# ASIA-PACIFIC

## AUSTRALIA

### New wave energy technology

New technology to measure ocean waves and currents with greater accuracy than ever before is being deployed off the Albany coast this week, as part of the new Wave Energy Research Centre, an initiative led by The University of Western Australia. In partnership with the State Government, this project will place WA at the forefront of marine renewable energy research and technology and increase knowledge and understanding of ocean processes. Two buoys will collect data on wave height, direction, period and surface current speed, then transmit this data via satellite to the Wave Energy Research Centre, where scientists will analyse it.

UWA Wave Energy Research Centre Chief Investigator Dr Jeff Hansen said it would be the first time detailed wave measurements in the near-shore area out of Albany would be collected using such superior instruments. "With swell and wind conditions looking favourable this week, the research team will deploy the instruments and use them to observe the marine environment in far more detail than ever before," Dr Hansen said.

The researchers have collaborated with industry partner Carnegie Clean Energy as part of the State Government funded Albany Wave Energy Project. Their data and ocean models will improve the placement, survivability and performance of Carnegie's CETO6 wave energy converter device. The new home for one of the wave buoys is approximately 45 kilometres offshore from the Albany wind farm at Sandpatch, where water depth is around 350 metres. The second wave buoy will bob closer to shore at a depth of 30 metres, at the same location as Carnegie Clean Energy's wave energy converter device when it is installed.

*http://www.news.uwa.edu.au*

## CHINA

### Power generating windows

Chinese scientists developed a window material with thin, see-through solar cells that could turn window into miniature electricity generators. The window-compatible material reported in a study published on Tuesday in the journal Joule could potentially double the energy efficiency of an average household.

"Building-integrated photovoltaics are a great example of a market where silicon photovoltaics, despite their cheapness and performance, are not the most appropriate due to their dull appearance and heaviness," said the paper's senior author Yip Hin-Lap, a professor of materials science and engineering at the South China University of Technology. "Instead, we can make organic photovoltaics into semi-transparent, lightweight, and colorful films that are perfect for turning windows into electricity generators and heat insulators."

To construct a prototype capable of simultaneously outputting electricity and preventing excessive heating, the researchers needed to perform a three-way balancing act between harvesting light for electricity generation, blocking it for heat insulation, and transmitting it as a window normally would. They put together a device that let the familiar visible portions of sunlight through, turned back the infrared light, and converted the near-infrared region in-between into an electric current.

In theory, installing windows outfitted with dual electricity-generating and heat-insulating properties could cut an average household's reliance on external electric sources by over 50 percent. These dual-function materials are still very much in their infancy, but the authors expect them to pave the way to new beneficial technologies.

*http://www.xinhuanet.com*

### Synthesis of liquid solar fuel

Chinese researchers have successfully increased the scale of synthesizing liquid solar fuel, taking a step forward to boost the use and output of renewable energy in the country. Researchers with the Dalian Institute of Chemical Physics under the Chinese Academy of Sciences divided the synthesis process of the liquid solar fuel into two steps: generating hydrogen decomposed from water by solar energy and making liquid fuel via carbon dioxide hydrogenation.

A 1,000-tonne industrialization of liquid solar fuel synthesis project has been launched in Lanzhou, capital city of northwest China's Gansu Province.

Liquid solar fuel is transformed and synthesised from carbon dioxide and water, using solar energy as the sole energy supply. The synthesis process provides clean fuel, as well as utilizing greenhouse gases.

*http://www.xinhuanet.com*

## INDIA

### Concentrated solar energy to produce hydrogen fuel

Researchers from the Indian Institute of Technology Bombay have begun a new study that is focused on determining the economic feasibility of solar-driven electrolysis used to produce hydrogen fuel. The study is meant to provide a framework for how solar hydrogen production could be used in an economically viable manner. Hydrogen has gained some popularity in India in recent years, but still has significantly less support that other forms of clean power and conventional fossil-fuels.

