ASIA-PACIFIC

AUSTRALIA

Cost-effective way to recycle solar panels

New research has proposed a cost-effective way to recycle solar panels to help handle an increasing volume of retired photovoltaic (PV) cells expected by the end of the decade. In a paper published by a team from the University of New South Wales, researchers outlined a process to collect and extract valuable materials from solar arrays to see if it was technically, economically, and environmentally feasible.

The process involves collecting solar arrays, stripping them of their aluminium frame, shredding the cells, and using an electrostatic separation to collect valuable materials including silver and copper, reducing the panels to 2%-3% of their original weight. The reclaimed material would then be shipped directly to a refinery for purification and processing.

A lead author of the study, Dr Pablo Dias, said it showed it was possible to run a low-volume facility capable of managing 1000 tonnes of solar panels a year. This is roughly equivalent to 50,000 panels a year, or about 4100 panels a month. "This is something someone can pick up elsewhere, it doesn't use any chemicals, it doesn't emit any pollution or hazardous pollution. It produces dust from crushing the panels, but you have dust collectors there," Dias said.

Dias said smaller-scale facilities were important as they could process material closer to their source before sending it on, reducing emissions from transport. "You could do this in a suburb in South Australia, concentrate the valuable material and then send it directly to the refiners who do extracting and purifying the metals," he said. He has also since moved to put the research into practice via a start-up company, Solarcycle, which is building a facility in Texas in the United States. It is expected to be operational by November.

https://www.theguardian.com

New light on solar cell development

An increase in the efficiency of solar panels may be on the horizon, as research from The Australian National University (ANU) reduces their current limitations. ANU researchers have found a way to improve the performance of silicon photovoltaic (PV) or solar cells. This is done through the addition of "passivating contacts" between the metal and silicon parts of the solar cell, making it more productive. "These findings will help push the performance of silicon solar cells closer to their theoretical limit," Mohamed Ismael, lead ANU researcher and PhD candidate said.

"Transition metal oxides such as titanium oxide have many qualities that make them ideal as passivating contact layers," Dr Lachlan Black said. "This isn't a new idea, but the way in which we combined these layers has produced better results and higher operating voltages than anything previously reported." The research team is hoping to develop the technology to a point where it can be applied to industrial solar cells on a large scale.

"If successful, we could see our technology in almost all new solar panels installed on your roof or utility-scale solar plants," Dr Black said. Some practical issues still need to be addressed before the technology can be implemented, but the PV community is already working to solve these challenges. "Improving the efficiency of solar cells guarantees more clean energy at a reduced cost. This not only helps to address climate change, but opens up new economic opportunities for this low-cost clean energy," Ismael said.

https://www.eurekalert.org

CHINA

Microcapsules for storing solar energy

In a recent breakthrough, researchers from China and USA synthesized PMC microcapsules showing unprecedented photothermal conversion and heat transfer by using n-Octadecane (ODE) as the PCM core and a silicon carbide (SiC) nanoparticle-doped crosslinked polystyrene (CLPS) as the outer shell. "Phase change microcapsule materials have been the focus of our research. In a previous study, we found that a single organic shell has defects in thermal conductivity and stability, while a single inorganic shell is not satisfactory in compactness and coverage. Therefore, we began to focus on doping organic shells with inorganic nanoparticles to obtain organic-inorganic hybrid shells," explains Prof. Jifen Wang from Shanghai Polytechnic University, China, one of the authors of the study, which was published online on 29 September 2022 in *Energy Storage and Saving*.

In their work, the team prepared a series of four microcapsules using a method called "suspension polymerization." They then characterized the microcapsules using scanning electron microscopy, energy-dispersive X-ray spectroscopy, and Fourier transform infrared spectroscopy. The results indicated that the microcapsules were spherical and the nano-SiC particles were embedded in the CLPS shells, aiding the heat transfer and photothermal conversion efficiency of the microcapsules.

The team next tested the thermal properties of the microcapsules and found that they showed superior photothermal conversion and thermal conductivity compared to the non-doped samples. Among the four types of doped microcapsules, the one with 1.25 wt% nano-SiC doping demonstrated the best performance, with a 54.9% photothermal conversion efficiency, a whopping 146% higher its non-doped counterpart!

With such encouraging results, the novel PCM microcapsule shells could provide a solid framework for further research on energy materials with excellent solar energy storage and conversion efficiency. The study also opens new doors to the practical application of multifunctional phase change microcapsules. "These microcapsules can have significant potential applications as energy storage materials in solar energy devices, intelligent thermal

insulation equipment, and energy-saving buildings," says Prof. Wang.

https://www.eurekalert.org

Offshore wind turbine

China's home-developed 13.6-megawatt offshore wind turbine has rolled off the production line in East China's Fujian Province recently, marking the country's breakthrough in the research and manufacturing of the high-end equipment in the sector. With propeller diameter of 252 meters, the wind turbine covers a swept area of 50,000 square meters, which is equivalent to seven standard soccer fields, the *People's Daily* reported on Saturday.

