

Asian Council on Water, Energy and Environment

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Message from the CACCI Director-General

It is our absolute pleasure to present the 10th edition of the Asian Council on Water, Energy and Environment (ACWEE) newsletter. This publication is a compilation of news articles, and reports on recent developments in the water, clean energy, and environment sectors across the Asia-Pacific region.

2020 has been a turbulent year, not only because of the COVID-19 pandemic, but also the many climate events that have impacted practically every corner of the globe. Now more than ever, industries need to do their part to help improve the state of the climate. Several articles included in this issue show what is currently being done, from ending coal-fired power plants and switching to sustainable finance, to using space technology to help tackle climate change. But without a doubt, more needs to be done.

Climate change likewise impacts access to clean water — a problem that remains prevalent in many parts of the world. This issue focuses on the many novel ways clean water can be had, such as nanofiltration membranes, wastewater recycling, and the use of solar-thermal technologies to make groundwater and seawater drinkable.

Regarding the clean energy sector, this edition of the newsletter includes several reports on renewable energy — in particular, solar-powered sources and green hydrogen. It also touches on the impact of cryptocurrency on energy consumption, as well as how to make wind turbines more wildlife-friendly.

In sum, we sincerely hope this publication will be useful and informative, and that it may help promote pro-environment behavior, and inspire more initiatives that will help make the world a more sustainable place to live in.



Ernest Lin
Director-General
*Confederation of Asia-Pacific Chambers of
Commerce and Industry (CACCI)*

Environmental activism begins to make its mark in Central Asia

Emerging Europe, Milana Nikolova, 27 February 2021

Grassroots environmental groups often have a tough time making their mark in autocratic states. But in Central Asia, there are signs that civil society is finding its voice, raising awareness about the region's many environmental issues.

The Aral Sea (or what's left of it) spans the countries of Kazakhstan and Uzbekistan and was once the fourth largest lake in the world. Its shrinking has been described as one of history's biggest environmental disasters.

The tragedy is arguably the first time the deteriorating environment in Central Asia has caught international attention and concerns have been raised over what local governments and societies are doing to prevent the same harm being done to other important natural formations in the region, such as the Caspian Sea.

Despite environmental awareness amongst Central Asians seeming to be on the rise, the countries' governments have, perhaps unsurprisingly, decided to adopt an illiberal, top-down approach to addressing the environmental issues affecting the region's most vulnerable. Vital regional cooperation is still in its infancy.

Since the death of long-time dictator Islam Karimov in 2017, the Shavkat Mirziyoyev government in Uzbekistan has been keen on opening the country up, and following in the footsteps of Kazakhstan in establishing an image of a state that is autocratic, but at the same time outward-looking and cosmopolitan.

Environmental reforms can be a particularly powerful tool for autocratic regimes looking



to improve their international standing (and as a consequence increasing funding for their regime), as long as these do not go as far as to threaten regime security.

ESG standards

The Uzbek government is thus one of the

few in emerging Europe to produce a report on environmental, social, and governance (ESG) standards the country has been taking into consideration, in a bid to attract funding from environmentally conscious investors.

The 2020 ESG Report includes the country's plan to increase renewable energy usage, solar energy in particular, as well as progress it has made in improving the condition of the Aral Sea. This mostly consists in utilising funds made available by international organisations, such as the International Fund for Saving the Aral Sea (IFAS) and the European Investment Bank in order to improve outdated irrigation systems and ensuring the reliable availability of water for citizens, according to the report.

The report further mentions the vulnerability of Uzbekistan to draughts and water scarcity. However, while the management of these issues mainly lies in the ability to cooperate with other Central Asian states, the report barely mentions any of its neighbours.

Uzbekistan's water management is largely dependent on some of its neighbours, because alongside Kazakhstan and Turkmenistan, it is a downstream country, meaning that some of Central Asia's most important rivers, including the Amu Darya and Syr Darya flow into them from the

upstream countries of Kyrgyzstan and Tajikistan.

Owing to their more fortunate location, Kyrgyzstan generates electricity through hydroelectric plants in the Nary river (which merges with the Kara Darya to form the Syr Darya), while Tajikistan has placed dams along the Amu Darya tributaries on its territory. Kyrgyzstan and Tajikistan's hydroelectric power produces over 50% of their electricity. It has further allowed them to export electricity to South Asia, and the expansion of their agricultural sectors.

Meanwhile, in downstream Turkmenistan and Uzbekistan 98% and 91% of the water supply, respectively, originates outside their borders, making them particularly vulnerable to droughts. This is not a desirable geographical feature for any state, but it is particularly worrying for Turkmenistan where the cotton industry employs much of its workforce, and for Uzbekistan where cotton production is responsible for 76% of its revenue, and are thus heavily reliant on having enough water for irrigation.

Tension, and potential for conflict

The Aral Sea crisis is the consequence of a variety of mistakes spanning decades. However, in Uzbekistan and Kazakhstan, which have suffered social and economic consequences from the presence of dams in Kyrgyzstan and hydroelectric power stations in Tajikistan, there has emerged the exaggerated narrative that upstream states are largely responsible for the near disappearance of the sea, thus creating further tension and aggravating the potential for conflict in the region.

Therefore, while an individual country's commitment to being environmentally cautious could be beneficial in attracting FDI, in order to truly address the environmental issues that are most threatening the livelihoods Central Asian people, the region's rule-makers need to improve mutual cooperation and practice fair river sharing.

Uzbekistan's self-produced 2020 ESG Report further mentions the country's supposed commitment to supporting "civil society and a strong legal system". However, the right to truly independent assembly and campaigning within the country remains sketch. There are essentially no grassroots environmental organisations or movements within the state.

One notable exception is the largely independent initiative of Uzbek doctors in raising awareness of the health impacts that the Aral Sea shrinkage has had on the Karakalpak people

who traditionally live in proximity to the lake. These included reduced fertility, lung and heart problems, and increased rates of cancer, cases of liver cancer, in particular, doubled between 1981 and 1991.

These were caused by the use of Soviet-era herbicides and pesticides used in cotton plantations and allowed to enter nearby rivers, and then the Aral Sea. The contaminated water caused issues as locals continue to drink it, but the issue was further exacerbated when the lake rapidly dried up and toxic chemicals were left exposed on the sea bed, these were then carried by sandstorms and inhaled.

In slightly more liberal Kazakhstan, droughts have led to organised action for a different reason. Food security is not a fact of life for many in Central Asia, and when the price of food in Kazakhstan spiked exponentially in 2007 and 2013 people protested. These were met with forceful retaliation by the Kazakh government, which was heavily criticized in subsequent reports on the country produced by the Helsinki Committee.

On the other hand, in 2011 a Kazakh movement was formed and demanded that local authorities stop the development of a ski resort in the Ile-Alatau National Park near Almaty. The petition received considerable support from locals and in April 2019 the Almaty district agreed to put the project on hold until the impact and location can be further studied. A notable win for Kazakhstan's civil society.

Greater plurality

In Kyrgyzstan, scholars have observed that when interacting with international monitoring organisations, political elites tend to blame-shift environmental issues within the country, such as littering, onto the supposedly uneducated rural population which refuses to observe the societal conventions.

Contrary to this perception, environmental participation in Kyrgyzstan appeared to be on the rise prior to the turbulent events of 2020.

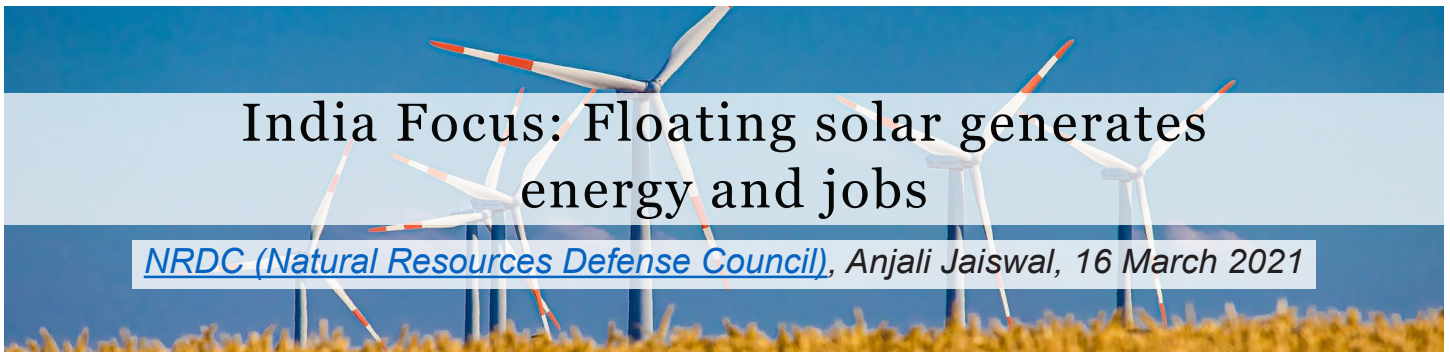
The MoveGreen youth environmental movement is spreading awareness and increasing transparency of the environmental issues in Kyrgyzstan, and especially the pollution in the country's sprawling capital city, Bishkek. Their Aba.kg mobile application informs Bishkek residents details about the quality of their air and has been downloaded by more than 3,000 people.

Supported by MoveGreen, as well as the

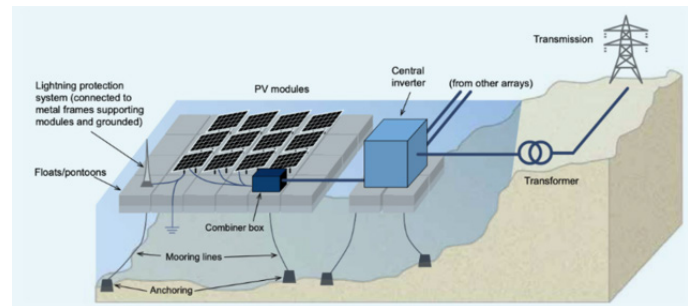
American University of Central Asia, Kyrgyzstan's first independent youth climate forum took place in 2019 and managed to bring together 400 participants. While it is still unclear what Kyrgyzstan's recent transition of power will mean for the future of politics in the country, but as of now, it does appear that Kyrgyz citizens still hold the most power in potentially challenging any government action that further threatens the natural environment.

Overall, the tragic faith of the Aral Sea has

brought the environmental issues of Central Asia to international attention and the region's leaders are facing increasing pressure to do more to ensure environmental protection. While this could bring about positive effects on the environmental quality in the region, there is a dire need for further cooperation between the states of the region, as well as transparency and a greater plurality of voices being heard in the discussion of issues that disproportionately affect the least fortunate members of Central Asian states.



Floating solar plant in India (Siddhant Agarwal, QuantSolar)



Schematic representation of a floating solar plant (World Bank Group, ESMAP, and SERIS, 2019)

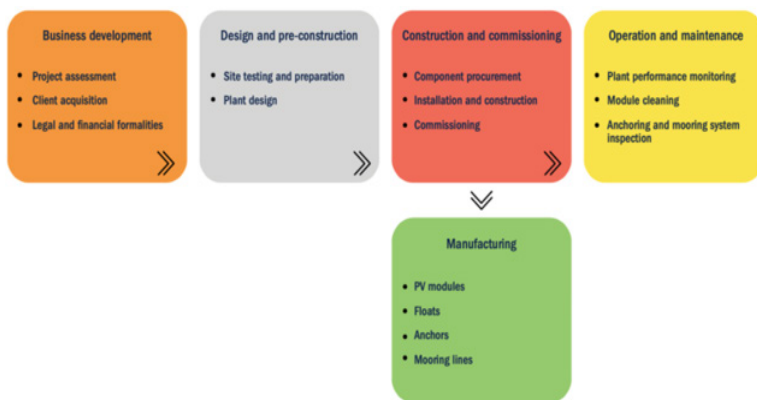
India's largest floating solar power project is expected to be commissioned in May 2021 in Telangana. Several other states, Karnataka, Madhya Pradesh, Tamil Nadu, and West Bengal recently are also developing floating solar projects. Floating solar photovoltaic is a new business opportunity to meet India's renewable energy targets and create jobs, as analyzed in a new case study.

Floating Solar

Floating solar photovoltaic is an emerging segment in which solar photovoltaic (PV) modules are installed (floated) on a water body. Asia leads in global floating solar photovoltaic (FPV) deployment. Floating solar accounts for 2.6 gigawatts (GW) of installed capacity in August

issues of ground-mounted solar, such as the lack of levelled land, evacuation infrastructure and performance degradation due to high operating temperatures. India could potentially build 280 GW of FPV capacity by utilizing about 30% (nearly 1,800 kms²) of its medium and large water reservoirs.

India had about 2.7 MW of installed FPV capacity by the middle of 2019, and projects with a combined capacity of 1.5 GW capacity are under development. The Indian government has set a target to achieve 10 GW of FPV capacity by 2022. Investment costs and bid prices for FPV tenders have also been rapidly declining. As a result, India achieved the lowest cost for FPV projects at ₹35 (\$0.5)/watt during the bid for 70 MW FPV capacity in Kerala.



An FPV solar project includes four stages for a successful deployment (CEEW-NRDC)

Floating Solar and Jobs

A new case study, [Employment Potential of Emerging Renewable Energy Technologies – Insights from the Floating Solar Sector](#), examines the direct employment potential across the floating solar project development cycle and captures the sector’s skill development needs. Estimates are drawn from project-based surveys and interviews with manufacturers, developers, and engineering, procurement, and construction (EPC) providers. The study provides insight into the operational strategies and team structure, in addition to discussing the typical duration of different phases of project development and the corresponding workforce employed. The case study is developed by the Council on Energy, Environment, and Water (CEEW) and Skill Council for Green Jobs (SCGJ) along with NRDC.

Key Findings

- A small-scale FPV plant (capacity <1 MW) directly employs 58 workers while a mid-scale (capacity <10 MW) plant employs 45 personnel, over the course of their deployment.
- FPV generates indirect job opportunities through manufacturers of specialized components like floats, anchors, and mooring system as well as domestic module manufacturers.
- FPV offers opportunities for people qualified in hydraulic engineering, marine architecture, and plastic blow-molding techniques in addition to those required in ground-mounted solar operations.
- By setting time-based targets for FPV capacity, the Indian government can widen the employment potential of this sector, bolster

efforts to drive the COVID-19 economic recovery and achieve its Paris Agreement climate goals.

Key Recommendations

- The Ministry of New and Renewable Energy (MNRE) should specify standards for PV modules used in the FPV sector.
- The Ministry of Skill Development and Entrepreneurship should develop training programs on specialized skills relevant to the FPV industry such as marine architecture and hydraulic engineering.
- The FPV industry should regularly release data on employment and skill development needs in the sector.
- MNRE should announce periodic targets for FPV capacity.
- The Solar Energy Corporation of India (SECI) should initiate hydropower-linked FPV project tenders.

With over 92GW of installed renewable energy capacity, India has made remarkable progress toward meeting its climate goals. Floating solar photovoltaic offers a new pathway for the country to realize its clean energy ambitions and create jobs. Floating solar helps tap into India’s large water reservoirs and overcome some of the persisting issues facing ground-mounted solar. FPV can generate additional employment opportunities in domestic manufacturing, research, and product design. New employment opportunities, especially in research and product design, beckon when FPV scales up in the country.

Number of jobs in deploying a floating solar photovoltaic plant of different capacities (CEEW-NRDC analysis)

Project phase	Duration (days)		Number of people engaged	
	Small-scale	Mid-scale	Small-scale	Mid-scale
Business development	30	110	11	12
Design and pre-construction	15	14	6	2
Construction and commissioning	53	195	36	27
Maintenance	30*	Not available	5**	4**

* Typical duration of one periodic maintenance

** The number of permanent employees overseeing these activities. In addition, temporary staff is also sourced during each maintenance cycle, who carry out the maintenance activities like module cleaning.

Myanmar coup worsens the country's broken EIA system

Mongabay, Andrew Nachemson, 19 March 2021



The Thanlyin River in Hpa-An, also known as the Nu or Salween, is one of the world's last free-flowing international rivers, but is threatened by a number of dam projects. (Remko Tanis via Flickr)

It started with the water changing color. Soon after that, the fish began to die. When the villagers bathed, they became itchy and covered in sores like an allergic reaction. Later, women and farm animals in the area started having miscarriages at an unusually high rate.

"We were very shocked," said environmental activist Saw Tha Phoe, who is currently in hiding, facing criminal charges. "We told the government it needs to take action, this is a very serious case, but the government refused to listen."

Instead of investigating the nearby coal-powered cement plant that the people of Kayin state in Myanmar believed to be responsible for the water contamination, the government went after Tha Phoe. While he was in a meeting out of town in March 2020, 10 police officers barged into his home in Hpa-an township, attempting to seize his nephew in a case of mistaken identity. The raid was the culmination of a years-long struggle between the activists and the government.

"In an interview with local media, the chief minister [of Kayin state] was very clear. She says that the development of Kayin state is delayed because of me. They made me into a villain," Tha

Phoe said.

That chief minister, like so many other officials from the National League for Democracy, is no longer in power following a military coup on Feb 1. Activists and environmental lawyers expressed disappointment with the limited progress made on environmental issues in the five years in which the NLD held power, but said they fear the situation will deteriorate even further under a military dictatorship.

It was a military-owned cement factory that polluted the villages in Kayin state, which the NLD government allowed to go forward despite local resistance and no environmental impact assessment (EIA), as required by law.

While he said he expects things will be worse under the new military regime, Tha Phoe noted that even the NLD was difficult to work with on environmental issues. He said he approached the previous government with proposals about clean-energy projects like solar power but was ignored.