The research team has conducted an economic analysis of an electrolyzer, which is powered by a concentrated solar energy system. This concentrated solar energy system allows for high-temperature steam electrolysis. Researchers also calculated the levelized cost of hydrogen fuel. Researchers discovered that the high-temperature steam electrolysis process is 3% more efficient than typical photovoltaic electrolysis. There was also a drop of approximately $4 in the overall cost of hydrogen fuel.

Finding more efficient ways to produce hydrogen fuel has become a major priority. Researchers throughout the world have begun experimenting with renewable energy in order to make hydrogen a more viable form of clean power. Solar has, thus far, proven to be the most promising option. By using renewable energy, such as concentrated solar energy, researchers believe that hydrogen production will no

longer be reliant on fossil-fuels or conventional steam reformation.

India is home to a robust solar market, where many promising projects have taken form over the years. The Indian government is eager to replace fossil-fuels with clean power and hydrogen may go a long way in making the country's transportation space more environmentally friendly. Fuel cell vehicles have begun to gain traction in China and other parts of Asia, and they will soon begin to establish a presence in India. In order to ensure that these vehicles are successful, India has been working to bolster its hydrogen production capabilities.

*http://www.hydrogenfuelnews.com*

## Solar powered system to convert plastic into fuel

Scientists from Indian Institute of Technology (IIT) Madras have developed a solar powered system to convert non-recyclable plastic into fuel that can substitute diesel used in generators, furnaces and engines. The technology - which consists of a mobile unit that can collect and process waste - currently yields around 0.7 litres of fuel oil per kilogramme of plastic, researchers said.

"India produces approximately 15,000 tonnes of plastic waste in a day. Centralised systems for plastic waste management cannot work to effectively deal with this much plastic waste on a daily basis," said Ramya Selvaraj, a research student at the IIT Madras in Tamil Nadu. "We thought that if the plastic can't come to the industry, let the industry come to the plastic," Selvaraj said.

The conversion of plastic to fuel involves a process called pyrolysis - a thermochemical treatment that exposes the material to high temperature in the absence of oxygen, leading it to go through physical and chemical changes. This creates a low density fuel oil by breaking down the polymer chain of plastic at the temperature of 350- 500 degrees Celsius. This oil can be used as a substitute for diesel to power generators, furnaces and engines.

"Our major proposition was instead of taking technology to waste, taking all the waste to a decentralised technology which is a very complex model in solid waste management," said Aravind E S, a research student at IIT Madras. "We found that the current plastic waste management systems were not working because of the logistics involved; there were cost and space requirements that could not be met," Selvaraj added.

The team was led by Divya Priya, assisted by technical guide Professor Indumathi Nambi of IIT Madras, and industrial mentor Sriram Narasimhan of Samridhi Foundation, a Chennai based NGO.

*https://energy.economictimes.indiatimes.com*

## Clean energy from Sunn Hemp

Researchers at the Indian Institute of Technology (IIT) Kharagpur have tapped microwave radiation to create clean energy for large-scale use from nitrogen-rich non-food Sunn Hemp plants. The IIT Kharagpur Bioenergy Lab team was led by Prof. Saikat Chakraborty, faculty at the Department of Chemical Engineering and P K Sinha Center for Bioenergy and researcher Souvik Kumar Paul, an IIT Kharagpur statement said. High-energy non-edible plant sources such as Sunn Hemp have the potential of making available biofuel on a large scale, as a replacement of fossil fuel.

The team successfully converted the non-edible lignocellulosic fibres (plant dry matter) of Sunn Hemp to biofuel precursors, an alternative to land-based crops for biofuels, the statement said. The entire conversion, which otherwise takes 8-10 hours, took 46 minutes to be completed by using the microwave reactors in the lab, the statement said. Sunn Hemp is widely grown in the sub-tropical regions of Bangladesh, Brazil, India, Pakistan, Russia, Sri Lanka, the US and Uganda.

The scientists have filed for a patent and their findings have appeared in the globally renowned journal Bioresource Technology published by *Elsevier*.

