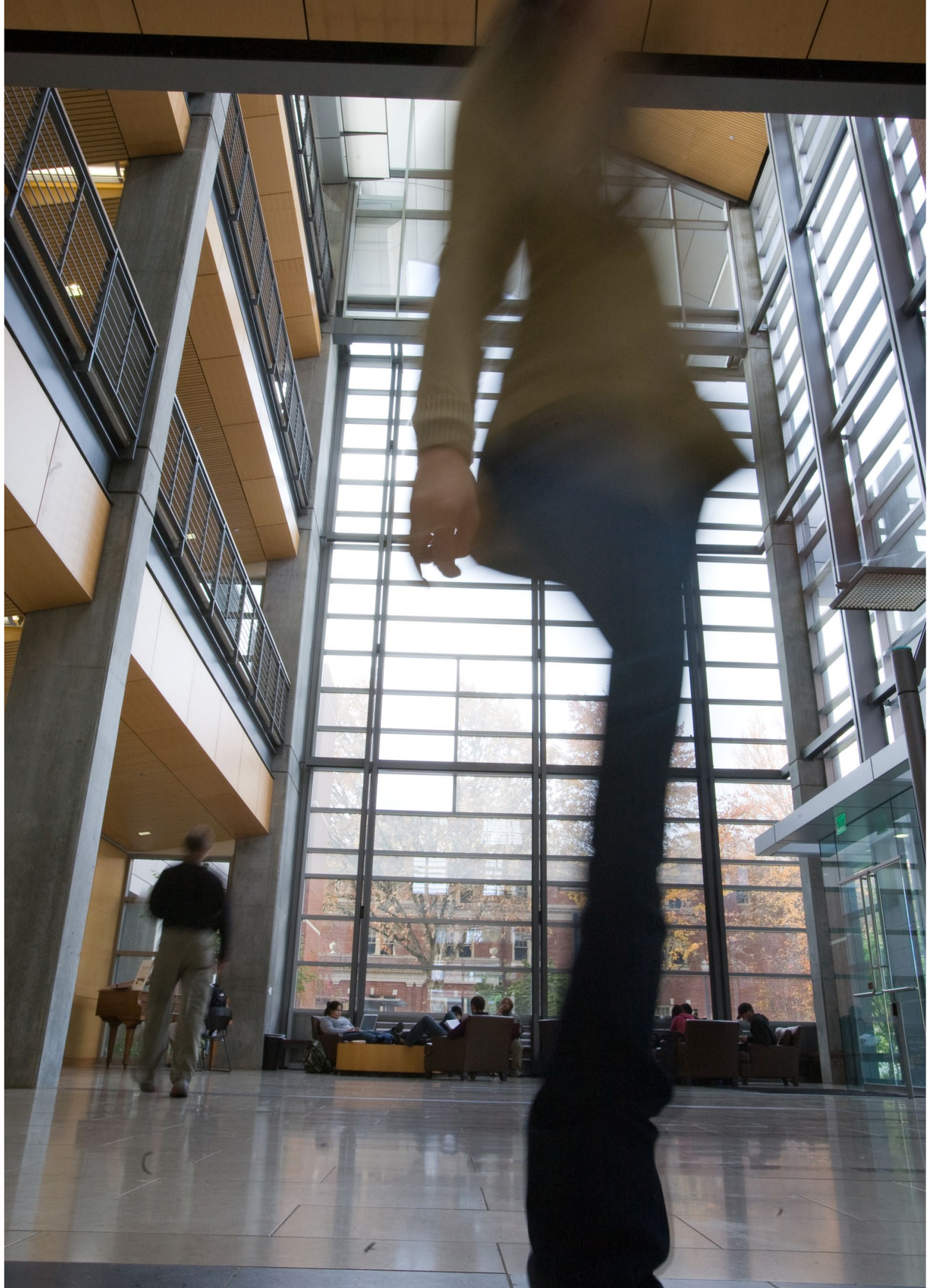
OSU researchers are also investigating hydrogen as an energy source. This includes developing a solid-state system that combines water, sunlight and cyanobacteria — more commonly known as blue-green algae — to produce hydrogen. OSU is also working with MBI to develop microfuel processors that produce hydrogen, along with research to improve the hydrogen fuel cells that store and generate power for electric vehicles.

Students in focus NGAN NGUYEN

FROM DROPOUT TO BIOFUEL ENGINEER

Ngan Nguyen has come a long way over the last seven years. After dropping out at 15, she went back to night school to get her high school diploma. Encourage by her teacher, who said she was already doing college-level work, Nguyen enrolled at Linn-Benton Community College, then transferred to OSU.

