

GRAND
TECHNION
ENERGY
PROGRAM

E



Grand Technion
Energy Program
Securing Israel today.
Transforming Israel's tomorrow.



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E

This is the dawn of a new industrial revolution... a global transformation creating cleaner, more sustainable sources of energy to power advanced civilization.

Necessity is the mother of invention - and it is at the world's top institutes of technology where the energy solutions of the future will be conceived.



The Nancy and Stephen Grand Technion Energy Program

Securing Israel today.
Transforming Israel's tomorrow.



MOST WIND ENERGY IS LOCATED AT HIGH ALTITUDES WHERE WIND SPEEDS REACH 160 KM/HR. THE ENERGY AVAILABLE FROM THIS POWER SOURCE AT THE EARTH'S SURFACE IS STILL FAR GREATER THAN OUR TOTAL ENERGY NEED.

WHEN CONSIDERING ENERGY RETURN ON INVESTMENT (EROI), WIND PERFORMS FAR BETTER THAN NEARLY ALL OTHER ENERGY SOURCES. THIS IS A VERY IMPORTANT INDICATOR AS TO THE RELATIVE IMPACT OF THIS ENERGY SOURCE ON THE ENVIRONMENT.

THINK POWER.

WIND IS THE FASTEST GROWING ENERGY SECTOR IN THE WORLD. BY 2006 THE WORLD MARKET FOR WIND REPRESENTED \$23 BILLION ANNUALLY.

WIND IS A FORM OF SOLAR ENERGY. APPROXIMATELY 1-3% OF SOLAR ENERGY ABSORBED BY THE EARTH IS CONVERTED INTO WIND ENERGY. THIS AMOUNT OF ENERGY IS 50-100 TIMES GREATER THAN THE SOLAR ENERGY TRANSFORMED BY PHOTOSYNTHESIS INTO BIOMASS BY ALL OF THE VEGETATION ON EARTH.

IF WE COVERED 0.16% OF THE LAND ON EARTH WITH SOLAR CONVERSION SYSTEMS. WITH JUST 10% EFFICIENCY, WE COULD GENERATE 20 TERAWATTS (1TW = 10¹² WATTS) OF POWER.

ALTERNATIVE ENERGY RESEARCH OFTEN INVOLVES A COMPLEX MULTIDISCIPLINARY APPROACH. FOR EXAMPLE, BUILDING INNOVATIVE WIND TURBINES INVOLVES KNOW-HOW IN AERONAUTICS, MECHANICAL, ELECTRICAL MATERIAL AND CIVIL ENGINEERING AS WELL AS METEOROLOGY AND OTHER SCIENCES.



PETROLEUM POWERED VEHICLES ARE VERY INEFFICIENT. ONLY 20% OF THE ENERGY PRODUCED BY THE FUEL IS SUCCESSFULLY CONVERTED TO USEFUL MOTION.



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ANNUAL CARBON COMPOUND EMISSION (OR GREENHOUSE GASES) EXPECTED TO REACH 9.8 BILLION TONS BY 2020. RESULT: ACCELERATED CLIMATE CHANGE AND LOSS OF BIODIVERSITY.

MORE ENERGY FROM SUNLIGHT STRIKES THE EARTH IN AN HOUR (4.3 X 10²⁰ JOULES) THAN IS CONSUMED ON THE PLANET IN ONE YEAR (4.1 X 10²⁰ JOULES).

GLOBAL ENERGY CONSUMPTION WILL SHIFT AS EARLY AS 10 YEARS FROM NOW FROM SOLIDS TO LIQUID AND GAS BASED FUELS. SUCCESSIVE FUEL SOURCES WILL BE INCREASINGLY DECARBONIZED. THE HYDROGEN TO CARBON RATIO WILL INCREASE.

ISRAEL IS FIRST IN PER CAPITA TRANSFORMATION OF SOLAR ENERGY IN THE WORLD.

THE TRANSPORTATION SECTOR IS ALMOST ENTIRELY DEPENDENT ON PETROLEUM.



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Prof. Gideon Grader, former GTEP Director



Assoc. Prof. Yoed Tsur, GTEP Director, since January 2016

EFFICIENT ENERGIES WILL CHANGE OUR WORLD

The demand for global energy supply is predicted to increase dramatically over the next few decades. Making energy supply secure and sustainable with clean, reliable and inexpensive resources is one of the most important challenges facing humanity today. In an era struggling with compounding factors of rising population, water scarcity, climate change, urbanization and increasing prosperity there is a critical need for energy sciences to deliver innovative solutions and technologies that diversify energy sources.

As the leading energy research and education program in Israel, the Grand Technion Energy Program (GTEP) brings together an exceptional cross-disciplinary community of energy scholars working jointly to come up with applications enabling the effective generation, use and storage of energy. The focus in the upcoming years will be on the effective integration of converging technologies (nano-, bio-, and info-technologies, each of which is progressing at a rapid rate) within energy research.

Since its establishment in 2007, GTEP-led activities have generated significant scientific discoveries and major national initiatives, forged strong industrial and academic collaborations in Israel and with prominent international institutes, and attracted first-rate faculty members and outstanding students from across the country. Today, GTEP is in a position to expand its global activities with leading universities and research institutes through joint research projects, faculty and student exchange, as well as dual-mentor research training programs for international students and postdoctoral scholars.

GTEP welcomes academic and industry collaborators as well as excellent graduate students and postdocs to join its growing community in advancing the frontiers of knowledge and its applications for a better future.

Sincerely,

Associate Professor Yoed Tsur,

Director, Grand Technion Energy Program

“Developing renewable energy sources is key to solving the global energy crisis and an important step in securing a greener and safer planet.”

PROF. GIDEON GRADER,
FORMER GTEP DIRECTOR

“

Israel is seeking to be a world leader in the area of alternative energy. Israel has made it a priority to advance its solar energy production technologies.”

SHIMON PERES, 2006

THINK POWER.

If 10 kilograms of matter spontaneously turned into energy there would be enough energy to power a 100 watt light bulb for 300 million years.

Policy makers, scientists and investors across the planet are awakened to an urgent need to revolutionize the way we generate energy.

Harnessing the ultimate resource of the sun, scientists are pioneering methods for the direct conversion of solar energy to electricity and chemical fuels. Learning to direct and control materials and chemical processes at the quantum level pave the way for essentially new quantum control impacting catalysis,

photochemistry, molecular biology, and device physics that are the foundational pieces in solar energy conversion.

Increased understanding of how biological feedstocks are converted into portable fuels; the way in which energy, entropy, and information are manipulated within the nanosystems of life provides researchers with information on how to develop sophisticated new energy technologies.

POWER OF SCIENCE



“Mass and energy are both but different manifestations of the same thing... very small amounts of mass may be converted into a very large amount of energy.”

ALBERT EINSTEIN
TECHNION FOUNDING FATHER

By designing and perfecting atom- and energy-efficient synthesis, there emerges a paradigm shift in the discovery and design of new chemical assemblies and materials that are mechanically strong; light-weight; and resistant to corrosion, decay, or failure in extreme conditions of temperature, pressure, radiation, or chemical exposures encountered in fission applications.

Addressing fundamental knowledge gaps in energy storage, scientists are developing the basis for effective use of renewable energy such as wind and solar. Similarly, current battery technologies can be taken beyond

their scientific limitations, turning the plug-in hybrid or all-electric cars into a viable and desirable economic alternative.

Through understanding the fundamental rules of correlations and emergence and by gaining mastery at the nanoscale, scientists are blazing the trail to produce phase change materials for thermal energy conversion, strong light-matter interaction and collective charge behavior for light emission nearing theoretical efficiency, and radically different combustion chemistry of alternative fuels.