Next, he wrote a letter to the state government offering to do scientific assessments together. "We are trying to test the air quality, the soil quality, water quality. Do everything together so the people trust the information. It would be good for transparency," he said. Instead, the government responded with threats. "They said if anybody tries to do their own research, they will be charged," he said.

"They should sue the company, but they sue me and make threats to other people to force their silence," he said.

Limited progress under NLD

Tha Phoe's story is far from unusual in Myanmar, where it's exceedingly difficult for villagers and environmental activists to hold companies accountable, but easy to jail critics.

A local environmental lawyer, "Y.S.," said there was hope the NLD would change things after taking power in 2015, including reforming

the Environmental Conservation Law, which was passed under the military-proxy Union Solidarity and Development Party in 2012.

Y.S. spoke to Mongabay before the coup, later asking to be made anonymous due to the increased risk now that the military has taken control, as did three other environmental experts working inside and outside of Myanmar interviewed for this piece. All have been randomly assigned pseudonymous initials to avoid reprisals against themselves or the organizations they represent.

“In the last five years, under the NLD, they didn’t do anything about it,” Y.S. said, calling for the law to be amended to give civil society organizations and individuals the right to “take action against businesses and any other illegal activity that can cause environmental pollution and degradation.”

Y.S. also criticized the 2016 Environmental Conservation Policy passed by the NLD as ultimately toothless. “We can’t reference a policy in court. They’re just guidelines that the government commits to, but it is not a law. We need a law and we need a good law,” he said.

Y.S. said he was disappointed that Myanmar’s brief experiment with democracy didn’t translate to more environmental protection. “It’s still happening under the democratic government. Things have not really changed,” he said.

While Tha Phoe came up against a military-connected company, another environmental lawyer, G.J., said the NLD government didn’t take action against private companies either.

“Sometimes the owner is from a military background, sometimes they are from a crony background. But we didn’t see very obviously special treatment for the military-owned companies. Most mining companies are doing a lot of harm and causing a lot of pollution,” G.J. said, adding that none are being held accountable.

A third legal expert, F.I., said the NLD may have been afraid of being seen as stalling development.

“It’s simply a government choice not to use the power it has. Perhaps it comes from the idea that Myanmar needs mining companies for development, yet without accountability, the harms to communities and the environment far exceed revenues,” F.I. said, also speaking before the coup.

F.I. said the NLD government consistently

failed to take action against damaging companies, for no clear reason, adding that the legal framework was already “perfectly adequate” for the government to hold companies accountable. “The Ministry of Natural Resources and Environmental Conservation has the power to bring administrative fines and prosecutions, but it chooses not to,” F.I. said.



Upland small-holder farmers, especially those who depend on rain to grow crops, are particularly vulnerable to the impacts of climate change. (Isabel Esterman/Mongabay)

A broken EIA system

One of the key problems under the NLD government was a broken EIA procedure. According to law, all projects are required to complete a full EIA. Even if companies simply need to renew their license or want to change their original proposal, they are meant to submit a new EIA. But the reality was different.

Vicky Bowman, director of the Myanmar Centre for Responsible Business, said her organization has seen EIA reports that “look more like press releases for the project than an impartial professional assessment of impacts.”

“Myanmar EIA consultants have told us that they are also pressured by their clients to remove references to negative impacts,” she said.

She said the Environmental Conservation Department refused to prioritize review of high-risk projects, instead ordering all preexisting investments to submit an “environmental compliance audit” at once, which led to a massive backlog of projects that it couldn’t work through. According to Bowman, this “overwhelmed the limited in-country expertise” and led to “a huge pile of paper on ECD’s desk, much of it worthless cut and paste text, which they are still struggling

to process.”

Bowman said some projects should not even reach a point where they undergo an EIA. “The best EIA in the world can’t fix a poorly considered and located project whose potential adverse impacts are so severe that nothing could adequately mitigate them. Some of the major dam projects like Mong Ton and Myitsone fall into this category. These projects should be screened out by the government at an early stage,” she said.

Soon after seizing power, Senior General Min Aung Hlaing floated the idea of “generating low-cost hydropower,” leading many to believe that the junta may seek to restart suspended projects like the environmentally devastating Myitsone dam.

Bowman defended the Environmental Conservation Department as “a new department which is slowly building up its experience.” But with the government in the hands of the military, that limited progress may have been lost.



Between 1990 and 2010, during the previous period of direct military rule, Myanmar lost 19% of its forest. (Isabel Esterman/Mongabay)

After the coup

While most observers were critical of the NLD’s lack of progress on environmental issues while in power, there was widespread agreement that the situation will likely worsen considerably under military rule.

R.G., an environmental lawyer with extensive experience in the region, said the coup “has been a disaster for the environment and climate change as the military is a corrupt and rent-seeking criminal organization.” R.G. said he expects the new regime will “only be interested in maximizing personal benefit” and “resource exploitation.”

He also said that given the coup was



Citizens protest the Myanmar military coup in Kayin State in Feb 2021. (Ninjastrikers via Wikimedia)

“unconstitutional,” any “permits and approvals issued by the coup are illegal.” While the regime may lack legal legitimacy, it has already moved to replace and reappoint judges, which could pose another problem for environmental protection.

The third lawyer interviewed, F.I., gave a similar assessment. “The junta is not a legitimate government — it simply does not have the right to award [environmental compliance certificates], implement laws, or grant licenses,” F.I. said. Furthermore, the military “has a long history of misappropriating these resources to fund its human rights abuses.”

F.I. said the already broken EIA process will also likely suffer under the new regime, adding it requires “public participation” and for communities to be able to openly object to projects.

“This is not possible under a junta with no respect for human rights, no rule of law, and new laws which mean that any opposition to an EIA process could be seen as ‘hindering’ a public servant, which the junta has made illegal,” F.I. said.

The regional expert, R.G., said he hopes that given the junta’s illegitimacy, the World Bank, countries in the region and other international institutions won’t engage with the military.

R.G. said even China may hesitate to engage with the military, given the possibility that the NLD could return to power. “If they betray the NLD and the Myanmar community then all their projects will be suspended or cancelled after democracy is restored.”

“Until the military goes there is no hope for Myanmar’s environment,” R.G. added.

Why coal-fired power plants in Southeast Asia are facing opposition heat

DownToEarth, Aleena Thomas, 3 February 2021

Southeast Asia's electricity consumption is projected to more than double of 961 terawatt-hour by 2040 owing to significant demographic and economic growth. On the power supply side, coal has played a key role.

But the world is aiming to limit global temperature rise to well below 2 degrees Celsius over pre-industrial standards, and coal cannot continue to be used excessively. It will have to be replaced by renewable energy sources or clean coal technologies with better energy efficiency.

Southeast Asian countries are planning to expand coal power, especially in Indonesia and Vietnam. Indonesia plans to add 27 gigawatt of new coal power capacity in the coming years, according to Indonesia Ministry of Energy and Mineral Resources, Electricity Supply Business Plan (RUPTL) 2019-2028.

Growing social and environmental opposition, however, has delayed some coal projects in Indonesia. For instance, 1,000 megawatt Cirebon 2 power plant is stuck in corruption allegations. The power plant has also been blamed for having adverse impacts on the surrounding mangrove and coastal marine ecosystems, as well as the livelihoods of the local communities.

When Cirebon 1 went online eight years ago, salt farmers reported significant losses in production; traditional fish farmers reported that the pollution from the plant destroyed their livelihood, reported in Mongabay Series 2020.

Myanmar has significant expansions plans. In 2014, its installed coal-based capacity was only three per cent of 3,633 megawatt; the country is likely to pull it up to 34% by 2030. Interestingly, there has been no active development in Myanmar



because of strong civil society opposition fearing for people's health, environment and livelihoods.

In 2010, the government planned to install a 4000-MW power plant. It could have been the largest coal power plant in Southeast Asia, but due to rising protests, the plan was suspended. Later, numerous plans were made

for new power plants. The Toyo-Thai coal power plant was planned in Hpa-an (Kayin State) in 2017, for instance.

But protests swelled again and the plan was shelved. Myanmar, meanwhile, began experiencing effects of climate change: Floods, droughts and cyclones became increasingly common.

Building coal power may satisfy short-term energy needs, but the decision will not be environment-friendly or sustainable in the long run.

The opposition to coal utilisation for power supply has been experienced by other countries such as the Philippines, Vietnam and Thailand. Resistance against coal power has been gaining traction in at least 12 provinces in the Philippines. The country faces the maximum opposition in Palawan, where the government approved a 15 MW plant.

According to local environmental groups, these plants threaten the province's biodiversity and overlooks cheaper renewable power generation options. Several communities, non-governmental organisations as well as several provincial and municipal governments declared they would become coal-free and look to renewable energy as alternatives.

The Philippine government chief in November

2020 declared that the country stopped accepting new coal-based power proposals. Communities in Thailand protested over the harmful effects on health and the environment of new coal power plants in Krabi in 2018, saying it could cause harm to the ecosystem, specifically fisheries, and harm the tourism industry.

Protests were organised in Songkhla provinces, eventually driving the government to cease all plans. In January 2020, it was reported that the Strategic Environmental Assessment Committee (SEA) was assessing the need for a coal plant in Krabi area.

According to multiple projections, Vietnam will continue to rely on coal-fired power generation as its major energy source in the following decades to ensure energy security despite the increasing share of renewables. Coal faces local opposition because it contributes to air pollution.

An alliance of social and professional organisations in Hanoi suspended 14 coal-fired plant projects with a total capacity of 17.4 GW in January 2021, according to Thanh Nien newspaper. As many as 12 organisations specialising in health and environment together have called on Vietnam to scrap 14 new coal plants.

Concerned by the environmental and health toll that coal-fired power plants exact, leaders of 12 networks and non-government organisations collectively urged Prime Minister Nguyen Xuan Phuc to stop 14 coal-fired plants in Vietnam.

Despite massive expansion plans, coal power in Southeast Asia is increasingly facing powerful opposition from socio-environmental and economic and financial perspectives. Moving towards low carbon transition pathways, the only option for ASEAN to keep on working with coal is to improve the state of its technologies.

Climate change and the dust environmental impact in the Middle East and North Africa

[Open Access Government](#), Georgiy Stenchikov, 12 February 2021



The consequences of climate change are complex, far-reaching, and are felt on global and regional scales. Climate projections on regional and local scales are essential for adaptation and planning on national and sub-national levels to increase resilience and robustness of industrial and social infrastructures. Adaptation on a regional scale is more feasible than on a global one, as proposed global geoengineering “solutions” such as solar radiation management could assure the planet cooling but cause adverse regional

consequences. The Middle East and North Africa (MENA) climate is especially vulnerable to these adverse effects.

Freshwater is the most vital resource in the desert environment. Management of water resources over MENA is challenging. Population growth, industries, and agricultural activities over the past century have led to an increase in demand for water supply. At the same time due to environmental conditions, per-capita freshwater consumption is high. For example, the Kingdom of Saudi Arabia (KSA) has one of the highest per-capita rates of water consumption (near 300t yr⁻¹) in the world. The KSA desalinises about 1Gt of water per year producing 25-30% of all desalinated water in the world.

Precipitation Modification

The idea of artificially increasing the precipitation has attracted attention for many years. The United Arab Emirates are currently funding research on a rain enhancement program

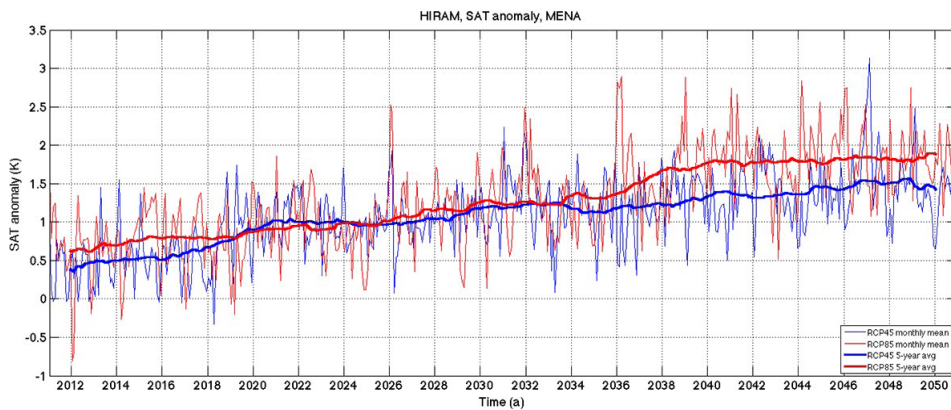


Fig. 1. Surface air temperature anomaly projection over the MENA region until 2050 in RCP4.5 and RCP8.5 emission scenarios. The projections are calculated at KAUST using global High-Resolution Atmospheric Model (HiRAM) with 25-km grid spacing.

that explores different technical options. There were marginally successful attempts using cloud seeding to trigger rain processes in desert environments. The ways in which dusts can affect clouds and precipitation is not widely known or fully understood. Afforestation is a known way of increasing precipitation. Instead, we found that decreasing surface albedo by distributing solar panels over the Red Sea coastal plain enhances sea breezes and triggers more precipitation over that region. This method has little environmental consequence in the surrounding areas. It can be used as a climate adaptation measure and is an example of regional-scale precipitation geoengineering.

Temperature trend

The Middle East experiences an enhanced level of warming in comparison with the average warming trend over the Northern Hemisphere. One of the reasons is extreme dryness of the region that prevents the land surface energy balance adjustment by increasing evaporation. Therefore, the desert temperature sensitivity to radiative forcing, solar and longwave, is higher than that averaged over the global landmasses. The highest warming trend is observed in Summer making temperature extremes more severe. Fig. 1 shows the temperature projection in MENA until 2050 for two IPCC emission scenarios RCP8.5 (red, business as usual) and RCP4.5 (blue) with decreasing of CO₂ emissions starting from 2030. This assessment was conducted for the United Nations Economic and Social Commission for Western Asia (UN ESCWA) project on water resources and social vulnerability in Arab countries. The projections were calculated on a

KAUST supercomputer using the global high-resolution atmospheric model (HiRAM) with a regional spatial resolution of 25×25 km². The results show steady warming for more than 1 K by the middle of the 21st century.

Regional climate predictions

Regional climate changes are driven by global climate trends. But predicting regional climate is more challenging than the global climate, as high spatial resolution is required, and natural variability, nonlinear circulation responses, and local

physical effects complicate the analysis. Professor Stenchikov's group at KAUST is focusing on the MENA region that is one of the most vulnerable to climate change. The MENA environmental characteristics are at the brink of livability, but global warming will be exacerbating impacts on health, infrastructure, human migration, biodiversity, tourism, and food production.

The current regional climate prediction technology is based on two pillars: Simulations with fine-resolution global models and downscaling Earth System Model outputs using nested regional models. The technology we are developing at KAUST is based on a combination of these two approaches, as we conduct a deep downscaling of the high-resolution global climate forecast using the regional atmospheric model. To add in physical consistency, we coupled the regional atmospheric model with the regional ocean model accounting for aerosol and atmospheric chemistry processes.

Global dust emissions

Along with Central and Eastern Asia, the MENA significantly contributes to global dust emissions, which are in the range of 1000–2000 Tg yr⁻¹. MENA accounts for more than half of global dust emissions. Dust affects solar and terrestrial radiation, the planetary energy balance, atmospheric circulation. Dust produces the world's largest solar radiative cooling reaching in the southern Red Sea 60 W/m². The prolonged dryness and social conflicts led to the growth of dust aerosol optical depth (AOD) that characterises the radiative effect of aerosols (see Fig. 2). Dust deposition on the surfaces of solar panels inhibits

their efficiency. However, absorption of UV radiation by dust diminishes the effect of UV on humans.

Dust radiative effect is complex as dust particles both reflect and absorb solar radiation, and generate a significant greenhouse warming. As a result, dust cools the surface but warms the atmosphere. The radiative effect of dust depends on the surface albedo and solar zenith angle. Atmospheric heating caused by Saharan dust alters both Hadley and Walker circulation moving the rain belt north in Summer increasing precipitation in Sahel. We found that the radiative cooling of the Southern Red Sea due to accumulated dust layers affects circulation and energy balance of the sea, the effect that was not previously recognised.

Dust is not the only aerosol in the Middle East. Anthropogenic aerosols are produced as a result of industrial activity, traffic, power generation are abundant, especially in the population centres. The aerosol's mix, so cold particulate matter (PM) severely affects air quality. The dramatic increase in the level of air pollution in developing countries over the last decades is forced by rapid economic and population growth, burning of fossil fuels, construction and agricultural activities. Still, the primary cause of air pollution in the MENA is mineral dust, and it is on the rise (see Fig. 2). In KSA dust is responsible for about 95% of aerosol concentration. But in the cities, an anthropogenic aerosol component is coming on the top of dust significantly deteriorating the urban air quality. At almost all territory of the Arabian Peninsula PM pollution exceeds the World Health Organization (WHO) limits.

Climate models allow us to understand the physical mechanisms of climate variability and estimate future climate changes. But models alone are not sufficient to make reliable estimates. The model parameter identification and testing require accurate observations of environmental characteristics, especially, associated with aerosols.

