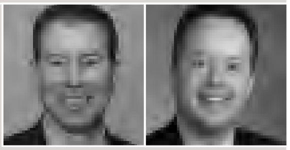
Case Western Reserve
University
Est. 1826

The Value of Research

2007 + 08

Case Western Reserve University is among the nation's leading research institutions. Founded in 1826 and shaped by the unique merger of the Case Institute of Technology and Western Reserve University, Case Western Reserve is distinguished by its strengths in education, research, service, and experiential learning.



MARK E. COTICCHIA
VICE PRESIDENT
RESEARCH AND TECHNOLOGY
MANAGEMENT

ERIC M. COTTINGTON, PH.D.
ASSOCIATE VICE PRESIDENT
FOR RESEARCH

Never underestimate what can be accomplished when individuals of intelligence, passion, and persistence come together.

We are pleased to present the fifth edition of *The Value of Research* to our dedicated stakeholders as well as to those for whom this is an introduction to Case Western Reserve University. Although this is but a sampling of the significant research and scholarship that takes place on our campus, our goal is to make tangible the remarkable achievements that, collectively, are the essence of a major research university.

In gathering information while preparing this book, many conversations informed our thinking. Professor Iwan Alexander, the faculty leader of the newly created Great Lakes Institute for Energy Innovation, reminded us that research is a cumulative endeavor. “We have no crystal ball, so evaluating a research project solely on whether the results have immediate application is not necessarily the best metric,” he noted. Indeed, universities are uniquely positioned for the work of pure research that often reveals its applications only over time.

President Barbara R. Snyder, in her inaugural address to The City Club of Cleveland, shared Dr. Alexander’s sentiment by telling the audience that, “Each individual discovery provides a legacy of its own, allowing those who follow to build and expand our frontiers of knowledge and understanding beyond anything we might imagine today.” To that she added, “Never underestimate what can be accomplished when individuals of intelligence, passion, and persistence come together.”

From an internationally-noted effort to eradicate tuberculosis—to the critical and poetic study of how cities have shaped our lives and history—to a solution-seeking analysis of the effects of the mortgage crisis on our neighborhoods—these are but a few of the endeavors that we share in this volume. Our researchers, including our extraordinary students, are making vital contributions that are changing the world. These accomplishments would not be possible without our many partners, both local and global, who contribute to our success—we acknowledge them with gratitude.

Discovering energy solutions for the twenty-first century

DAVID H. MATTHIESEN

Increasing global energy demands require revolutionary **energy solutions.** Researchers at the Case School of Engineering and College of Arts and Sciences are already delivering breakthrough discoveries that contribute to renewable, sustainable, and efficient energy options that are positioning Ohio at the forefront of this frontier.

Exploring the Wind Energy Potential of Lake Erie

While not without its challenges, using wind power to create electricity is an attractive form of energy because it is renewable, essentially pollution-free, reliable, and affordable. Under the direction of **David H. Matthiesen, Ph.D.,** associate professor of materials science and engineering, Case Western Reserve is working on many fronts to build this new industry in the Great Lakes region. Working in partnership with the Cleveland Foundation and the Cuyahoga County Commissioners, the university is currently engaged in a feasibility study to develop the Great Lakes Wind Energy Research Center, which would be the first fresh water, offshore wind project in the world.

"The best wind energy resources in the Midwest are located out in the Great Lakes. With this ample wind resource and shallow depth, Lake Erie makes an ideal nucleation center for the economic development that will occur as this new industry develops," notes Dr. Matthiesen.

Wind power is converted to electricity by wind turbines. A collaborative research program with Lubrizol Corporation, Phillips Electric Company, and The Timken Company is aimed at improving the operating lifetime of the gearbox assembly for utility-scale wind turbines. Because the power a wind turbine can generate depends on the wind velocity and direction, research is also being conducted to measure and analyze the wind energy resource atop the 50-meter tower at the City of Cleveland's water intake crib, a man-made island located three miles off the coast of downtown. Working in collaboration with Green Energy Ohio and the Renaissance Group, these measurements are critical to the future development of offshore wind farms.

Given the intermittent nature of wind output, the storage of electrical energy generated by wind turbines for usage at peak demand times is required to make wind energy viable for consumer use. Research for storing and incorporating wind-generated electricity into the larger electrical grid is being done in partnership with Phillips Electric and FirstEnergy Service Corporation.