WHY THINK ENERGY?

The global forecast of the European Renewable Energy Council (EREC) shows that in the year 2040, the part of alternative energies will reach almost half of all energy sources of the world. With this in view, it is clear that research and development is needed in almost all fields of the alternative energy sector.

**WAR, POVERTY, POLLUTION,
ENVIRONMENTAL CATASTROPHE,
ECONOMIC CRISIS OR...**

**WORLD COOPERATION,
CLEAN ENERGIES, STABILITY,
ENVIRONMENTAL HARMONY.**

Alternative fuels such as hydrogen will be derived from readily available feedstocks such as water and biomass and will be harvested through a variety of available technologies such as electrolysis, reforming, gasification and photocatalytic conversion. Weaning ourselves off our dependency on geological deposits will put an end to the age of cartels and geo-political conflicts over energy.

WHY THINK ENERGY?



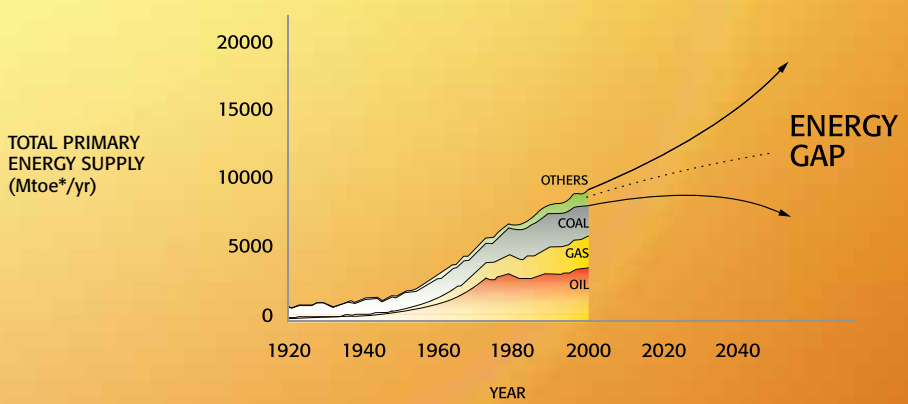
Two hundred years ago, the industrial revolution transformed agriculture, manufacturing, mining, and transport. This was a major turning point in human history. A key generator of change was energy: steam power fuelled by coal, and the use of water wheels and powered machinery caused dramatic increases in production. Around 1850, the second industrial revolution heralded steam-powered ships, railways, and the internal combustion engine and electrical power generation.

With the escalation of high-technology and the evolution of civilization, energy has been called the ultimate resource. Without energy, all the other resources on the planet are unobtainable. Unlike water

or carbon, energy cannot be recycled. With the world population still growing and with ever increasing demands for energy, energy supplies become connected with the survival of nations, life-styles and with civilization itself.

Today's status quo on energy is unsustainable. About 90% of the world's energy comes from the fossil fuels which are finite... they will run out. Oil and gas reserves could be gone within a few generations. Coal could last longer but its use could have created unprecedented changes in global climate. Nuclear power takes too long to install, and involves unresolved political issues.

THE GLOBAL ENERGY PROBLEM UNRESOLVED DILEMMA OF INDUSTRIALISED SOCIETY

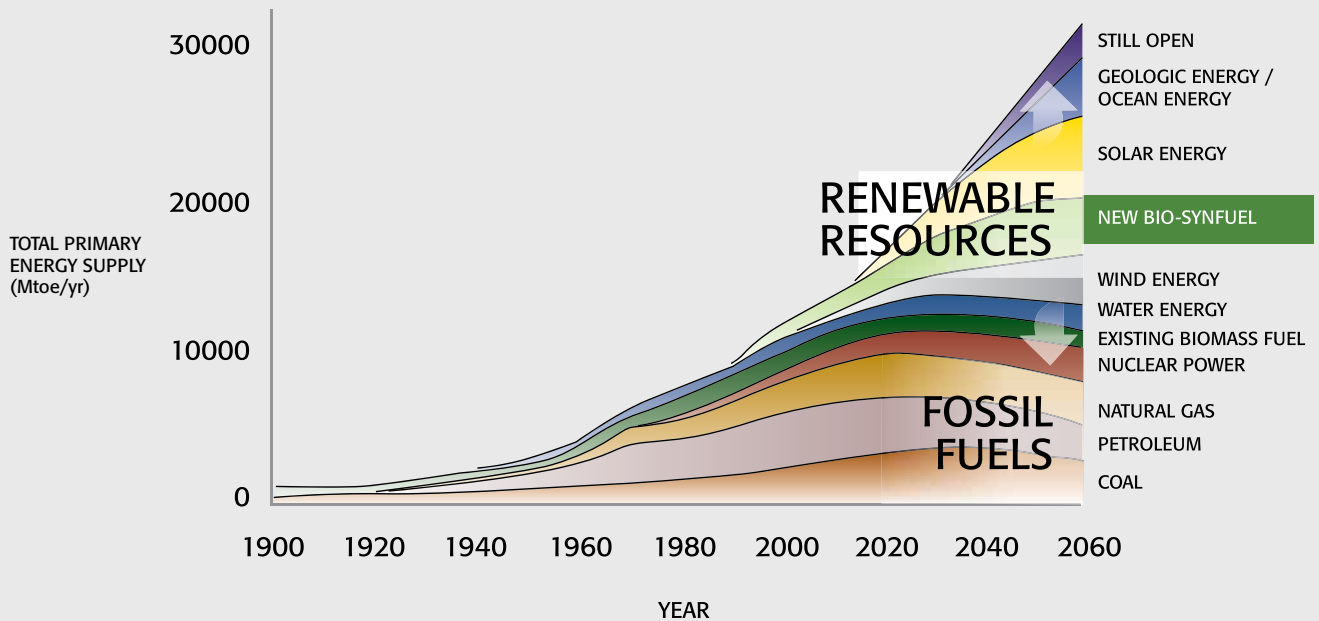


*Million Tons of Oil Equivalent
Source: BP Statistical Review of World Energy; LBST, www.lbst.de

WHY THINK ENERGY?

BRIDGING THE GAP

GLOBAL ENERGY CONSUMPTION: 1960-2060



“If we could cross the oceans, fly the skies, and reach the moon, we should be able to harness water, wind and sun to power our world.”

BINYAMIN NETANYAHU
PRIME MINISTER OF ISRAEL

Predictions of the energy portfolio in year 2060 show that two thirds of the global energy budget should come from renewable resources.

Environmental damage, both local and global, such as global warming, damage to flora and fauna, and health damages to humans all underscore the need for cleaner energies.

There is no doubt that research and development will not be possible without the inspiration and effort of individual gifted scientists who have the determination and brainpower to uncover new possibilities through basic research. Places like the Technion - with its powerful integration of basic and applied research and engineering are perfectly positioned to be a major generator of global energy transformation.

WHY ISRAEL?

WHY ISRAEL?

Renewable energy is not a choice.
There is no choice. It is our future.

Israel is an international power-center for global problem solving.

The art of survival. For Israelis, every challenge is an impetus for creative vision, original solutions driven by pure brainpower, and powerful, world-changing application. In the fast lane of anticipating global threats, Israeli scientists, entrepreneurs and decision makers are already focusing together on powerful expert strategies to stay ahead of any future energy crisis. Israel has a fundamental national interest in developing alternative energy resources. As one of the few non-oil producing countries in the Middle East, its security situation

makes energy independence a matter of survival.

Imagine air conditioning powered by the sun and genetically modified plants for efficient biofuels. Imagine futuristic, elegant solar panels that incorporate nanotechnology and stronger, longer lasting batteries. Scientists believe that new energy sources could have a transformational effect as great as that of the industrial revolution. Pioneering Israeli scientists are on the frontlines of research to manifest the promise of the world's future energy sources.