The single unit could produce clean energy of 63.5 million kilowatt-hours annually, meeting the annual electricity needs of more than 30,000 three-people households. It will greatly save energy and reduce carbon emission. It's estimated to reduce the consumption of coal by 19,000 tonnes and reduce carbon dioxide by 48,000 tonnes a year, according to the report. The wind turbine has the largest single-unit capacity in the Asia-Pacific region and the largest propeller diameter in the world. The application of the offshore wind turbine would drive up the industrial upgrading of the country's wind power sector and boost the transformation of the country's energy structure, according to *People's Daily*.

https://www.globaltimes.cn

Selenium solar cell

Researchers from the Wuhan National Laboratory for Optoelectronics (WNLO) in China have fabricated a selenium (Se) solar cell with a selenium-tellurium (Se-Te) absorber, which they claim can optimize the selenium bandgap, thus improving the overall cell efficiency. "Selenium element is a promising light-harvesting material for solar cells because of the large absorption coefficient and prominent photoconductivity," the scientists said. "However, the efficiency of Se solar cells has been stagnated for a long time owing to the suboptimal bandgap (> 1.8 eV) and the lack of a proper electron transport layer."

The researchers built the cell with an indium tin oxide (ITO) substrate, an electron transport layer (ETL) made of zinc-oxide (ZnO), a Se-Te absorber alloyed by using 70% of Se and 30% of Te, and a gold (Au) metal contact. "Alloying selenium with tellurium, which has the same crystal structure and a narrow bandgap, can tune the bandgap and increase the melting point, thus expanding the absorption spectrum and improving the quality of the selenium solar cell films," said the lead author, Chao Chen.

The research group pointed out the ZnO ETL as another decisive factor contributes to increasing the overall cell efficiency. It is reportedly able to slightly react with selenium to enhance its interfacial adhesion and to reduce dangling bonds, and thus, reduce interfacial defects. It tested the device under standard illumination conditions and found its power conversion efficiency reached 1.85%.

"The efficiency of ZnO/$Se_{0.7}Te_{0.3}$ solar cells has more than doubled after nine months in the air," Chen also said, noting that the next steps in the research are to prepare high-quality Se-Te alloy films, eliminate holes and vacancy defects, and optimize device structure.

The scientists said that, thanks to the Se-Te absorber, the cell open-circuit voltage decreased as expected, while the short-circuit current did not always increase due to the current loss at long wavelengths. In addition, they found the fill factor was rather low because of the cliff at the interface and the leakage according to the small shunt resistance. "We mainly focused on the device and analyzed its air stability, defect properties and recombination mechanism, for the sake of providing guidance for the further performance optimization," they said.

https://www.pv-magazine.com

INDIA

Sustainable battery ecosystem

As the popularity of electric vehicles (EVs) grows in India, there are concerns on the environmental impacts of the waste they could leave behind, highlighting the need for appropriate disposal and recycling of EV batteries and associated waste. Some solutions are brewing in Bengaluru, known as the information technology (IT) capital of India, where technocrats and startups, have, over the past few years, been developing innovations to reduce the carbon footprint as well as the hazardous impact on the environment and human health, of EVs and their waste.

One such effort is toward developing indigenous alternatives to the imported lithium-ion batteries, a key component of EVs. Akshay Singhal, Kartik Hajela, and Pankaj Sharma came together in 2015 and co-founded Log9 Materials in Bengaluru. The startup earlier was involved in material science focusing on innovations in nanoparticles and graphene materials. While Singhal and Hajela are alumni of the Indian Institute of Technology (IIT)-Roorkee, Sharma is a former scientist from IIT-Delhi.

The trio, through their venture, has developed a lithium-ion battery for EVs, which uses the nanomaterial lithium titanate (LTO) chemistry. This advanced battery, they say, has a shelf life of 15 years and can charge nine times faster, and has nine times better performance than the standard lithium-ion batteries.

"In India the lithium-ion batteries are used for EVs but they do not seem to be crafted for countries with hot climates like India.

We started working on advance nano materials that could reduce the degradation of Li-ion cells during charge discharge cycles and by now have commercialised the LTO chemistry in the market. With lithium titanate nano particles, the batteries are charged in a very short time, last nine times longer than conventional batteries and also can withstand temperatures up to 230 degrees Celsius. The conventional lithium-ion batteries start degrading by anywhere between 60 degrees to 100 degrees," Sharma told *Mongabay-India*.

