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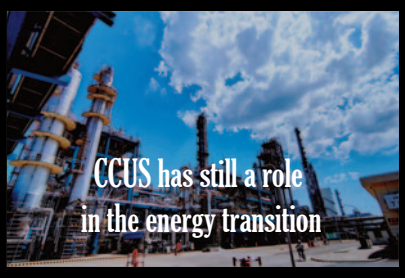
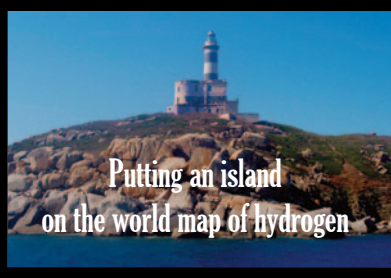
Climate change is global, pain private

The Law of the Many



CCUS has still a role in the energy transition

Less Fuel Use in Harvesting Maize



Putting an island on the world map of hydrogen

YEAR VIII - NUMBER 4 - OCTOBER-DECEMBER 2022

THE ENERGY TRANSITION
THE ROLE FOR SUSTAINABLE CARBON
CAGLIARI, ITALY 16-18 NOVEMBER 2022

Identifying the policies and technologies needed for a realistic route to achieve net zero

More than 120 countries have announced commitments to achieve net zero emissions by 2050.

The technologies, policies and measures needed to make it happen will be presented and discussed by experts from around the world at the **Workshop on the energy transition – the role for sustainable carbon**, organised by the International Centre for Sustainable Carbon with Sotacarbo and Only Natural Energy. This exploration of the role of sustainable carbon in the energy transition will include sessions on:

- Policy drivers for a low carbon energy transition
- Advanced low carbon technologies
- CCUS - technical progress, supportive policies and business models
- Green and blue hydrogen, ammonia and methanol – developments and markets
- Biomass combustion and cofiring – challenges and solutions
- Alternative products from coal – as a source of carbon and its role in agriculture
- A panel discussion on international perspectives to achieve net zero scenarios

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ONE
Only Natural Energy

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The Conversation
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Cover Photo:
Nurnahar and her daughter. Their first house was destroyed in a storm, and with nowhere to go, they were forced to take the children and live in a tent by the side of the road. That makeshift shelter offered even less protection and soon was also lost in a storm. For two years, the family lived on a boat, a cramped struggle with three children. Finally, they were at last able to rebuild their house again, only to see it destroyed by Cyclone Amphan in May 2020.
Photo cedit: Environmental Justice Foundation

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Delegates to the COP21 climate change conference assemble in the Plenary Hall at LeBourget Airport in Paris, France, on December 12, 2015.
Photo credit: U.S. Department of State

The Law of the Many

GIANNI SERRA
ONE

Private jets pollute more. They pollute like all planes but serve few people, which is why the amount of co2 emitted per capita is unacceptable. Especially at a time when more responsible behaviour and sacrifices are being demanded from everyone to reduce emissions. According to the European non-governmental organisation (NGO) Transport & Environment (T&E), private jets are five to 14 times more polluting than commercial planes per passenger, and 50 times more than high-speed rail, emitting two tonnes of CO2 in a single hour.

This is a marginal situation which involves very few private citizens. But it's illuminating. It shows how a zero point zero [and counting] per cent of the earth's population can nullify a collective effort.
According to UK-based sustainability marketing agency Yard, in July 2022, actors and sports stars - but it can also be said of politicians and industrialists travelling by private jet - had emitted around 483 times more CO2 into the atmosphere in seven months than the average person produces in a whole year.
We can conclude that if private jets affect serve so few individuals, humanity can easily do without them. Instead, those tiny numbers are the key argument to justify inaction: "we are talking about a trifle", "cancelling private jets would not change anything", and "the problem lies elsewhere". So private jets keep receiving tax break bonuses and similar boosting packages.

And so, for the private-jet aficionados, nothing changes. At the same time, an insistent attempt is made to raise the consciousness and sensitivity of those with a minimal carbon footprint. Paradoxically, we ask those who pollute less for more sacrifices.

This tricky method applies not only to private jets or yachts but to all climate policies. In fact, 195 countries signed the Paris climate agreement because the climate is a global problem, and the solution has to be global. Even if everyone does not equally determine the problem, China, the US and India together emit almost half of the world's total CO2. Three governments have the power to solve half of the problem alone. And are also in the position to spread infectiously any policy.