KAUST Dust monitoring

Professor Stenchikov has established a comprehensive aerosol monitoring research at KAUST campus. The KAUST AERONET site has been operational for almost a decade providing multi-wavelength observations of column integrated aerosol optical depth, aerosol size distribution, Angstrom exponent, and refractive

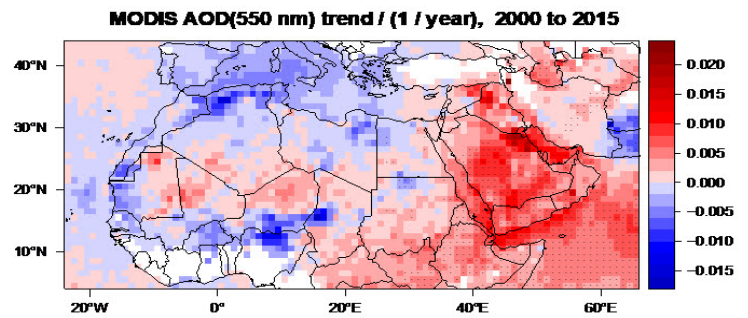


Fig. 2. Visible AOD trends between March 2000 and February 2015 based on the Dark Target/Deep Blue 550nm AOD from MODIS Terra, collection 6. Pixels with significant trend (p value < 0.01) are marked with a dot (Klingmueller et al., 2016).

index. A micro-pulse lidar measures vertical distribution of aerosol backscattering coefficient. We developed a new retrieval algorithm that allowed us to obtain vertical distribution of aerosol extinction, single scattering albedo, and aerosol mixing ratio. We were the first who conducted systematic measurements of aerosol optical depth over the Red Sea using a hand-held sunphotometer (MICROTOPS). These measurements are conducted in cooperation with the NASA Goddard Space Flight Center and observations are accessible at the NASA website within AERONET, MPLnet, and MARITIME archives. We also conducted a multi-year campaign on measuring aerosol deposition rate and conducted mineralogical and size distribution analysis of deposition samples. This is meant to help predict the dust health effect, its radiative properties, and provide the means to test dust mass balance.

The combination of advanced modelling with the integrated results of environmental monitoring is a proven approach to advance regional climate forecast for MENA to inform environmental decision making. There is a lot that must be understood regarding the effect of dust in the desert environment. For example, dust chemically and microphysically interacts with anthropogenic pollutants e.g. sulphate aerosols, that changes dust radiative effect and life cycle. The comprehensive climate models allow integrating empirical data with physical mechanisms and are invaluable for understanding complex climate processes. These models could be used for assessment of the efficacy of adaptation and mitigation measures, and are instrumental in evaluating and mapping renewable energy resources.

Hong Kong's fragile coral reefs boosted by 3D printing

AFP via The Hindu, 21 March 2021

In jade waters off Hong Kong's eastern shoreline, scientists are thrilled to spot a cuttlefish protecting her eggs inside an artificial, 3D-printed clay seabed helping to restore the city's fragile coral reefs.

On postcards and in the popular imagination Hong Kong is a byword for urban density, a thicket of towering skyscrapers crammed along the harbour or clinging to the vertiginous hillsides above.

Yet it is circled by a surprising array of nature and the small number of coral reefs are some of the city's best-kept secrets.

Around 84 species of coral are found in Hong Kong's waters, scientists say, more diverse than those found in the Caribbean Sea. Most can be found on remote inlets, far from the sediment-filled Pearl River Delta and its busy shipping channels.

But like all reefs in a rapidly warming world, they are under enormous pressure. Which is where Vriko Yu and her team of fellow marine scientists come in.

They have begun using 3D printed tiles that work as an artificial bed for corals to latch onto and thrive, with promising results.

"The first time we put down the tiles, there were a few fish around," she told AFP on a recent inspection by University of Hong Kong (HKU) researchers.

Now the artificially produced reef laid down last summer is teeming with wildlife, including the cuttlefish, something Yu described as "very, very exciting".

Terracotta warriors

Hong Kong's government commissioned



research into local coral ecosystems after the reefs at Hoi Ha Wan marine park were struck by bleaching and mass die-offs.

Corals are colonies of billions of living polyp invertebrates and are hugely sensitive to temperature changes. When they get too hot,

they lose their vibrant colour and die.

Repopulating a dead or damaged reef requires suitable ground for the remaining coral larvae to latch onto and build a new home — and the printed tiles have so far proven dependable.

"3D printing allows us to customise a tile or a solution for any type of environment and I think that's the real potential that the technology brings," David Baker, an associate professor at HKU's School of Biological Sciences who led development of the technology, told AFP.

Tiles carrying 400 coral fragments have been laid on a 40 square-metre (430 square-foot) section of sea floor in the marine park. "The corals now on the tiles definitely survive better than the traditional way of transplantation," said Yu, putting the success rate at around 90%.

Some projects around the world have deliberately sunk ships or concrete onto the sea floor to encourage coral growth. And while those methods have had some success, they can change the chemistry of the water.

The tiles used in the Hong Kong project are made with terracotta, minimising the environmental impact. "Clay is basically soil, so soil you can find everywhere on earth," said Christian Lange, an associate professor from HKU's Department of Architecture. It leaves water chemistry unchanged, Lange added, and if a tile fails to spawn a new colony it will simply erode

without leaving a trace.

Tougher colonies

Marine biologists pay close attention to successful reef repopulation programmes because corals are at risk of disappearing.

Rising sea temperatures have decimated reefs around the world, especially those in warmer tropical waters.

Australia's Great Barrier Reef — the world's largest coral system — is now so badly damaged that it is listed by the International Union for Conservation of Nature (IUCN) as "critical", the worst category.

Corals that exist in subtropical waters are of particular interest to scientists because they form generally hardier colonies that are better able to withstand a greater range of temperatures.

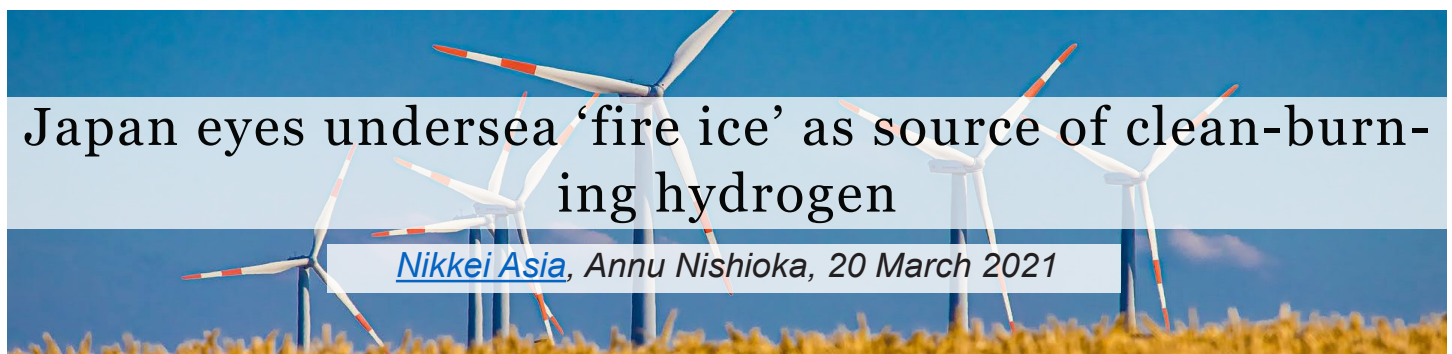
A recent Royal Society paper found some evidence that some subtropical corals were

thriving in warmer oceans, compared with their tropical cousins.

"The Great Barrier Reef... has many corals living offshore in clear tropical waters, they're not used to change," explained Baker. "So just having a little extra warmth is going to push them over the edge faster than we think our local corals would succumb to bleaching."

Baker said the tiles are not a panacea for the mass bleachings. But he hopes the project can identify species with the genetic resilience to endure future environmental stress and buy time for corals "to adapt and to migrate into more suitable areas".

"We might actually be creating a new potential home for corals as they try to escape climate change from equatorial regions," he said.



Deep down on the ocean's floor lies a sherbet-like substance that could revolutionize the way the Japan consumes energy, but there's just one problem: extracting the fuel from the dark depths of the seas.

One Japanese company believes it has the solution. Modec, a maker of offshore oil platforms, has plans to develop a system that is designed to extract methane hydrate, also known as "fire ice," from the ocean bottom and become a source of clean-burning hydrogen.

Modec will pilot the technology during the next fiscal year starting April. The technology will be used in a novel floating unit that will retrieve the methane hydrate.

The project aligns with the Japanese government's goal of attaining net-zero emissions of greenhouse gases by the year 2050. A stable source of hydrogen would play a pivotal role in achieving that objective.

One cubic meter of methane hydrate can

produce roughly 160 cubic meters of methane gas, which in turn, can be transformed in hydrogen.

Methane hydrate has long been a subject of exploration as a source of natural gas. This February, a Japanese government panel cited methane hydrate as an untapped repository of hydrogen and ammonia, another clean energy source.

The conventional way to explore for methane hydrate is at deep-sea locations where the ocean floor lies 1,000 meters below the water surface. The deposits are located a few hundred more meters beneath the sea bed. This method, however, has yet to attain commercial viability.

Modec looks to achieve a breakthrough by drilling for methane hydrate in shallow waters close to shore. The fire ice is broken down and lifted into the floating gasification unit, where it is converted into methane gas and transported to an onshore terminal through an underwater pipeline.

Modec specializes in making floating



units for petroleum exploration, among other resources. The company possesses the know-how to efficiently retrieve oil and natural gas using the natural upward pressure of the deposits.

Similarly, methane hydrate steadily becomes more gasified the closer it reaches the ocean surface. Modec believes it can apply its extraction technology to that concept.

Modec has already developed a prototype methane hydrate extraction unit. Next fiscal year, Modec will collaborate with Hokkaido's Kitami Institute of Technology to launch an onshore test extracting ice bars resembling methane hydrate measuring 3 meters in length and 2 meters high. The pilot will take place in Kitami, Hokkaido Prefecture.

Once the technology is developed, Modec aims to sell the equipment. An order for one floating unit is expected to fetch tens of billions of yen (10 billion yen equals \$91.6 million).

Currently, most hydrogen is derived from



One cubic meter of methane hydrate can produce roughly 160 cubic meters of methane gas, which in turn can be transformed into hydrogen. (U.S. Department of Energy)

natural gas, a fuel that resource-poor Japan imports. Securing stable supplies of hydrogen sources, as well as the costs, have been long-standing hurdles.

If Japan is able to access the methane hydrate deposits near its coastlines, the country can avoid the geopolitical risks inherent in procuring hydrogen sources. Methane hydrate emits 30% less carbon dioxide when burned than either coal or petroleum.

The government plans to raise Japan's annual hydrogen consumption to about 20 million tons by 2050. For that to happen, the cost needs to be lowered to 20 yen per cubic meter from approximately 100 yen currently. If production of methane hydrate reaches a certain scale, it will play a role in bringing the hydrogen prices to a level that is competitive with imported liquefied natural gas.

Modec believes that its floating units will cut costs of procuring hydrogen below that of hydrogen sources obtained overseas, even when accounting for transport expenses.

Other engineering companies have moved toward hydrogen exploration. Mitsubishi Shipbuilding, a unit of Mitsubishi Heavy Industries, is developing a methane hydrate floating unit as well based on its offshore mining tech.

A need to nurture a new source of earnings is also driving this business trend. The shipbuilding and offshore platform business have been hammered by the drop in energy demand amid the pandemic.

Stiff rivalry from China and South Korea has worsened the business environment. The worldwide shift away from carbon threatens to impede new oil projects, so next-generation fuel such as hydrogen are seen as viable alternatives.

The scientists turning the desert green

[The Guardian](#), Steve Rose, 20 March 2021

Flying into Egypt in early February to make the most important presentation of his life, Ties van der Hoeven prepared by listening to the podcast 13 Minutes to The Moon – the story of how Nasa accomplished the lunar landings. The mission he was discussing with the Egyptian government was more earthbound in nature, but every bit as ambitious. It could even represent a giant leap for mankind.

VanderHoeven is a co-founder of the Weather Makers, a Dutch firm of “holistic engineers” with a plan to regreen the Sinai Peninsula – the small triangle of land that connects Egypt to Asia. Within a couple of decades, the Weather Makers believe, the Sinai could be transformed from a hot, dry, barren desert into a green haven teeming with life: forests, wetlands, farming land, wild flora and fauna. A regreened Sinai would alter local weather patterns and even change the direction of the winds, bringing more rain, the Weather Makers believe – hence their name.

“If anybody doubts that the Sinai can be regreened,” Van der Hoeven told the Egyptian delegates, an assortment of academics, representatives of ministers and military top brass, “then you have to understand that landing on the moon was once thought unrealistic. They didn’t lay out a full, detailed roadmap when they started, but they had the vision. And step by step they made it happen.”

Van der Hoeven is nothing if not persuasive. Voluble, energetic and down-to-earth, the 40-year-old engineer’s train of thought runs through disciplines from morphology to esoteric



The Loess plateau, in China, in 2007, left, and transformed into green valleys and productive farmland in 2019. (Composite: Rex/Shutterstock/Xinhua/Alamy)

mysticism, often threatening to jump the tracks. But he is keenly focused on the future. “This world is ready for regenerative change,” he says. “It’s going to be a complete change of our behaviour as a species in the longer term. It is going to be a step as big as fire was for humanity.”

It sounds impossibly far-fetched, but not only is

the Weather Makers’ plan perfectly feasible, they insist, it is precisely the type of project humanity should be getting its head around right now. In recent years, discussion about the climate crisis has predominantly focused on fossil fuels and greenhouse gases; now, we’re coming to realise that the other side of that coin is protecting and replenishing the natural world. There is no better mechanism for removing carbon dioxide from the atmosphere than nature, but in the past 5,000 years, human activity has reduced the Earth’s total biomass by an estimated 50%, and destroyed or degraded 70% of the world’s forests. As UN secretary general António Guterres put it last year: “Human activities are at the root of our descent toward chaos. But that means human action can help to solve it.”

The Weather Makers know this very well: their origins are in dredging, one of the heaviest industries there is. Over the past few centuries, dredging has helped humans alter the face of the planet on ever-greater scales. Trained as a morphological engineer, Van der Hoeven has spent the past decade in the industry, working on projects across the world, including the artificial islands of Dubai, whose creation involved large-scale dredging and land reclamation. He got

sucked into the expat lifestyle there, he admits: drinking, eating, partying, “I lost a little bit of my soul.” Returning to the Netherlands in 2008, he began to reexamine his own profession: “What I could see is that the dredging industry had so much potential; we were just misusing it.”

Working for the Belgian company Deme, he devised a new method of dredging that was both more eco-friendly and more efficient. He used inexpensive sensors to model maritime conditions in real time – waves, currents, tides – so as to determine more precisely where and when it was safe to work. Trialling the system, he won over sceptical colleagues by living on the vessel with them, even cooking meals. Head office was also convinced when his technique saved a small fortune.

In January 2016, Van der Hoeven was contacted by Deme’s Egyptian representative, Malik Boukebous, who had been asked by the Egyptian government to look into restoring Lake Bardawil, a lagoon on the north coast of the Sinai. The lake was once 20 to 40 metres deep, but today is just a few metres deep. Dredging the lake and cutting channels to allow more water in from the Mediterranean would make it deeper, cooler and less salty – all of which would boost fish stocks.

But Van der Hoeven did not want to stop there. “If I feel I’m on the right track, it’s difficult for people to distract me,” he says. He began looking at the Sinai Peninsula in more detail: its history, weather patterns, geology, tides, plant and animal life, even religious texts. He took himself off other projects and spent long hours in his apartment surrounded by charts, maps, books, sketched diagrams. “People were afraid for me because I was forgetting myself. My friends were cooking for me.” The deeper he looked, the more potential he saw.

There is evidence that the Sinai once was green – as recently as 4,500 to 8,000 years ago. Cave paintings found there depict trees and plants. Records in the 1,500-year-old Saint Catherine’s monastery, near Mount Sinai, tally harvests of wood. Satellite images reveal a network of rivers flowing from the mountains in the south towards the Mediterranean.

What turned the Sinai into a desert was, most likely, human activity. Wherever they settle, humans tend to chop down trees and clear land. This loss of vegetation affects the land’s ability to retain moisture. Grazing animals trample and



The Sinai Peninsula today, and how it could look after greening. (Composite: The Weather Makers)

consume plants when they try to grow back. The soil loses its structure and is washed away – hence the silt in Lake Bardawil. Van der Hoeven calculated the lake contained about 2.5bn cubic metres of silt. If one were to restore the Sinai, this vast reserve of nutrient-rich material was exactly what would be needed. “It became clear we had a massive opportunity,” he says. “It wasn’t the solution to a single problem; it was the solution to all the problems.”

By this stage, Van der Hoeven and Deme agreed that he would be best off working as a separate entity, so in 2017 he founded the Weather Makers with two friends: Gijs Bosman and Maddie Akkermans. Both appear to be steadying influences. Bosman, a project manager at Dutch engineering firm Royal HaskoningDHV and a friend since student days, had the ability to translate Van der Hoeven’s grand vision into actionable technical detail. Akkermans has a background in finance and economics. “Ties said, ‘I’m too chaotic. So I can’t do this alone,’” she says. “Having someone like me who could tell him the truth and keep him on track gave him the confidence to start a company.”