"If the Great Lakes Wind Energy Research Center is found to be feasible, we will not only be creating new alternative energy technologies that efficiently and durably harness wind power, but providing a national model for the renewable energy industry," adds Dr. Matthiesen.

http://dmseg5.case.edu/people/faculty.php?id=dhm5

J. IWAN D. ALEXANDER

Q + A

Establishing the Great Lakes Institute for Energy Innovation

A Conversation with J. Iwan D. Alexander, Ph.D.

J. Iwan D. Alexander, Ph.D., is a professor in the Department of Mechanical and Aerospace Engineering and Director of the National Center for Space Exploration Research. In addition, he is the faculty director of the newly formed Great Lakes Institute for Energy Innovation, based at the Case School of Engineering and spearheaded by Dean Norman C. Tien.

Q: What is the primary goal of the Great Lakes Institute for Energy Innovation?

A: The purpose of the Institute is, through farsighted energy research and energy-use strategies, to develop innovative energy-technology platforms that will provide low-cost, reliable, and sustainable energy resources for the future. Through coordinated research, participation in economic development, and education, the work of the Institute will enable the transition to sustainable energy generation, storage, distribution, and utilization.

Q: Case Western Reserve already has diverse resources and strategic partnerships in place to develop pioneering energy solutions. Elaborate on these strengths.

A: Our Wright Fuel Cell Group, a national leader in fuel cell research and development, is a statewide consortium of Ohio universities and industry collaborators. In addition to electrochemistry and fuel cells, Case Western Reserve has internationally recognized expertise in materials research and smart sensor technology, both areas being very relevant to advanced energy technology and efficiency. As the Institute grows, we see a vital role for the University's other areas of expertise such as policy, ethics, and management—all of which contribute toward implementation of emerging energy issues.

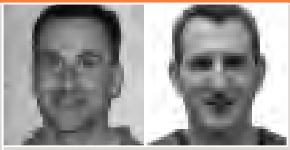
Q: What role does the University have in positioning Ohio as a national leader in meeting the energy challenges of this century?

A: As one of the largest research universities in the region, we have expertise in multiple energy platforms. By combining the knowledge of our researchers with Ohio's breadth of natural resources, a framework is created for innovation in biomass and hybrid technologies, wind and solar energy, and fossil fuel efficiencies. Our participation in The Great Lakes Wind Energy Research Center, for example, is an important step in exploring alternative energy for the region, including the potential manufacturing of components for wind turbines.

Q: You are the director of the National Center for Space Exploration Research that partners with NASA—how does the Center contribute to energy issues?

A: There are problems of affordable energy generation and sustainability in space, and while not contributing directly, our work at the Center is certainly relevant. We are located at the NASA Glenn Research Center which has extensive experience in power generation and energy storage, including solar arrays, batteries, fuel cells, and large horizontal-axis wind turbines, the most popular systems used today.

http://www.case.edu/energy



VINCENZO LIBERATORE + MICHAEL S. BRANICKY

Smart Energy: Revolutionizing the Electrical Power Grid

The array of current energy technologies—from newer choices for electricity generation, such as fuel cells and wind turbines, to smart appliances that adjust to grid conditions—will be the most effective when linked together in a cohesive system.

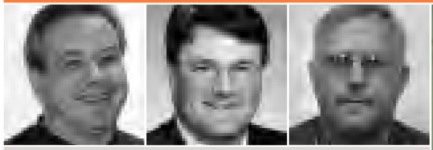
While electrical power is critical to the economy, national security, and public health, the power grid has not fully harnessed the might of digital technology and, accordingly, is becoming increasingly obsolete. As a result, capital assets are underutilized and susceptible to massive failures. In fact, most current equipment was designed before the development of modern microprocessors—perhaps the most powerful energy technology available today.

Defined as energy that uses the most cost effective long-term approach while maintaining the lowest environmental impact, smart energy will revolutionize the power grid by means of advanced communications, control, and software. The research of **Vincenzo Liberatore, Ph.D.** and **Michael S. Branicky, Sc.D.,** both associate professors in the Department of Electrical Engineering and Computer Science, is applying cutting-edge computing to improve the electrical power grid to meet the demands of this century.

"Intelligent devices will be involved at all levels—from the utilities that are responsible for the generation, transmission, and distribution of electricity to the markets and consumers that use it," explains Dr. Liberatore. "They will sense, respond, and share real-time information." One step toward creating smart electrical grids has been the recent development of an integrated simulation tool by a team led by Dr. Liberatore and Dr. Branicky. The co-simulation tool combines a full-fledged simulator of computer communication networks with a full-fledged simulator of power systems. The main technical challenge is the synchronization of two parallel simulations, and the solution is to enslave the power system simulation to the event-driven network simulation. In future research, the co-simulation tool will be used to analyze and devise distributed and networked strategies for real-time, secure communication that achieve situational awareness and control of power distribution.

