INTERNATIONAL

New solar energy system

A Dutch-Indonesian initiative has developed a new system for photovoltaic (PV) solar energy, offering a solution to rapid increases in electricity demand in Indonesia due to the country's vibrant economic growth and rising prosperity.

Solar energy expert from Twente University, Angele Reinders, who is also the project leader, said that the new system could produce about 50,000 kilowatt hours (kWh) of electricity per year, the equivalent of saving around 5,000 liters of diesel and 11,000 kilograms of coal annually.

"A pilot plant has been installed in Papua. We have provided training courses in the field of solar energy, and there is now a monitoring system for the PV system," said Reinders, an associate professor in Industrial Design Engineering at the university, in a release made available to *The Jakarta Post*. She further said that the local town hall in Jayapura, where the project took place, is now using the solar energy system, and has become largely self-sufficient regarding its energy needs.

Reinders received a grant of 700,000 euro from the Dutch government to develop grid-connected PV systems in Indonesia. Under the program, Twente University and its local counterparts, namely the Bandung Institute of Technology (ITB), the World Wildlife Fund, and various local installers have worked together to develop the PV system in Papua over the past 2 years.

The program also set up training courses on solar energy. Ten ITB professors are currently conducting research on solar energy and more Indonesian engineers are being trained. Some of the engineers are undertaking a Master's in Sustainable Energy Technology, a degree program offered jointly by Twente and ITB.

http://www.thejakartapost.com

Solar panels that are part of a new photovoltaic (PV) solar energy system in Jayapura, Papua (Credit: The Netherlands Education Support Office Indonesia)

ASIA-PACIFIC

CHINA

Fresnel lens concentrates solar energy

Micro-machining could be used to create almost flat, Fresnel lenses, which boost the electrical efficiency of solar panels, according to new research in China. Fresnel lenses were invented by French engineer and scientist Augustin-Jean Fresnel, in the early nineteenth century; they are essential two-dimensional equivalents of conventional optical lens, but they have ridges in concentric rings that focus the light to a point behind the lens without the three-dimensional bulk of a conventional lens. Image quality is reduced when using a Fresnel lens to focus, because the concentric rings which can be used to significantly reduce the depth of the lens compared to a standard convex lens mean that some light is not focused at the gaps between the ridges. This limits the use of Fresnel lenses in photography and other applications where the user does not wish to lose fine detail.

However, where a detailed image is not needed this quality compromise is acceptable especially if the benefits of reduced bulk outweigh the losses. As such, early applications of Fresnel lenses were in providing a lower-cost way of focusing the light from a lighthouse beacon. More recently, Fresnel lenses have found use in inexpensive focused rear-view mirrors that allow drivers to see a wider angle view of the rear of their vehicles. Fresnel lenses have also been used in inexpensive handheld magnifiers to assist the visually impaired and for artificially enlarging a display from a television or other device.

In the area of solar panels, researchers have attempted to use bulky and cumbersome parabolic reflectors to boost efficiency. Now, Y. Cheng, X.D. Zhang, and G.X. Zhang of the State Key Laboratory of Precision Measuring Technology & Instruments, at Tianjin University, in China, have developed a technology that allows them to craft the necessary surface structures on a Fresnel lens, an array of microscopic cones, rather than concentric ridges, so that incident light is brought to a point at a more precise depth on the photoactive layer in the panel.

Initial tests with their precision-machined Fresnel solar collector showed that they could obtain a peak power four times that possible with a standard panel at low resistance. The difference in power falls off quickly as the device's resistance rises, which it does as it gets hotter under sunlight and as a byproduct of its generating

electricity. Nevertheless, the differential would be enough to boost its electrical output substantially offsetting the additional cost of the Fresnel collector so that the overall cost of solar panels might be reduced. This simple addition to older, less efficient solar panels might also make them viable for places and applications where modern devices of higher intrinsic efficiency are not commercially tenable.

http://www.sciencedaily.com

Stacked electrodes to make solar cells wearable

Wearable solar cells are now one step closer to reality with the development of flexible and efficient solar cells based on stacked electrodes. Chinese researchers have developed efficient solar cells based on flexible textile electrodes that can be integrated into fabrics. This research has been published in the journal *Angewandte Chemie*.

Thread-like solar cells that can be woven into textiles have previously been produced by twisting two electrically conducting fibers together as electrodes. However, it has proven difficult to make efficient and thread-shaped electrodes of a sufficient length. Furthermore, the wire-shaped cells are limited to lengths of few millimeters and it is difficult to connect a large number of wire-shaped solar cells to generate adequate power.