*https://www.financialexpress.com*

# REPUBLIC OF KOREA

## Energy storage device

A research team at the Korean Advanced Institute of Science and Technology (KAIST) has developed an energy storage device that can operate after only 30 seconds of charging. The new hybrid energy storage device utilises aqueous electrolytes instead of flammable organic solvents making it environmentally friendly and safe. It can also be used with portable electronic devices as it facilitates a boosting charge with high energy density.

The device was developed by Professor Jeung Ku Kang and a team of scientists from KAIST's Graduate School of Energy, Environment, Water, and Sustainability. The team assembled fibre-like polymer chain anodes and sub-nanoscale metal oxide cathodes on graphene to develop a hybrid energy storage with high energy and power densities. Conventional aqueous electrolyte-based energy storage devices have a limitation for boosting charges and high energy density due to low driving voltage and a shortage of anode materials. The research team came up with new structures and materials to facilitate rapid speed in energy exchange on the surfaces of the electrodes and minimise the energy loss between the two electrodes. Anodes were made with graphene-based polymer chain materials, graphene having a web-like structure that produces a high surface area, thereby allowing higher capacitance.

With regard to cathodes, the team used metal oxide in sub-nanoscale structures to elevate atom-by-ion redox reactions. This method realized higher energy density and faster energy exchange while minimizing energy loss. The device can be charged within 20 to 30 seconds using a low-power charging system, such as a USB switching charger or a flexible photovoltaic cell. The developed aqueous hybrid energy device shows more than 100-fold higher power density compared to conventional aqueous batteries and can be rapidly recharged. Further, the device showed high stability with its capacity maintained at 100 percent at a high charge/discharge current.

The research, led by a PhD candidate Il Woo Ock, was published in *Advanced Energy Materials* on January 15th.

*https://www.renewableenergymagazine.com*

## SINGAPORE

### Cheaper technique for biofuel production

A team of engineers from the National University of Singapore (NUS) recently discovered that a naturally occurring bacterium, *Thermoanaerobacterium thermosaccharolyticum* TG57, isolated from waste generated after harvesting mushrooms, is capable of directly converting cellulose, a plant-based material, to biobutanol. A research team led by Associate Professor He Jianzhong from the Department of Civil and Environmental Engineering at NUS Faculty of Engineering first discovered the novel TG57 strain in 2015. They went on to culture the strain to examine its properties.

Assoc Prof He explained, "The production of biofuels using non-food feedstocks can improve sustainability and reduce costs greatly. In our study, we demonstrated a novel method of directly converting cellulose to biobutanol using the novel TG57 strain. This is a major breakthrough in metabolic engineering and exhibits a foundational milestone in sustainable and cost-effective production of renewable biofuels and chemicals."

Traditional biofuels are produced from food crops. This approach is highly costly and competes with food production in the use of land, water, energy and other environmental resources. Biofuels produced from unprocessed cellulosic materials such as plant biomass, as well as agriculture, horticultural and organic waste, are expected to meet growing energy demands without increasing greenhouse gas emissions resulting from the burning of fossil fuels. These cellulosic materials are in great abundance, environmentally friendly, and economically sustainable.

Among various types of biofuels, biobutanol offers a great promise as petrol substitute because of its high energy density and superior properties. It can directly replace gasoline in car engines without any modification. However, commercial production of biobutanol has been hampered by the lack of potent microbes capable of converting cellulosic biomass into biofuels. The current technique is costly and also requires complicated chemical pre-treatment.

The novel technique developed by the NUS team could potentially be a game-changing technology for cost effective and sustainable biofuel production. Spent mushroom compost, typically composed of wheat straw and saw dust, is the residual compost waste generated by mushroom farming. The microorganisms in the waste are left to evolve naturally for more than two years to obtain the unique TG57 strain.