They consulted with experts across disciplines, in particular a handful of veterans who have been ploughing the eco-restoration furrow for decades. Van der Hoeven calls them his “Jedi”. The first of these is John D Liu, a Chinese-American ecologist with a background in broadcasting. Restoring a landscape as large and as degraded as the Sinai sounds like science fiction, but it has been done before. While Van der Hoeven was immersed in his research, a friend implored him to watch a documentary called Green Gold, which Liu had made for Dutch television in 2012. It chronicles the story of the

Loess plateau, an area of northern China almost the size of France. In 1994, Liu, who was working as a television journalist in Beijing, was asked by the World Bank to film the start of an ambitious restoration project, led by a pioneering Chinese scientist, Li Rui. At that time, the Loess plateau was much like the Sinai: a dry, barren, heavily eroded landscape. The soil was washing away and silting up the Yellow river. Farmers could barely grow any crops. The plan to restore it was huge in scale but relatively low tech: planting trees on the hilltops; terracing the steep slopes (by hand); adding organic material to the soil; controlling grazing animals; retaining water. The transformation has been astonishing. Within 20 years, the deserts of the Loess plateau became green valleys and productive farmland, as Green Gold documents. “I watched it 35 times in a row,” says Van der Hoeven. “Seeing that, I thought, ‘Let’s go for it!’”

The Loess plateau project was also a turning point for Liu, he says – away from broadcasting and towards ecosystem restoration: “You start to see that everything is connected. It’s almost like you’re in the Matrix.” Despite his Jedi status, 68-year-old Liu is easygoing and conversational, more midwestern ex-hippy than cryptic Zen master. Since 2009, he has been an ambassador for Commonland, a Dutch nonprofit, and an adviser to Ecosystem Restoration Camps – a global network of hands-on, volunteer communities.

After watching Green Gold, the Weather Makers practically burst into Commonland’s Amsterdam headquarters to share their plans. “They were not going to be denied!” Liu recalls. “I said, ‘We have to work with these people, because this is the most audacious thesis I’ve ever seen.’”

Liu brought Van der Hoeven to China to see the Loess plateau first-hand. “To be in a place that had been essentially a desert where now it’s raining cats and dogs, and it’s not flooding, because it’s being infiltrated and retained in the system – it was all just so impressive to him.”

Through Liu, Van der Hoeven met another Jedi: Prof Millán Millán, a Spanish meteorologist. In the 1990s, Millán began investigating the disappearance of summer storms in eastern Spain for the European commission. “What I found is that the loss is directly linked to the building up of coastal areas,” he says. Rainfall in the region comes almost entirely from Mediterranean sea breezes. However, the breeze alone doesn’t carry

enough water vapour to create a storm inland; it needs to pick up extra moisture, which it used to do from the marshes and wetlands along the coast. Over the past two centuries, however, these wetlands have been built on or converted to farming land. No additional moisture; no more storms. “Once you take too much vegetation out, it leads to desertification very quickly,” says Millán.

Such changes do not just affect the weather at a local level, Millán discovered: “The water vapour that doesn’t precipitate over the mountains goes back to the Mediterranean and accumulates in layers for about four or five days, and then it goes somewhere else: central Europe.” In other words, building on the Spanish coast was creating floods in Germany. Millán’s findings have gone largely unheeded by the European commission, he says. Now 79 and retired, he speaks with the gentle weariness of a long-ignored expert: “My criticism to them was: the old township barber would pull your teeth with pliers. It hurt, but it was effective. You’re still using those procedures, but you could save all your teeth.”

Millán’s research and Liu’s experience in the Loess plateau arrived at essentially the same conclusion. Chop down the trees, destroy the ecosystem, and the rains disappear; restore the ecosystem, make a wetter landscape, and the rains come back. Millán distilled his work down to a simple maxim: “Water begets water, soil is the womb, vegetation is the midwife.”

Regreening the Sinai is to some extent a question of restarting that “water begets water” feedback loop. After restoring Lake Bardawil, the second phase is to expand and restore the wetlands around it so as to evaporate more moisture and increase biodiversity. The Sinai coast is already a major global crossing point for migratory birds; restored wetlands would encourage more birds, which would add fertility and new plant species.

When it comes to restoring inland areas of the Sinai, there is another challenge: fresh water. This is where another Jedi came into play: John Todd, a mild-mannered marine biologist and a pioneer in ecological design. In the 1970s, frustrated by the narrowness of academia, Todd established the New Alchemy Institute, an alternative research community in Massachusetts dedicated to sustainable living. One of his innovations was the “eco machine” – a low-tech

installation consisting of clear-sided water barrels covered by a greenhouse.

“An eco machine is basically a living technology,” Todd explains. The principle is that water flows from one barrel to the next, and each barrel contains a mini ecosystem: algae, plants, bacteria, fungi, worms, insects, fish; like a series of manmade ponds. As the water flows, it becomes cleaner and cleaner. “You could design one that would treat toxic waste or sewage, or you could design one to grow food. They are solar-driven, and have within them a very large amount of biodiversity – in a sense, they reflect the aggregate experience of life on Earth over the last 3.5bn years.” In the Sinai, eco machines would be used to grow plants and to produce fresh water.

Last autumn, the Weather Makers built their own eco machine on a pig farm on the outskirts of the Dutch city of s’-Hertogenbosch, where they are based. For the first step in a plan to change the world, it is not exactly prepossessing. It looks like a standard agricultural polytunnel. On a cold, drizzly day, Weather Maker Pieter van Hout gives me a virtual tour. Inside the greenhouse are six clear-sided barrels filled with water of various shades of green and brown. In some of the tanks is leaf litter and dead plant material. Van Hout points out the brown algae growing on the sides: phytoplankton, the basis of the food web, which feeds life further up the chain: insects, snails and, in one tank, fish (in the Sinai these would be edible tilapia).

Some water evaporates from the barrels and condenses on the inside skin of the greenhouse, where it is collected by a system of gutters. Even on a cold day in the Netherlands, there is a constant trickle into a container on the ground. In the heat of the Sinai, the cycle would run much faster, says Van Hout. The water feeding the eco machine would be salt water, but the water that condenses inside would be fresh water, which can then be used to irrigate plants. If the structure is designed correctly, one would only need to drum on the outside to create an artificial “rain” inside. When the plants and the soil inside the greenhouse reach a certain maturity, they become self-sustaining. The greenhouse can then be removed and the process repeated in a different spot. “The idea is that you may have 100 of these structures,” says John Todd. “And they’re spending five years in one site and then they’re moved, so these little ecologies are left behind.”

In the Sinai, the sediment from Lake Bardawil would be pumped up to the hills, 50km inland, where it would then trickle back down through a network of eco machines. The saltiness of the sediment is actually an asset, says Van Hout, in that it has preserved all the nutrients. Flushing them through the eco machines will “reactivate” them. Around the water tanks, they are now testing to see which salt-tolerant plant species, or halophytes, grow best. Van Hout proudly points out a stack of white plastic tubs containing silt freshly scooped from the bottom of Lake Bardawil. “This is what ecosystem restoration looks like in real life,” he laughs, “buckets of very expensive mud.”

Estimates of how much difference a regreened Sinai could make are hard to quantify. In terms of carbon sequestration, it would doubtless be “billions of tons”, says Van der Hoeven. But such metrics are not always helpful: if you convert atmospheric carbon into, say, phytoplankton, what happens when a fish eats that phytoplankton? Or when a bigger fish eats that fish?

Another useful measure could be global temperature. In addition to sequestering carbon, green areas also help cool the planet. Deserts are heat producers, reflecting around 60% to 70% of the solar energy that falls on them straight back into the atmosphere. In areas covered by vegetation, much of that solar energy is instead used in evapotranspiration: the process of condensation and evaporation by which water moves between plants and the atmosphere. “If vegetation comes back, you increase cover, you reduce temperature, you reduce solar reflection, you start creating a stable climate,” says Van der Hoeven. “If we want to do something about global warming, we have to do something about deserts.”

At present, the hot Sinai acts as a “vacuum cleaner”, drawing moist air from the Mediterranean and funnelling it towards the Indian Ocean. A cooler Sinai would mean less of that moisture being “lost”. Instead, it would fall as rain across the Middle East and north Africa, thus boosting the entire region’s natural potential. Van der Hoeven describes the Sinai peninsula as an “acupuncture point”: “There are certain points in this world where, if we accumulate our joint energy, we can make a big difference.”

The Sinai is also an acupuncture point geopolitically, however. Post-Arab spring, the

region has become a battle zone between Egyptian security forces and Islamist insurgents. There have been numerous terrorist incidents: the bombing of a Russian airliner in 2015 killed 224 people; an attack on a Sufi mosque in 2017 killed more than 300 worshippers. Northern Sinai is currently a no-go area to outsiders, controlled by the military, and plagued by poverty, terrorism and human rights abuses. Since 2018 the military has restricted access to Lake Bardawil for local fishermen to just a few months a year, says Ahmed Salem, founder of the UK-based Sinai Foundation for Human Rights. “There’s a lot of suffering,” he says, “because they don’t have any other way to earn money and feed their families.” A restored landscape would bring tangible benefits to locals, says Salem, but it all depends on the president, Abdel Fatah al-Sisi. “If Sisi really wants to help them [the Weather Makers], it will be OK for them because he’s like a god in Egypt. But if he doesn’t, they will fail.”

But the Sisi government seems to have recognised that ecosystem regeneration could fix many problems at once: food security, poverty,



The Weather Makers have forged links with Habiba organic farm in southern Sinai (Maged El Said)

political stability, climate goals, as well as the potential for a green project of international renown. The government is close to signing contracts for the first phase of the restoration plan, which covers the dredging of Lake Bardawil. Subsequent phases may well require financial support from external bodies such as the EU.

As outsiders, the Weather Makers are aware their plan will require local support, cooperation and labour. Because of the military restrictions, none of them has visited Lake Bardawil, although they have forged links with an organic farm in southern Sinai named Habiba. Habiba

was established in 1994, by Maged El Said, a charismatic, Cairo-born tour operator who fell in love with the region. Originally it was a beach resort, but in 2007 El Said branched into organic farming, and Habiba now connects other farms, local Bedouin tribes and academic institutions.

El Said has some reservations about the Weather Makers’ plan: “It’s a big shiny project, but also you’re drastically changing the environment, the flora and fauna. I don’t know if there will be side-effects.” But in terms of the larger mission, they are very much aligned: “We are all in the same boat. Desertification and climate change is happening so fast, so we need action on the ground. Enough of workshops, enough seminars, talks, talks, talks.”

On a global level, the tide is turning in the Weather Makers’ direction. Discussions about greening, reforestation and rewilding have been growing in volume and urgency, boosted by high-profile advocates such as Greta Thunberg, David Attenborough and British ecologist Thomas Crowther, who made headlines in 2019 with research suggesting the climate crisis could be solved by planting 1tn trees (he later acknowledged it was not quite that simple).

This year marks the beginning of the United Nations Decade on Ecosystem Restoration, “a rallying call for the protection and revival of ecosystems around the world”. The UN hopes to restore 350m hectares of land by 2030, which could remove an additional 13 to 26 gigatons of carbon from the atmosphere. After decades of compartmentalising environmental issues and missing its own targets, the UN, too, has come to realise that the only viable solution is to do it all at once. It particularly wants to rally younger people to the cause; its social media campaigns carry a “generation restoration” hashtag. “Ecosystem restoration is not a technical challenge; it’s a social challenge,” says Tim Christophersen, head of the Nature for Climate branch at the UN Environment Programme.

Nations and corporations are also making ever more ambitious commitments to greening, even if they are struggling to live up to them. The UK, for example, plans to create 30,000 hectares of woodland a year by 2025. India has pledged to restore 26m hectares of degraded land by 2030. Africa’s Great Green Wall, “the world’s largest ecosystem restoration project”, aims to plant an 8,000km line of trees across the Sahara

Desert, from Senegal to Djibouti (14 years on, it is only around 15% complete). Meanwhile, green companies are taking root, such as Ecosia, the Berlin-based search engine, which to date has planted more than 120m trees around the world.

“The main challenge,” Christophersen says, “is the lack of human imagination; our inability to see a different future because we’re staring down this dystopian path of pandemic, climate change, biodiversity loss. But the collective awareness that we are in this together is a huge opportunity. People don’t have a problem imagining what a four-lane highway would look like. But to imagine a restored landscape of over a million hectares – nobody knows what that would look like because it hasn’t really been done before.”

Van der Hoeven would agree. He cites

Yuval Noah Hariri’s book *Sapiens*, which argues that humans prevailed because of our ability to share information, ideas, stories: “We were able to believe in a myth – in something which was not there yet.”

Regreening the Sinai is presently little more than a myth, just as the Apollo missions once were; but it now exists in the imagination, as a signpost for the future we aspire to. The more it is shared, the more likely it is to happen. It could come to be a turning point – an acupuncture point: “We’re not going to change humanity by saying, ‘Everything has to be less,’” says Van der Hoeven. “No, we have to do more of the good things. Why don’t we come together and do something in a positive way?”



Energy consumption has become the latest flashpoint for cryptocurrency. Critics decry it as an energy hog while proponents hail it for being less intensive than the current global economy.

One such critic, DigiEconomist founder Alex de Vries, said he’s “never seen anything that is as inefficient as bitcoin.”

On the other side of the debate, research by ARK Investment Management found the Bitcoin ecosystem consumes less than 10% of

the energy required for the traditional banking system. While it’s true the banking system serves far more people, cryptocurrency is still maturing and, like any industry, the early infrastructure stage is particularly intensive.

The cryptocurrency mining industry, which garnered almost \$1.4 billion in February 2021 alone, is not yet unusually terrible for the environment compared to other aspects of modern life in an industrialized society. Even de Vries told TechCrunch that if eco-conscious regulators “took all possible actions against Bitcoin, it’s unlikely you’d get all governments to go along with that” mining regulation.

“Ideally, change comes from within,” de Vries said, adding he hopes Bitcoin Core developers will alter the software to require less computational energy. “I think Bitcoin consumes half as much energy as all the world’s data centers at the moment.”

According to the University of Cambridge’s bitcoin electricity consumption index, bitcoin

miners are expected to consume roughly 130 Terawatt-hours of energy (TWh), which is roughly 0.6% of global electricity consumption. This puts the bitcoin economy on par with the carbon dioxide emissions of a small, developing nation like Sri Lanka or Jordan. Jordan, in particular, is home to 10 million people. It's impossible to say how many people use bitcoin every month, and they certainly use it less often than residents in Amman use Jordanian dinars. But CoinMetrics data indicates more than 1 million bitcoin addresses are active, daily, out of up to 106 million accounts active in the past decade, as tallied by the exchange Crypto.com.

"We get the total population of unique bitcoin (BTC) and ether (ETH) users by counting the total number of addresses from listed exchanges, subtracting addresses owned by the same users on multiple exchanges," said a Crypto.com spokesperson. "We then further reduce this number by accounting for users who own both ETH and BTC."

That's a lot of people using these financial networks. Plus, many bitcoin mining businesses rely on environmentally friendly energy sources like hydropower and capturing natural gas leaks from oil fields. A mining industry veteran, Compass Mining COO Thomas Heller, said Chinese hydropower mines in Sichuan and Yunnan get cheaper electricity during the wet season. They continue to use hydropower all year, he added, although it's less profitable during the annual dry season.

"The electricity price outside of May to October [wet season] is much more expensive," Heller said. "However, some farms do have water supply in other parts of the year."

The best way to make cryptocurrency mining more eco-friendly is to support lawmakers that want to encourage mining in regions that already have underutilized energy sources.

Basically, cryptocurrency mining doesn't inherently produce extra carbon emissions because computers can use power from any source. In 2019, the digital asset investing firm CoinShares released a study estimating up to 73% of bitcoin miners use at least some renewable energy as part of their power supply, including hydropower from China's massive dams. All of the top five bitcoin mining pools, consortiums for miners to cooperate for better profit margins, rely heavily on hydropower. This statistic doesn't

impress de Vries, who pointed out that Cambridge researchers found renewable energy makes up 39% of miners' total energy consumption. "I put one solar panel on my power plant, I also have a mixture of renewable energy," de Vries said.

In terms of geographic distribution, Cambridge data indicates Chinese bitcoin mining operations represent around 65% of the network's power, called hashrate. In some regions, like China's Xinjiang province, bitcoin miners also burn coal for electricity. Beyond cryptocurrency mining, this province is known for human rights abuses against the Uighur population, which China is violently suppressing as part of a broader struggle to capitalize on the region's natural resources. When critics sound the alarm about cryptocurrency mining and energy consumption, this is often the dynamic they're concerned about.

On the other hand, North American miners make up roughly 8% of the global hashrate, followed closely by miners in Russia, Kazakhstan, Malaysia and Iran. Iranian President Hassan Rouhani called for the creation of a national bitcoin mining strategy in 2020, aiming to grow the Islamic nation's influence over this financial system despite banking sanctions imposed by the United States.

Wherever nations and organizations offer the most profitable mining regulations, those are the places where bitcoin mining will proliferate. Chinese dominance, to date, can be at least partially attributed to government subsidies for the mining industry. As such, nations like China and Norway offer subsidies that incentivize bitcoin miners to use local hydropower sources.

As the Seetee research report by Aker ASA, a \$6 billion public company based in Norway, said: "The financiers of mining operations will insist on using the cheapest energy and so by definition it will be electricity that has no better economic use."

The best way to make cryptocurrency mining more eco-friendly is to support lawmakers that want to encourage mining in regions that already have underutilized energy sources.

When it comes to North America, Blockstream CEO Adam Back says his company's mining facilities, with 300 megawatts in mining capacity, rely on a mix of industrial power sources like hydropower. He added Blockstream is exploring solar-powered bitcoin mining options as a sort of "retirement home" for outdated machines.



“With solar energy, if you’re only online 50% of the time, that’s something to consider in terms of the cost analysis,” Back said. “That’s a better option for older machines, after you’ve already recouped the costs of the equipment.”

Due to surging cryptocurrency prices, there’s now a global shortage of bitcoin mining equipment, Back added, with demand outpacing supply and production taking up to six months per machine. Emma Todd, founder of the consultancy MMH Blockchain Group, said the shortage is driving up the price of mining machines.