Yet, here, too, numbers are used to avoid changing the status quo: to find a global and lasting solution, almost 200 countries need to be brought together, each target and progress monitored and revised, and overall policies and targets realigned. An ideal ploy to dilute responsibilities and never reach a solution or a proper contribution from those who really could (and should). ONE

Climate change is global, but the pain is private

LENORE HITCHLER
ONE

Imagine that your community has been battered or even destroyed by a climate change-induced flood, tornado, hurricane, or drought. Some community members have perished, including people that you know. You are lucky if everyone in your family survived. Perhaps you have lost your home and everything that your family accumulated. Maybe you lost all your mementos and photos of grandparents, parents, children, friends, and pets. Your family or friends might have been forced to relocate.

When people are forced to relocate, they lose their old community, and in turn, their old community loses them. The original community will never be the same. Any of these scenarios could be used to show the pain caused by climate change-induced migration. Or perhaps you lost the family farm because of a long drought. This scenario could be used to introduce such agricultural issues as farm crops

Jamila, 35, by a toilet on the banks of the river Rupsha, Bangladesh. Tidewaters overflow this area regularly and the cyclone Amphan destroyed most of the riverside toilets.
Photo credit: WaterAid/ DRIK/ Habibul Haque

that are unable to adapt to climate change or even famines. Or maybe you lost a beloved pet from Lyme Disease, which has spread to new areas because of climate change.

This story can be part of a larger discussion on the spread of diseases because of climate change. Or imagine that you suffered through a climate change-induced heat wave, and perhaps you lost someone you cared about.

Perhaps you haven't yet experienced any of these hardships. However, your region is probably vulnerable to climate change-induced disasters. In all likelihood, you either live on a coast, a floodplain, an area susceptible to wildfires, or extreme weather such as devastating storms, heat waves, and droughts.

The preceding scenarios could be further elaborated to become stories that show how the suffering and heartache that climate change-induced disasters affect their victims. These stories then can be used to influence people to join the movement to combat climate change.

The importance of climate change stories was studied by George Marshall, who studied climate change communication for many years. He is the author of *Don't Even Think About It—Why Our Brains Are Wired to Ignore Climate Change*. He wrote that "The author Philip Pullman, who has been among the handful of writers struggling to build stores around climate change, stated that 'After nourishment, shelter, and companionship, stories are the thing we need most in the world.' Stories perform a fundamental cognitive function: they are how the emotional brain makes sense of the information collected by the rational brain. People may hold information in the form of data and figures, but their beliefs about it are held entirely in the form of stories."

The climate change movement has mainly relied on facts and data in its arguments. However, convincing evidence is available regarding the persuasive value of telling stories. This is not to say that science, theories, and evidence are not important. For example, stories about disasters may emotionally move your audience.

They may even help to motivate them to mobilize against climate change. However, your audience also needs to know how climate change contributes to these disasters.

There are many ways of telling stories besides personally telling them out loud to a specific audience. For example, there are short stories, novels, magazines, children's stories, fairy tales, puppet shows, myths, fables, legends, religious stories, radio programs, television, films, plays, podcasts, cartoons, video games, drawings, paintings, murals, and graffiti, song, and dance.

Use whatever method of storytelling that is appropriate, that you feel comfortable with, and are good at.

Devastation of Drought Felt by Communities in Galmudug, Somalia. The International Organization for Migration (IOM) has provided water trucking, distribution of hygiene kits, and construction and rehabilitation of boreholes and shallow wells. Photo credit: IOM Somalia 2022/ Ismail Osman

Understanding the neurology of stories is essential in analyzing their value. Environmental author Rob Hopkins in *From What Is to What If—Unleashing the Power of Imagination to Create the Future We Want* provided an excellent introduction to the neurological functioning of stories. He stated, "Neuroscience tells us that amazing things happen when we listen to and tell stories. When we listen to a lecture about climate change, for example, with PowerPoint slides, graphs and bullet points, the parts of our brain that show we are listening and the part where words are processed both light up. But when we listen to a story, something very different happens. First, the same parts of the storyteller's brain and the listener's brain light up together. …That is, we experience the story rather than just absorbing information. We understand it more deeply. We retain it longer."