The fermentation process is simple, and no complicated pre-treatment or genetic modification of the microorganisms is required. When cellulose is added, the bacterium simply digests it to produce butanol as the main product. Moving forward, the research team will continue to optimise the performance of the TG57 strain, and further engineer it to enhance biobutanol ratio and yield using molecular genetic tools.

*https://phys.org*

## EUROPE

## FINLAND

### Biofuel breakthrough

A research group from the University of Turku, Finland, has discovered an efficient way for transforming solar energy into the chemical energy of biohydrogen through the photosynthesis of green algae that function as cell factories. Molecular hydrogen is regarded as one of the most promising energy carriers due to its high energy density and clean, carbon-free use.

The leader of the research group, Yagut Allahverdiyeva-Rinne, Associate Professor of Molecular Plant Biology at the University of Turku said, "When algal cells are first incubated under anaerobic conditions in the dark and then exposed to light, they start producing hydrogen efficiently, but unfortunately only for a few seconds."

The researchers at the University of Turku decided to apply the knowledge retrieved from the basic research on the photosynthesis of algae and established a new method for producing hydrogen that does not expose green algae to additional nutritional starvation and, thus, without applying any significant stress to the cells. The team's research paper has been published in the journal Energy & Environmental Science. The researchers showed that the production of hydrogen could be significantly extended by simply exposing the anaerobic algal cultures to a train of strong yet short light pulses, which are interrupted by longer dark periods.

"Under these conditions, algal cultures exposed to sunlight do not accumulate oxygen in the medium. In addition, algae steer the electrons resulting from the decomposition of water and charged by sunlight into hydrogen production instead of biomass accumulation. The process lasts for, at least, several days and the maximum rate of the production of hydrogen occurs during the first eight hours," Kosourov said. The research indicated clearly that a major obstacle to efficient hydrogen production is not oxygen but a strong competition between two metabolic pathways: carbon dioxide fixation leading to the biomass accumulation and the hydrogenase enzyme catalyzing photoproduction of hydrogen.

The new method developed by the researchers is valuable both for the basic research of the photosynthesis of algae and for the research and development work of the industrial sector when producing new technologies for the large-scale production of carbon neutral biofuels.

*https://oilprice.com*

## UK

### Technique for more efficient solar energy

Scientists from the University of Exeter have developed a method that has the potential to harvest three times more photovoltaic (PV) energy compared with traditional systems by funnelling the energy more efficiently, the university said. The technique "funnels" the sun's energy directly into power cells, such as solar panels or batteries. "The idea is similar to pouring a liquid into a container, as we all know it is much more efficient if we use a funnel," said Adolfo De Sanctis, lead au-

thor of the paper. "However, such charge funnels cannot be realised with conventional semiconductors and only the recent discovery of atomically thin materials has enabled this discovery," De Sanctis added.

According to the researchers, the innovation could lead to solar panels that have the size of a book and can power a family-sized house. The announcement says that the new technique has the potential to convert around 60% of the sun's energy into electricity, compared to around 20% for the current solar cells.

The scientists devised a method to "funnel" electrical charge onto a chip. They used the atomically thin semiconductor hafnium disulphide (HfS2), oxidized with a high-intensity UV laser, to engineer an electric field that funnels electrical charges to a specific area of the chip, where they can be more easily extracted.

*https://renewablesnow.com*

# NORTH AMERICA

## CANADA

### Better fuel from biowaste

Researchers have found a way to produce a higher quality, more stable fuel from biowaste, such as sewage, that is simpler and cleaner than existing methods. "This puts biofuel closer to being a good substitute for fossil fuels," said Hua Song, an associate professor of chemical and petroleum engineering at the University of Calgary.

Song and his research team recently published the results of their research conducted at the Canadian Light Source in the journal *Fuel*. "The world energy market is currently dominated by fossil fuels. With increasing concern surrounding climate change and dwindling resources that are associated with the use of fossil fuels, renewable energy sources are becoming increasingly desirable and are currently the fast growing energy source," wrote Song in the research paper.

Currently, biowaste is converted into biofuel in a complex two-step process.