WHY ISRAEL?

“ISRAEL’S NEW MARKET IS NOT CHINA OR INDIA BUT ALTERNATE ENERGY! THIS IS THE NEXT PLACE WHERE ISRAEL HAS INNOVATIVE ADVANTAGE. SPEED! FLEXIBILITY! **IF THERE IS ONE AREA READY FOR LEADERSHIP, THIS IS IT! THIS CAN BE THE NEXT GROWTH ENGINE, INFINITE IN ITS POTENTIAL SIZE. IT IS A NEW WORLD. WE MUST CREATE A WHOLE SUPPORT SYSTEM.**”

ERAN GOREN, FOUNDER, NESUA ZANEX INVESTMENTS



WHY ISRAEL?



Israel has the most scientists and engineers in the world per capita. With the highest number of academics per square meter, Israel is the world's most concentrated and accessible resource of advanced skills. Among the world's top seven countries for patents per capita, Israel has a powerful record of innovation: playing central roles in every technology revolution - from medicine, communications and software to nanotechnology.

With scarce resources, existential threats, a need for independence, and a culture of applying ingenuity to guarantee security, Israel has long been investigating alternative energy. Even before its birth in 1948, Israel has been engineering, researching, developing and commercializing products to mitigate energy, water and environmental problems.

The politics of oil in the Middle East has frequently brought Israel into war situations, such as the Gulf War of 1991.

After the government decreed that all new buildings install rooftop solar water heaters, multiple companies were created to sell to the market. Installation of these solar water heaters has saved about 3% of overall energy usage annually and made Israel a world-leader in solar water heaters, with installations in 75% of households.

Israel has a history of innovative and entrepreneurial individuals who can creatively solve energy crisis issues. Many of them are experienced and successful entrepreneurs from the high-tech sectors and are ready to apply the knowledge and lessons they have learned to the cleantech field. There is wide government support for new technologies to solve Israel's

water and energy problems, and robust cleantech-related research in Israel's public universities and research institutions.

Israel has the history, the entrepreneurs, the expertise, and the cooperation of universities, government and private interests necessary to make it a leading creator of alternative energy technologies.

THINK POWER.

Israel has the most scientists and engineers in the world per capita. With the highest number of academics per square meter, Israel is the world's most concentrated and accessible resource of advanced skills.

A man with glasses, wearing a blue and black jacket, is smiling and looking towards the camera. He is sitting at a table with his hands clasped. In the background, there is a complex piece of laboratory machinery with various pipes and components. The overall setting is a laboratory or industrial environment.

WHY TECHNION?

Associate Professor Avner Rothschild of the Faculty of Materials Engineering is working on new ways of using sunlight to efficiently split water into hydrogen and oxygen. Assoc. Prof. Rothschild is also working on a promising idea to reduce carbon dioxide, emitted in combustion processes such as that of power plants, and convert it with solar energy back into fuel.

WHY TECHNION?

Leaders in Energy Science

Recruitment of first-rate new faculty members in energy-related fields is a top GTEP priority. Its existing powerful base of expertise combined with state-of-the-art research facilities is already making Technion an attractive first choice research location for excellent scholars. GTEP's close contacts with national and international high-tech industries is an added incentive to researchers motivated by the desire to help create the powerful energy solutions of tomorrow. *See page 27.*

As a world-class institute of technology, Technion is a central station of scientific collaboration, drawing experts from across the globe. Empowered by a penchant for survival through applied brainpower, Technion scientists show the flexibility, creativity and innovation that will make scientific understandings about energy an applied new reality.

As guardians of over two-thirds of Israel's technological leaders, the

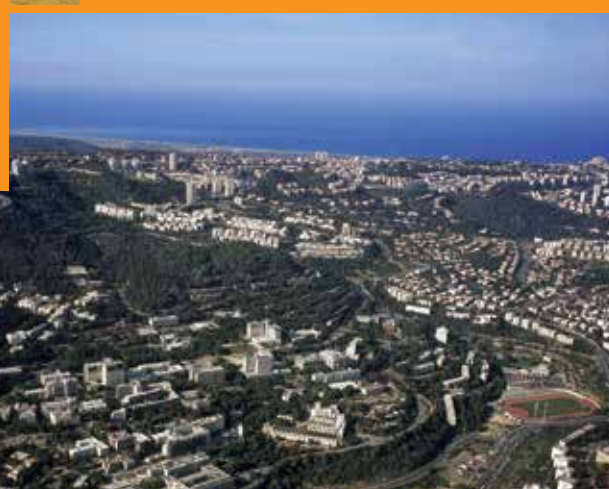
pioneering skills and technology transferred to Technion students today will empower the energy industries of tomorrow.

Facilitating intense cooperation between faculties, Technion is a brainstormer's power house, combining multidisciplinary expertise with the energy for application to create real change. Technion has strong bonds with high-tech industries across the world, an exchange which gives direction to pure research, bringing targeted solutions at the frontiers of new technology. Its powerful basis in engineering means that energy research can integrate nano-scale revelations with large-scale mechanical application.

Technion infrastructure, faculty and multidisciplinary centers are ranked among the best in the world and it is a dynamo of international outreach and cooperation.



Former graduate student Dahvyd Wing came to Technion from Caltech to pursue the creation of polymer or organic solar cells – using a polymer-metal oxide. His ambition is to create Hybrid Polymer Metal Oxide Photovoltaic Cells whose higher conductivity means they can harness the energy of the sun far more efficiently.



**THINKING POWER
IS THINKING ABOUT
THE CHALLENGES
THAT FACE THE NEXT
GENERATION**





HOW DO WE TRANSFORM OUR ECONOMIC MODEL TO EMBRACE ALTERNATIVE ENERGIES?





Technion students graduate with a wide range of integrated skills in the energy science and technology of tomorrow.


ENVIRONMENTAL DAMAGE,
BOTH LOCAL AND GLOBAL,
SUCH AS GLOBAL WARMING,
DAMAGE TO FLORA AND
FAUNA, AND HEALTH
DAMAGE TO HUMANS ALL
UNDERScore THE NEED
FOR CLEANER ENERGIES.



**INVESTMENTS IN R&D OF
ALTERNATIVE ENERGIES
IS EXPECTED TO GIVE
RETURNS OF \$50 FOR
EVERY INVESTMENT OF \$1.**



THE ENERGY GENERATION



Technion is empowering future generations of students through the GTEP graduate program in energy studies. Multidisciplinary skills and a flair for integration and cooperation makes the education of students in energy science and engineering a national priority.

The Interdisciplinary GTEP Graduate Study Program

The potential effects of new energy technologies are revolutionary, but as knowledge accumulates, challenges multiply even faster. Solutions depend upon unprecedented integration of tools and concepts originating from a wide range of science and engineering fields.

In order to train the next generation of researchers and engineers, the Technion has established an interdisciplinary graduate study program under the auspices of GTEP. This program provides the wide-ranging education necessary to discover the next generation of energy solutions. GTEP provides an environment conducive to interdisciplinary research, the resources necessary to recruit and retain the best minds, which together will generate unparalleled cross-fertilization in a stimulating environment.

The Technion is uniquely suited to carry out this initiative because it has all the individual components required for success: strong engineering and basic science faculties – including Aerospace, Biomedical, Biotechnology and Food, Chemical, Civil and Environmental, Electrical, Materials and Mechanical Engineering, as well as Architecture & Town Planning, Chemistry, Biology and Physics.

GTEP cooperates with leading international universities on student exchange programs in the field of energy. The idea is to enable students to benefit from the developments and advances in other countries.