Log9 already has several clients, including EV manufacturers. Its LTO batteries are already commercialized for three-wheeler and four-wheeler vehicle

categories. The company has also set up a 50-megawatt hour (Mwh) commercial level lithium-ion cell production facility based on LTO technology and are commissioning their battery pack facility with a capacity of 2-gigawatt hour (Gwh) battery production capability.

Another effort in Bengaluru is to mitigate the quantum and effect of EV battery waste by reusing discarded batteries. Darshan Virupaksha is the co-founder of a Bengaluru-based battery startup called Nunam. The startup initially experimented with reuse of laptop batteries. Now, the team is working on reusing discarded batteries of EVs for other electric energy needs, including for electricity needs in rural and low-income areas. The recycled batteries have so far been used to light up carts of street-side vendors, small shopkeepers, and more as well as meeting some of the energy needs of a BSNL Telecom Tower at Jayanagar in Bengaluru. The recycled battery initiative has been funded by a Government of Karnataka grant which supported pilot projects and has received further support from research and renewable energy organizations such as TERI (The Energy and Research Institute) and the Selco Foundation.

Another Bengaluru-based startup, Metastable Materials, was founded by an IIT-Roorkee alumnus, Shubham Vishwakarma, in the light of increased battery wastes due to the rise of EVs in the country. Vishwakarma calls his company an urban mining company as it is involved in the extraction of valuable materials out of urban waste items like EV batteries.

The startup claims that 90 percent recovery of the crucial components of the batteries like copper, aluminium, cobalt, nickel, lithium, and others make it into re-use by other industries, leading to reduced flow of battery wastes into waste sites in cities. The startup says it is using a patented technology to eliminate the use of chemicals and reduce the generation of waste in recycling of lithium-ion batteries that is allegedly done when using the conventional methods.

https://india.mongabay.com

JAPAN

Three-junction III-V solar cell

Researchers led by Japan's National Institute of Advanced Industrial Science and Technology (AIST) have fabricated a three-junction solar cell based on indium gallium phosphide (InGaP), gallium arsenide (GaAS) and copper, indium, gallium and selenium (CIGS) with a mechanical stacked design. "We are currently increasing our efforts to improve the cell efficiency and the development of the mass production technology," researcher Kikuo Makita told *pv magazine*, noting that this kind of cell has the potential to achieve efficiencies close to 35%.

The scientists built the cell with a two-junction InGap-GaAs upper cell with a bandgap of 1.49 eV, based on a rear-emitter heterojunction structure developed by Japanese manufacturer Sharp, and a CIGS bottom device with a bandgap of 1.01 eV, with improved surface roughness. They connected the cells through a modified smart stack with palladium (Pd) nanoparticles and adhesive.

The research group improved the bottom cell's surface via wet etching. They used a bromine-based solution and modified its thin transparent conducting oxide (TCO) layer. "Surface roughness leads to an increase in the gap width at the bonding interface," they explained, noting that this roughness, combined with the TCO thickness may lead to reflection loss. "Therefore, in this study, we focused on minimizing surface roughness and TCO thickness."

The academics tested the performance of the cell under standard illumination conditions. They found it achieved a power conversion efficiency of 29.3% for the aperture area (31.0% for the active area), an open-circuit voltage of 2.97 V, a short-circuit current density of 12.41 mA/cm^2, and a fill factor of 0.80. They said the obtained efficiency of 29.3% is superior to that of the group's previous results. They claimed it was the highest value ever reported for any two-terminal GaAs-CIGSe-based multi-junction solar cell.

"We examined the costs of the cells using Smart stack technology and, according to our simulation, they may result in a final module cost of US$ 2/W," Makita said. "GaAs cell cost, CIGSe cell cost, bonding cost, and modulization cost are 86%, 7%, 3%, and 4%, respectively." The GaAs cell, especially the GaAs substrate and GaAs epi-growth, is the main factor affecting device-fabrication costs.

"In our project, device epitaxial lift-off (ELO) and substrate reuse techniques are studied to reduce the GaAs substrates costs," Makite said. "In addition, the AIST has developed a hydride vapor phase epitaxy (H-VPE), which is a new growth method for GaAs cells. H-VPE is a low-cost technique compared to the general metal-organic chemical vapor deposition (MOCVD) technique. We think that the development of these fabrication technologies contributes to the cost reduction of expensive GaAs cells."