“For example, a Bitmain Antminer S9 mining machine that used to cost \$35 – \$55 in July 2020 on the secondary market, now costs about \$275 – \$300,” Todd said. “This means that most, if not all mining companies looking to purchase new or secondary equipment, are all experiencing the same challenges. As a result of the global chip shortage, most new mining equipment that is scheduled to come out in the next few months, will almost certainly be delayed.”

Critics like de Vries point out that, due to market forces, industrial miners are unlikely to reduce their power consumption with new machines, which are more efficient. “If you have more efficient machines but earn the same money, then people just run two machines instead of one,” de Vries said.

And yet, because cryptocurrency prices are rising faster than new miners can be constructed, Back said “retiring” old machines with renewable energy sources becomes more profitable than

simply abandoning them for new equipment. In addition, Back said, robust bitcoin mining infrastructure can support communities rather than draining resources. This is because bitcoin miners can help store and arbitrage energy flows.

“You can turn miners on and off if you get to a surge prices situation, you can use the power for people to heat their homes if that’s more urgent or more profitable,” Back said. “Bitcoin could actually support power grids.”

Meanwhile, just north of the Canadian border, Upstream Data president Steve Barbour said a growing number of traditional oil and gas companies are quietly ramping up their own bitcoin mining operations. This puts the bitcoin economy on par with the carbon dioxide emissions of a small, developing nation like Sri Lanka or Jordan.

“Right now it’s hydro and coal. That’s the majority of the big industrial mining. But on the global scale, that’s going to shift more toward any cheap power, including natural gas,” Barbour said. “Oil fields already have cheap energy with the venting flares, the waste gas, there’s potential for approximately 160 gigawatts [of mining power] this year.”

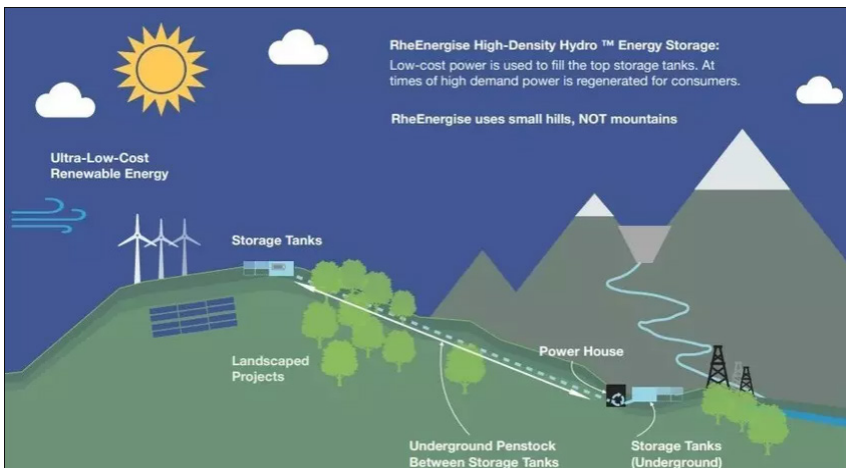
Upstream Data helps oil companies set up and operate bitcoin miners in a way that captures waste and low quality gas, which they couldn’t sell before, totaling 100 deployments across North America. These companies rarely go public with their bitcoin mining operations, Barbour said, because they’re concerned about attracting negative press from Bitcoin critics.

“They are definitely concerned about reputational risk, but I think that’s going to change soon because you have big, credible companies like Tesla involved with Bitcoin,” Barbour said.

Even within the cryptocurrency industry, there are many people who dislike how power-intensive bitcoin mining is and are experimenting with different mining methods. For example, the Ethereum community is trying to switch to a “proof-of-stake” (PoS) mining model, powering the network with locked up coins instead of Bitcoin’s intensive “proof-of-work” (PoW) model.

British hills could soon be generating electricity - Here's how.

[World Economic Forum](#), Victoria Masterson, 16 February 2021



A diagram of how the RheEnergise system operates on small hills

Hillsides are hidden sources of power just waiting to be unlocked, according to a British renewable energy company.

RheEnergise has developed a way to use hills as 'batteries' that create and store electricity for use when needed.

Instead of using water, RheEnergise has invented a fluid which is two and half times denser. This means it can provide two and half times more power and energy when it is released downhill.

"Unlike conventional pumped hydro energy storage, a RheEnergise High-Density Hydro system can operate beneath small hills rather than mountains," says the company on its website.

This, in turn, opens up many more sites as potentially suitable for this kind of hydropower system. Quicker and cheaper to build than traditional hydropower dams, the systems would also be more sustainable.

Around 160,000 hills in Africa, 80,000 in Europe and 9,500 in the United Kingdom could use the new hydropower system, the company says.

The RheEnergise system operates on small hills, meaning there are more sites available for projects.

How it works

The high-density fluid is pumped uphill at times of low energy demand and stored in an underground storage tank. When extra electricity is needed, the fluid is released downhill over generating turbines. This way, the energy used to get the water uphill is returned to the grid.

So-called 'pumped-hydro' systems like these are one of the oldest forms of energy storage and traditionally use reservoirs and dams to store and release water.

They help bridge potential gaps in electricity supply when demand is high or production from the electricity grid drops. They also help offset the seasonality of variable renewables like wind and solar power.

A renewable future

While the pandemic has undoubtedly slowed down global renewable energy growth, electricity-generating technologies have proved fairly resilient, according to the International Energy Agency's Renewables 2020 report.

The global energy storage market needs to grow 100 times its current size, according to Bloomberg New Energy Finance, which estimates the market will be worth in excess of \$620 billion by 2040.

Pumped hydro accounts for about 96% of the world's energy storage capacity. But as global energy demand continues growing, so does the need for more storage projects.

And these are coming in all shapes and sizes. One Swiss-based project is making use of concrete blocks to store energy.

RheEnergise says its system can work on hills with a height of 200 metres and is aiming to have its first commercial system operating in 2024, with a further 100 systems operating within the next decade.

The Power Environment: making wind turbines work for birds and bats

Power Technology, Matthew Farmer, 18 February 2021

Public consultations for wind power projects often hear the same question: how will this affect wildlife? The issue has followed wind generation since it first became widespread and has never truly gone away.

Still now, bird protection causes significant delays to wind

projects. As an example, the 2.4GW Hornsea Three project recently committed to working with conservation groups to minimise its damage to nearby kittiwake populations. Planning around the local bird populations likely contributed to the six-month planning delay as central government reviewed plans.

How much of a problem do turbines make for birds and bats?

In Canada, studies sponsored by wildlife groups estimated 23,300 bird deaths were caused by wind turbines in 2011. The authors estimated this would reach 233,000 over the following 10-15 years, getting ten times greater as wind power grows. While even this seems small compared to the 25 million birds killed by windows, the remote locations of turbines mean they will likely present risks to rarer bird species.

Conservation groups often object to the developments they believe present the most danger to local wildlife populations. This can delay consent, lead to costly conservation projects as part of developments, or stop projects outright.

Research has found that low-flying birds, such as puffins and terns, tend to avoid offshore turbines by flying under them. However, gulls tend to fly approximately 20m above water, putting them in the danger zone. The British Trust for Ornithology therefore suggests that using fewer,



larger turbines could minimise bird deaths compared to large fields of small ones.

What can operators do to protect birds from turbines, and turbines from birds?

At the most basic level, most conservation groups highlight the location of turbines as key. Developers often use computer models of bird activity to help predict

where projects can have the least impact.

Some other measures are relatively simple. A paper published to *Ecology and Evolution* in June 2020 studied the effects of painting one blade of a turbine black. Researchers hypothesised that the paint would allow birds to notice and avoid turbines sooner.

A trial at the Smøla wind power plant in Norway gathered results over 11 years, until July 2020. After painting, the trial turbines killed 72% less birds. The authors noted that painting the blades in-situ took considerable resources, but that painting during construction would minimise costs.

Joel Merriman, campaign director for American Bird Conservancy, pointed out that in the US, Federal Aviation Administration standards require developers to paint blades white or light grey to make them more visible during daylight.

He said: "This is a good start in identifying additional ways to reduce the threat of wind turbines to wildlife. That said, it's too soon to bill this as a proven technique to minimise bird mortality at wind energy facilities. We're seeing many people refer to this paper as if it's a proven method, rather than what it is — an encouraging starting point for further study.

"Different colours, patterns, or less-conspicuous approaches like using UV-reflective

paint could also be promising ways to reduce bird mortality. Above all, siting turbines away from high bird-use areas remains the best way to reduce bird mortality.”

There are also more active methods of preventing fatalities. A paper published in January 2021 tested a camera system that would automatically identify and classify flying objects. This system would then decide whether to pause turbine operations to avoid risk to birds.

The authors trialled the system at a facility in Wyoming, US, looking to minimise the deaths of local eagles. When adjusted, the authors found that turbines using the system killed 82% less birds than control studies.

While this helps birds, the technology remains at an early stage. Turbine shutdowns mean lost power, meaning operators may favour generation over conservation. If the system works at a wider level, authorities may choose to make these systems mandatory to avoid such conflict.

Large birds, such as eagles, can be relatively easy to identify during the day. But what systems can save nocturnal fliers?



Where do bats present a big turbine problem?

In some areas, turbines present their greatest danger not to birds, but to bats. While the fundamental risks are the same, bats are much less understood than birds, and are often more endangered with less protections.

In the EU, all bats have legal protection because of Eurobats legislation. A Eurobats meeting from 2014 outlined two methods of preventing bat deaths: “Current knowledge continues to suggest two measures: change of the cut-in speed to higher wind speed values, and the use of blade feathering position during low wind speeds. This means preventing turbines from freewheeling or doing so only at very low rates, generally less than one revolution per minute.”

Raising the cut-in speed for turbines would

mean less generation for operators, and hence can prove unpopular. However, in some areas the need for power and conservation overlaps, leaving developers no choice.

Bats are most active at periods with low wind speeds, so limiting generation to higher wind speeds helps prevent deaths. As a US National Renewable Energy Laboratory paper writes: “Currently, only stopping turbine blades from spinning during predictable high-risk periods has demonstrated effective reductions of fatalities of bats.”

Can technology help operators react to wildlife more adaptively?

Natural Power global head of wildlife technology Christine Sutter told us: “In the US, within the range of the federally endangered Indiana bat, it is common for wind farms to operate under a Technical Assistance Letter that requires curtailment at night during the peak fatality season, when wind speed is at or below 6.9m/s. Generally, this lasts from July to October, but the periods are location specific.” As in this example, periods of blanket generation curtailment can mean lost generation at low speeds. At the same time, some species of bat remain active at higher speeds. European operators will encounter more migratory bats such as *Nathusius’ pipistrelle*, which will not receive protection from blanket curtailment such as this.

In January 2021, Natural Power, a renewable energy consultancy, announced the development of turbine control software to help prevent bat deaths. The Detection and Active Response Curtailment (DARC) software shuts down turbines when sensors detect bat activity.

Sutter continued: “The DARC system only curtails when bats are at risk: when they are present in the rotor-swept area. The decision subsystem within DARC considers both wind speed, as a surrogate for energy production, and bat risk when determining when to pitch out the turbine blades. At each site, there is a threshold wind speed above which the turbines will never curtail, and this prevents significant power losses.”

Field tests carried out by the company in 2020 found the system caused fewer bat deaths and generated 40% more energy than with blanket shutdowns. Sutter says the company has since added better system health monitoring and alerting.

Flower Turbines are blowing wind energy onto the grid

[Israel21c](#), Abigail Klein Leichman, 1 February 2021



Solar is a hot commodity in the arena of distributed renewable energy. Wind, however, hasn't picked up much speed. What is stifling the potential of distributed wind energy?

"Many small wind turbines are loud, inefficient, and interfere with each other when placed in groups. Furthermore, the larger ones are big and clunky – fine for an industrial zone but not so nice for a residential zone," says Dr. Daniel Farb, inventor of the Israeli-developed Wind Tulip by Flower Turbines.

Already generating energy at installations in Colombia and The Netherlands, Wind Tulips' unique aerodynamic design makes them quiet, efficient and capable of producing up to 50 percent more electricity in clusters because they feed air currents into one another, says Farb.

"That's a gamechanger. It means you can make wind farms out of small turbines," says CEO Farb, recently picked as a 2021 Innovator by the US Department of Energy. "This is the basis of what I hope will be a major global company."

Shaped like sleek flowers in assorted colors and sizes (1-meter, 3-meter, and 6-meter high) for small-scale installations, Wind Tulips are designed to do double duty as eco-art on the roof of a house, shopping mall, school or skyscraper.

Flower Turbines is based in New York with a European subsidiary and showroom-manufacturing plant in The Netherlands. Its lead

engineering team is in Israel, and the Wind Tulip has patents from the US, EU, Israel, Australia, India, Canada, and China.

The company received the 2019 Dutch Sustainability Award after its participation in the PortXL maritime accelerator in Rotterdam. Recently, Wind Tulips were installed on a container in a Dutch marina.



Wherever there's wind

Farb tells ISRAEL21c that Wind Tulips can work well in any coastal area, on mountains and in plains – anywhere with strong winds.

One prime location is the sea rim of northern Europe, where high wind, high electricity prices, and a motivation to create sustainable economies provide Flower Turbines

with a potential of €60 billion (\$72.8) in total sales, says Farb.

"In the United States, the Great Plains have hundreds of thousands of square kilometers of the best wind location in the world," he adds.

"There's a lot going on there in terms of large turbines, but not small turbines. We hope to change that."

The turbines are also bird friendly, as this video from Colombia demonstrates.

Farb says Flower Turbines does not have direct competition "because nobody else has solved the problems of efficiency and noise and they don't have the cluster effect that ours do."

And, he adds, "Another thing that keeps people from buying small wind turbines is they don't like the design. Our design, done in Israel, is beautiful."

The company's indirect competition comes from solar, especially as the price of generating solar energy drops.

"But that only works when there is sun, and at least half the day there is no sun," Farb points out. Furthermore, the competition can be turned into a beneficial synergy, he says.

A combined solar-and-wind system could prevent brownouts during late-afternoon peak power periods, as happens in many parts of the world when sunlight is waning and wind is kicking up.

"Wind is the best solution in coastal areas for preventing brownouts at the most vulnerable time for the grid," says Farb, an American-Israeli physician by training.

Raising funds and awareness

Flower Turbines finished two \$1 million rounds of equity crowdfunding and launched a third round of \$14 million on January 4 with the aim of scaling up.

Raising awareness of wind energy is just as necessary as raising funds. A growing list of accolades is helping in that regard.

In addition to its sustainability award in



The Netherlands, Flower Turbines was a semifinalist in the InnoSTARS startup competition hosted by the US-China Innovation Alliance in 2018.

Faculty and advisers at Pepperdine University's Business School chose Flower Turbines as one of 2020's 20 most fundable US companies – that is, most likely to provide a

10x return on investment in the first five years – out of 4,500 contenders.

In addition to Wind Tulips, Flower Turbines recently acquired Ecotap's product line of charging stations in Europe for e-bikes, e-scooters, and mobility scooters.

Renamed Tulip Power, these on-grid and off-grid public charging solutions are also powered by wind and/or solar energy. "We are further developing the products to maximize their performance by, for example, adding our unique Wind Tulip turbines," says Farb.

Sunlight Powers Portable, Inexpensive Systems to Produce Drinking Water

Scientific American, Prachi Patel, 1 February 2021

In an increasingly hot and crowded world, clean water is becoming a precious commodity. Two thirds of the global population will have problems accessing fresh water by 2025, and removing salt and contaminants from the oceans and groundwater is one way to slake humanity's thirst.

Today's large desalination plants, though, cost millions of dollars to build. Most use reverse osmosis, which forces seawater through salt-blocking membranes. The required electricity accounts for up to half of a plant's expenses, and the process leaves behind a supersalty, chemical-laced soup that can harm local ecosystems. Such facilities are typically powered by carbon-emitting fossil fuels; efforts have been made (especially

in the Middle East, Asia and Africa) to use solar panels instead, but that also comes at a cost and does not address the toxic discharge.

So researchers are trying to use the sun's heat more directly to remove salt and other contaminants. The simplest option is to let water evaporate, leaving behind salts and chemicals, and then condense the vapor into clean water. Humans have used versions of this technique, called solar distillation, for hundreds of years. Today Saudi Arabian engineers plan to build a plant with giant mirrors that concentrate sunlight and superheat water within a steel-and-glass dome more than 50 meters across.

But by using novel materials and designs, researchers are trying to make the process

cheaper, simpler and portable enough to make high-quality desalination far more accessible worldwide. “The needs for clean water in developing countries are enormous,” says Naomi Halas, an electrical and computer engineer at Rice University. “Solar-thermal technologies should allow you to lower the energy



Solar-thermal technologies could process seawater and groundwater to make it drinkable at less cost. (Credit: Warren Keelan)

needs of desalination but also to do it in remote locations where you are completely off the grid.”

The U.S. Department of Energy will soon announce semifinalists for its Solar Desalination Prize. The goal: a system that produces 1,000 liters of usable water for \$1.50. “No technology today can handle high-salinity water at these costs,” says Qilin Li, a civil and environmental engineer at Rice.