As a chemical engineering major, Nguyen has completed research and internships where she's learned how to scale up, quantify and commercialize her scientific discoveries. At Corvallis start-up Beaver Biodiesel, Nguyen researched ways to integrate algae into biomass fuel production. And after graduation, she already has a job at General Atomics in San Diego, where she'll lead efforts to commercialize technology from the company's biofuel program.



Fossil fuels

Cleaning up coal

America gets more than 50 percent of its electricity from coal, and domestic coal reserves are 200 times greater than those of oil and natural gas. Which means coal isn't going away. And while much of the focus of OSU energy research is on renewable energy, it also includes research to meet a goal of near zero-emission coal plants by 2020.

Supported by the National Energy Technology Lab (NETL), mechanical, industrial and manufacturing engineers are investigating alloys and developing new tools to reduce mercury, nitrogen, sulfur and particulates discharged from coal-fired plants. At the same time, chemical, biological and environmental researchers are working on minute-scale physical and chemical processes to control storage of carbon dioxide in deep saline aquifers.

In addition, OSU researchers are investigating how microorganisms and plants, — especially algae — capture CO_2. As a bonus, the captured CO_2 can be converted into biodiesel and ethanol.

Energy efficiency

Achieving sustainability through conservation

With all the interest in green energy, it's important to remember that the cleanest energy is the energy we don't use. That's why OSU is also developing more energy-efficient building materials and controls for lighting, heating and cooling.

OSU's colleges of Engineering and Forestry share the new Green Building Research Lab. Their discoveries include hybrid poplar wood engineered to be three times stronger than old-growth Douglas fir, new types of concrete and pavement that are more durable and environmentally friendly, recycled plastics used as building insulation.

OSU also puts the principles of energy efficiency into practice. Opened in 2005, the Kelley Engineering Center was awarded a Leadership in Energy and Environmental Design (LEED) Gold certification by the U.S. Green Building Council. And the renovation of the 100+ year-old Kearny Hall is in the process of certification for either a LEED Gold or Silver rating.

Transportation

Building up range and infrastructure

Although sales of gas/electric hybrid cars have skyrocketed in recent years, vehicles powered exclusively by electricity currently have limited range and a lack of supporting infrastructure. But that's changing.

OSU is collaborating with MBI on improved material and process technologies to improve battery range and performance. OSU is also working with Apex Drive Laboratories to develop high-performance electric motors for vehicle applications. In addition, OSU will likely be involved in the partnership between Nissan North America and the state of Oregon to bring zero-emission electric cars to government agencies by 2010 as well as expand the infrastructure for electric car charging stations statewide.