The array of current energy technologies—from newer choices for electricity generation, such as fuel cells and wind turbines, to smart appliances that adjust to grid conditions—will be the most effective when linked together in a cohesive system. Computing will support collaborative management, planning, and operations; will enable instantaneous communication, situational awareness, and control; will increase efficiency and productivity; will enable plug-and-play asset integration; and will support market dynamics, as well as reduce peak prices and stabilize costs when supply is limited.

http://vorlon.case.edu/%7Evxl11/NetBots/#modelicans2



VLADIMIR GURAU + THOMAS ZAWODZINSKI
+ MIRKO ANTLOGA

A Fuel Cell Powerhouse

Ohio is an international leader in fuel cell research and innovation—and Case Western Reserve is at the center of this achievement. With significant funding from the state's Third Frontier Project along with matching funds from its constituent members, the Wright Fuel Cell Group (WFCG) was launched in 2003 as a coalition of academic institutions and industrial partners to accelerate development of this important advanced energy technology.

While there are many research facilities around the world where next-generation fuel cell technology is being developed, bringing technology to market requires testing, refinement, and streamlining in the manufacturing process. The Wright Fuel Cell Group serves as the hub for this emerging industry by providing the specialized equipment and experienced technical staff to speed the path to commercialization. WFCG includes a team of more than 40 university faculty researchers and dozens of other faculty at partner institutions engaged in cutting-edge electrochemistry and fuel cell research. In addition to this wealth of knowledge capital, WFCG state-of-the art testing equipment and infrastructure allows partners to minimize start-up costs by avoiding investments in equipment they will only temporarily need.

A current example of how the Wright Fuel Cell Group provides a competitive advantage is its partnership with GrafTech International. This locally-based company is the major producer of bipolar plate materials and gas diffusion substrates for PEM (proton exchange membrane) fuel cells that have proven field use for automotives, materials handling, and back-up power applications. By collaborating with Research Associate **Vladimir Gurau, Ph.D.,** and **Thomas Zawodzinski, Ph.D.,** Ohio Eminent Scholar in Fuel Cells and F. Alex Nason Professor of Engineering, GrafTech and Case Western Reserve are carrying out durability and high temperature testing on a $2.9 million project from the U.S. Department of Energy.

"Beyond their ability to generate electricity from a range of energy sources, in many ways, fuel cells are like batteries—you must string them together to provide enough energy to power a car or bus. This interconnection, provided by bipolar plates, is a critical factor. GrafTech's technology uses natural graphite and offers the premier material for PEM fuel cells," explains **Mirko Antloga,** Technical Director of the Wright Fuel Cell Group.

The ever-increasing proliferation of types of fuel cells and potential applications places the Wright Fuel Cell Group in a key position in developing alternative energy sources, as well as creating spinoff businesses and jobs. Regarded as one of the world's most powerful fuel cell development resources, it is in the process of joining forces with the newly established Great Lakes Institute for Energy Innovation to continue its cutting-edge research and further economic development across the state and the nation.

http://www.wfcg.org

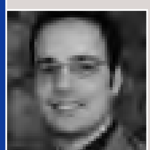
STUDENT RESEARCH

Saving Energy for Spacecraft Launches

The problems of energy generation and conservation are not earthbound—energy problems in space also require solutions. Under the guidance of Dr. Mohammad Kassemi, research associate professor, and Dr. Iwan Alexander, **Stephen Barsi,** a graduate student in the Department of Mechanical and Aerospace Engineering, is engaged in research involving the management of cryogenically-stored propellants. Because launching spacecraft requires propellant, the work is of particular interest to NASA.

Typical propellants such as hydrogen are stored as liquids under high pressure. 'Boil-off' of the propellant due to temperature fluctuations or 'heat leaks' results in pressure increases inside the storage vessel and, ultimately, if the pressure cannot be controlled, propellant loss through ports or valves. Figuring out how to provide pressure control and avoiding 'boil-off' significantly reduces the mass of propellant required for a given mission—less mass means less energy required to launch the spacecraft. While the problem has long been under examination and a practical solution has been elusive, Mr. Barsi's research is a significant step forward.