The researchers presented the cell design in "Mechanical stacked GaAs//$CuIn_{1-y}Ga_ySe_2$ three-junction solar cells with 30% efficiency via an improved bonding interface and area current-matching technique," which was recently published in *Progress in Photovoltaics*. The cost of producing solar cells based on compounds of III-V element materials – named according to the groups of the periodic table that they belong to – has confined such devices to niche applications, including drones and satellites, where low weight and high efficiency are more pressing concerns than costs in relation to the energy produced.

https://www.pv-magazine.com

REPUBLIC OF KOREA

Microalgal strain for biofuel production

A state-run research body in the Republic of Korea has discovered a method to quickly cultivate a microalgal strain from cyanobacteria, known as blue-green algae, that can produce twice as much biofuel as other microorganisms due to rapid proliferation. The study opened the way for researchers to commercialize cyanobacteria-based carbon-neutral fuels.

A research team from the National Institute of Biological Resources (NIBR) would conduct additional studies to reveal the characteristics of the microalgal strain identified as *Pseudanabaena mucicola* GO0704 and lay the foundation for genetic engineering research to increase productivity, according to the Ministry of Environment. "Microalgae also have a greenhouse gas reduction effect that absorbs carbon dioxide, making it a promising next-generation biofuel material," Kim Chang-mu, a senior NIBR researcher, said in a statement released by the ministry on November 3. "We will study how to use it as a biofuel through various research."

GO0704, which contains ethanol and diesel, can be used as biofuels, but optimal growth conditions have not been known. NIBR researchers discovered optimal culture conditions by applying the volatile fatty acid-treated mixotrophic cultivation of GO0704 for the enhancement of biofuel production. The treatment of butyric acid or acetic acid enhanced the growth of cells, resulting in the production of high amounts of biodiesel and bioethanol.

The optimal incubation period was shortened by four days when sodium acetate was added, and the production of biofuels per day more than doubled when butyric acid was added, the institute said, adding that the method can dramatically reduce biofuel production costs because acetic acid or butyric acid is a cheap substance that can be obtained when organic substances such as food waste are decomposed.

https://www.ajudaily.com

Inverted perovskite solar cell

Researchers at South Korea's Ulsan National Institute of Science and Technology (UNIST) have developed an inverted perovskite solar cell with a vertically oriented passivation layer. It relies on two-dimensional Ruddlesden–Popper perovskites (RPP), which are known for their excellent stability. The scientists said they were able to achieve a "highly ordered" passivation layer by gauging the deposition rate of the RP phase perovskite, which has a direct influence on its crystallographic orientation. "We demonstrate the use of a highly oriented butylammonium RP perovskite as a surface passivation layer with bottom-up growth on the bulk perovskite absorber layer via vacuum deposition," they explained. "In this process, the crystal formation time directly affects the crystallographic orientation of the passivation layer."

They built the cell with an indium tin oxide (ITO) substrate, a hole transport layer (HTL) made of poly-triarylamine (PTAA), methylammonium lead iodide (MAPbI3) perovskite layer, the RPP passivation layer, an electron acceptor made of phenyl-C61-butyric acid methyl ester (PCBM), a zinc-oxide (ZnO) layer, and a silver (Ag) metal contact. They said the 2D perovskite layer passivates the bulk perovskite defects and promotes charge transport efficiency. The champion cell designed with this configuration achieved a power conversion efficiency of 21.4%, which the academics described as the highest ever achieved for perovskite solar cells formed by vacuum deposition. They described the cell in "A vertically oriented two-dimensional Ruddlesden–Popper phase perovskite passivation layer for efficient and stable inverted perovskite solar cells," which was recently published in *Energy & Environmental Science*. "Our findings provide a new perspective toward further improving the performance of perovskite solar cells by mitigating nonradiative recombination pathways in perovskites," they said.

https://www.pv-magazine.com

SAUDI ARABIA

Smart glass windows that can polarize sunlight

Basem Shihada, an associate professor of Computer Science at the King Abdullah University of Sciences and Technology (KAUST), had been exploring data encoding into an artificial light source when he wondered if the same could be done with sunshine. "I was simply hoping to use a cell phone camera to record a video of the encoded light stream to try to decode the video to retrieve the data; that's when I thought, why not do the same with the sunlight?" Shihada said in a statement. "This would be much easier and can be done over the cell phone camera too. So we began to explore sunlight as an information carrier."

According to his study, "considerable amounts of ambient light remain unexploited and are mainly used for illumination purposes. Such light can be modulated to transmit data offering a complementary solution for wireless communication." Sunshine streaming through a window could easily be harnessed for wireless data transmission to electronic devices.

Shihada and his team of KAUST researchers immediately got to work and designed a smart glass system (switchable glass) that can regulate sunlight passing through it. The system would encode data into the light that can be detected and decoded by devices in the room. Not only is the system innovative, but it also offers a greener mode of communication in comparison to conventional Wi-Fi or cellular data transmission.