Such systems could surmount a big downside of reverse osmosis: it typically desalinates only half of the input saltwater, and the solution left behind eventually builds up enough salt to clog the membrane, says Craig Turchi of the DOE’s National Renewable Energy Laboratory (NREL). This noxious by-product, called a brine, is typically dumped into the ocean or injected underground. Solar-thermal desalination systems can purify water with salt concentrations at least twice that of seawater. This would include brines from reverse osmosis plants and brackish groundwater from places such as the U.S. Southwest, as well as some industrial and agricultural wastes that reverse osmosis cannot handle, says NREL spokesperson Meghan Hughes: “Generally, only thermally driven technologies, like the ones we’re working to develop through this program, can treat these highly concentrated brines.”

Li, Halas and their colleagues have built a solar desalination device with a porous plastic membrane that lets water vapor through but not liquid. One side of it is coated with tiny carbon particles that heat up in the sun, vaporizing the salty water as it contacts them. This vapor passes through and condenses as clean water on the membrane’s other side. Halas’s group recently boosted the system’s efficiency by 50 percent by using plastic lenses to focus sunlight on the membrane, producing more heat.

The team’s calculations show that meeting

the DOE’s cost target, with a square-meter-sized device that produces up to 20 liters of water an hour, should be possible in a few years. “We’re at the Ford Model T stage—not the Mustang stage yet,” Halas says. “But it’s good enough that we’re starting to get commercial interest.”

Civil and environmental engineer David Jassby’s group at the University of California, Los Angeles, integrated heat-conducting materials into the membrane in a similar setup. Underneath it, the researchers added a fine aluminum mesh that heats up in sunlight. “So you can roll the membrane into spiral modules because you don’t have to have large surface areas directly exposed to the sun,” he says. In rooftop tests, the device produced eight liters of fresh water per square meter of membrane in an hour.

Such systems could lend themselves to compact units suitable for off-grid villages in Asia and Africa, communities with brackish groundwater, and emergency uses almost anywhere. But they will need to pick up the pace and convert more solar heat into vapor, says Lenan Zhang, a graduate student in mechanical engineer Evelyn Wang’s laboratory at the Massachusetts Institute of Technology.

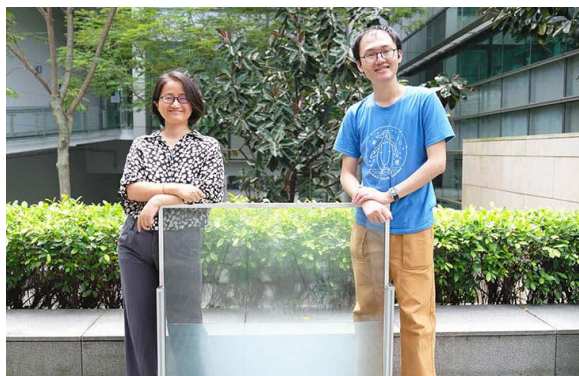
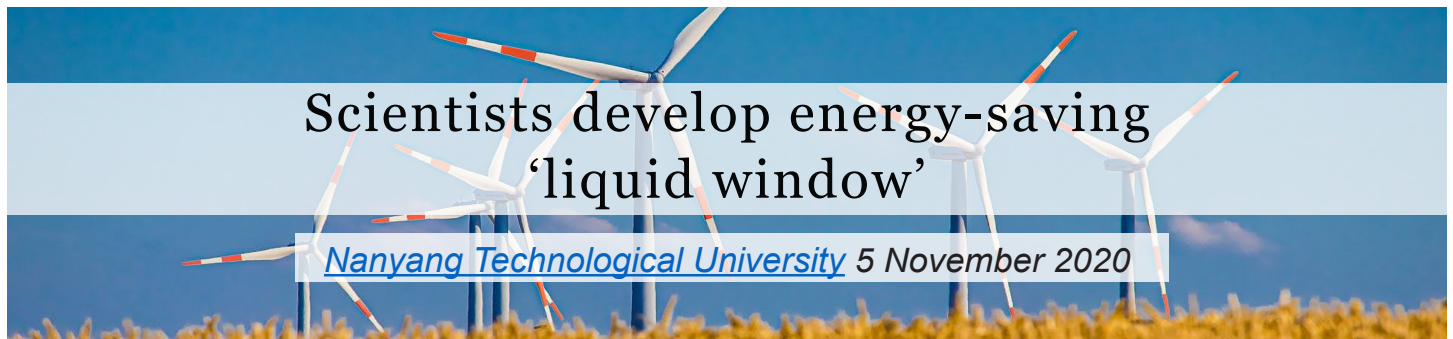
Wang’s team boosts its device’s efficiency by “reusing energy over and over,” Zhang says. It includes 10 stages, each a nylon frame holding a black sun-absorbing layer, a paper towel and an aluminum film. When heated, the black layer evaporates salty water as it wicks up into the paper towel, and the vapor condenses on the aluminum. Condensation releases heat, which rises to the next paper towel layer and aids evaporation instead of being lost. The \$100 setup yields almost six liters an hour in the lab and about half of that outdoors; with more sophisticated materials and stages, Zhang says, the efficiency could be doubled.

Another intriguing approach takes advantage of humidification by passing air through a saltwater spray. “Air absorbs the water and leaves behind solid salts,” says Oregon State University mechanical engineer Bahman Abbasi. His system uses solar radiation to heat, compress

and eject a mix of saltwater and air through nozzles at high speed, thereby creating a vortex that pushes salts and other solids to the device's walls as the humidified air rises for collection and condensation. Abbasi says the backpack-sized device can clean water with salinity up to three times higher than that of seawater and produce about 20 liters an hour.

All these relatively low-cost technologies

could unlock new markets for portable water cleaners or off-grid uses—and beyond. They may eventually lead to large-scale solar-thermal systems to provide cities with drinking water, Turchi says. For now, they “will complement reverse osmosis and be a key player in niche applications where reverse osmosis may not work.”



Scientists at the Nanyang Technological University, Singapore (NTU Singapore) have developed a liquid window panel that can simultaneously block the sun to regulate solar transmission, while trapping thermal heat that can be released through the day and night, helping to reduce energy consumption in buildings.

The NTU researchers developed their 'smart window' by placing hydrogel-based liquid within glass panels and found that it can reduce up to 45% of heating, ventilation, and air-conditioning energy consumption in buildings in simulations, compared to traditional glass windows. It is also 30% more energy efficient than commercially available low-emissivity (energy-efficient) glass, while being cheaper to make.

The 'smart window' is the first reported instance in a scientific journal of energy-saving smart windows made using liquid, and supports the NTU Smart Campus vision which aims to

develop technologically advanced solutions for a sustainable future.

Windows are a key component in a building's design, but they are also the least energy-efficient part. Due to the ease with which heat can transfer through glass, windows have a significant impact on heating and cooling costs of a building. According to a 2009 report by the United Nations, buildings account for 40% of global energy usage, and windows are responsible for half of that energy consumption.

Conventional energy-saving low-emissivity windows are made with expensive coatings that cut down infrared light passing into or out of a building, thus helping to reduce demand for heating and cooling. However, they do not regulate visible light, which is a major component of sunlight that causes buildings to heat up.

To develop a window to overcome these limitations, the NTU researchers turned to water, which absorbs a high amount of heat before it begins to get hot – a phenomenon known as high specific heat capacity.

They created a mixture of micro-hydrogel, water and a stabiliser, and found through experiments and simulations that it can effectively reduce energy consumption in a variety of climates, due to its ability to respond to a change in temperature. Thanks to the hydrogel, the liquid mixture turns opaque when exposed to heat, thus blocking sunlight, and, when cool, returns to its

original 'clear' state.

'Liquid window' most suitable for office buildings

At the same time, the high heat capacity of water allows a large amount of thermal energy to be stored instead of getting transferred through the glass and into the building during the hot daytime. The heat will then be gradually cooled and released at night.

Dr. Long Yi, lead author of the [research study published in the journal Joule](#), and Senior Lecturer at the School of Materials Science & Engineering said, "Our innovation combines the unique properties of both types of materials – hydrogel and water. By using a hydrogel-based liquid we simplify the fabrication process to pouring the mixture between two glass panels. This gives the window a unique advantage of high uniformity, which means the window can be created in any shape and size."

As a result of these features, the NTU research team believes that their innovation is best suited for use in office buildings, where operating hours are mostly in the day.

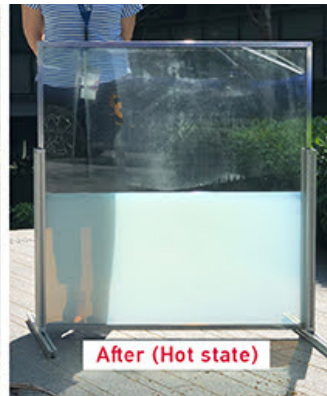
As a proof of concept, the scientists conducted outdoor tests in hot (Singapore, Guangzhou) and cold (Beijing) environments.

The Singapore test revealed that the smart liquid window had a lower temperature (50°C) during the hottest time of the day (noon) compared to a normal glass window (84°C). The Beijing tests showed that the room using the smart liquid window consumed 11% less energy to maintain the same temperature compared to the room with a normal glass window.

Smart window shifts electricity load peak, blocks noise

The scientists also measured when the highest value of stored thermal energy of the day occurred.

This 'temperature peak' in the normal glass window was 12pm, and in the smart liquid window was shifted to 2 pm. If this temperature peak shift is translated to a shift in the time that a building needs to draw on electrical power to cool or warm the building, it should result in lower energy tariff charges for users.



Simulations using an actual building model and weather data of four cities (Shanghai, Las Vegas, Riyadh, and Singapore) showed that the smart liquid window had the best energy-saving performance in all four cities when compared to regular glass windows and low

emissivity windows.

Soundproof tests also suggested that the smart liquid window reduces noise 15% more effectively than double-glazed windows.

First author of the study Wang Shancheng, who is Project Officer at the School of Materials Science & Engineering said, "Sound-blocking double glazed windows are made with two pieces of glass which are separated by an air gap. Our window is designed similarly, but in place of air, we fill the gap with the hydrogel-based liquid, which increases the sound insulation between the glass panels, thereby offering additional benefit not commonly found in current energy-saving windows."

The other first author, Dr Zhou Yang was a PhD student in NTU and is currently an Associate Professor at China University of Petroleum-Beijing (CUPB).

Providing an independent view, Professor Ronggui Yang, of the Huazhong University of Science and Technology, China, a recipient of the 2020 Nukiyama Memorial Award in Thermal Science and Engineering and an expert in thermal and energy systems said, "This is the first instance of a hydrogel-based liquid smart window, and it takes us far from a conventional glass design. The disruptive innovation leads to solar regulation and heat storage, which together render outstanding energy-saving performance."

The research team is now looking to collaborate with industry partners to commercialise the smart window.

The research is supported by the National Research Foundation, Prime Minister's Office, Singapore, under its Campus for Research Excellence and Technological Enterprise (CREATE) programme and the Singapore-HUJ Alliance for Research and Enterprise (SHARE), and the Sino-Singapore International Joint Research Institute.

What is green hydrogen, how is it made, and will it be the fuel of the future?

ABC Science James Purtill, 23 January 2021

Abundant, cheap and clean-burning, hydrogen has long been described as the fuel of the future. That future has never quite materialised, however, due to hydrogen's disadvantages. It's difficult to transport, it can make metal brittle and it's 20 times more explosive than petrol.

But in recent years, "green hydrogen" — hydrogen made without fossil fuels — has been identified as the clean energy source that could help bring the world to net-zero emissions.

Billions of dollars of investment capital and taxpayer support has flowed into the industry, and company share prices have soared.

This has accelerated in recent months, driven by the rising adoption of zero-emission vehicles, a deadline set by many countries to go carbon-free by 2050 and US President Joe Biden's support for clean energy.

The European Union plans to scale up renewable hydrogen projects and invest a cumulative amount of 470 billion euros (\$740 billion) by 2050.

In November, Western Australian mining magnate Andrew Forrest announced plans to invest billions of dollars in green hydrogen to grow his new energy business.

In the first of the ABC Boyer lectures on Friday, he focused on the potential for Australia to produce "green steel", which uses green hydrogen in place of fossil fuels to power the iron ore blast furnaces.

"The immediate and multiplier impact on the Australian economy, if we get this right, could be nothing short of nation-building," he said in the lecture.

So what is green hydrogen? How can it be



used? And is the hype a lot of hot air?

What makes green hydrogen 'green'?

Hydrogen is the universe's most abundant element, but here on Earth it doesn't appear pure in nature, and requires energy to separate.

The most common technique is to extract hydrogen from water, which is two parts hydrogen and one part oxygen (hence H₂O).

Doing this is fairly simple. You can use heat and chemical reactions to release hydrogen from organic materials such as fossil fuels.

But this is enormously polluting. Worldwide hydrogen production is responsible for CO₂ emissions equivalent to that of the United Kingdom and Indonesia combined. (The hydrogen is mostly used in the oil refining industry and to produce ammonia fertilisers.)

There is a cleaner way of getting hydrogen: a strong electrical current passed through a tank of water splits the molecule into its two constituent elements. This is called electrolysis.

Hydrogen atoms form hydrogen molecules (H₂) and oxygen molecules pair up too. Each can then be bottled up (more on that later).

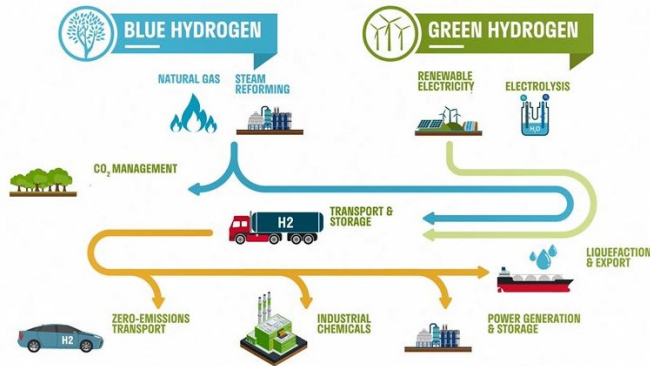
If the electricity is generated from renewable sources such as solar or wind, production of hydrogen in this way emits no greenhouse gasses.

This is how we come to all the different shades of hydrogen:

- brown hydrogen is produced using coal where the emissions are released to the air
- grey hydrogen is produced from natural gas where the associated emissions are released to the air
- blue hydrogen is produced from natural gas,

where the emissions are captured using carbon capture and storage

- green hydrogen is produced from electrolysis powered by renewable electricity.



Expensive, but getting cheaper

Conventional hydrogen and blue hydrogen cost about \$2 per kilogram (though the price varies depending on where it's produced), while green hydrogen is around twice as much. That price, however, is falling steeply with renewable energy prices and cheaper costs to make equipment used for electrolysis, called electrolyzers.

An Australian National University report last year estimated Australia could currently produce green hydrogen at about \$3.18-3.80 per kg and at \$2 per kg by the end of the decade. At that price, it would be cost-competitive with fossil fuels, experts say.

Fiona Beck, an ANU physicist and convenor of the Zero-Carbon Energy for the Asia-Pacific research initiative, a hydrogen fuel project, said there were no "technological blocks" to producing cheap green hydrogen. "It's all feasible," she said. "There's things that need to be solved but they're incremental solutions we know how to do — there's nothing we have to discover."

Tim Buckley, an energy market analyst from the Institute for Energy Economics and Financial Analysis (IEFA), predicts the price of green hydrogen will drop 70% in the next decade in countries with cheap renewables.

"Where green hydrogen is almost inevitably going to work is where green energy is going to be almost free," he said. "Places like Rajasthan in India or the Pilbara in Australia."

How can green hydrogen be used?

Hydrogen can be used in broadly two ways. It can be burnt to produce heat or fed into a fuel cell to make electricity. A 2018 CSIRO report outlines several potential applications for hydrogen:

- fuel-cell hydrogen electric cars and trucks
- container ships powered by liquid ammonia made from hydrogen
- "green steel" refineries burning hydrogen as a heat source rather than coal
- hydrogen-powered electricity turbines that can generate electricity at times of peak demand to help firm the electricity grid
- as a substitute for natural gas for cooking and heating in homes.

The report foresaw an opportunity for Australia to export hydrogen to energy-hungry countries that don't have access to cheap renewable energy. It estimated potential demand for imported hydrogen in China, Japan, South Korea and Singapore could reach \$9.5 billion by 2030.

By 2050, according to investment management firm Goldman Sachs, green hydrogen could supply up to 25 per cent of the world's energy needs and become a US\$10 trillion (\$13 trillion) market.

But amid all this hype, hydrogen's future is not yet assured. To become a major export commodity, problems of storing and transporting hydrogen need to be overcome.

A few big caveats

Like any gas, hydrogen can be compressed and stored in tanks, then used as needed. However, the volume of hydrogen is much larger than that of other hydrocarbons; nearly four times as much as natural gas, for instance.

Its storage requires compression to 700 times normal atmospheric pressure or refrigeration to minus 253 degrees Celsius, which is near absolute zero. It's estimated that the cost of doing this could add anything from 60 cents to \$7 per kg, making it less competitive with other fuels.

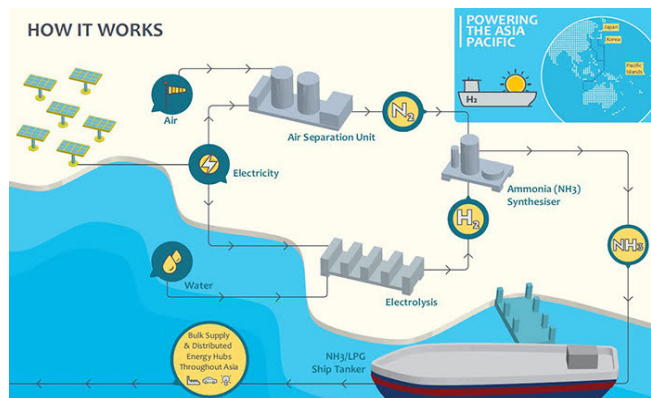
On top of the cost of storage, there's a problem with pipes. Hydrogen atoms under pressure are small enough to slip through solid steel, meaning natural gas plumbing often cannot be easily converted for pumping hydrogen, Dr Beck said. Appliances set up for natural gas, like stoves and heaters, would also need to be replaced or refitted to handle hydrogen.