Through his involvement in research while still an undergraduate, Mr. Barsi was already proficient at computational fluid dynamics. His approach to the 'zero-boil-off' problem involved developing a computational model to enable him to simulate boil-off conditions and to calculate and predict the impact of different pressure control strategies. In addition to providing answers that will lead to better pressure control for 'zero-boil-off,' Mr. Barsi has made a significant contribution to computational thermodynamics by creating 'state-of-the-art' software capable of simulating the boil-off process.



STEPHEN BARSI

Energy Devices That Build Themselves

For the past 25 years, **Kenneth D. Singer, Ph.D.,** professor of physics and macromolecular science, has pioneered the study of organic and polymeric materials for applications in the emerging photonics industry that focuses on the science and engineering of light. Recently, he has turned his attention to examining the potential of such materials for energy applications.

In particular, Dr. Singer is studying the basic electronic and optical properties of polymers and liquid crystal semiconductors for use in solid state lighting and solar energy conversion. As evidenced by computer and television liquid crystal displays, liquid crystals and polymers are easily cast into very large areas at low cost. A major motivation for Dr. Singer's lab, then, is to explore ways to lower the high manufacturing cost for the large areas needed for solar energy conversion. In fact, the high manufacturing cost of photovoltaic devices is the main impediment to their widespread use. In one fascinating approach, Dr. Singer is working with **Volodimyr Duzhko, Ph.D.,** a visiting physics professor, to study how liquid crystals self-assemble into nanodots and nanowires and interact with light to produce electrical current.

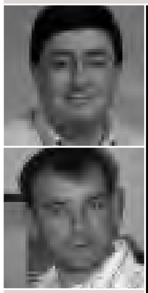
"Nature has the ability to self-assemble complex systems that build themselves. Living things are examples of self-assembly—you start with a molecule and build a body. As scientists, we are learning how to mimic nature and produce nanoscale self-assembling materials to create the next generation of energy devices," notes Dr. Singer.

The research team is investigating how self-assembling nanostructures can be formed to create a photovoltaic device with a bottom-up approach that, according to Dr. Singer, will usher in a new era where electronic devices will build themselves. From a physics point of view, their laboratory is also investigating the basic processes needed for solar conversion, including those for optically exciting the light harvesting material, and for creating, transferring, and collecting the electrical current. For example, the research team has found that liquid crystals might serve as effective semiconductors in solar cells because they exhibit electronic transport mechanisms similar to more commonplace semiconductors, such as silicon. This interdisciplinary work includes chemists at various institutions who are synthesizing novel materials specifically designed for self-assembly, and for efficient solar conversion and electrical transport.

"Our work seeks to exploit the intrinsic processability, tailorability, and favorable optoelectronic properties of these materials to create low-cost, lightweight, and flexible energy devices," adds Dr. Singer.

http://nlo-server.phys.case.edu/

KENNETH D. SINGER + VOLODIMYR DUZHKO



KATHLEEN KASH + JOHN C. ANGUS

A Breakthrough for the Next Generation of Semiconductors

Newly created semiconductors can be found in a remarkable array of devices that touch our lives every day. The research group led by **Kathleen Kash, Ph.D.,** professor in the Department of Physics, is focusing on producing new and enabling semiconductor alloy systems that are high quality, economical, and energy efficient. Such systems combine different semiconductors that can be grown together as single crystals, both as layers of one on top of the other, and as mixtures.

For example, the system composed of gallium nitride, indium nitride, and aluminum nitride has given us Blu-Ray Disk™ technology, compact blue and ultraviolet lasers, large multi-color display panels, bright green traffic lights, and even may be poised to replace incandescent bulbs, with enormous energy savings. The emitters and receivers in fiberoptic communications are also made of semiconductor alloys. Such systems have been crucial both to the discovery of new physics and to the development of new technologies.

The technical challenge remains to provide a high-quality substrate for gallium nitride-based semiconductors. Typically, these devices are grown on sapphire, although it is not an ideal choice. Dr. Kash's group, in close collaboration with **John C. Angus, Ph.D.,** Kent Hale Smith Emeritus Professor of Engineering, is doing basic research on new methods for growing large, high-quality single crystals of gallium nitride. These methods are especially inexpensive to set up and run, and are also more environmentally friendly than other growth methods. If successful, they could solve the "substrate problem" for gallium nitride-based devices.

Most recently, the research team has achieved a breakthrough in the growth of zinc germanium nitride, a material on which little research has been done. Zinc germanium nitride has virtually the same lattice constants as gallium nitride, so it is an appropriate and promising substrate material for gallium nitride-based devices. In addition, the team is working on methods for growing even newer materials—zinc silicon nitride and zinc tin nitride. The growth of zinc tin nitride has never been reported, and together with zinc germanium nitride, a new alloy semiconductor system is formed.