The devised system comprises two parts—a light modulator that can be embedded in a glass surface and an in-room receiver. "The modulator is an array of our proposed smart glass elements known as Dual-cell Liquid Crystal Shutters (DLSs)," Osama Amin, a research scientist in Shihada's labs, said. The liquid shutter array would require only one watt of power to operate, its function being to encode signals into the light as it passes, acting like a filter. The power would be supplied using a small solar panel.

Sahar Ammar, a student in Shihada's team, explained that data is usually encoded by varying the light intensity. "But if the frequency of these intensity changes is too low, it can be detected by the human eye and cause an uncomfortable flicker effect," she said. Therefore, the DLS is designed in such a way that it can manipulate polarization. "Change in light polarization is imperceptible to the eye, eliminating the flicker problem," Ammar said. "The

communication system works by changing the polarization of the incoming sunlight at the modulator side. The receiver can detect this change to decode the transmitted data."

According to the team, the designed setup can transmit data at 16 kilobits per second. "We are now ordering the necessary hardware for a testbed prototype implementation. We would like to increase the data rates from kilobits to mega- and gigabits per second," Shihada added.

https://interestingengineering.com

SINGAPORE

Cheap wind harvester

While wind energy systems can come in some pretty big forms, scientists at Nanyang Technological University (NTU), Singapore, have been working on a low-cost solution at the other end of the spectrum. The team has developed an inexpensive device sensitive enough to capture energy from a light breeze and turn it into electricity, generating enough to run a small commercial sensor.

The harvester is small, low-cost, and measures around 15 × 20 cm (6 × 8 in). It consists of a cantilevered beam attached to a middle plate made of layers that harness energy through the triboelectric effect, in which different materials become electrically charged as they separate, in this context caused by vibrations from the wind. We've seen this type of triboelectric technology deployed in other advanced wind harvesters, such as wearable devices that generate energy from the wind as you walk.

The NTU team's device is instead designed to be mounted on the exterior of buildings in urban environments. In their testing, the scientists showed it could harvest energy from a light breeze and can generate up to 290 microwatts of electricity, produce up to 3 volts and also store electricity for use when there is no wind.

In one experiment, they used the device to power 40 LEDs consistently from a wind speed of 4 meters (13 ft) per second. In another, it was used to power a sensor that wirelessly relayed room temperature data to a mobile phone. The team is continuing work to improve the performance of the device, and are filing a patent as they pursue commercialization of the technology.

"As a renewable and clean energy source, wind power generation has attracted extensive research attention," said Professor Yang Yaowen, who led the research. "Our research aims to tackle the lack of a small-scale energy harvester for more targeted functions, such as to power smaller sensors and electronic devices. The device we developed also serves as a potential alternative to smaller lithium-ion batteries, as our wind harvester is self-sufficient and would only require occasional maintenance, and does not use heavy metals, which if not disposed of properly, could cause environmental problems."

https://newatlas.com

EUROPE

NORWAY

Thermal battery to store solar power

SINTEF, an independent research organization in Norway, has developed batteries based on PCM, which are able to store wind and solar power in the form of heat via a heat pump. PCM can absorb, store, and release large amounts of latent heat over defined temperature ranges. They have often been used at the research level for PV module cooling and the storage of heat.

"The heat battery can use any heat source as long as a fluid carries the heat to/from the heat battery," researcher Alexis Sevault told *pv magazine*. "For example, district heating is also coupled to our demo unit, for more flexibility in winter. In that case, water is the heat transfer fluid, since it is very well suited for most buildings. Our technology can also be used in industrial processes, using pressure heat transfer fluid, for example, pressurized CO2 for refrigerated or freezing industrial processes."

The scientists embedded what they described as a "bio-battery" in a silver-colored container that hosts 3 tonnes of a type of PCM – a liquid biowax based on vegetable oil. It is reportedly able to melt at body temperature and becomes a solid, crystalline material when it gets "cold" below 37°C. The heat storage system also contains a heat exchanger for heat extraction. "This is achieved with the help of 24 so-called cushion plates that release heat to the process water which serves as an energy carrier that removes the heat from the storage system," the scientists explained. "Together, the PCM and the plates enable the heat bank to be both compact and efficient."

The PCM absorbs large amounts of heat by changing its physical state from solid to liquid, and then releases it when the material hardens. The battery is then able to heat cold water and release it toward a building's radiators and ventilation systems, thus supplying heated air.

"The PCM-based heat storage system is delivering exactly the performance we expected," Sevault said, noting that his team tested the device for more than a year at the ZEB laboratory operated by the Norwegian University of Science and Technology (NTNU). "We're utilizing as much as possible of the building's self-produced solar energy. We're also finding that the system is very well suited to so-called peak shaving."