A team from Fudan University and Tongji University in Shanghai has developed an alternative approach for the production of flexible solar cells that can be integrated into fabrics. Their method is based on textile electrodes that are stacked into layers.

Solar cells need a working electrode that captures light, as well as a counter electrode and an electrolyte. Researchers led by Dr. Peng Huisheng produced a working electrode composed of titanium wires woven into a fabric and perpendicularly layered with titanium dioxide nanotubes filled with light-absorbing dye.

For the counter electrode, the researchers produced layers of highly parallel carbon nanotubes that were then twisted into fine threads with a high degree of mechanical strength and woven into a textile. The working electrode and counter electrode were stacked on top of each other and the double layer was soaked with a liquid electrolyte and sealed or equipped with a solid electrolyte.

The resulting layered solar cell showed higher energy conversion efficiency than conventional planar solar cells due to its ability to capture incident light at multiple angles. The electrodes also work well when they are bent, which allows them to be easily integrated into knit fabrics or other flexible structures. By using several small textile solar cells, the researchers were able to power an LED.

http://www.asianscientist.com

INDIA

Green plastic from bio-fuel residue

Bhavnagar-based research institute, Central Salt and Marine Chemicals Research Institute (CSMCRI), has developed a "green plastic" using the residues of bio-fuel that is made from a tropical weed *jatropha*. What's more, the institute has been granted a European patent for its biodegradable plastic in January this year. "We had initiated a research on using the residue of bio-diesel to be converted to plastic. The idea of green plastic came as a result of our concern to effectively utilize the crude glycerol which is the byproduct of the Jatropha biodiesel," said S. Mishra, principal scientist, CSMCRI.

Council of Scientific & Industrial Research (CSIR) and CSMCRI have started research related to the development of "green plastic" in 2005 during the second phase of the project entitled "Biofuels from eroded soils of India" sponsored by Daimler Chrysler, Germany.

More than 500 g of green plastic has already been produced in the laboratory at gram scale, which was distributed to some firms for research analysis and studies on its further applications in bio-medical area. "Now, our target is to scale up the process from gram to kilogram scale per batch production. Besides, we are also trying to improve functional/physical properties of the product," she added.

Recently, European patent has been granted in January 2014 for the process of bioplastics made by CSIR-CSMCRI (Grant no. EP 2475754 B1). Tests conducted on the polymers have shown that they completely degrade in moist soil within three months. A senior ex-scientist associated with the institute claimed that such plastics can find suitable use in the automotive industry, and by replacing conventional plastics with biodegradable plastics could enhance the "green" content of a car. However, institute sources confirmed that so far no car manufacturer has shown any interest to test it on their vehicles.

http://www.business-standard.com

JAPAN

Novel wind generator

The Japanese have always been resourceful and inventive, and they have developed the "Wind Lens." It was the brainstorm of researchers at Kyushu University, who thought they could generate more than traditional wind power using a unique design. The Wind Lens focuses airflow just like a lens focusing light. The circle made up of the turbine blades has a ring that curves inward, and this directs the flow of air and accelerates the speed. The team leader states that by using an inlet shroud, a diffuser, and a brim in the inward ring, these cause the air to be drawn in more quickly. This means that it generates more power. The researchers have claimed that this new wind turbine technology will allow turbines to triple their output and even reduce the noise that the turbines cause.

Since Japan is an island, it will be able to make full use of offshore wind farms, since that is where researchers feel that the new technology will perform the best. The Wind Lens can float on platforms shaped like hexagons, and at sea will not be subject to large waves or tsunamis, since these achieve their destructive power only upon nearing a shoreline. So, the Wind Lens holds great promise for Japan as a source of green renewable energy. The first step

Wind Lens concept

many times is at the university level. Next is commercialization.

http://www.whirlopedia.com

Micro wind turbines

Research in Japan and Italy on how dragonfly wings react to air currents could soon allow on-site wind power to be used in low-wind regions. Nippon Bunri University Professor Akira Obata has built a micro wind turbine that works like the distinctive corrugated surface of a dragonfly's wing and could generate power in very low wind speeds — such as the average Japanese wind speed of 2–4 mps.