Managed by an interdisciplinary committee for graduate studies in energy, the GTEP Graduate Study Program attracts excellent graduates in science and engineering who are eager to develop

expertise, and provide them with the necessary infrastructure and research framework. The students are required to carry out a research project under the guidance of professors from different disciplines.

Tomorrow's energy researchers and engineers will need to be educated in all classical science and engineering subjects, as well as know-how in economics

and policy. Thus, the study program will produce scientists, engineers and researchers with a better understanding of all energy-related issues.

Graduate MSc students with an outstanding academic track record are encouraged to pursue a direct PhD study program.

MSc in Energy Engineering
MSc in Energy
PhD Program





THE GLOBAL WIND ENERGY INDUSTRY IS BOOMING.

CONSUMPTION MORE THAN QUADRUPLED BETWEEN 2000 AND 2006. AT THIS GROWTH RATE, INDUSTRY EXPERTS PREDICT THAT BY 2050 THE ANSWER TO ONE TENTH OF OUR ENERGY NEEDS WILL LITERALLY BE FOUND BLOWING IN THE WIND.



Viable, cost-effective energy generated by the power of the wind can already be felt from the north of Israel as faculty member Associate Professor David Greenblat sets up his revolutionary 175 m² wind tunnel laboratory at the Faculty of Mechanical Engineering. With a background in aerodynamics and patents for industrial fans under his belt, Greenblatt is well set to fix the problems of friction, performance and shelf-life involved in harnessing the awesome power of the wind.

“

As yet, the wind is an untamed, and unharnessed force; and quite possibly one of the greatest discoveries hereafter to be made, will be the taming, and harnessing of it.”

ABRAHAM LINCOLN, APRIL 6, 1858

GTEP

The Nancy and Stephen Grand Technion Energy Program The Ultimate Resource



Nancy and Stephen Grand
together with former GTEP Director,
Prof. Gideon Grader

It is well known that economic development requires affordable, reliable energy sources, and that the demand for power is growing exponentially. An energy shortage or supply cut-off can be catastrophic, and Israel's security situation makes energy independence a matter of survival. Innovative technology is needed to promote growth while reducing pollution.

Since its opening in 1924, the Technion has been the engine driving the Israeli economy. Its graduates built the infrastructure and devised innovative solutions to the extensive problems faced by a tiny new-born country with few natural resources except brainpower.

Industry leaders are very interested in replacing dirty, wasteful fuels with cheaper, more efficient, cleaner energy sources to reduce energy losses at every stage from production to the end user. These leaders appreciate the importance of supporting research and development in an academic setting, which is the only environment where there is a clear chain from basic research through to application.

The Technion has long been active in the fields of energy conservation and energy production, developing ingenious solutions that will improve the quality of life in Israel and throughout the world. The establishment of the Grand Technion Energy Program (GTEP) is bringing this

research together to empower national and international multidisciplinary collaboration. In addition to physical infrastructure, GTEP provides the essential structure for data sharing, seminars, conferences and industrial collaboration.

Creativity and innovation cannot be taught or purchased, but an environment conducive to their growth can be created. Technion's experience in multidisciplinary science has shown the powerful difference made where individual scientists studying different aspects of a problem are brought together in a targeted center. The Technion is allocating facilities for GTEP to set up infrastructure centers which will function as national facilities, as well as to upgrade existing laboratories. Bringing together researchers with highly specialized expertise in different fields, GTEP is creating the ultimate environment for integrated energy research.

FROM THE TECHNION PRESIDENT & GTEP DIRECTOR



Prof. Peretz Lavie
Technion President



Assoc. Prof. Yoed Tsur
GTEP Director

THINK POWER.

World energy consumption should increase by 50 percent between 2005 and 2030, “driven by robust economic growth and expanding populations in the world’s developing countries,” according to the latest projections from the US Department of Energy.



A key priority is to attract first-rate new faculty members in energy-related fields, and the planned state-of-the-art research facilities and conditions will make the Technion a very attractive first-choice for scholars. The Technion’s intimate contacts with Israel’s high-tech industry mean that new discoveries are quickly put to work. This is a major incentive to researchers who are motivated by the desire to make a real difference.

The effort to bring the scientific solutions to transform our energy use of the future is not a choice. It is a commandment. As one of the world’s leading institutes of technology, where basic research exists dynamically alongside applied research and commercial expertise, Technion sees research in the field of energy as a central responsibility, locally, nationally, and globally. Join us in creating the environment that will empower the research and development that will make a tremendous difference to the future of us all.

Prof. Peretz Lavie
Technion President

Assoc. Prof. Yoed Tsur
Director, Grand Technion Energy Program

A FUTURE

Powered by

THE GRAND TECHNION ENERGY PROGRAM

GTEP FACULTIES:

Aerospace Engineering

Architecture and
Town Planning

Biology

Biomedical Engineering

Biotechnology and
Food Engineering

Chemical Engineering

Chemistry

Civil and Environmental
Engineering

Electrical Engineering

Materials Engineering

Mechanical Engineering

Physics

Energy is so broad and so essential, that the scientific response to a pending energy crisis is equally broad and essential.

GTEP unites expertise from across the faculties to tackle energy issues at one multidisciplinary program. It is combining conservation, the development of renewable energy sources, and the improvement of efficiency of combustion technologies and buildings that consume energy.

Earth abounds in energy and water – the vital resources for human survival and development. The sun provides orders of magnitude more energy to Earth than humans could possibly use, and water, wind, and biofuels can be harnessed to serve us all. Seawater can be desalinated and made fit to drink. The challenge is to develop innovative, efficient, economical, and clean methods to deliver energy where it is needed, when it is needed.

The Technion is carrying out vital work on both energy conservation and energy production, developing ingenious solutions that will improve the quality of life in Israel and throughout the world. GTEP is bringing these research efforts together under one umbrella so that researchers who are approaching similar problems from different perspectives will be able to carry out multidisciplinary collaboration on the local and international levels, sharing both ideas and expensive research tools. In addition to physical infrastructure, the program provides the necessary administrative framework for a website and e-mail forum, data sharing, seminars, conferences, visiting lecturers, and publicity for energy research activities, putting the Technion on the map and promoting increased participation in and financial support for this vital field.

THE FOUR POLES OF RESEARCH

THE GTEP POWER AGENDA

I. Alternative fuels

- Non-carbon fuels
- Biomass-based fuels
- Hydrogen technology

II. Energy storage and conversion

- Energy storage
- Fuel cell technologies

III. Renewable energy

- Photovoltaics
- Wind power
- Solar thermal energy
- Optics and light manipulation

IV. Energy conservation

- Energy saving measures
- Efficient buildings
- Smart grids

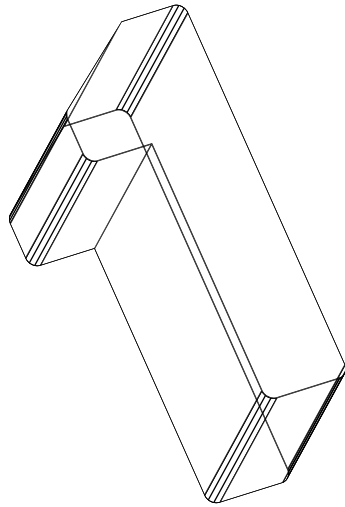
Leaders in Energy Science

The Technion's Leaders in Energy Science Program will play a critical role in enabling the Technion to attract first-rate future leaders in energy research by offering them the best physical facilities, up-to-date equipment, technical support, and the necessary resources to carry out their research. Providing conditions that facilitate groundbreaking research at the Technion is now more important than ever. Exceptional faculty members also serve as a magnet to continue attracting other outstanding lecturers and top-level students. These researchers must receive whatever support is necessary to conduct their pioneering work and contribute to maintaining the Technion's tradition of excellence.