According to the group's analysis, charging the bio-battery before the coldest parts of the day may help significantly reduce power consumption from the grid while taking advantage of fluctuations in the spot price. "The system is thus much less sophisticated than a traditional battery – but it isn't suitable for all buildings. As a new technology, investment costs remain high," the group said.

According to Sevault, the proposed storage technology is much simpler than conventional batteries, as it does not require any rare materials, with a long expected lifetime and little need for maintenance. "That being said, the specific cost in euros per kilowatt-hour is already comparable

or lower than regular batteries, without being mass-produced yet," he stated, without providing further details.

Other researchers at SINTEF recently developed a high-temperature industrial heat pump than can work with pure water as its work medium, and reportedly reach a temperature of up to 180°C. The machine, which the research group describes as the "world's hottest heat pump," can be used with different industrial processes that rely on steam as an energy carrier and can reduce a facility's energy consumption by between 40% and 70%, as it enables the recovery of low-temperature waste heat, according to its creators.

https://www.pv-magazine.com

SPAIN

Underground heat exchanger to cool down solar panels

Researchers at the University of Alcalá in Spain have developed a cooling technique for solar modules that uses an underground, single-phase, closed-loop heat exchanger circuit that acts as a natural heat sink. "Our analyses, made for various types of residential and commercial installations, show that the system is economically viable with investment amortization periods that range between five and 10 years," researcher Ignacio Valiente Blanco told *pv magazine*.

The cooling technique involves the application of a heat exchanger onto the back side of a solar panel to remove excess heat. This heat is transferred underground by a coolant fluid that is refrigerated by another U-shape heat exchanger introduced in a borehole at a depth of 15 meters, filled with natural water from the aquifer in the underground. "The cooling system needs extra energy to activate the pump of the coolant," the researchers explained. "As it is a closed-circuit, the potential energy difference between the bottom of the borehole and the solar panel does not impact the power consumption of the cooling system."

The scientists tested the cooling system at an off-grid PV installation, which they described as representative of a typical solar farm with single–axis tracking systems. The array consists of two 270 W modules supplied by Spain's Atersa. They feature a temperature coefficient of –0.43% per degree Celsius.

The heat exchanger of the solar panel is mainly composed of a set of six plastically deformed, flattened U-shaped copper tubes, each measuring 15 mm in diameter. The tubes are all thermally isolated by polyethylene foam and are connected to common 18-mm-diameter inlet and outlet collectors. The research group used using a constant coolant flow rate of 3 l/min or 1.8 l/min per square meter of solar panel.

The experiment showed that the cooling tech could reduce the operating solar module temperature by between 13°C and 17°C. It also improved module performance by around 11%, which means that during an entire day, the cooled panel would provide 152 Wh more than its uncooled counterpart, according to the study. The academics introduced the cooling system in "Efficiency Improvement of Photovoltaic Solar Modules by Cooling Using an Underground Heat Exchanger," which was recently published in the *Journal of Solar Energy Engineering*.

https://pv-magazine-usa.com

SWITZERLAND

Transparent solar cells

In a paper published in the journal *Nature*, researchers from Switzerland's École Polytechnique Fédérale de Lausanne detail the way in which they helped DSCs harvest energy from the full visible light spectrum. DSCs, a type of low-cost, thin film solar cell, use photosensitized dye attached to the surface of a wide band gap semiconductor to convert visible light into energy. Despite their financial and physical practicality, they're not as efficient as conventional solar cells, which delegates both light absorption and energy generation to the semiconductor. This means that even though energy-generating windows have technically been possible for a while, the devices wouldn't have been worth the resources.

This new efficiency record could change that. The team in Switzerland enhanced DSCs' efficiency by meticulously controlling the assembly of dye molecules on the cells' nanocrystalline mesoporous titanium dioxide (TiO_2) films. Pre-adsorbing a single layer of hydroxamic acid derivative on the film's surface allowed the scientists to improve the molecular packing and performance of two custom-designed sensitizers. These sensitizers were found to be capable of harvesting light from the entire visible spectrum.

During a simulation of standard air mass 1.5 sunlight—the air mass coefficient typically used to measure solar cells' performance—the enhanced DSCs achieved a power conversion efficiency (PCE) of 15.2 percent. Considering the fact that 12.3 percent was the best-known DSC PCE in 2019, that figure is impressive, especially when you factor in that the enhanced cells maintained operational stability over 500 hours of testing. Better yet, when the scientists tested their enhanced DSCs on devices with a larger active surface area, they achieved a groundbreaking PCE range of 28.4 to 30.2 percent.