Given that's the case, in many cases it might be easier to simply use electricity, she said. "However, there are certain things you might not be able to directly electrify, or there might be some places where you're not able to generate renewable energy," she said. "In these places,

having a liquid fuel is a very useful thing."

One solution to transportation problems is converting the hydrogen into ammonia (where three hydrogen atoms bond to a nitrogen to make NH₃). Unlike hydrogen, ammonia can be relatively cheaply stored under pressure or refrigerated as a liquid at -33C at normal atmospheric pressure.

For many applications, once it arrived at its destination, the ammonia would then have to be converted back into hydrogen. With each conversion — from water to hydrogen to ammonia and back to hydrogen — energy is lost.



Electric vehicles have 'won' transport: experts

Because of these shortcomings, hydrogen will struggle to compete with electricity in most situations, said Peter Newman, a professor of sustainability at Curtin University. "Creating a whole new hydrogen grid will take decades and why bother when we already have an option that will be cheaper than gasoline and diesel in the 2020s?" he said.

He predicted hydrogen will have a more niche role and be used for industry in regional and rural areas. Electric vehicles powered by lithium-ion batteries have "won" the battle for transport, he said. "They're clearly the better option. We just need to roll it out."

Tim Buckley from the IEFA similarly predicted green hydrogen's role would be to decarbonise industries and applications that can't be electrified. The list of what can't be electrified is steadily decreasing as the cost of renewables and batteries falls. "What I've been watching is the Tesla share price," he said. "That's the financial market saying 'who cares about hydrogen fuel cell transport?' Electric vehicles have already won the race."

Tesla, which makes electric cars as well as large batteries for power grids, has seen its stock market value go up seven-fold in the past year.

Richie Merzian, director of the climate and energy program at the Australia Institute, said the cost of converting appliances and upgrading gas networks meant hydrogen probably wouldn't be seen in most homes.

If that's the case, the future for hydrogen may be in high-temperature industrial processes such as steel works or to make ammonia-intensive products such as fertiliser. "There's a lot of potential there and that's exciting," he said. "We're likely to see manufacturing facilities crop up right near hydrogen facilities."

What's Australia doing?

Several major green hydrogen projects are in development in Australia. Among the largest of these is the \$51 billion Asian Renewable Energy Hub, which plans to produce 26 gigawatts of cheap solar and wind power for the Pilbara. That's more power than Australia's entire fleet of coal-fired power stations.

Some of this electricity will be used to electrolyse water to create hydrogen, which will be converted into ammonia for export.

The Pilbara, of course, is a major supplier of iron ore. With a plentiful supply of hydrogen, "green steel" could be produced in towns like Port Hedland or Karratha and exported to the world.

In October last year, the Federal Government granted the hub "major project status" to expedite its approvals process and help it export its first shipments in 2028.

Other developments include Origin Energy working with Japan's Kawasaki Heavy Industries on a green liquid hydrogen export project in Townsville.

The South Australian Government has launched a \$240 million project to build the largest green ammonia plant in the world.

The Federal Government, meanwhile, has prepared a strategy to "position the [hydrogen industry] as a major player by 2030".

But whether the hydrogen produced by that industry will be green or blue (or another category of emissions) remains to be seen. The government has partly funded a trial to produce "blue hydrogen" from coal in Victoria's Latrobe valley, then ship it to Japan. To be blue, the greenhouse emissions must be captured and stored underground in a process called carbon capture and storage. So far, this hasn't happened, Mr Buckley said. "It's brown hydrogen, not blue," he said.

There are also questions around whether

money earmarked for clean energy projects will be used to finance carbon capture and storage, including blue hydrogen. In May last year, the Government announced the Clean Energy Finance Corporation will administer a \$300 million Advancing Hydrogen Fund. A couple

months later, it introduced amendments to allow the Clean Energy Finance Corporation to invest in technology such as natural gas and carbon capture. The proposed legislation was opposed by the Greens and Labor, referred to a Senate committee, and has not yet passed.

Calgary brewery uses recycled wastewater to make beer

[World Economic Forum](#), Leland Jackson, 19 November 2020

As the Earth's population grows and approaches a projected 9.7 billion by 2050, the world's freshwaters will face mounting pressure to supply the needs of population growth. Approximately 33 per cent of people do not have access to safe drinking water and a similar number do not have access to proper sanitation — numbers that will increase as populations grow.



In addition, climate change is predicted to increase the severity of floods and droughts, which in some places will limit water availability and reduce water quality. In some Canadian watersheds, like the South Saskatchewan River Basin in southern Alberta, licences for new water withdrawals — for municipal, agricultural, industrial or other uses — have reached their limit. To continue to sustain or grow populations — and economies — more is going to have to be done with the same amount of water, or even less.

But water can be reused. It can be repurposed, following treatment, for drinking water and non-drinking water, such as car washes, and can be part of the solution to help communities build water resilience in the face of growth and climate change. It can also be transformed into beer.

Barriers to reuse

One of the barriers to widespread water reuse

is the perception that Canada has an endless supply of freshwater. There's also the yuck factor: people have a hard time thinking about drinking or cooking with water that someone else showered in or, worse still, flushed down the toilet. Together, that means there is little

market pull to drive innovation.

The division of water management between different levels of government and their ministries or sub-groups leads to fragmented systems that are not managed as a whole but rather as individual parts. This management siloing means decisions and communication often lack a whole-watershed perspective. A lack of regulations describing the standards for treated water, particularly for direct potable reuse, means there is little push to create solutions.

What many people do not realize is that we already drink dilute wastewater today, after it has been through a treatment plant and spent time in lakes or rivers, called environmental buffers, where natural processes provide additional treatment. Direct potable reuse is the process of taking wastewater and treating it to drinking water standards without using a reservoir or aquifer as an environmental intermediary.

Technologies exist to produce direct potable water from wastewater — astronauts living on the

International Space Station have known this for two decades. But there is a lack of regulations in almost all jurisdictions, with the exception now, of Alberta.

On Earth Overshoot Day (August 22 in 2020), Village Brewery, a Calgary craft beer-maker, joined University of Calgary researchers and Xylem Technologies, a U.S.-based water technology company, to brew a crisp blond ale from reused wastewater — the first case of direct potable reuse in Alberta and possibly Canada.

Safe to consume

Treating municipal wastewater for potable reuse involves using a variety of technologies to clean it and remove disease-causing organisms, called pathogens. The water is treated by physical screening and settling of solids, biological processes that remove nutrients. Filtration and treatment with highly reactive forms of oxygen, comes next, followed by ultraviolet radiation.

To turn wastewater into beer, the collaboration took wastewater from a treatment plant and ran it through a series of sophisticated purifying steps: ultra-filtration, ozonation, UV radiation and reverse osmosis.

The idea was to remove and inactivate

several types of pathogens, including Giardia and Cryptosporidium, parasites that cause diarrhea, and viruses like Norovirus and SARS-CoV-2. The treatment reduced the number of pathogens in the treated water by a factor that exceeded 10 trillion for bacteria and viruses and one trillion for Giardia and Cryptosporidium.

The collaboration used standards based in other jurisdictions that already produce direct potable water, including Singapore, Germany and California. It also met all specifications of the Canadian Drinking Water guidelines for organics and metals.

So, how did the beer taste? It tasted great! Attendees at the launch enjoyed drinking the beer and many sampled more than one.

In the future, if we can do more with the same amount of water or use water multiple times, it will mean there will be less demand for new water. The use of technology to treat and reuse water, whether it be for watering parks, flooding ice rinks, fighting fires or washing cars and buses, can be part of a solution to reduce demand for new water, mitigate impacts from growing populations and changing climate, and provide resilience to water-scarce communities.



Floating solar technologies make use of unoccupied bodies of water, such as lakes or artificial basins, to locate and produce solar power. Proponents of the technology say that it could scale up the use of renewable power significantly, particularly in countries that have large populations and limited spare land, such as in many Asian nations.

In fact, demand for floating solar is growing exponentially. According to a World Bank report, 'Where Water Meets Sun', installed capacity increased more than 100-fold from 2014-2018, to 1.1GW.

The biggest of its kind to be given the green

light so far is a 41MW floating photovoltaic (PV) power plant at the Hapcheon Dam in South Korea. Seoul-headquartered Q-CELLS won approval for the project from K-water (the Korea Water Resources Institute) in November and say it will become the world's largest floating PV constructed on a dam, as well as the largest floating PV plant permitted in Korea.

The plant will produce enough solar electricity to meet the annual power needs of 60,000 people, which is more than the actual 44,434 population of Hapcheon-gun, the county in which it will be sited. All electricity from the project will be sold to the local power utility.

The merits of floating solar

The first ever floating PV system was built in 2007 in Aichi, Japan. Since then, several other countries, including France, Italy, the Republic of Korea, Spain, and the US have tested small-scale systems.

According to Ian Clover, manager for corporate communications at Q CELLS, when compared to onshore installations, floating solar plants can, in the right conditions, generate up to 10% more power than a comparable land-based array.

“This is because the cooling effect of the water ensures solar modules do not operate at a higher than optimal temperature, thereby ensuring peak power output is more easily achieved,” he explains.

Furthermore, floating solar plants, he says, are highly unlikely to encounter any third-party shading, which means they can enjoy “longer, uninterrupted peak performance than many onshore plants”.

At the Hapcheon Dam, Q CELLS is planning to install its Q.PEAK DUO Poseidon Edition solar panels, which are specifically developed for floating PV installations and to endure high temperature and high humidity environments. Testing conditions for these modules include exposure of more than 3,000 hours in an environment of 85°C and 85% relative humidity. The design of the arrays for the actual Hapcheon Dam site is inspired by the plum blossom, a symbolic flower of Hapcheon-gun.

Besides the decorative display, Clover says that the general layout of a floating PV system is similar to land-based systems. However, the arrays and inverters are mounted on a floating platform and the direct current electricity generated is gathered by combiner boxes and converted to alternating current by inverters.

He adds that from an engineering perspective, installing the Hapcheon Dam floating solar power plant offered no additional or unique challenges for Q CELLS. In fact, the technology is well suited to a dam.

“Adding floating solar to dams makes sense because dams are generally large, open bodies of water with good road access and pre-existing



infrastructure,” explains Clover.

However, as is customary, the company did have to conduct environmental stability tests to ensure the installation would not adversely impact on the dam or its ecological balance.

“Monitoring tests showed water quality is unaffected, and there is no significant difference between the water area covered by the power plant and the uncovered water area,” he explains.

Increased cost implications

However, there are some additional costs associated with the installation process of a floating solar plant. For example, specially trained installers are required to work on and with water.

“These modules [Q.PEAK DUO Poseidon Edition] cost a little more than standard modules, but for long-term OPEX viewpoint, they make perfect financial sense,” explains Clover.

“Once the solar plant is up and running, operations and maintenance costs may differ according to location, but as more and more floating solar plants are installed around the world, any cost difference between floating and onshore will be closed,” he adds.

However, experts say that the exact magnitude of these performance advantages, and whether they outweigh any increase in capital costs, has yet to be confirmed by larger installations.

Molly Cox, solar PV technology systems and operations analyst at Wood Mackenzie, wrote that although costs will be lowered by the increasing number of larger project sizes, which has been climbing steadily since 2015 and is expected to continue rising, lack of empirical data on system performance over time compounds the challenge.

“As a result, the technical due diligence for floating solar projects typically takes longer compared to a ground mount array of the same size and location, contributing to higher all-in costs,” she said.

“These cost challenges, however, will respond to the growth of the market and increasing project scale -which is exactly what we expect to see in the floating solar market over the next few years.”

A recent report by DNV GL, an international accredited registrar and classification society, notes that it sees offshore PV as a complementary technology for offshore wind, with solar panels installed in spaces between wind turbines and connected to their transmission lines. Overall, they expect a floating solar system of approximately 1MW will be linked to each offshore wind turbine in the North Sea from 2025 to 2030.

In June, the company launched a collaborative joint industry project with 14 industry participants to develop the industry's first recommended practice for floating solar power projects.

Future gazing

Q CELLS will begin construction of the Hapcheon Dam floating solar power plant by the

end of 2020. But Clover says that the company continues to look out for new and innovative solutions in solar cell and module technology and for "opportunities worldwide to develop large-scale solar power plants, both in the floating space and the onshore space".

The World Bank, in its 2018 report, highlights ample opportunity for floating solar due to the more than 400,000km² of man-made reservoirs in the world, 'suggesting that floating solar has a theoretical potential on a terawatt scale'.

Meanwhile, analysts at Wood Mackenzie estimate that global floating solar demand will grow by an average of 22% year-over-year from 2019 through 2024. By 2020, it will likely satisfy 2% of global solar demand.



Satellites and other space technologies could be used to help mitigate the effects of climate change, as well as protect both animals and communities.

Satellite technology has long been used to predict the weather, with meteorological forecasts able to act as early warning systems for extreme weather events.

The technology is also key for documenting environmental changes and informing decision making by measuring sea levels, atmospheric gases and the planet's changing temperature, among other factors.

There are currently more than 160 satellites measuring different global warming indicators, with more than half of essential climate variables only measurable from space, according to the World Economic Forum.

But the technology could do more. Here are



five ways space tech can help improve life on Earth.

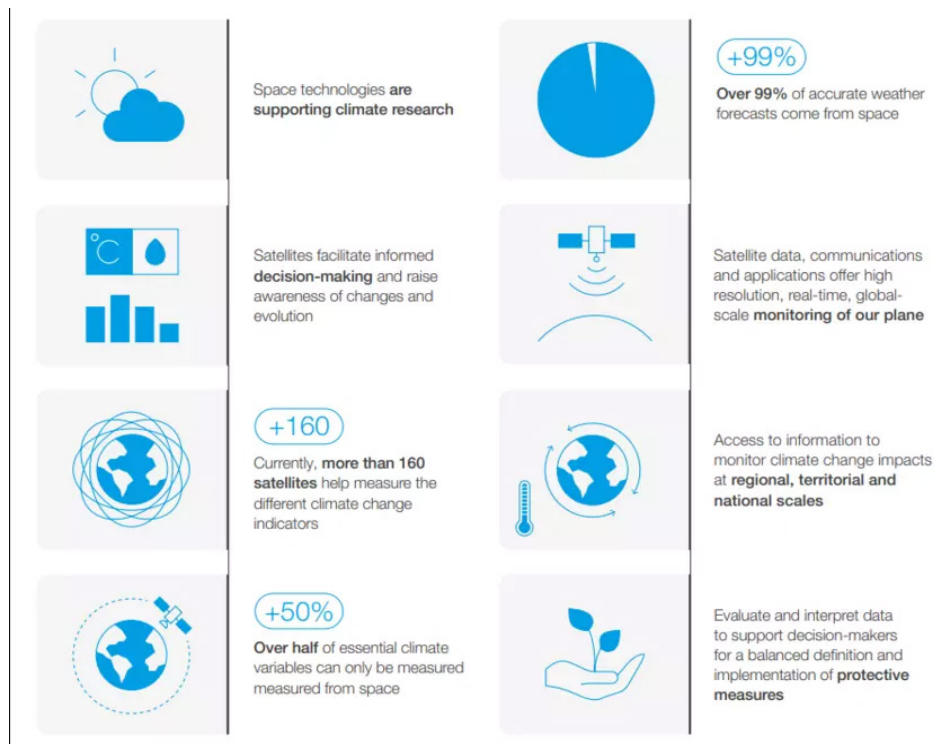
1. Frontier technologies to tackle climate change

The arrival of frontier technologies such as Space 2.0 systems – along with other innovations including artificial intelligence (AI), 5G, the Internet of Things (IoT) and robotics – offers further

potential for supporting the fight against climate change.

Information and communication technologies could play a fundamental role in meeting the Paris Agreement's target of limiting global warming to 1.5C, according to Frontier Technologies to protect the environment and tackle climate change, a joint report from the International Telecommunication Union and the United Nations.

Among these are Space 2.0 technologies, which build on those developed during the first space age of 1957-2000. Space 1.0 resulted in



technologies such as the Global Positioning System (GPS), which became widely adopted commercially.

The report says it is vital that satellite measurements continue, and get more advanced over time, so that changes to geological features such as ice sheets can be accurately monitored.

2. Satellites to track weather patterns

One such example is NASA's Ice, Cloud and land Elevation Satellite-2 (ICESat-2) spacecraft, which launched in 2018.

ICESat-2's predecessor showed the thinning of sea ice and how ice cover had disappeared from coastal parts of Greenland and Antarctica. NASA's latest satellite was developed to provide extra information on how ice cover changes over the course of a year.

Scientists hope that information from next-generation satellites such as ICESat2 – which takes measurements every 85 centimetres along its ground path – could improve forecasts for rising sea levels, as well as global weather and climate patterns.

3. AI cameras to monitor wildlife crime

Satellites have also been used in Africa to help prevent big game poachers from killing protected species. US nonprofit Resolve has worked with UK satellite provider Inmarsat to develop a Trailguard AI anti-poaching camera system that helps national parks detect, stop and locate poachers.

Testing at Tanzania's Grumeti Reserve led to the arrest of 30 poachers and the seizure of more than 590 kilogrammes of bushmeat.