"Our next step is to explore the electronic and optical properties of these new materials," notes Dr. Kash. Working together with **Dr. Walter L. Lambrecht** to this end, they anticipate that some properties may be unique to this system and may be the basis for the development of new technologies.

http://www.phys.case.edu/faculty/index.php?kash

Q + A

Bringing Energy Efficiency to Industry

A Conversation with David Schwam, Ph.D.

DAVID SCHWAM

In 2005, when the price of natural gas spiked, energy intensive industries scrambled to come up with ways to reduce energy consumption. The "Save Energy Now" program, initiated by the U.S. Department of Energy (DOE), was created to identify energy saving opportunities in large plants. **David Schwam, Ph.D.,** research associate professor in the Department of Materials Science and Engineering, is a DOE-Qualified Energy Specialist who was recruited to support this nationwide effort. As the director of the Case Metal Processing Laboratory (CMPL) that engages in cutting-edge research to advance metal processing technologies, Dr. Schwam brings noted expertise to each project.

Q: How is the "Save Energy Now" program implemented?
A: As one of ten DOE energy specialists, I conduct assessments for companies that are striving to conserve energy. In addition to identifying methods to save energy, we train plant personnel in the use of computer software tools to evaluate energy consumption.

At the Kohler Company's Cast Iron facilities in Wisconsin, for example, we focused on reducing the amount of energy used in process heating systems—monitoring the amount of time furnace doors were open and recovering energy from the furnace exhausts were two initial recommendations. Using DOE-provided "Process Heating Assessment and Survey Tool," Kohler was able to measure heat balance from around an enameling furnace and make informed decisions from the data.

Q: What impact does research at the Case Metal Processing Laboratory have on the energy-consuming metal casting industry?
A: Metal casting is indeed one of the most energy intensive industries because significant amounts of heat are required for melting, transferring, and holding metal. The efficiency of these processes has a direct impact on the profitability of the operation. Accordingly, the DOE has funded a wide range of die casting and foundry research projects at the CMPL—and each one must demonstrate an energy saving component.

One example is the "Melting Efficiency in Aluminum Die Casting" project that quantified the benefits of improved ladle insulation in reducing heat losses during molten metal transfer. Our researchers are addressing multiple aspects of aluminum melting and handling to increase the energy efficiency of these operations while improving the quality of the molten metal.

Our researchers are addressing multiple aspects of aluminum melting and handling to increase the energy efficiency of these operations while improving the quality of the molten metal.

Q: What is the role of your research in national energy conservation programs?
A: Through my field work with "Save Energy Now" I recognized that most industries could benefit from a more permanent source of information and expertise on energy efficiency. With the support of an active industrial advisory board, the Case Center for Melting Efficiency and Thermal Technologies was recently established. The Center held its first workshop last fall for representatives of various thermal processing industries, including metal casting and glassmaking, to identify topics of common interest.

http://dmseg5.case.edu/groups/cmpl

CLEMENS BURDA + WALTER L. LAMBRECHT + FRANK ERNST

Nanostructured Materials: Third Generation Solar Cells

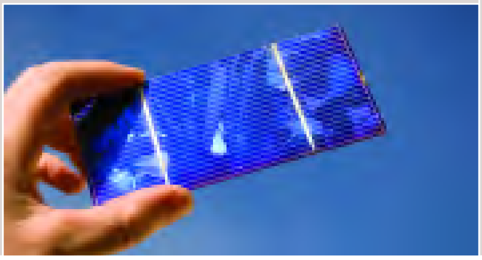
The use of photovoltaic cells to convert light energy into electricity is becoming an increasingly viable energy source for an ever-growing variety of applications. With the goal of using greener materials and devices to generate environmentally friendly, renewable energy, a research team led by **Clemens Burda, Ph.D.,** associate professor and director of the Center for Chemical Dynamics and Nanomaterials Research in the Department of Chemistry, and **Walter L. Lambrecht, Dr. Sc.,** professor of physics, is working with nanostructured materials to create what is known as third generation photovoltaic solar energy conversion cells.