Mirror neurons help explain this phenomenon. Mirror neurons are brain cells that respond when either observing others performing a specific action or expressing emotion.

Further discussion of this neurological process is provided by Jonathan Gottschall, professor of literature, in *The Storytelling Animal—How Stories Make Us Human*. He quoted neuroscientist Marco Iacoboni on what occurs when watching a movie. Still, it is also likely true when we are exposed to other forms of storytelling. Iacoboni stated, "We have empathy for the fictional characters—we know how they're feeling—because we literally experience the same feelings ourselves."

Alina Siegfried provided additional information on our neurological response to storytelling in *A Future Untold—The Power of Story to Transform the World and Ourselves*. She included information from "*Why Inspiring Stories Make Us React: The Neuroscience of Narrative*" by neuroscientist Paul Zak. Siegfried wrote that "Hearing stories can release brain chemicals such as oxytocin and cortisol, evoking an empathy response and even inspiring post-story actions such as making a donation."

Lisa Cron in *Wired for Story* added further evidence about the brain's response to stories. She reported that "A recent study [in *Psychological Science*], in which subjects underwent functional magnetic resonance imaging (fMRI) of the brain while reading a short story, revealed that the areas of the brain that light up when they read about an activity were identical to those that light up when they actually experience it." Thus, various neuroscientists find that when people respond to stories, they react to them as if they are real.

There are still further neurological explanations on why stories are so important to humans. Cron wrote that "As neuroscience reveals, what draws us into a story and keeps us there is the firing of our dopamine neurons signaling that intriguing information is on its way."

Gottschall stated that stories are so intrinsic to humans that they create them in their dreams and daydreams. He said, "Even when the body goes to sleep, the mind stays up all night, telling itself stories. … dream researchers now know that storylike dreams actually occur independent of REM and across the whole sleep cycle. Some researchers think that we dream almost all night long."

He also reported that people spend a lot of time daydreaming. He wrote, "Clever scientific studies involving beepers and diaries suggest that an average daydream is about fourteen seconds long and that we have about two thousand of them per day. In other words, we spend about half of our waking hours—one-third of our lives on earth—spinning fantasies."

These statistics suggest that our brains are almost always processing internally produced stories.
While Gottschall wrote about stories in general, his advice is valuable to climate change activists. He stated, "if you want a message to burrow into a human mind, work it into a story." He added, "The emotions of fiction are highly contagious, and so are the ideas. As the psychologist Raymond Mar writes, 'Researchers have repeatedly found that reader attitudes shift to become more congruent with the ideas expressed in a [fiction] narrative.' Fiction seems more effective at changing beliefs than nonfiction, designed to persuade through argument and evidence. … People can think differently about sex, race, class, gender, violence, ethics, and anything else based on a single short story or television episode."

Journalist Will Storr provided an example of this in *The Science of Storytelling*. He wrote, "One study had a group of white Americans viewing a sitcom, Little Mosque on the Prairie, that represented Muslims as friendly and relatable. Compared to a control group (who watched Friends), they ended up with 'more positive attitudes towards Arabs' on various tests – changes that persisted when re-tested a month later.

Siegfried provided further substantiation on the capability of stories to change attitudes.

She stated, "Recent research supports the idea that sharing stories can change a person's deeply held point of

view on divisive topics, in ways that the exchange of rational arguments cannot. A wide-reaching study, published in *American Political Science Review*, investigated whether it was possible to change exclusionary attitudes towards undocumented immigrants and transgender people. In three field experiments, 230 canvassers conversed with 6869 voters across seven US locations, engaging them either over the phone or face-to-face by knocking on doors. They found that while conversations deploying arguments alone had no effects on voters' exclusionary immigration policy or discriminatory attitudes, otherwise identical conversations that also included the non-judgmental exchange of stories significantly reduced exclusionary attitudes for at least four months following the conversation. By first listening carefully without judgment to the concerns of the voters whose doors they knocked on, canvassers shared stories of transgender individuals or undocumented immigrants they knew. In the sort of conversational tone you might expect from a couple of friends chatting over a beer down at the pub or café. No arguing, no defensiveness, just telling stories and sharing how current exclusionary policies affect the lives of real people."