Meanwhile, Italy's Enel Green Power is testing a 55 kW dragonfly-inspired small wind turbine designed by architect Renzo Piano. Testing began in October 2013 and serial production is planned for this year. In both cases, low wind speed conditions were the impetus for the design. Obata's goal is to develop micro wind turbines that will generate power anywhere in Japan, not just in the windy coastal regions or offshore. His prototypes have generated 4.6 W at wind speeds of 5 mps, while in two months of testing, Enel's turbine generated over 1,200 KWh in wind speeds of 2 mps.

http://www.cospp.com

MALAYSIA

Smaller seeds produce more biodiesel

Researchers at the University Teknologi MARA in Malaysia have discovered cotton and palm kernel seeds to be suitable for production of biodiesel. Using the reactive extraction method, wherein biodiesel is extracted directly from seed particles, researchers found that biodiesel from cotton seeds could lower carbon monoxide, nitrogen oxide, and smoke emission in internal combustion engines. In order to maximize outcome of biodiesel production, they investigated how seed particle size influences the amount of oil, extraction efficiency of reactive reaction, and biodiesel conversion.

Results showed that the smallest cotton seed particles, which were 0.5–1 mm, produced the biggest amount of oil as well as a high percentage of extraction effectiveness. The same was true for palm kernel seeds with the smallest range yielding the greatest outcome (58 per cent) within 24 hours reaction time. The same size groups and reaction period showed 90 per cent of the extraction efficiency of fatty acid methyl esters (FAME).

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SINGAPORE

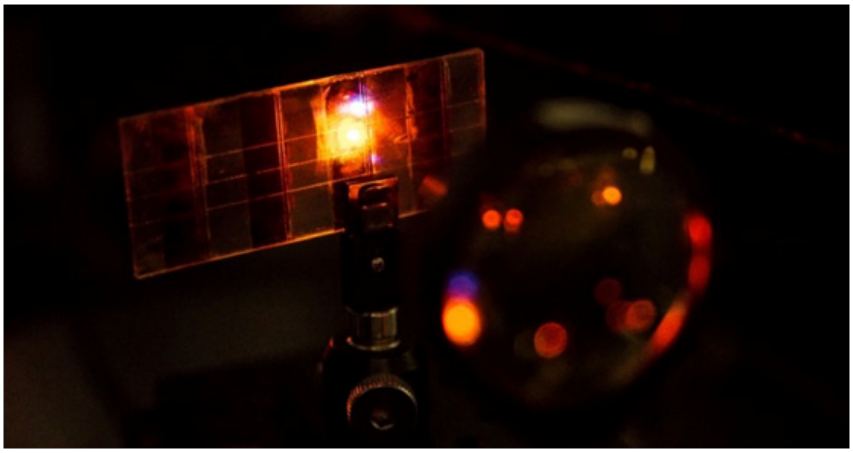
Solar cell material

In future, when your mobile or tablet runs out of battery, you could just recharge it by putting it out in the sun. Nanyang Technological University (NTU) scientists have developed a next-generation solar cell material which can also emit light, in addition to converting light to electricity.

This solar cell is developed from Perovskite, a promising material that could hold the key to creating high-efficiency, inexpensive solar cells. The new cells not only glow when electricity passes through them, but they can also be customized to emit different colors. This discovery, published in the top academic journal *Nature Materials*, was discovered almost by chance when NTU physicist Sum TzeChien, asked his postdoctoral researcher Xing Guichuan to shine a laser on the new hybrid Perovskite solar cell material they are developing.

Assistant Professor Sum said to the team's surprise that the new Perovskite solar cell glowed brightly when a laser beam was shone on it. This is a significant finding, as most solar cell materials are good at absorbing light but are generally not expected to generate light. In fact, this highly luminescent new Perovskite material is also very suitable for the making of lasers.

"What we have discovered is that because it is a high quality material, and very durable under light exposure, it can capture light particles and convert them to electricity, or vice versa," said Assistant Professor Sum, a Singaporean scientist at NTU's School of Physical and Mathematical Sciences (SPMS). "By tuning the composition of the material, we can make it emit a wide range of colors, which also makes it suitable as a light emitting device, such as flat screen displays."



New material could lead to new touch and display screens doubling up as solar panels

Newest FLATCON® concentrator module with an efficiency of 36.7%. ©Fraunhofer ISE (Credit: Alexander Wekkeli)

The advanced material, which is currently patent pending, is five times cheaper than current Silicon-based solar cells. This is due to its easy solution-based manufacturing process, which works by combining two or more chemicals at room temperature.

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EUROPE

GERMANY

New world record for concentrator photovoltaics

The Fraunhofer Institute for Solar Energy Systems ISE has been successfully developing concentrator photovoltaic (CPV) technology for many years. In this technology, Fresnel lenses are used to bundle sunlight and focus it onto miniature, highly efficient solar cells. The FLATCON® module technology originates from Fraunhofer ISE and is continually under further development at the Institute. Now with their newest CPV module technology, the Freiburg researchers announce a world record module efficiency of 36.7%, achieved by adapting the concentrating lens to a new solar cell structure. The high module efficiency was measured under Concentrator Standard Testing Conditions, or CSTC, and marks the best value ever achieved for a photovoltaic module.