The biomass is first converted into a biocrude oil using a chemical and thermal process. Crude oil, in general, is oil that has not yet been refined and still contains impurities. The second stage is a form of refining in which hydrogen is added under high pressure and heat, and serves to remove contaminants such as sulfur, nitrogen and oxygen. However, hydrogen is expensive, the two stages are energy intensive, and carbon waste is left in the form of char and $CO_2$ emissions.

A process to reduce reliance on fossil fuels that still produces the harmful greenhouse gas is counterproductive. Song and his team set out to simplify the conversion process in a way that is sustainable, cost-effective, and clean. "In our work, we've developed a process which simultaneously produces and upgrades bio-oil in one step and without the need for high pressures," says Song.

The researchers used methane instead of hydrogen for the purification process and they used it directly in the crude stage, but they had to chemically remove the hydrogen from the methane during the purification process since hydrogen is still needed to remove impurities. Using the CLS, they developed a novel catalyst that reacted with methane to trigger it to release hydrogen. They were faced with a challenge because methane is a very stable compound that doesn't react with many other compounds.

The researchers call the catalyst they developed HZSM-5. To improve its ability to react with methane, they coated the surface of several samples of HZSM-5 with different materials. They then analyzed the samples and studied the surface features using the bright light of the synchrotron.

Initial studies using the catalyst in this new approach for producing biofuels show it is more efficient and has lower potential production costs than the current method. As well, carbon remains in the oil in liquid form which leads to a better quality biofuel that is more stable with significantly less greenhouse gas emissions.

*http://biomassmagazine.com*

### Methanation technology

Researchers at the University of Waterloo are developing technology to produce renewable natural gas (RNG) from manure so it can be added to the existing energy supply system for heating homes and powering industries. That would eliminate particularly harmful gases released by naturally decomposing manure when it is spread on farm fields as fertilizer and partially replace fossil natural gas, a significant contributor to global warming.

"There are multiple ways we can benefit from this single approach," said David Simakov, a professor of chemical engineering at Waterloo. "The potential is huge." Simakov said the technology could be viable with several kinds of manure, particularly cow and pig manure, as well as at landfill sites.

To test the concept, researchers built a computer model of an actual 2,000-head dairy farm in Ontario that collects manure and converts it into biogas in anaerobic digesters. Some of that biogas is already used to produce electricity by burning it in generators, reducing the environmental impact of manure while also yielding about 30 to 40 percent of its energy potential.

Researchers want to take those benefits a significant step further by upgrading, or converting, biogas from manure into renewable natural gas. That would involve mixing it with hydrogen, then running it through a catalytic converter. A chemical reaction in the converter would produce methane from carbon dioxide in the biogas.

Known as methanation, the process would require electricity to produce hydrogen, but that power could be generated on-site by renewable wind or solar systems, or taken from the electrical grid at times of low demand. The net result would be renewable natural gas that yields almost all of manure's energy potential and also efficiently stores electricity, but has only a fraction of the greenhouse gas impact of manure used as fertilizer.

The modelling study showed that a $5-million investment in a methanation system at the Ontario farm would, with government price subsidies for renewable natural gas, have about a five-year payback period. A paper on modelling of a renewable natural gas generation

involved a post-doctoral researcher and several Waterloo students, was recently published in the *International Journal of Energy Research*.

*http://biomassmagazine.com*

## Bacteria-powered solar cell

Researchers at the University of British Columbia (UBC) have developed a solar cell that uses bacteria to convert light to energy, generating electricity efficiently even in dimmed light conditions. These 'biogenic' solar cells could become just as efficient as synthetic cells used in conventional solar panels, with further development that is.

"Our solution to a uniquely B.C. problem is a significant step toward making solar energy more economical" said Vikramaditya Yadav, lead researcher on the project and a professor in UBC's department of chemical and biological engineering. "These hybrid materials that we are developing can be manufactured economically and sustainably, and, with sufficient optimisation, could perform at comparable efficiencies as conventional solar cells."