The Technion's Leaders in the Energy Science Program will make the Technion a very attractive first choice research location for excellent scholars. The Technion's exceptionally close contacts with Israel's flourishing high-tech industries means that new discoveries and technologies can be rapidly translated into products and treatments that will improve quality of life worldwide. This is a major incentive to researchers who are motivated by the desire to make the world a safer, healthier place. Furthermore, the unique synergy between the Technion and Israeli high-tech industries will continue to play an important role in ensuring Israel's security and economic growth. Creating the proper environment for innovation at the Technion will help create jobs throughout Israel.



POWER



Hydrogen has superior “energy content” to all other fuels (120 MJ/kg) and is the most abundant element in the universe. We need not be concerned about scarcity.

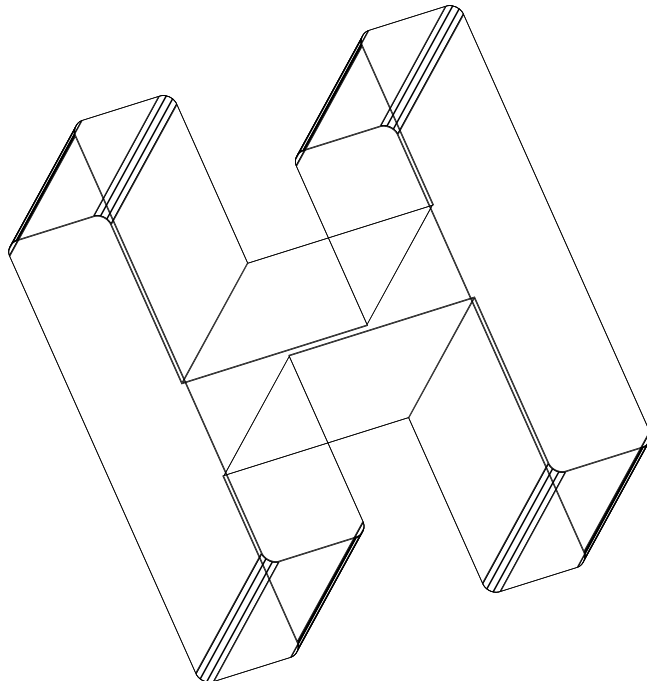
1.

HIDDEN POWERS

Alternative fuels

**THINK
POWER.**

Today, about 90% of vehicular fuel needs are met by oil. Petroleum’s worth as a portable, dense energy source powering the vast majority of vehicles and as the base of many industrial chemicals makes it one of the world’s most important commodities.



THE FOUR POLES OF RESEARCH:

Alternative fuels

“

“This economic crisis must mark the beginning of a new sustainable development path that has been long overdue. Solar power needs big investments to expand and create significant effects. For the 2 billion people currently living without electricity, the sun is the best hope.”

MIKHAIL GORBACHEV, former President of the USSR, Technion Harvey Prize Laureate and Founder of the International Green Cross movement

“

The energy crisis is a global problem... one key way to solve this problem is to reduce global dependence on fossil fuels in general and petroleum in particular.”

PROF. GIDEON GRADER, former GTEP Director

When renewable electricity becomes available, it must be stored as a transportable fuel. Conversion of water into H₂ by electrolysis is possible but transport of pure H₂ as a fuel is not practical. Conversion of the H₂ into a transportable non-carbon fuel is a challenging, high-impact proposition. Just imagine a fuel that emits nitrogen and water.

Hydrogen Hiatus

Hydrogen is a clean and potentially abundant alternative to fossil fuels. Its use could lead to the energy independence and security of many nations.

Led by chemical engineer Prof. Moshe Sheintuch, a GTEP team is researching ways to reform hydrocarbons for hydrogen generation from natural gas - a natural resource found in Israel. Using efficient energy-coupling technologies along with membranes to achieve high-purity hydrogen, this approach could bypass hydrogen distribution problems by generating hydrogen in situ on demand from safely transportable fuels. For example, the process could be used in a car, exploiting both the current low price of natural gas compared to liquid fuels, and the high efficiency of fuel cells.

Split 4 Power

Photoelectrochemical cells (PECs) can split water into H₂ and O₂, and thereby promise renewable, clean production of hydrogen from sunlight. PECs involve great challenges in tuning the photoelectrode electrical and optical properties to optimally balance the requirement for stability against (*photo*) corrosion on the one hand, and efficient solar energy harvesting on the other. Technion researchers propose several innovative strategies that will advance the science of photoelectrochemistry and bring water splitting closer to technological realization. They are exploring new materials and developing advanced PEC schemes designed to achieve high photoconversion efficiencies, using highly innovative approaches: (*a*) advanced nanostructures; (*b*) innovative semiconductors; and (*c*) fundamental studies on model systems. The most successful materials will be used to model and construct test devices.



Assoc. Prof. Avner Rothschild
Materials Engineering



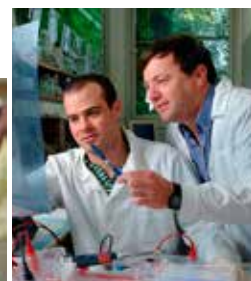
Prof. Yuval Shoham
Biotechnology &
Food Engineering



Prof. Gideon Grader
Chemical Engineering



Prof. Shimon Gepstein
Biology



Prof. Gadi Schuster
Biology

Sun + Sea = Hydrogen Power

At the Faculty of Materials Engineering, Assoc. Prof. Avner Rothschild and his team are part of a large European collaborative project looking to split water into hydrogen and oxygen using the energy of the sun - thus initiating a 100 percent clean fuel.

Efficiency, says the self-described idealist-realist, is very low. Splitting water is not easy. It can be done with electrolysis but this expensive process at best achieves 70 percent efficiency. Solar energy is free, but efficiency drops to 14-18 percent and systems last no more than 1-2 hours before corroding. Stable systems have only an efficiency of 1-2 percent. "The process is possible - it works - but the problem is the cost," says Rothschild, who sees the solution in the development of new electro-ceramic materials. "We are aiming at 5,000 hours survival at 10% efficiency. The material we're looking at doesn't involve rare elements - we are checking iron, copper and titanium for example. They are all abundant and cheap."

In the Can

At the Faculty of Aerospace Engineering, Prof. Alon Gany and his research team canned an innovative method for self-sustained reaction of powdered aluminum and water to produce hydrogen. Initial experiments have revealed that a fast, self-sustained, complete reaction of the activated aluminum with water can take place at room temperature. This method has been tested systematically revealing 100 percent yield of the reaction. The reaction rate may be controlled by the aluminum particle size, water temperature, metal activation conditions, and metal/water mass ratio. "Our invention consists of original chemical treatment and activation of aluminum powders," explain the researchers. Applications include fuel cells and power generation on Earth, Sea, Air and Space; energy storage for emergency power generation, battery replacement; and direct automotive and marine propulsion.

Former GTEP Director, Prof. Gideon Grader of the Wolfson Faculty of Chemical Engineering is coordinating a research project into methods to combine hydrogen into a more energy dense fuel that is not prone to explosion, is easily liquefied, and safer to transport and store. Substances investigated include fertilizer materials based on nitrogen and hydrogen compounds - such as urea and different ammonia derivatives. The main challenge in this research is finding the way to convert such Nitrogen Hydrogen Alternative Fuels (NHAf) in an efficient, controllable and clean fashion. Developing the technology for harnessing this energy is a new wide open field that can potentially change global energy usage.