Decisive in this achievement was Soitec's newly developed four-junction solar cell based on the wafer bonding technology and developed in cooperation with Fraunhofer ISE. Recently this four-junction solar cell could be implemented into the Institute's FLATCON® module concept. The module aperture area, defined as the surface area of the module exposed to light, is 832 cm^2. The sunlight is concentrated by a factor of 230 suns onto fifty-two 7 mm^2 miniature solar cells with the help of fifty-two 16 cm^2 Fresnel lenses. "Naturally we are incredibly excited about this high module efficiency," says Dr. Andreas Bett, who has led the CPV research at Fraunhofer ISE over many years. For his efforts, Bett has received many awards, among them the German Environmental Award 2012, together with Hansjörg Lerchenmüller of Soitec Solar.

Only several months ago, Fraunhofer ISE together with Soitec, the French research center CEA-Leti, and the Helmholtz Center in Berlin announced a new solar cell world record of 44.7% under concentrated light. This record cell consisted of four sub-cells made up of the compound semiconductors GaInP, GaAs, GaInAs, and InP, respectively. In comparison to standard silicon solar cells, the manufacture of four-junction solar cells is more expensive so that up to now their terrestrial applications have been exclusively in concentrator systems. Concentrator photovoltaic systems (CPV) are installed in sun-rich regions, where such systems produce solar electricity for less than 8 eurocents per kilowatt-hour.

Key to this technology is the solar cell efficiency and the concentrating optic. In the record module, the newly developed four-junction solar cell was combined with Fresnel lenses, which were

manufactured by the industry partner ORAFOL Fresnel Optics based on a new design developed at Fraunhofer ISE. The successful transfer of this high module efficiency to commercially manufactured modules is expected within 1–2 years.

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UK

Cheaper way of making solar cells

Researchers have developed a new manufacturing method which could bring down the cost of making a type of solar cell. A team at Liverpool University has found a way of replacing the toxic element in the process with a material found in bath salts. The scientists say that this could have a "massive, unexpected cost benefit." The research has been published in the journal *Nature* and unveiled at the ESOF conference in Copenhagen.

Dr. Jon Major, who led the research, said that his team's work might be the development that brings the cost down to the level of fossil fuel," he told BBC News. More than 90% of the solar cells are made from silicon. Around 7% are made from a material called cadmium telluride. The cadmium telluride cells are thinner than silicon and these are popular, because they are also lighter and cheaper.

Dr. Major discovered that a cheaper, non-toxic alternative, magnesium chloride, could be used instead of the toxic compound and work just as well.

Magnesium chloride is completely safe. It is used to make tofu and is found in bath salts. It also extracted from sea water and so is a small fraction of the price of cadmium chloride.

Dr. Major's boss, Professor Ken Durose, who is the director of the Stephenson Institute for Renewable Energy at Liverpool University, believes that his colleague's discovery has the potential to transform the economics of solar energy.

http://www.bbc.com

NORTH AMERICA

CANADA

Nanoparticle solar cells, smaller and more efficient

Researchers at the University of Toronto (UT) are trying to redefine how people see solar panels and have developed "a new class of solar sensitive nanoparticles. "According to a UT press release, the Edward S. Rogers Sr. Department of Electrical & Computer Engineering researchers believe their new solar technology would also be cheaper than the traditional panels, large and rectangular. Post-doctoral researcher ZhijunNing led the study, published this week in the journal *Nature Materials,* with UT Professor Ted Sargent.

"This is a material innovation, that's the first part, and with this new material we can build new device structures," Ning said in the release. "Iodide is almost a perfect ligand for these quantum solar cells with both high efficiency and air stability-no one has shown that before."

The new nanoparticle solar cells rely on two semiconductors: n- and p-type. Typically, electron-rich n-type materials attach themselves to oxygen atoms when exposed to air, which forfeits their electrons and turns them into p-types. The pride of his team's study, Ning and his colleagues has developed a new n-type material that is not altered when exposed to the air.

If these new nanoparticle solar cells made it into everyday life, the world could have better weather satellites, remote controllers, pollen detectors, and more. Given their tiny size and potential for high performance, the nanoparticle solar cells could also lower the price and accessibility of adding a solar energy generator to one's home.