Previous attempts to develop biogenic solar cells have focused on the extraction of a natural dye that bacteria use for photosynthesis. However, this is a costly and complex process that involves the use of toxic solvents and which can also cause the dye to degrade. The UBC researchers have instead chosen to use the bacteria directly, genetically engineering e.coli to produce lycopene, a substance that produces the red-orange colour in tomatoes and which is particularly effective at harvesting light for energy conversion.

The researchers coated the bacteria with a mineral that could potentially be used as a semi-conductor. The mixture was then applied to a glass surface, which then acts as an anode. The solar cell subsequently generated a current density of 0.686 milliamps per square centimetre - an improvement on the 0.362 achieved by others in the field.

The researchers are hoping they can find a way in which the dye can be produced indefinitely, without killing the bacteria. The research has been published in the most recent edition of the journal *Small*.

*https://www.renewableenergymagazine.com*

# USA

## Water-based battery

Researchers at the Stanford University have developed a water-based battery that could provide a cheap way to store wind or solar energy generated when the sun is shining and the wind is blowing so it can be fed back into the electric grid and be redistributed when the demand is high. The battery uses a cheap industrial salt—manganese sulphate—to go through the chemical process which stores the excess energy in form of hydrogen gas.

"What we've done is thrown a special salt into water, dropped in an electrode, and created a reversible chemical reaction that stores electrons in the form of hydrogen gas," Yi Cui, professor of materials science at Stanford and senior author on the research paper, explained the project. He added that manganese-hydrogen battery technology could be one of the missing pieces in the energy puzzle – a way to store unpredictable wind or solar energy so as to lessen the need to burn reliable but carbon-emitting fossil fuels when the renewable sources aren't available.

The team which developed the prototype of the device attached a power source to the battery to mimic power fed by solar or wind energy. The electrons flowing in reacted with the manganese sulphate dissolved in the water to leave particles of manganese dioxide clinging to the electrodes. Excess electrons bubbled off as hydrogen gas, thus storing that energy for future use.

The researchers re-attached device's power source to the depleted prototype, this time with the goal of inducing the manganese dioxide particles clinging to the electrode to combine with water, replenishing the manganese sulfate salt. Once this salt was restored, incoming electrons became surplus, and excess power could bubble off as hydrogen gas, in a process that can be repeated again and again.

Though, currently, the prototype is just three inches tall and generates a mere 20 milliwatt-hours of electricity, around the same as LED flashlights that hang on a key ring, the researchers said that it can be easily scaled to an industrial-grade system that could charge and recharge up to 10,000 times, creating a grid-scale battery with a useful lifespan in excess of a decade. Cui estimated that, given the water-based battery's expected lifespan, it would cost a penny to store enough electricity to power a 100-watt lightbulb for twelve hours. The device is specifically developed to tap the variability of renewable energy sources—sunlight and wind—and, can also form as a backup against demand surge our outages.

*https://www.moneycontrol.com*

## Graphene-enhanced biophotovoltaic technology

Researchers at UC Riverside are attempting to integrate biological components with photovoltaic cells to deliver fully sustainable solar energy. The team's biophotovoltaic device is built from renewable carbon by integrating graphene hybrids and the phototropic protein bacteriorhodopsin.

A biophotovoltaic cell integrates biological materials as functional elements in the solar cell. Instead of silicon, the researchers use the protein bacteriorhodopsin, found in halobacteria from salty lakes, as the component that captures sunlight in the device. Halobacteria are an ancient group of microbes that live in water too salty to sustain most other forms of life. They produce a purple protein called bacteriorhodopsin that absorbs energy from sunlight and uses it to transport protons, along with their electrical charge, as an energy source that sustains the organism's biological functions.

Bacteriorhodopsin offers a potentially more environmentally friendly and effective alternative to silicon because it naturally converts solar radiation into electricity and can be produced with very little environmental impact.

*https://www.graphene-info.com*