THE FOUR POLES OF RESEARCH: Alternative fuels

The Hydrogen challenge:

To date, the storage and transportation of Hydrogen are costly, dangerous, inefficient and impractical due to the low energy density of this extremely light element.



THINK POWER.

How will
energy
markets

deal with the current credit crunch and how will current economic instability effect these markets? Are we heading for supply crunch? How will new "clean energy" systems be financed?

Plant Power

"Our goal is to develop a platform technology for conferring new genetic traits to crop plants; such crop plants should provide a net energy gain, have environmental benefits, be economically competitive, and be producible in large quantities for biofuel production without reducing food supplies."

It makes sense and has been done since antiquity: the burning of wood, animal fat and plant oil to generate heat and light. The scientific challenge today is to get the right plants involved in the right processes to empower our world on an even grander scale.

The GTEP group on biomass-based fuels coordinated by Prof. Yuval Shoham of the Faculty of Biotechnology and Food Engineering is applying ancient energy wisdom to modern industrial processes. The goal is an industrial process that converts foliage and agricultural refuse into easily transportable fuels such

as ethanol or methanol as shown by Prof. Shimon Gepstein's team in the Faculty of Biology. New technologies able to increase the biomass of plants - especially those grown under harsh conditions such as in the developing world. Genetic engineering is used to develop a platform technology for conferring new genetic traits to plants that can be grown on marginal lands with minimal water supply.

"Right now, the only way to use this agricultural waste is to burn it, which is very unclean," says former GTEP leader Prof. Grader, "Can you take it and convert it cleanly to a liquid fuel such as alcohol? Many experts are working on the problem."



2.

POWER 2 GO

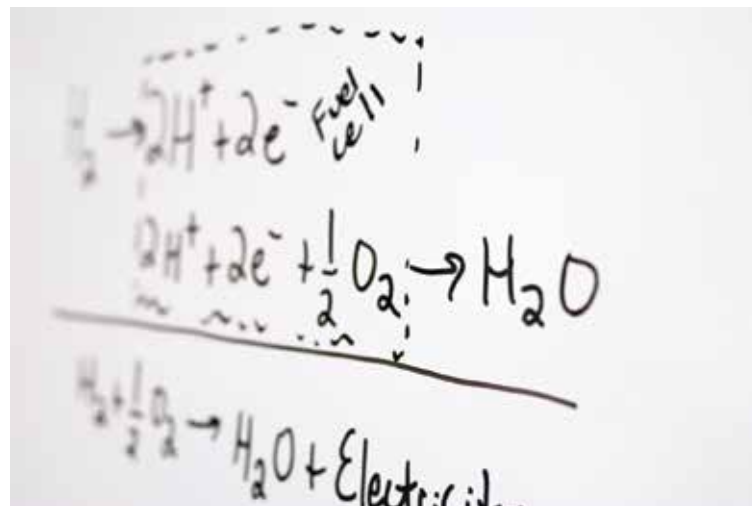
Energy Storage & Conversion

THINK POWER.

A fuel cell is an electrochemical cell that converts a source fuel

into an electrical current. It generates electricity inside a cell through reactions between a fuel and an oxidant, triggered in the presence of an electrolyte.

By contrast, batteries store electrical energy chemically and hence represent a thermodynamically closed system.



THE FOUR POLES OF RESEARCH:

Energy Storage & Conversion

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“We can create very lightweight batteries with infinite shelf life and high energy capacity...”

PROF. YAIR EIN-ELI

The development of practical proton exchange membrane fuel cells (PEMFCs) is particularly promising for the automotive industry. Solid Oxide Fuel Cells (SOFCs) are promising for small-and-large scale stationary applications.

Fuels of the Future

Technion researchers are working on improved ways to safely and efficiently generate clean energy on demand.

Fuel cells are electrochemical devices that convert the chemical energy of a reaction between fuels and oxidants directly into electrical energy, and continue producing energy as long as the fuel and air are supplied. Fuel cells have many unique advantages over other methods of power generation: they are highly efficient, clean and silent, in addition to being easy to maintain. They can be scaled for use in a wide variety of applications ranging from personal electronic devices to industrial-scale power plants. The heat generated by larger fuel cells can be used as an additional energy source or to heat water and buildings in both residential and industrial applications.

With oil prices and environmental concerns on the rise, fuel cells using elements such as hydrogen can become a competitive and more widely used energy source for both vehicles and stationary generators - but some significant technological obstacles remain. Hydrogen, for example, must be stored in heavy canisters, cutting its efficiency in car engines.

Technion researchers, under the coordination of GTEP Director, Prof. Yoed Tsur, from the Wolfson Faculty of Chemical Engineering, are working to make fuel cells more potent, practical and economical in the hopes of making their application more widespread.

Joining Assoc. Prof. Tsur in this research are world leading experts such as Prof. Yair Ein-Eli from the Faculty of Materials Engineering, who is working on novel polymer electrolytes and water management in fuel cells, as well as advanced materials to improve the storage of solar power and its release as electricity.

A new generation of porous materials that are lighter and more versatile could have a wide range of applications in fuel-cell technology. A new PolyHIPE substance (polymers based upon high internal phase emulsions) is being developed by Materials Engineering Prof. Michael Silverstein.

A new type of fuel cell invented by Assoc. Prof. Tsur, is being developed by his group in the Wolfson Faculty of Chemical Engineering.



Prof. Yair Ein-Eli
Materials Engineering



Assoc. Prof. Yoed Tsur
Chemical Engineering

THINK POWER.

There are two
main forms
of energy:

potential and kinetic.

Potential energy is energy
that is stored, while kinetic
energy is energy in use.

Battery Beyond

Prof. Yair Ein-Eli won world attention with a new Israeli battery based on silicon and air that provides thousands of hours of power. The portable electrochemical battery could soon replace expensive regular or rechargeable batteries in hearing aids and sensors and eventually in cell phones, laptop computers and even electric cars. The unique battery is based on silicon as a fuel that reverts to its original sand. The battery can also be left on the shelf for years and inserted into a device to provide immediate power.

In collaboration with Prof. Digby Macdonald of Pennsylvania State

University in the US and Prof. Rika Hagiwara of Kyoto University in Japan, Prof. Yair Ein-Eli spent over a decade investigating silicon in all aspects and the possibility of its serving as the major component of a highly efficient and environmentally friendly battery.

Ordinary portable batteries are composed of a positive electrode called a cathode and a negative one called an anode. They are separated by material containing ions (electrolytes in a liquid form). Some metal-air batteries exist, such as those using lithium, and are cheaper and lighter because they lack a cathode structure. Many of the world's largest tech companies are collaborating

GTEP's research and development efforts in the field of energy storage range from batteries to fuel cells and capacitors, and from developing advanced cathode materials in lithium and lithium metal batteries via a novel fuel cell based on silicon anode, to high-surface area carbon materials to be used in novel ultra capacitors.

THE FOUR POLES OF RESEARCH:

Energy Storage & Conversion

The density challenge:

One of the important Technion research goals is to increase the energy density of Li-ion batteries by at least a factor of five. We plan to achieve this goal using metal-air battery technology.

Worldwide demand for high energy density batteries and portable power supplies is growing steeply.

with research universities to develop rechargeable lithium-air batteries that could function 10 times longer than conventional batteries, but with no outstanding success to date.

The ionic liquid developed a decade ago in Japan is the perfect substance for this purpose, Ein-Eli explains. In such electrolytes, the highly doped silicon - a semi-conductor - is activated and acts as a highly metallized conductor. "We bought ready-made flat metallized silicon wafers, which serve as the anode. There is no corrosion or evaporation with the ionic liquid, and unlike conventional batteries, the silicon-air battery does not absorb water from the outside."