Keeping both n- and p-type materials stable at the same time significantly boosts efficiency in how the cells absorb and output energy. In Ning's study, the team achieved eight percent solar power conversion efficiency, the best on record.

http://www.universityherald.com

USA

Innovative solar-powered toilet

A revolutionary University of Colorado Boulder toilet fueled by the sun that is being developed to help some of the 2.5 billion people around the world lacking safe and sustainable sanitation will be unveiled in India this month.

The self-contained, waterless toilet, designed and built using a $777,000 grant from the Bill & Melinda Gates Foundation, has the capability of heating human waste to a high enough temperature to sterilize human waste and create biochar, a highly porous charcoal, said project principal investigator Karl Linden, professor of environmental engineering. The biochar has a one-two punch in that it can be used to both increase crop yields and sequester carbon dioxide, a greenhouse gas.

The project is part of the Gates Foundation's "Reinvent the Toilet Challenge," an effort to develop a next-generation toilet that can be used to disinfect liquid and solid waste while generating useful end products, both in developing and developed nations, said Linden. Since the 2012 grant, Linden and his CU-Boulder team have received an additional $1 million from the Gates Foundation for the project, which includes a team of more than a dozen faculty, research professionals, and students, many working full time on the effort.

According to the Gates Foundation, the awards recognize researchers who are developing ways to manage human waste that will help improve the health and lives of people around the

Novel solar-thermal toilet developed to improve sanitation and hygiene in developing countries (Credit: University of Colorado)

world. Unsafe methods to capture and treat human waste result in serious health problems and death — food and water tainted with pathogens from fecal matter results in the deaths of roughly 700,000 children each year.

Linden's team is one of 16 around the world funded by the Gates "Reinvent the Toilet Challenge" since 2011. All have shipped their inventions to Delhi, where they will be on display March 22 for scientists, engineers, and dignitaries. Other institutional winners of the grants range from Caltech to Delft University of Technology in the Netherlands and the National University of Singapore.

The CU-Boulder invention consists of eight parabolic mirrors that focus concentrated sunlight to a spot no larger than a postage stamp on a quartz-glass rod connected to eight bundles of fiber-optic cables, each consisting of thousands of intertwined, fused fibers, said Linden. The energy generated by the sun and transferred to the fiber-optic cable system — similar in some ways to a data transmission line — can heat up the reaction chamber to over 600 degrees Fahrenheit to treat the waste material, disinfect pathogens in both feces and urine, and produce char.

Tests have shown that each of the eight fiber-optic cables can produce between 80 and 90 watts of energy, meaning the whole system can deliver up to 700 watts of energy into the reaction chamber, said Linden. In late December, tests at CU-Boulder showed the solar energy directed into the reaction chamber could easily boil water and effectively carbonize solid waste.

While the current toilet has been created to serve four to six people a day, a larger facility that could serve several households simultaneously is under design with the target of meeting a cost level of five cents a day per user set by the Gates Foundation. The CU-Boulder team is now applying for phase two of the Gates Foundation Reinvent the Toilet grant to develop a field-worthy system to deploy in a developing country based on their current design, and assess other technologies that may enhance the toilet system, including the use of high-temperature fluids that can collect, retain, and deliver heat.

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Nano-liter photobioreactors to produce algal biofuel

A team led by Arum Han, associate professor in the Department of Electrical and Computer Engineering at Texas A&M University, recently had its paper on microfluidic systems for algal biofuel development published in the journal *Lab on a Chip* as a cover article. Han's team is developing microfluidic lab-on-a-chip systems that can be used as high-throughput screening tools to quickly evaluate the growth and oil production characteristics of numerous algal strains under various growth conditions. Their paper describes how the team demonstrated the development of 10s or 100s of pico-liter sized photobioreactors on a business card sized chip. The developed microsystem utilizes microfluidic technologies to individually control light conditions (intensity and day-night cycle) for each of the 10s or 100s of photobioreactors, and was used to understand how microalgae grow and produce oil under different environment. The article also was featured as a Lab on a Chip HOT article.

Using these microsystems, Han and his collaborators in Biochemistry and Biophysics at Texas A&M, Dr. Tim Devarenne, and in the Boyce Thompson Institute for Plant Research at Cornell University, Dr. David Stern, are working together to transfer the valuable hydrocarbon synthesis pathway of the slow-growing alga, *Botryococcus braunii,* to faster-growing algae with commercial potential through metabolic engineering. This multidisciplinary team is currently funded under a two million dollar award from the National Science Foundation's (NSF) Emerging Frontiers in Research and Innovation (EFRI) office. With the new microsystem technology, the team is expected to significantly shorten the development time, where testing that previously required up to a year in a standard laboratory environment can be achieved in a week.

http://engineering.tamu.edu