Power distribution infrastructure

Modernizing the grid

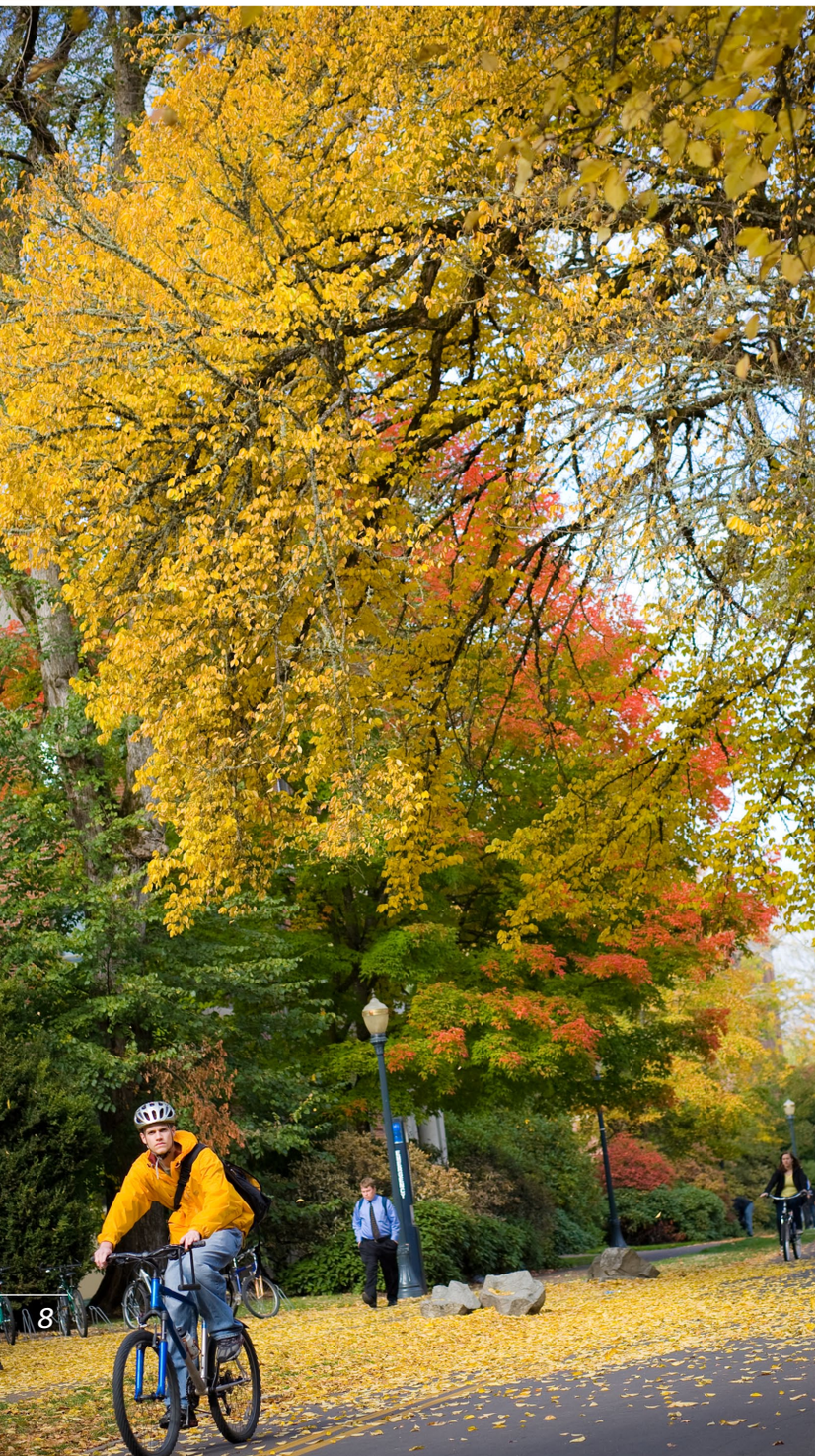
Beyond finding new sources of energy and reducing consumption, OSU energy research also addresses the need to modernizing America's aging and outdated power distribution infrastructure. This includes scale modeling, control systems, machine learning and networks that support smart grids. These digitally controlled transmission and distribution systems are designed to be more reliable, energy efficient and economical, as well as able to readily accommodate renewable energy sources. OSU has one of the only grid-scale laboratories capable of testing products for utility performance.

Because some renewable energy sources like wind power are variable or intermittent, OSU researchers are working with the BPA, the Central Lincoln People's Utility District and Oregon BEST to develop sophisticated power electronic systems that precisely control when wind energy should be used immediately, directed to a storage system, or sent in both directions, smoothing out the peaks and valleys of wind energy. Other research is aimed at finding better ways to store excess energy for later use, including membrane separator materials for batteries and high-energy-density capacitors. In addition, OSU faculty and students are collaborating with ONAMI and Pacific Northwest National Labs (PNNL) to produce the next generation of lithium ion battery. The research combines chemical engineering and nanoscience to make a battery that's smaller, lighter, faster and tougher.

Students

Gaining real-world experience through research and internships

Engineering at OSU is a hands-on experience. Both undergraduate and graduate students make real contributions to faculty research projects. Most engineering students also complete internships, either through the Multiple Engineering Program (MECOP) or by other opportunities. Established in 1978, MECOP is a this partnership with more than 100 companies throughout the Pacific Northwest that gives students real-world engineering experience over two, paid, six-month internships.



In the classroom, the College of Engineering is integrating clean and renewable energy concepts into the curriculum and introducing a new major in energy engineering management. Also, recognizing the need to make clean, renewable energy economically feasible and transfer these technologies to the commercial market, a new engineering master's degree incorporates a business minor.

SENERGI

Turning energy research into reality

Green, renewable energy is a strong and growing part of the state, national and international economy. According to a United Nations report, 2007 saw record growth in renewable energy investment worldwide, with renewable energy accounting for 23 percent of total new generation added globally. Federal investments will provide capital over the next three years to eventually double the capacity for domestically produced renewable energy.

The SENERGI initiative is tapping into the enormous potential for clean energy and energy efficiency, turning that potential into economically viable solutions. We've already made great progress, but it's only a start. With the continued support and leadership of our faculty, students, alumni and friends, along with our partners in government, industry and the scientific community, we will solve the challenges of clean, renewable energy for Oregon and beyond.