In the GTEP battery, oxygen from the air in the battery capsule passes through a membrane and interacts with oxidized silicon, which is inert, stable, lightweight and nontoxic, has a high-energy content and can be used later as a building

material. Most computer chips are also made from silicon. The new invention is not rechargeable, but it can supply power for thousands of hours, said Ein-Eli. The battery ranges from one square centimeter - small enough for hearing aids and much more efficient than the highly expensive, short-lasting lithium ones used now - to several square centimeters.

In another year, the power output can be significantly increased, and in three or four years, says Ein-Eli, it could be made rechargeable as well. "Think of an electric car battery made from silicon that will turn into sand that would be recycled into silicon and then into power again. This would take about 10 years more and be revolutionary. It could be used in any portable electronic device or be integrated with solar or wind power as well as electric energy."

A number of foreign and Israeli companies have shown strong interest

in the battery, he says, "The system is highly promising, as it is capable of out-performing other existing metal-air battery technologies."

The Si-air Battery Invented at Technion

The Si-air battery developed at the Technion is a new kind of portable electrochemical battery that can produce thousands of hours of power. It is expected to replace more expensive batteries used for hearing aids and sensors and will eventually power mobile phones, laptops and potentially, electric cars etc. etc.



3.

POWERS THAT BE

Renewable Energy

Sources

**THINK
POWER.**

According to 2008 statistics, 32% of all the world's crude oil production came from the Middle East while OECD countries including the US, Canada and Europe counted for less than 22% of world crude oil production. By contrast, OECD countries counted for over 42% of all hydroelectric production worldwide.

Source: International Energy Agency Report 2009

THE FOUR POLES OF RESEARCH: Renewable Energy Sources

Solar energy is abundant, while fossil fuels are limited in supply.”

“

“If we make this technology work, people will be able to use solar air conditioning in the middle of the day, during hours of peak demand for AC.”



Sun Science

Israel has the highest per capita use of solar energy worldwide. Most of this solar energy is used for domestic water heating, but innovative technology from the nano-scale through to applied engineering has a tremendous potential to revolutionize our use of solar power.

Sun Power Can Cool

Solar-thermal energy can be used to produce electricity and to heat, cool or regulate temperature and humidity in office complexes. “Solar energy is abundant, while fossil fuels are limited in supply,” says Gershon Grossman, professor in the Faculty of Mechanical Engineering who holds the Sherman-Gilbert Chair in Solar Energy. Through GTEP, Prof. Grossman is seeking ways to improve techniques for solar AC (air conditioning), using solar energy to dehumidify the air.

Back in 1980, Grossman was part of a team that pioneered one of the biggest

solar AC projects in the world at Tel Hashomer Medical Center. There are two basic functions of AC: one is to cool the temperature and the other is to lower the humidity. Typically, the consumer is not given separate control over these two factors, and in humid climates, such as Florida or Israel’s Coastal Plain, reducing the humidity is more important. “If we make this technology work, people will be able to use solar air conditioning in the middle of the day, during hours of peak demand for AC,” says Grossman.

Solar Balloons

Technion graduate Dr. Joseph Cory is floating an intriguing idea: small lightweight balloons with a thin coating of photovoltaic cells. The balloons are tethered to the ground via one line to send helium up and another to pass the gathered solar power down. One or two of these floating disks might meet a household’s complete electric needs, while larger buildings or municipal

facilities could float numerous vertical cables with balloons stacked every few feet. Cory and his Technion aerospace engineering research partner Assoc. Prof. Pini Gurfil also envision bringing much-needed power to impoverished regions far from power lines. And unlike a big, noisy power plant, “They have no negative effect on the environment at all,” says Cory, a professional architect. Prototypes of various sizes are now being tested. Solar energy cell coated helium balloons can generate and harness energy.

Nano Power

Nano scientists are making breakthroughs with new energy in mind; just as energy scientists frequently turn to nano to engineer the substances and materials they need to repower our world. As a result, cooperation between the Technion’s Russell Berrie Nanotechnology Institute (RBNI) and GTEP is dynamically creating new alliances of excellence.

THINK POWER.

In 2007, 32% of worldwide electricity generation was derived from alternative fuels. The principle component is hydro power with 21% and nuclear energy in second place with only 3.3% of total energy production.

Source: International Energy Agency Report 2009



Prof. Nir Tessler
Electrical Engineering

Quantum dots 4 Power

Prof. Efrat Lifshitz discovered that nano-sized materials consisting of nanocrystal quantum dots can absorb sunlight not only in the visible range, as materials currently used in solar panels do, but also in the infrared and UV ranges. This makes them ideal in photovoltaic cells used to turn sunlight into electricity, promising much more efficient solar power.

At the Faculty of Electrical Engineering in another dynamic laboratory, Prof. Nir Tessler has a group on organic photovoltaic material. Both Lifshitz and Tessler are also active within the Technion's Russell Berrie Nanotechnology Institute (RBNI).

"We're trying to use nano-scale understanding and capabilities to produce microscale devices and through the nano we simply improve their properties and performance," says Tessler, "In Israel when you see solar panels, most of them are heating water to get a shower in the middle of the night. Most of them will use silicon.

Instead of these hard materials we're trying to develop flexible solar cells that can be printed like wallpaper so you can really spread them on miles and miles of area and get the most of the sun's energy that is really spread around without being used. In this way you can really lower the cost of making these devices and installing them and they can be used on rooftops and any other place you can think of. We are on the right track."

Illuminano

Prof. Gitti Frey is illuminating tomorrow's world, where nano-scale science and the principle of self-organization at the molecular scale could make familiar objects like the household light-bulb an antiquated curiosity.

Whole new concepts in domestic and industrial lighting, limited only by the breadth of the designer's imagination could be making the "ideal" light bulb seen above the head in cartoon strips an icon of the past. But new concepts for emitting light is just one possible

future application of the research done by Frey at the Faculty of Materials Engineering; new ways of receiving light - such as vastly improved systems for harnessing solar power is another.

Frey specializes in organic electronics - plastic electronics that are functional electronically and optically. They emit light and can transmit electrical signals, or absorb light and generate energy such as electricity. Frey introduces whole new properties in this field, creating the most effective and useful self-organizing structures on the nano-scale. "Their functionality is not only due to chemical properties, but to the organization - the hierarchy," explains Frey. "In the nano dimension, we can only achieve order through self-direction. We self-organize organic and inorganic components into hierarchies applicable in optoelectronic devices - the outcome is a light emitting diode (or a solar cell)."

THE FOUR POLES OF RESEARCH: Renewable Energy Sources



Prof. Efrat Lifshitz
Chemistry



Prof. Gitti Frey
Materials Engineering



Prof. Gershon Grossman
Mechanical Engineering



Prof. Aviv Rosen
Aerospace Engineering



Assoc. Prof. David Greenblatt
Mechanical Engineering

And the reverse process is equally fascinating for Frey, who is also working on a solar cell to convert sunlight into electrical energy. She predicts this research will lead to solar-power systems which are cheaper, unbreakable, flexible, more aesthetic and versatile. “We ask ourselves the fundamental questions about the conditions needed to self-organize a structure so we can generate currents in a specific material... we ask the fundamental scientific questions and the devices are the outcome...”

Listen to the wind

Viable, cost-effective energy generated by the power of the wind can already be felt from the north of Israel as faculty member Assoc. Prof. David Greenblatt sets up his revolutionary 175 m² wind tunnel laboratory at the Faculty of Mechanical Engineering. With a background in aerodynamics and patents for industrial fans under his belt, Greenblatt is well set to fix the problems of friction, performance and shelf-life involved in harnessing the

awesome power of the wind. “There are many problems with wind turbine blades,” he explains, “You cannot ‘see’ the wind and therefore you cannot appreciate how it hammers the blades and the whole structure. The wind is unsteady and turbulent, which means the performance drops and design life becomes compromised by high loads. I’m developing flow effectors or actuators that are embedded in the surface of the blades. If I can work out how to use them cleverly, then they will reattach unpredictable flow to the blades, increase the performance of the turbine, and extend the design life of the structure. You are squeezing more power out of the wind... and the same structure might last double the time and need much less maintenance.”