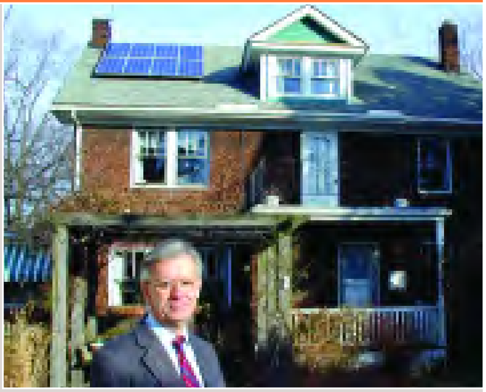
Simply put, when the photons in sunlight hit solar cells, they are absorbed by semiconducting materials. The energy of the photon is used to put an electron in an excited state in which it is free to move—this net flow of charge is the electrical current generated by the light. The goal is to separate the electron and hole before they have a chance to recombine. While silicon is the most widely used semiconductor, copper sulfide is one of the earliest semiconductors used in solar cells because it is an excellent absorber of light that requires only very thin, micron-sized layers to convert light efficiently into electricity.

Drs. Burda and Lambrecht are currently working on solar cell configurations that improve on the use of copper sulfide. Because titanium dioxide and copper sulfide are both nontoxic metals with minimal negative environmental impact, combining them may become a breakthrough in solar cell production. Previously used in conjunction with elements such as cadmium, which is toxic, or indium, which is costly, copper sulfide was also found to deteriorate when used as the top layer and exposed to air. By combining copper sulfide nanoparticles with mesoporous conducting oxides, such as titanium dioxide and zinc oxide, a dual-connected network is formed. The nanosize of the structure is important because it implies that any electron-hole pair that is created is close to an interface and is efficiently separated, the electron going into the oxide and the hole into the copper sulfide.

The team is in the basic research stage, having produced a benchtop prototype—a one-inch by one-inch solar cell. Team member Jeff Dyck, Ph.D., of John Carroll University, is measuring the electrical properties of the prototype. **Frank Ernst, Ph.D.,** Leonard Case Jr. professor of engineering in the Department of Materials Science and Engineering, is using his state-of-the-art electron microscopy facilities to image the structure of a solar cell atom by atom, which will prove invaluable to improve the microstructure. Pavel Lukashev, a recently graduated doctoral student in Dr. Lambrecht's group, provided calculations for copper sulfide which elucidated the relation between its complex structure and the electronic energy levels.

http://pablo.case.edu





PHILIP L. TAYLOR

A Scientist's Viewpoint: Society and Energy

The research endeavors of **Philip L. Taylor, Ph.D.,** Perkins Professor of Physics, are two-fold. First, his work contributes directly to more efficient energy production and conversion by exploring the technical issues and theoretical mechanisms for increased use of highly efficient organic solar cells and the refinement of hydrogen fuel cells. His research team's fuel cell projects are included, for example, in the United States Department of Energy's program to promote hydrogen energy as a viable clean energy choice.

The second aspect of Dr. Taylor's research focuses on how society makes use of energy and, in particular, how society should organize itself to take advantage of the enormous potential of renewable energy sources. The principles of physics inform many of today's difficult societal issues, including energy shortage and climate change. By using these principles to quantify various aspects of such problems, Dr. Taylor has been a trailblazer in encouraging public understanding of the subject. For more than 30 years, he has traveled around the country lecturing on the science of climate change and the threat of increased atmospheric carbon dioxide.

Using the scientific methodology of a physicist, Dr. Taylor's technique is to take a complex problem and extract its essence to the point where a realistic physical model can be formulated, and from which solid predictions can be made. For example, while global climate change makes our summers hotter, the response to buy more air conditioners is an action that will increase the demand for electricity, and perhaps stimulate the construction of yet another coal-fired power station. Subsequently, the resulting greenhouse gases will rise into the stratosphere, add to the thermal blanket engulfing the earth, thus warming the climate further. To break the vicious circle, an increasing fraction of our energy must clearly come from renewable sources. Determining how such cycles are to be averted is the type of problem that Dr. Taylor tries to quantify and solve with the aid of computer models.

Dr. Taylor's belief in photovoltaic solar cells as one of the solutions to counter our society's oil- and coal-based energy dependence is evident on the roof of his own home where solar cells harvest electricity. With just a few more technological advances, he contends, solar cells will fuel our cars, our commerce, and our industries.

http://www.case.edu/nanobook/pages/faculty/ptaylor.htm

Case Western Reserve Receives $3.6 Million for Great Lakes Institute for Energy Innovation

Case Western Reserve's new Great Lakes Institute for Energy Innovation received a large boost with the awarding of a $3.6 million grant from the Cleveland Foundation. The Cleveland Foundation funds will support recruitment of new faculty for the institute. In addition, faculty and researchers at the Institute will also develop outreach programs in science, technology, engineering, and math for Cleveland-area primary and secondary students and teachers.

