Renewable Energy Research

Science for Sustainability

Tradition of Excellence

Bar-Ilan University

Israel has emerged as a world leader in alternative energy research, with many of its most promising discoveries emanating from laboratories at Bar-Ilan University.

Pictured from left to right:
Dr. David Zitoun
Dr. Gil Goobes
Prof. Yosef Yeshurun

Energy Science for


Sustainability

Auguste Mouchout

Modern activists were not the first to sound the alarm about mankind's dependence on fossil fuels. In the late nineteenth century, Auguste Mouchout – believing that coal was running out – unveiled the first known device that turned solar energy into mechanical steam power. Attached to a refrigerator, Mouchout's invention astounded French society by harnessing the sun's heat to create ice. However, it was soon dismissed as a mere curiosity; coal, and much more of it, was the order of the day.

What a difference a century makes. Today, it is universally understood that reliance on fossil fuel endangers both the environment and human health, and that the development of renewable energy sources is an urgent priority. As a small, resource-poor country with an abundant supply of both brainpower and entrepreneurial spirit, Israel has emerged as a world leader in alternative energy research, with many of its most promising discoveries emanating from laboratories at Bar-Ilan University.

Bar-Ilan is home to an outstanding group of scientists who specialize in renewable energy conversion, storage and management. BIU experts are collaborating with top industrial concerns on new materials and techniques for electric vehicles. A BIU lab recently became the first in the world to characterize an important type of surface interaction on the atomic scale – revealing data relevant to many renewable energy and battery applications. And a BIU discovery that uses advanced materials to protect overloaded electric grids from blackouts was named by General Electric Corporation as one of the top five inventions of 2010, based on its potential to change the face of the global electricity market for the greener.

Through its interdisciplinary initiatives, Bar-Ilan University is advancing the knowledge that leads to new, environmentally-friendly energy sources, and is empowering sustainable economic and industrial growth in Israel and beyond.

Reaping the Solar Harvest

BIU's Prof. Arie Zaban – a multiple patent holder who is an expert in dye-activated nanoparticles for photovoltaic solar energy production – recently reduced costs by designing a quantum-dot-sensitized solar cell (QDSC) that improves charge collection efficiency by 70%. In another study, Zaban – who serves as Head of BINA, Bar-Ilan's Institute of Nanotechnology and Advanced Materials – showed that modifying the configuration of QDSC electrodes can result in a dramatic 600% increase in photovoltaic performance. Other recent projects include a paradigm-breaking dye-sensitized solar call, designed with semiconductor quantum dots that serve as "antennas," as well as a solar cell fabricated inside a glass tube that increases the collection of direct sunlight while decreasing the wind resistance that poses a challenge for conventional cell designs. In his previous work, Zaban demonstrated how metallic wires mounted on conductive glass can form the basis of photovoltaic cells that produce electricity with efficiency similar to that of conventional, silicon-based cells, but are much cheaper to produce. He also created a low-cost technology in which dye-activated semiconductor nanoparticles are arranged in a sponge-like array on flexible plastic sheets.

BIU scientists are making important advances in renewable energy conversion, storage and management.

Silicon is the basis of conventional photovoltaics, and Dr. David Zitoun has created a patented method for producing amorphous silicon nanoparticles which will form the basis of a new, "ink-jet" based method for printing solar cells. In another area of his research, Zitoun creates contaminant-free surfaces for thin films, powders and other manufactured nanomaterials. Employing a "one-step" strategy in which metallic nanoparticles are synthesized directly from precursor

materials bound to silicon, Zitoun's method results in a perfectly clean interface between layers, and may form the basis of new hybrid materials for energy conversion and storage.

The world's most efficient users of solar energy are plants – and that's one of the reasons that Dr. Yaakov Tischler – an expert on light-matter interactions and energy transfer dynamics – is using organic materials to create next-generation nanolasers and high efficiency OLED-based lighting. Tischler's research focuses on the nano-catalytic and nano-fabrication potential of devices in which light is produced by monolayers of fluorescing organic material. Localizing energy into thin films, Tischler plans to take advantage of the resultant super-radiant effects in applications ranging from medical imaging to improved photovoltaics.