4. Sensors to track animals

The International Co-operation for Animal Research Using Space (Icarus) initiative is using a satellite on the International Space Station (ISS) to create an "internet of animals".

Scientists hope to track the migratory patterns of birds and animals from space with the aid of thumbnail-sized transmitters attached to their backs.

The data is then beamed to the ISS, where it is transmitted to a ground station. The resulting synopsis of animal life on Earth could later be used to transmit other environmental data.

5. Satellite images transformed into data for farmers

Satellite imagery and climate data can also support other sectors such as agriculture and industry, with additional benefits to the communities they serve.

Digital Earth Africa uses Open Data Cube and Amazon Web Services to make global satellite data more accessible and highlight how it can be used to bridge social and economic inequalities.

Such information can be used to help farmers improve agricultural yield, thereby reducing hunger; tackle unregulated mining and its knock-on effects; and identify new opportunities for economic growth.

Nanofiltration membranes to treat industrial wastewater from heavy metals

Water Technology, 22 March 2021



National University of Science and Technology (NUST MISIS) scientists together with Indian colleagues from Jain University and Sri Dharmasthala Manjunatheshwara College recently presented innovative membranes for the complete removal of heavy metals from industrial wastewater. The special nanostructure of zinc-modified aluminum oxide made it possible to remove arsenic and lead from water with an efficiency of 87% and 98%, respectively. The results of the work were published in the *Chemosphere* journal.

Industrialization is the main cause of water pollution due to the ingress of industrial waste. In particular, heavy metals — arsenic, lead and cadmium — can cause metabolic disorders and multiple critical effects to the body, which make them extremely toxic to the environment.

One of the most promising methods of purification and removal of heavy metal ions from water is the membrane technology. It acts as an effective barrier and is relatively easy to manufacture. At the same time, it has some serious limitations such as high energy consumption, short membrane life, low productivity and selectivity.

The challenge for scientists is to make the membrane technology a more versatile and commercially available method of wastewater purification. An international team of researchers from Russia and India proposed a solution to the problem by synthesizing a new type of membranes — especially porous nanoparticles of zinc-doped

aluminum oxide.

“The nanoparticles that we obtained by solution combustion method have a very large surface area (261.44 m²/g) at a size of 50 nanometers. Cross-sectional images of nanoparticles obtained using scanning electron microscopy showed the finger-like morphology and porous nature of the membranes,” said Vignesh Nayak, co-author of the work, a postdoctoral researcher at NUST MISIS.

According to scientists, the synthesized membranes showed increased hydrophilicity, surface charge and super porosity, which made it possible to remove arsenic and lead from an aqueous solution with an efficiency of 87% and 98%, respectively.

The second important advantage of the membranes obtained is antifouling properties. It means that the material is resistant to fouling by aquatic microorganisms, which disable devices that have been in aquatic environments for a long time.

The antifouling study conducted by developers at various pressures with a feed solution containing bovine serum albumin showed 98.4% recovery and reusability of membranes for up to three continuous cycles.

In the future, the membranes obtained can be used for effective treatment of industrial effluents, as well as in large city water treatment plants. The team is currently completing laboratory tests of the samples obtained.

Beating climate change: Why finance needs to flow to small entrepreneurs in the Pacific and Caribbean

Pioneers Post, Julie Pybus, 23 March 2021

Entrepreneurs in the Caribbean and Pacific could help battle the ever more dramatic effects of climate change, but at the moment there is little of the right kind of finance available to help their businesses to take off.

These were the findings of recent research presented at a webinar run by the Investment Climate Reform Facility, a project co-funded by the European Union, the Organisation of African Caribbean and Pacific States (OACPS), the German Federal Ministry for Economic Cooperation and Development and the British Council at the end of February. The event examined what finance is available to support the growth of social and green enterprises in the Caribbean and the Pacific.

“There’s an urgent imperative for financing climate change solutions in Caribbean and Pacific regions,” said Bonnie Chiu, managing director of The Social Investment Consultancy, which collated research from a number of sources.

She added that this was particularly relevant for small island states which were especially vulnerable to the effects of sea level rises and storms. What’s more, she pointed out, natural disasters associated with extreme weather events caused US\$93bn of damage to the Caribbean region between 2015 and 2019.

“Climate change is not just an environmental issue, but an issue that has environmental and social impact,” she said. The other participants in the event agreed that these were pressing concerns.

Escipión Joaquín Oliveira Gómez, assistant



secretary-general of the Department of Structural Economic Transformation and Trade at OACPS, and a Dominican Republic citizen, said: “Social finance and green investments are important themes – especially for island people like us.”

A gap for impact investors to fill

Drawing upon research from the Stockholm Environment Institute, Chiu said that while billions of dollars of climate focused finance was flowing to the Pacific and the Caribbean, it wasn’t meeting the needs of social and green enterprises. For example, in Pacific countries, smaller investments were missing from the finance mix. In both areas, most of the funding was via grants rather than other types of impact investment.

“There is a lot of room for impact investors to be focusing on climate change,” said Chiu.

The panellists in the webinar backed up these findings. Buriata Eti-Tofinga, a lecturer at the social of business at Monash University in Malaysia who has studied the development of social enterprises in the small islands of the Pacific, said start-up entrepreneurs had limited finance options; often their only choice was their local bank. “They don’t have anything specifically tailored for social enterprise,” she said.

“They have plenty of ideas,” she added. “In the Pacific we are training entrepreneurs, but matching them with the financial options out there in the Pacific is a problem because it’s so limited.”

Ruth Houlston, private finance lead specialist at the Inter-American Development Bank, said in the Caribbean “we have finance if you are a blue

chip company”. “Access to finance is the most pressing issue that constrains entrepreneurs” growth,” she added.

Targeting the ‘blue economy’

The speakers, however, did pick out some examples of good practice. These included the Global Fund for Coral Reefs, which is seeking to raise and invest US\$500m in coral reef conservation over the next ten years.

The fund is still new – it launched in September 2020 – but “it is likely that a lot of the beneficiaries will be a number of the least developed island countries”, said Chiu.

She pointed out that the fund intends to offer innovative finance to enterprises operating in the “blue economy” – the sustainable use of ocean resources for economic growth, improved livelihoods and jobs, and ocean ecosystem health – such as ecotourism, sustainable fisheries and waste management.

Chiu also highlighted PacificRISE, which operates across 14 island countries with the goal of attracting US\$10m of new private investment into the Pacific by July 2021 and which supports investors to consider gender equality.

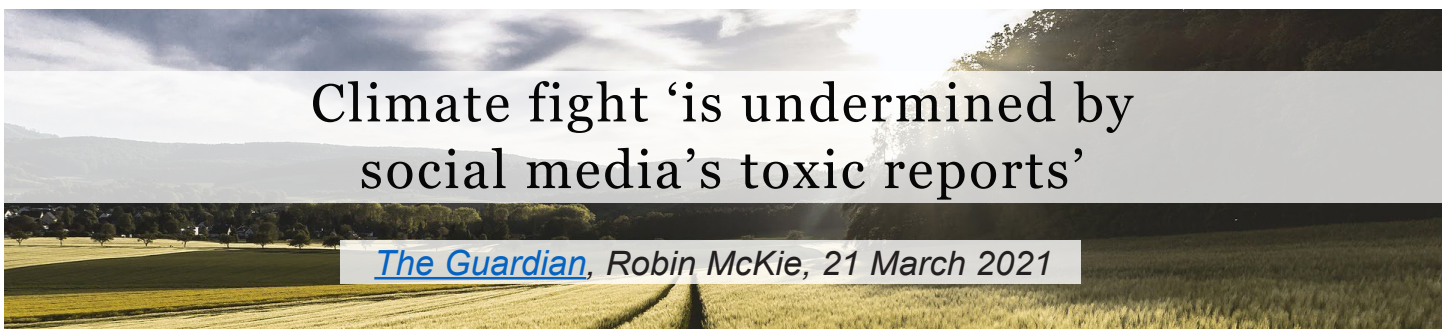
We are now seeing more innovative financing structures to ensure that climate finance can be channelled to enterprises, including start-ups and

SMEs,” said Chiu.

The webinar chair, the British Council’s Owen Dowsett, said: “The discussion highlights the potential role that there is at a structural level to ensure that capital is flowing in the right direction to the right communities. Increasingly, globally, there is a recognition that responsibilities lie with policy makers, investment professionals and others to up their game in terms of the innovations that they use.”

Communicating with Pioneers Post after the event, Miguel Campo Llopis, policy officer in the private sector and trade unit of the European Commission, emphasised that the new EU Global Recovery Initiative aims to be the backbone for a recovery from the Covid-19 pandemic that is “green, digital and just”. The initiative should, he said, “support the transition towards climate neutrality and resource-efficient economies”.

He added that EU and the OACPS are also jointly promoting a new programme for the Caribbean aiming to consolidate a Caribbean investment ecosystem for inclusive private sector innovation. The focus, he explained, would enable early stage and growth-oriented SMEs to “innovate and thrive”, benefiting from a strengthened network of innovation ecosystem actors and investors.



Fake news on social media about climate change and biodiversity loss is having a worrying impact in the battle to halt the growing environmental threats to the planet, a group of scientists and analysts have warned.

In a report published by the Royal Swedish Academy of Science, they say measures needed to create a healthier, more resilient planet – by reducing fossil fuel emissions, overfishing and other threats – will be hard to enforce if they continue to suffer targeted attacks in social media. The international cooperation that is needed to halt

global heating and species loss could otherwise be jeopardised, they say.

“Social media reports have created a toxic environment where it’s now very difficult to distinguish facts from fiction,” said one author, Owen Gaffney, of the Stockholm Resilience Centre. “One of the biggest challenges now facing humanity is our inability to tell fact from fiction. This is undermining democracies, which in turn is limiting our ability to make long-term decisions needed to save the planet.”

This view was supported by the report’s lead



author, Professor Carl Folke, director of Sweden's Beijer Institute of Ecological Economics. "Improvements are occurring – we are getting a lot of promises from big nations about tackling environmental threats – but the media still causes polarisation of views and that is not helpful. We need to tackle that."

The group's report is published as a background paper to the first Nobel Prize Summit, which will be held in April, on the subject "Our Planet, Our Future". Originally scheduled to take place in Washington last year, the meeting was postponed because of Covid-19. This time it will be held – from 26 to 28 April – as a virtual event.

Those taking part will include Nobel laureates such as Al Gore, the gene-editing pioneer Jennifer Doudna, and immunologist Peter Doherty, as well as Anthony Fauci, the chief medical adviser to US president Joe Biden, and the Dalai Lama.

"The aim is to highlight ways to reduce climate change, biodiversity loss and inequalities and suggest how new technologies such as AI and synthetic biology could help save the planet," added Gaffney, who is also one of the summit's organisers.

However, the report makes it clear that this task is a daunting one. As it points out, humanity's dominion over nature has now reached startling levels. Three hundred years ago, there were 1 billion people on our planet. By the end of this century that figure will approach 10 billion or possibly surpass it. As a result of these dramatic increases, the totality of human beings alive today, plus the livestock that provides us with food, represent 96% of the sum weight of all mammals on Earth. The residual 4% is made of the planet's remaining wild animals.

Today, there is no place on our world that is untouched by homo sapiens, state the report's authors. Three-quarters of all Earth's ice-free land has now been directly altered by humans. Every eight days, we build the equivalent of a city the size of New York. We simplify landscapes to ensure they provide maximum economic benefits and, in the process, erode the biosphere's resilience. One result is the emergence of new pathogens such as Covid-19.

The relatively cool years that make up the Holocene epoch, which began 11,700 years ago, have now been replaced by the Anthropocene, an epoch in which humanity is the main driver of ecological events. We are destroying rainforests that absorb carbon dioxide and are driving countless species – from insects to gorillas and chimpanzees, our closest evolutionary cousins – towards extinction. At the same time, global heating – caused by our continued burning of fossil fuels – is triggering unprecedented heatwaves, droughts, storms, floods and wildfires.

"Climate change impacts are now hitting people harder and sooner than was envisaged only a decade ago," states the report, *Our Future in the Anthropocene Biosphere*.

Given the vast scale of the problem, the report concludes that "modest adjustments" to our current industrial and agricultural practices are now going to be insufficient. "Transformative changes are now necessary," it concludes.

How waste CO₂ is helping to turn renewable energy into liquid fuel

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Storing power generated by strong winds or bright sunshine by turning it into liquid fuel such as methanol can help to ensure green energy does not go to waste, without having to rely on batteries.

Methanol can be made from CO₂ captured from industrial sources, combined with hydrogen split out of water using surplus renewable energy. And the resulting fuel can be used in cars or ships, reducing the use of fossil fuels as well as emissions of greenhouse gases.

“We are ... transforming renewable energy into a liquid fuel that can be used in standard internal combustion engines,” said David Cuesta, of the Spanish energy consultancy i-deals. “In the end you are taking a standard vehicle, and somehow, you are ‘electrifying’ it,” he added.

Cuesta coordinated the MefCO₂ project, which showed how industry can play a role in conserving renewable energy as it is produced and help to absorb some of the fluctuations inherent in sustainable energy production.

The project used carbon capture technology at a coal-fired power plant in Germany to demonstrate the process, storing some of the emissions as methanol.

Reproducing the process at scale could also help to reduce EU imports of methanol, which is easily stored and transported but currently produced from fossil raw materials. In addition to its use as fuel, methanol is a feedstock with widespread use in the chemical industry.

Electrifying

Hydrogen made from renewables has long been recognised as a clean fuel, but taking the extra step to make methanol provides a higher energy density product, without the technical



demands of high-pressure storage and transport, or the need to provide new infrastructure for use by retail consumers.

One hurdle to using renewable energy to split off the hydrogen from oxygen in water was the demand by some electrolysis systems for constant supplies of power. But

using innovations such as polymer electrolyte membrane (PEM) technology allows flexibility in adjusting to natural fluctuations in conditions.

MefCO₂ also paved the way for renewables to be harnessed by other carbon-emitting industries, such as steelmaking, where i-deals is coordinating the FReSMe project to produce methanol as a fuel for ocean-going ferries. Large-scale battery-powered engines may not be viable for such ships, but methanol may be accommodated readily.

Renewable

By meeting various standards, such as CO₂ footprint reduction, methanol can be considered a renewable fuel, which can command a premium from businesses working to reduce their carbon emissions.

That additional income for the producer can cover the cost of the infrastructure and provide an additional economic incentive.

“We’re helping certain industries to decarbonise and they can even make a profit out of this, so that decarbonisation is not as much of a burden,” Cuesta said.

Coordination between industry players to provide raw materials for renewable energy, as well as careful management of production and storage, can help to smooth out fluctuations in supply and demand for green power, stabilising

the grid as well as making carbon capture and use more economically viable.

That kind of coordination is an essential element of industrial symbiosis – where different industries share resources, data, and materials to make the whole ecosystem more sustainable.

Working in this way could help industry play a greater role in renewable energy production and use. Such coordination could ensure waste products or byproducts from one process – such as CO₂ – can be used as a raw material for another, such as in the MefCO₂ project.

“If I am a company and I am acting alone, I tend to satisfy what I think is ... best (for me),” said Andrea Ballarino, of Italy’s Institute of Intelligent Industrial Technologies and Systems for Advanced Manufacturing (STIIMA-CNR). “But if I can combine my action with the action of other companies, I can achieve symbiosis and I can achieve a global optimum – as well as my (own) optimum,” he added.

Collaborate

Ballarino coordinated the SYMBIOPTIMA project, which showed that one company could tailor a byproduct to meet the needs of another user, turning it into extra income as well as lowering costs for the buyer who could avoid purchasing some primary raw material.

Embracing that approach brings industry together to play a pivotal role in reducing waste of all kinds. SYMBIOPTIMA also focused on making savings in energy use at the level of individual factories, while smoothing out collective demand for power from the grid, including renewables, and being able to plan ahead more accurately.

SYMBIOPTIMA used close monitoring of industrial processes and cooperation between companies to demonstrate they could make energy cost-savings of the order of 10%-15%.

By building up and adjusting a detailed profile of the energy demand in one factory, software tools were able to both govern its production in an energy-aware way and calculate its expected power purchases. Those could then be aggregated with the profile of another factory, and a software system that preserved their

anonymity would mesh their purchases together, matching peak demand from one with an energy dip from the other.

By staggering the industrial processes, the software ensured factories were not having to pay peak prices by demanding maximum power at the same time. The result was to cut costs for both factories as well as help the grid manager to balance demand, and to plan for what backup power may be needed to support renewable inputs.

Attractive

In addition to energy planning, industries could tune the characteristics of their byproducts and time their availability to make them more attractive to other industrial users.

“At the end of the day and at the end of the month, it provides an economic advantage – money in the pocket,” Ballarino said.

One of the SYMBIOPTIMA aims was to uncover economic opportunities in value chains of companies and even industries that may not have obvious links – and where the players are clearly not competitors.

Those included a four-way collaboration between a foundry, a cement factory, a paper mill and a brickmaker. The Symby-Net software developed during the project showed how slag and waste sand from a foundry could be used by a cement factory and a brick factory. And the brick factory could also reuse sludge left over from paper manufacturing, reducing its need for raw clay.

Ballarino pointed out that the incentives to cooperate range from financial benefits to ensuring the long-term security of scarce resources or compliance with regulations, such as those encouraging environmental sustainability or renewable energy production.

“We have a number of companies for which resources are scarce, energy efficiency is a problem, (and) sustainability is a must,” Ballarino said.

“And the only way to achieve all these goals is to collaborate, so we need the tools to collaborate,” he added.