Based at the Case School of Engineering and building on the University's strengths in fuel cell research and materials science, the new institute will generate and implement achievable solutions today to build and sustain tomorrow's industries through development of innovative energy technology platforms and farsighted energy-research and energy-use strategies. Three major areas of research are envisioned: renewable power, energy storage, and efficiency of larger energy systems. The goal of the institute is aimed at developing economically viable, reliable, and sustainable energy resources for all.

The Institute is already leading the Great Lakes Wind Energy Research Center, a resource for government and industry to innovate, test, and deploy new alternative energy technologies that efficiently and durably harness wind power. In August 2007, Case Western Reserve committed $200,000 to the Board of Commissioners of Cuyahoga County and the county's Great Lakes Energy Development Task Force to partially sponsor a study that would determine the feasibility of developing a wind energy research center on Lake Erie. Currently, Case Western Reserve is working closely with the task force and with other universities, government laboratories, and industry, to conduct the study.

If the study determines it to be feasible, the Great Lakes Wind Energy Research Center—co-managed by the university—would be comprised of two components: an approximately 20-megawatt wind turbine project located in Lake Erie three to six miles from downtown Cleveland and an affiliated research center to facilitate industry testing of next-generation utility-scale wind technologies.

Case Western Reserve Leads Technology Transfer in Ohio

Case Western Reserve led Ohio universities, hospitals, and research institutes by collecting $30.2 million in licensing revenues over the last three years, according to the recently released U.S. Licensing Survey for fiscal year 2006 (the latest statistics available) by the Association of University Technology Managers (AUTM). Case Western Reserve also led the Ohio field last year.

Specific to Ohio colleges and universities participating in the survey, Case Western Reserve ranks:

- Number one in gross licensing income ($10.8 million);
- Number one in cumulative active licenses (160);
- Number one in executed licenses (37); and
- Number two in university-based startups (4).

At the national level, according to the survey, Case Western Reserve continued its successful performance, ranking in the top ten with respect to the other 109 institutions whose research base is $300 million or less:

- Number four in invention disclosures received (174);
- Number five in gross licensing income; and
- Number seven in executed licenses.

And in the top 15 nationally:

- Number 11 in cumulative active licenses;
- Number 13 in licensing revenue as a percentage of research funding (3.72%); and
- Tied for number 14 in startups.

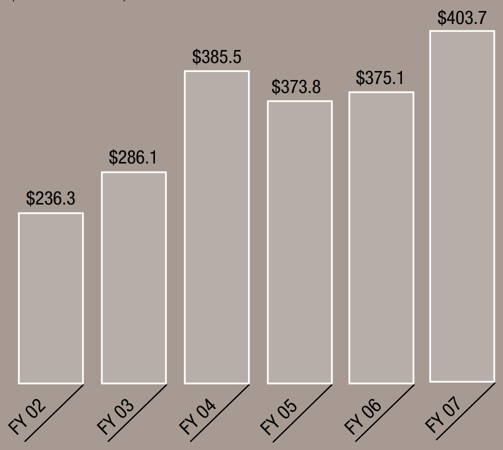
Among Ohio colleges and universities, Case Western Reserve University ranks number one in gross licensing income.

	FY2007 COMPETITIVE SPONSORED PROJECT PROPOSALS *(submitted by school)*	FY2007 AWARDS BY SCHOOL *(dollars in millions)*
Applied Social Sciences	36	$ 5.0
Arts and Sciences	195	16.6
Dental Medicine	18	4.2
Engineering	401	42.1
Law	2	0.6
Management	12	0.8
Medicine	1,354	325.3
Nursing	54	4.7
University General	10	4.4

FY2007 AWARDS BY SPONSOR

	(dollars in millions)	*(percentage of total)*
National Institutes of Health	$273.9	67.8
National Science Foundation	16.4	4.1
Department of Defense	7.3	1.8
National Aeronautics and Space Administration	3.4	1.0
Department of Energy	5.1	1.2
Other Federal Agencies	26.4	6.5
State + Local Government	12.5	3.1
Industry	11.8	2.9
Foundation + Associations + Societies	23.0	5.7
Other	23.9	5.9

FY2002-2007 SPONSORED PROJECT AWARDS
(dollars in millions)