The team believes the enhanced DSCs could pave the way for energy-generating windows, skylights, and greenhouses in the near future. They could even find a place in low-power electronic devices, which would then use ambient light as an energy source.

https://www.extremetech.com

UK

Inverted perovskite solar cell

Researchers from the University of Surrey in the United Kingdom have fabricated an inverted perovskite solar cell by using a surface modulator that reportedly facilitates superior passivation on perovskite surfaces, increasing overall cell efficiency. As the surface modulator, the scientists tested two organic halide salts known as 4-hydroxyphenethylammonium iodide (HO-PEAI), and 2-thiopheneethylammonium iodide

(2-TEAI). "These modulators can affect the surface energy of the perovskite films," they explained.

They noted that the two compounds can dramatically reduce non-radiative interfacial recombination. This can have a significant impact on electrical performance in perovskite cells, with implications for open-circuit voltage, short-circuit current, fill factor, and ultimately, power conversion efficiency. They reported that "2-TEAI showed a stronger interaction than HO-PEAI, forming a quasi-2D structure on the perovskite surface without further annealing."

The scientists built the p-i-n structured cell with poly-TPD coated indium tin oxide (ITO) substrate, a hole transport layer made of carbazole (2PACz), the perovskite layer, the 2-TEAI modulator, an electron acceptor made of phenyl-C61-butyric acid methyl ester (PCBM), a bathocuproine (BCP) buffer layer, and a silver (Ag) metal contact. The salts were deposited onto the surface of perovskite films through a facile spin-coating process without annealing. Through different measurements, the research team ascertained that the surface modulator does not alter the absorption spectra of perovskite films.

"The 2-TEAI induces a deeper valence band edge, which is expected to provide a stronger hole-blocking effect at the perovskite/PCBM interface and thus is more beneficial for reducing the interfacial recombination," the group said. "Based on these results, we believe the 2-TEAI would enhance the open-circuit voltage of manufactured perovskite solar cells."

The solar cell achieved a power conversion efficiency of 21.85%, which the scientists described as the highest reported efficiency for inverted perovskite solar cells that use 2PACz as the hole transport layer. The device also achieved an open-circuit voltage of 1.2 V, a short-circuit current of 21.93 mA cm^{-2}, and a fill factor of 0.83. For comparison, a reference perovskite solar cell without the modulator achieved an efficiency of 19.95 and was able to retain only 53% of the initial efficiency after 180 minutes.

"The findings suggest that the role of the modulator is more than surface passivation," the scientists concluded. "Our study will provide insight into the selection and molecular design of post-treatment materials for highly efficient and stable perovskite solar cells."

https://www.pv-magazine.com

NORTH AMERICA

USA

New system converts sewage to biogas

Researchers have developed a new method to convert leftover sludge to biogas, lowering waste treatment costs and helping the environment. A Washington State University research team has tested a pre-treatment technology in waste management systems, adding an extra step to typical treatments and using oxygen-containing high-pressure steam to break down sewage sludge. It was found that they were able to convert more than 85% of the organic material to biogas, which can be used to produce electricity or upgraded to renewable natural gas (RNG) for the natural gas grid or for local use.

The work, funded by the U.S. Department of Energy, was published in the journal *Waste Management*, under the title "Improved valorisation of sewage sludge in the circular economy by anaerobic digestion: Impact of an innovative pre-treatment technology."

The researchers treated the sludge at a high temperature and pressure with oxygen added before the anaerobic digestion process. The oxygen acts as a catalyst under high pressure, subsequently breaking down the polymers in the material. The pre-treatment process has been studied for several years, previously being used to break down straw and woody materials. The team was not sure whether the process would work to produce biogas from the sewage sludge, due to different compositions such as lipids and proteins. However, they were positively surprised by the outcome. Now, the team is working with Clean-Vantage, a Richland-based clean technology start-up company active in the pre-treatment area, and the Pacific Northwest National Laboratory (PNNL), which is doing a techno-economic analysis of the new process.

Adding the new pre-treatment step improves the anaerobic conversion of sewage sludge at the wastewater treatment facility from the current less-than-50% conversion rate. The new method also produces 98% more methane than the current practice, which can be used as biogas.

Birgitte Ahring, professor in the Gene and Linda Voiland School of Chemical Engineering and Bioengineering and leader of the study, stated: "It was shown to be extremely efficient, and that's very exciting. This can be applicable and something we could begin to explore in Washington state. Not wasting waste, but using its potential instead, has major advantages."