Charging Ahead – With Batteries

Prof. Doron Aurbach is a Bar-Ilan alumnus who is best known for the primary role he played in the development of rechargeable lithium batteries – now standard issue in cellphones and computers. Today, he is working on several electrochemical technologies for the storage and conversion of sustainable energy – applications called "load leveling." These include advanced rechargeable Li ion (lithium ion), magnesium batteries – which maintain a high level of safety, can undergo thousands of charge-discharge cycles, and use materials that are abundant in nature. They also demonstrate almost none of the "self-discharge" that causes batteries to weaken over time. Holder of 12 patents related to energy storage, Aurbach was recently named by BASF – one of the world's

leading chemical companies – as one of five founding members of an international research network charged with addressing fundamental questions related to materials, components and systems for electromobility – that is, batteries for electric vehicles – as well as electricity storage. Aurbach also collaborates with DOW Chemicals, General Motors, Merck, and several Israeli firms.

BIU experts are collaborating with top industrial concerns on new materials and techniques for electric vehicles.

Battery performance depends on materials – and designing the right materials depends on gaining a detailed understanding of fundamental processes that occur inside batteries throughout their lifetime. Dr. Gil Goobes uses solid state NMR to examine materials used in cutting-edge lithium batteries. His studies – which resolve the dynamics of lithium ion migration down to the atomic level – help characterize processes associated with material deterioration. By revealing obstacles that impede efficient shuttling of lithium ions inside batteries, Goobes's discoveries are making an important contribution to the design of next-generation lithium battery electrodes.

BIU labs are creating new techniques for transforming plant biomass and industrial waste into useful energy.

In another achievement related to the creation of materials for battery technology, Prof. Moshe Deutsch – an expert in the experimental study of condensed matter by X-Ray and synchrotron radiation techniques – recently became the first in the world to reach atomic-scale resolution in examining the interface between liquid electrolytes and mercury electrodes. Also recently, Prof. Deutsch became the first to determine the atomic-level structure of how a metal in liquid phase orders itself near a solid surface. His current research addresses the nanoscale structure of ionic liquids, a new class of liquids that are being extensively studied because of their potential for use as environmentally-friendly replacements for volatile and toxic fluids currently used in the chemical, pharmaceutical, petrochemical and renewable-energy industries.

Waste Not

If transforming plant biomass and industrial waste into useful energy sounds like a good idea to you, you're in agreement with Prof. Aharon Gedanken. Gedanken is a pioneer of sonochemistry – a discipline in which reactions are accelerated through the application of ultrasonic sound waves. In a series of projects, he has demonstrated how useable biodiesel can be created from materials no one wants, including supermarket oil, and cooked oil discarded by restaurants. Recently, he created a five-minute sonochemistry-based process that transforms micro-algae – tiny organisms which collect as a waste product in pools adjacent to polluting industrial factories – into a "green" form of biodiesel fuel.

Getting It There

One of the biggest challenges in producing energy – whatever the source – is ensuring safe and efficient delivery to the end user. General Electric Corporation recently named a "fault current limiter" created by the group of BIU Prof. Yosef Yeshurun as one of the top five technological breakthroughs of 2010. Yeshurun's self-regulating system – which protects power grids from the surges that can cause blackouts – is based on the special properties of superconductors, materials that, at low temperatures, conduct electricity with virtually no resistance. Rather than relying on circuit breakers – which must be physically closed to reactivate the flow of electricity – Yeshurun's device takes advantage of superconductors' special magnetic properties. When a surge occurs, the magnetic fields inside the device automatically adjust. When the crisis passes, the material's internal magnetic structure – and the flow of electricity – is restored.

A BIU discovery was named one of the top five technological breakthroughs of 2010 by General Electric Corporation.

Fueling Discovery

Bar-Ilan University is a leader in the development of practical, cost-effective technologies for solar energy harvesting, as well as new materials and techniques for renewable energy generation, storage and transfer. By helping to loosen mankind's dangerous dependence on fossil fuels, Bar-Ilan is paving the way toward a more eco-friendly and energy-rich world for generations to come.

For more about the research of BIU faculty listed in this brochure go to: www.biu.ac.il and click Research.

BIU's Engineering Complex with the Dahan Family Unity Park in the foreground

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Bar-Ilan University

Science and Technology

Bar-Ilan University stands at the forefront of cutting-edge research. Bar-Ilan researchers are making breakthroughs that improve life around the globe in areas such as drug-development, nanotechnology, medical research, bio-engineering, microscopy, optics, communications, energy, security, and more. As part of a national program to combat Israel's brain drain, BIU has taken the lead by committing to absorb dozens of returning experimental scientists within its world-class research infrastructure, and has added state-of-the-art physical facilities in engineering, brain sciences and nanotechnology to house these innovative initiatives. The Science and Technology Series highlights some of the University's most exciting research endeavors.

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