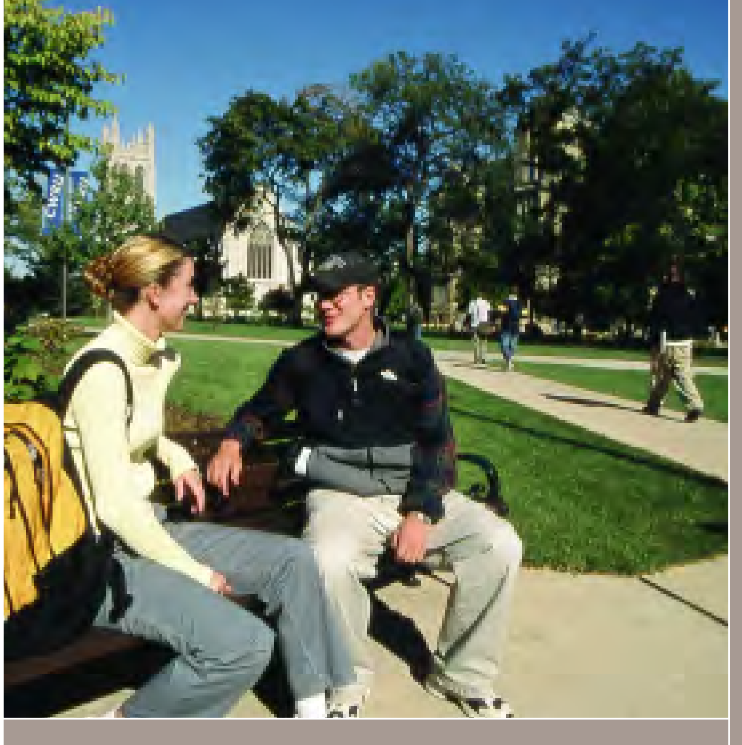


CASE WESTERN RESERVE UNIVERSITY		RANKINGS
AMONG ALL UNIVERSITIES	FY06 Total R+D Expenditures	38th
	FY06 Total Federal R+D Expenditures	24th
AMONG ALL PRIVATE UNIVERSITIES	FY06 Total R+D Expenditures	15th
	FY06 Total Federal R+D Expenditures	12th

Case Western Reserve University at a Glance

Case Western Reserve University is located in Cleveland's University Circle, the one-square mile parkland home of more than 40 cultural, medical, educational, religious, and social service institutions, with an additional 30 institutions nearby. These institutions include The Cleveland Museum of Art, The Cleveland Orchestra, The Cleveland Institute of Music, The Cleveland Institute of Art, The Cleveland Play House, University Hospitals, and Cleveland Clinic, to name a few.

The only independent, research-oriented university in a region bound by Pittsburgh and Rochester on the east, Nashville on the south, and Chicago on the west, Case Western Reserve holds membership in the Association of American Universities, and is fully accredited by the Higher Learning Commission of North Central Association of Colleges and Schools and by several nationally recognized professional accrediting associations.



PRESIDENT
Barbara R. Snyder, J.D.

SCHOOLS + COLLEGE
College of Arts and Sciences
Case School of Engineering
School of Graduate Studies
School of Dental Medicine
School of Law
Weatherhead School of Management
School of Medicine
Frances Payne Bolton School of Nursing
Mandel School of Applied Social Sciences

ENROLLMENT
Undergraduate 4,207
Graduate and Professional 5,637
Total 9,844
States represented 50
Countries represented 78

FACULTY AND STAFF
2,600 full-time faculty; 3,300 full-time staff

ALUMNI
102,300

CAMPUS
150 acres; more than 125 buildings

LIBRARY HOLDINGS
2,518,324 volumes
54,252 serials
2,590,449 microform units

RESEARCH
External awards for research/FY2007
$403.7 million

ENDOWMENT FUNDS
$1.864 billion as of June 30, 2007

TOTAL NET ASSETS
$2.258 billion as of June 30, 2007

FIGURES AS OF FALL, 2007

The Value of Research

Number 5

Produced by the Office of Research and Technology Management in cooperation with the administrative and communications offices of the University's schools, college, and research centers, as well as the mentioned collaborating institutions.

Mark E. Coticchia
Vice President, Research and Technology Management

Eric M. Cottington, Ph.D.
Associate Vice President for Research

Cynthia S. Barker
Director of Communications and Development

Some of the articles contained in this book, or parts of them, were excerpted from or informed by articles and news releases written by Kimberly Bonvissuto, the named researchers, University Marketing and Communications staff, or staff members of individual schools or various departments of Case Western Reserve University. Additional information was derived from articles found in existing University publications.

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