The unique tunnel to test the turbine blades has been designed for optical measurements. Transparent, the tunnel allows Greenblatt’s team to simulate the conditions of nature, measure the wind flow around the turbines with a

laser, and optically measure the effects. “I appreciate GTEP because it gives the opportunity to pursue cutting-edge research,” says Greenblatt who joined the Technion in 2007. “For me it’s exciting. You’re looking at new phenomena, learning about things that haven’t been seen before... It was my dream to build and design this flow-control laboratory.”



4.

THE STREAMLINE

Energy
Conservation



THE FOUR POLES OF RESEARCH: Energy Conservation

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We can create a more sustainable, cleaner and safer world by making wiser energy choices.”



THINK POWER.

In 2007, oil, coal and peat accounted for nearly 80% of global CO₂ emissions.

Source: International Energy Agency Report 2009

Traditional internal combustion engines burn fossil fuels and cause noise and air pollution. Advanced combustion technologies are being researched and developed at GTEP to improve the efficiency of traditional motors, lowering their energy consumption and lowering contaminating engine emissions with new techniques and alternative non-fossil-fuel additives. One goal is to adopt an all-electric vehicle that uses both fuel cells and improved batteries. Advanced combustion technologies can also be applied to systems such as industrial furnaces, boilers and gas turbines, and possibly industrial waste management.

Gel Propel

“The result is a device that gives you more mileage with less fuel.”

Prof. Benny Natan of the Faculty of Aerospace Engineering is developing higher performance possibilities in rocket or ramjet propulsion applications with a jelly-like substance, based on gasoline.

“I address the safety of gel propellants, as well as performance issues,” says Natan. “Gel fuel is a liquid fuel to which you add a gelling agent, and you get something that looks like the Jell-O in your kitchen. The safety aspect relates to leakage. For example, if the fuel storage tank is hit, then the fuel won’t leak because the gel forms a crust and keeps it in place, or even if it does leak, it’s at a reduced rate, so it’s a safer fuel from this point of view.”

He explains that the addition of metal particles to the gel – analogous to the fruit segments added to Jell-O – leads to much better performance than regular fuel. “With the gel alone, you just get the advantage of safety. For performance, you need the metal particles,” he says. “You get much more from the metals than from the regular hydrocarbon; the problem is that they sink down in a liquid fuel. But with gel, there is no sedimentation. They stay in place, like the banana stays in Jell-O,” he says. “So, you can use the fuel, which is hydrocarbon plus metal particles, to achieve much better performance.”



Prof. Benny Natan
Aerospace Engineering



Prof. Rachel Becker
Civil & Environmental
Engineering



Prof. Yeshayahu Levy
Aerospace Engineering



Assoc. Prof. Guedi Capeluto
Architecture & Town Planning

For example, you use less fuel to reach higher ranges. This can be very important in rocket or ramjet propulsion applications, and, in general, in fuel consumption.”

This, Natan maintains, is a unique solution. “For example, a ramjet air-breathing engine, using gel and metal particles, can cover large distances and we proved it – theoretically at least.” Boron and aluminum are the metals of choice. “Boron is a very attractive metal – it’s ‘hot stuff’,” quips Natan. The metal particles are important because they have much higher performance. “If you compare them with regular hydrocarbon,” Natan explains, “they can give you 30 to 40 percent more energy per unit mass when they burn, and sometimes three times more per unit volume, which means you get a more compact motor and save space, and thus reduce the aerodynamic drag. The result is a device that gives you more mileage with less fuel.”

“You get much more from metal-enhanced fuel than from hydrocarbons, and it is much safer,” he concludes. “It is important from every aspect, and there is simply no damage to the environment.”

Power Houses

A Zero-Energy House, designed to balance the energy coming in and going out of the structure. The Civil Engineering and Architecture faculties have teamed up to integrate features such as windows and insulation that can collect energy when available (on a sunny summer day, for example) for use when needed, at night or in winter.

The building sector is the largest consumer of electrical power, and therefore a major research goal is to provide the knowhow for designing zero energy buildings that consume minimal power and can produce as much power as they use. Significant reductions in energy demands, which do not adversely affect the standard of living and are well controlled to provide

the required levels of thermal and visual comfort and air quality in the building sector, also have major potential to contribute to sustainable growth.

Technion researchers headed by Prof. Rachel Becker are combining innovative building materials - such as transparent insulation, dynamic shading and phase change materials - to greatly reduce cooling and heating energy needs, as well as building integrated hybrid photovoltaic systems to achieve efficient, comfortable buildings.

“We believe that bio-climate, solar-and-low-energy building design are important factors that should influence the design of buildings and their surroundings. Our premise is that we can achieve thermal comfort without using so much energy and without compromising the aesthetics of the buildings.”

The Technion saved millions of shekels on energy consumption after a test carried out in the Faculty of

THE FOUR POLES OF RESEARCH: Energy Conservation

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New advanced combustion technologies are being developed to reduce energy consumption and energy loss, improving the efficiency of traditional motors.”

Electrical Engineering succeeded in saving a quarter of a million shekels. This faculty's pioneering electricity-saving project involved operating a number of relatively low-cost means and measuring energy consumption before the project began and after. It was found that this single project saved NIS 232,499 in energy expenditures over a period of nine months. The total sum invested in the project was NIS45,000.

“This result demonstrates the environmental and economic potential of a coordinated operation between environmentalists and engineers,” states Prof. Yoram Avnimelech, one of the heads of the Technion's “Green Campus” project.

Power 2 Change

To bring about the required breakthroughs in energy conservation, new ideas and innovative technologies are needed. Among other international initiatives, GTEP facilitated the US-Israel workshop on sustainable buildings, materials and energy, held at Technion in July 2010.

Considerable impacts on the environment are caused by the construction sector in the lifecycle of buildings and structures and are a source for worldwide concern. According to international committees, the contribution of the construction sector to the emission of greenhouse gases is estimated to be nearly 33%. Energy consumption in buildings is one of the main contributors. In the developed countries, the building sector is responsible for more than 66% of the total annual electrical energy consumption.

Economic growth and raised expectations with regard to the overall standard of living boost energy consumption in buildings in the developing countries as well. With the worldwide growing rate of population growth and urbanization, the consumption of building materials and components by the building industry is rising, increasing the total energy demand and the depletion of natural resources, such as limestone, clay, sand, iron ore, bauxite, gypsum, wood, and water.

Combined interdisciplinary efforts of researchers from various scientific

fields may be instrumental in yielding progressive results. The drive of the US National Science Foundation (NSF) to promote such innovative collaboration and teamwork was implemented in the Emerging Frontiers in Research and Innovation 2010 program.

For a number of years, the Building and Maintenance Division has been involved in environmental planning and construction at the Technion. An example of one of its many activities is the Rabin Building, which has a cooling system that stores cold (ice) during the night when temperatures are low and cheap electricity is available. The ice is accumulated and stored in the basement and used for cooling in the middle of the day. In addition, water condensed from the air conditioning in the Computer Science building is saved and used to irrigate the Technion's main lawn.

ENERGY.

THIS IS THE PLACE.

NOW IS THE TIME.



**THINK
POWER.**

**Grand Technion
Energy Program**
Securing Israel today.
Transforming Israel's tomorrow.

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