One reason why stories are so important is that facts alone do not seem to change many people's attitudes. Marshall stated that "extensive research evidence shows that information does not change people's attitudes." Unfortunately, he did not provide any evidence to substantiate this assertion. Similarly, Cron stated, without any scientific evidence, that "Facts that don't affect us—either directly or because we can't imagine how the facts affect someone else—don't matter to us. And that explains why one personalized story has infinitely more impact that an impersonal generalization, even though the scope of the generalization is a thousand times greater. In fact, it is only via a specific personalization that the point of a generalization is shot home."

Further discussion on the disadvantages of relying solely on data to convince people was provided by Dr. Hans-Bernd Brosius, professor of communications, and Anke Bathelt in an article published in *Communication Research*. They wrote that "Research in social psychology has demonstrated the difficulties people have in processing or comprehending general statements that include percentages, probabilities, and so forth. … Handbooks on journalism recommend a combination of general statements with individual illustrations as a means of conveying a complex and abstract issue to a broader audience." In other words, stories make it easier to process facts.

Members of the Florida National Guard conduct search and rescue missions in St. Augustine after heavy flooding and high winds due to the impact of Hurricane Matthew. Photo credit: The National Guard

A few experts have offered advice on good storytelling for climate change activists. Frank Luntz is a communications expert who usually advises Republicans. In the past, he was a climate change denier. However, an article in *Politico* stated that he changed his mind and has recently stated that those fighting climate change should "personalize, individualize and humanize" the impacts of climate change to make it more relatable to the average person. Marshall reported on Luntz's general advice on telling stories. Luntz stated that 'a compelling story … can be more emotionally compelling than a dry recitation of the truth.' Luntz claims to have personally sat in more than two hundred focus groups, from which he has extracted his own rules for what constitutes a compelling story: simplicity, brevity, credibility, comprehension, consistency, repetition, repetition, and repetition."

Additional good advice for climate change storytellers is found in *What We Think About When We Try Not to Think About Global Warming* by psychologist Per Espen Stoknes. He wrote, "Make the issue feel near, human, personal, and urgent."

Therefore, climate change activists should show through stories the harmful effects of climate change on the many individual concerns that people have. For example, the health of almost every person will be harmed both by burning fossil fuels and climate change. Exposure to fossil fuel pollution increases the risk of autism, dementia, and various mental illnesses, in addition to asthma, cardiovascular disease, and cancer. Climate change will affect recreation and outdoor activities, including winter and summer sports. It will also affect political and economic systems. Almost everyone either has children or grandchildren or they eventually hope to. Most people want to leave a decent world to their descendants, and climate change will damage their legacy.

Fortunately, positive stories can be told about the future. For example, great alternatives can be shown through stories regarding the following topics. Deforestation increases climate change and ending it and planting new trees will both slowdown climate change and lead to increased biological diversity.

Climate injustice can be rectified. Food, water, and sewage systems can be made more sustainable. Urban areas can be made more pleasant with better and increased public transportation. Cities can become greener. The future does not have to be all doom and gloom, and stories can contribute to the dialogue on creating a more pleasant and sustainable future. ONE

Less Fuel Use in Harvesting Maize

THEO HART
ONE

Maize is one of the New World plants nobody else had experienced before 1500. Compared with wheat or rye, it certainly looked peculiar. The grain is hidden in a wrap of leaves, the many kernels attached to a large core (cob). The two 'ears' per plant stick out at a height convenient to pick by hand. Also, the kernels are large and relatively soft, with no need for a miller. It is little wonder maize became so popular with growers.

Commercial production at a large scale is another matter. Today, the combine harvester is generally used, with only grain leaving the field. But this style of harvest is peculiarly expensive with maize.

The combine is a general-purpose harvester used in many different crops. It is a mobile thresher being fed material by a detachable front unit, of which there are several types meant for other crops. A maize header picks the ears from the plants, strips off the leaves wrap, and then sends cobcorn (naked ears) into the machine's maw.
The threshing action is much too aggressive, with cobs being broken into small bits. Then freed kernels are gathered, and the broken bits of cob ejected. No surprise that threshing is the largest use of the engine's power, and a big engine is both necessary and a major cost item for this expensive machine.
If instead cobcorn were wanted, a combine harvester would no longer be used in maize — only the front-end unit would be attached to something else.