Now, the researchers are scaling up the work in their pilot facility located at WSU Tri-cities to further demonstrate the process. The team is studying how to efficiently convert biogas to more valuable renewable natural gas by a new bioprocess. Although the biogas created can be used to produce electricity, producing renewable natural gas could allow rural communities to generate local transportation fuel for fueling their municipal vehicles.

https://www.innovationnewsnetwork.com

Flow battery technology

The research team has founded a startup company, Flux XII LLC, in Madison to commercialize their long-duration grid energy storage solution with the help of the University's technology transfer office. University of Wisconsin-Madison researchers have developed a new "flow battery" technology that stores energy in organic salts dissolved in benign water.

The team hopes to scale and demo their solution with regional partners, which

they believe will enable safer and more adaptable clean energy than current grid energy storage products.

This team's story began in 2015 when Dr. Wenjie Li started researching aqueous (water-based) redox flow batteries as a chemistry Ph.D. student at UW-Madison. "I wish my research can really contribute to creating a better world. Having been trained as an electrochemist, redox flow battery is a pathway where I can apply my knowledge and skills to deliver affordable and renewable energy to everyone," Dr. Li said when asked what motivated him to begin research on this topic.

Grid batteries act as an energy insurance plan while increasing savings by optimizing solar (or wind) usage with your utility's policies. The current market relies on lithium-ion technologies for emerging grid-scale battery applications, the same technology used in rechargeable computers and phones.

Professor Dawei Feng, who worked on lithium-ion battery materials as a Stanford postdoc from 2017-2018 and began research at UW-Madison as an assistant professor in Materials Science and Engineering in 2019, says lithium-ion batteries for the grid "just don't make sense," referencing their fire risk and short-duration (6-hour) limitation for end-users.

Patrick Sullivan, who also performed summer undergraduate research on lithium-ion batteries in 2018 and has been a UW-Madison Chemistry Ph.D. student in Dawei's lab since 2019, is passionate about the sustainability of new technologies after having learned to comprehensively evaluate solutions through a UW-Madison Energy Analysis and Policy graduate certificate.

Sullivan notes the supply chain constraints and international mining concerns of lithium-ion materials. "There's really just not enough Lithium for both the grid and electric vehicle markets, and we may just make the global sustainability crisis worse if we aren't careful," Sullivan said.

With these passions and experiences, the team formed a natural collaboration in 2019 to develop a better grid energy storage solution. Instead of relying on rare foreign metals, the team researches sustainable "organic redox molecules" that can be produced domestically from inexpensive, readily available materials. These organic salts are then dissolved in water and pumped through the battery to store energy while eliminating concerns over fire risk. These materials have been researched in academic labs for the past decade. Still, commercial progress has been slow due to scientific trade-offs in material properties that are ultimately detrimental to either energy efficiency, energy density, or cost.

Since 2019, with the help of postdoc synthetic expert Dr. Xiuliang Lyu and funding from WARF, Development to Product (D2P), and UW System grants, Dawei's University research lab has screened over 500 different flow battery chemistries. The lab has published some of these results in peer-reviewed academic journals and patented related materials that overcome the decade-long performance hurdles. Dawei contributes impactful research progress to their expertise in designing, synthesizing, and evaluating organic materials. At the same time, Sullivan believes their passionate and collaborative team allows them to be more creative.

Both agree that this is just the beginning, as they are now forming partnerships to move the technology beyond a "lab research project." In September 2022, the team set up a 1 kW flow battery prototype at UW-Madison, roughly 1000 times larger than what they typically use to test their materials. With the support of UW-Madison and regional industry partners, the Flux XII team aims to demo a 20 kW flow battery device with a regional customer sometime in late 2023 at a discounted price. This demo – a "lego block" to building larger systems – will validate this exciting technology to help spur safe and secure clean energy adoption in the region.

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New biogas process

A Washington State University (WSU) research team has developed a new method to treat sewage sludge and turn it into biogas—methane—that could help reduce the cost of waste treatment and help the environment, according to a WSU press release. The process involves adding oxygen-rich, high-pressure steam to help break down and convert as much as 85% of the sludge to biogas, which can be burned in the same way natural gas is burned, to generate heat and electricity, the press release said.

Most wastewater treatment plants in the United States use an anaerobic digestion process in which bacteria, with no oxygen present, break down sewage waste. However, according to the press release, the process is inefficient and creates a fair amount of sludge, much of which is dried and carted to landfills. The high-pressure steam is added before anaerobic digestion, the press said, allowing oxygen to act as a catalyst in breaking down complex molecules.

"This is not a very high-tech solution," said Birgitte Ahring, an engineering professor at WSU. "It's actually a solution that can be useful even at small scale. The efficiency has to be high or else you cannot warrant adding the extra costs to the process." WSU is working with Richland-area clean-tech startup Clean-Vantage to help further develop and commercialize the technology, which was funded through a grant from the U.S. Department of Energy.

https://www.chronline.com