Cobcorn Harvester

Comparatively, little power is used to pick, strip, and deliver cobcorn. A self·propelled unit may be the maize header fronting something like the tractor end of a self·propelled windrower.

A conveyor to a wagon or box receiving the cob-

Maize landscape view.
Photo credit: frontierag.co.uk

corn completes this picture. Such a 'cobcorn harvester' is a less complex machine with a smaller engine, so less cost to build and then less expensive to buy. Due to much less fuel being used in the field, it also will be cheaper to operate. And there are other cost differences, with yet more fuel saved.

Loose grain coming off the field is often too moist to store safely and, unless dried, may rot. Typically, fossil fuel is burnt to heat the air blown through the grain. How much depends on the moisture in the grain, which in part depends on weather conditions at harvest.

However, any farmer growing a large amount of maize is sure to harvest some that are too moist to store safely because it is impractical to wait for all the crops to dry to an acceptable level. So, they will always incur a drying cost that varies greatly.

Natural Drying

Drying cobcorn is a breeze comparatively, as it uses natural air circulation. Unlike loose grain, which packs closely, cobcorns have much air space around them, and air moves through easily. If necessary, fans can blow more unheated air through.

Since cobcorn is less expensive to harvest and less costly to dry, profitability is not the primary consideration in the choice of harvesting system for maize. Convenience is.

It is inconvenient to harvest ears as cobcorn and

An aerial view of the maize harvest underway.
Photo credit: northeasternadvertiser.com

store them for many weeks before separating the grain from the cobs. However, one positive is a lower investment in portable machinery specific for maize, mainly when using a smaller machine over a long run of days. And if it is powered by electricity, this would further reduce the total fuel use of the farm.

No one focussed on profits first, last and always would use a combine harvester in maize. This creates doubt about whether farmers are capitalists, even though most economists presume they must be.

Markets for Cobcorn

In the USA, and Europe, to a lesser degree, ethanol by fermentation is based on maize. But this starchy grain is mainly used to feed livestock. At times it can be pricey, which is one reason why this style of ethanol production has iffy economics. It usually needs some form of subsidy to be financially viable.

Cobcorn could change this situation, depending on how it is priced and used in the ferment. Likely, cobcorn would be valued at the same price as the grain it has. This benefits the farmer, who avoids the expense of threshing. Though less noticeable, the fermenter need not thresh the cobcorn either.

Yeast or bacteria will only tolerate a low percentage of fermentables in the water they inhabit. That may be provided from the kernels without removing them from the cob. Puncture or slice the tops of the kernels, then immerse the cobcorns in hot water, having in it the enzymes used to turn starch into something the microbes can use. Drain that water and send it to the fermenters. Alternatively, flow water containing enzymes repeatedly over the prepared cobcorn.

Once all the starch has disappeared, the soggy cobs can be sent to a furfural digester on site. Furfural is made only from plant material, and being high priced, would be another significant income stream for the fermenter.

Of course, there would be other changes besides, but even this brief glimpse should be enough to demonstrate that a market for cobcorn can exist, and it is a large one, given how much fermentation ethanol is being made. [Though 2,3·butanediol is a better choice of ferment to produce an engine fuel and should displace ethanol.]

Hybrid Power

Returning to the cobcorn harvester, it could have hybrid power, a combination of combustion engine and storage. Not electric batteries but hydraulic oil under high pressure as storage, with hydraulic motors doing all the work, including moving the wheels.

It would mean the engine runs at full power or off, making it fuel efficient. Its only purpose is to provide high-pressure hydraulic fluid. Given a reasonably large reservoir on board, that reservoir could be charged with pressurized fluid at the beginning of each day using an electric motor and pump, further reducing the amount of combustion fuel used on the farm.

The cobcorn harvester has almost all the crop·specific parts in the detachable header unit, and as the weeks of harvesting are not many, the tractor end of it may work the rest of the year in or near the farm yard.

It could then rely mainly on the electric route of fluid pressurizing. Perhaps also on a windmill pump with a large reservoir. Either or both would lessen the total annual use of combustion fuel on the farm for this equipment. ONE


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Climate change amplifies the risk of conflict, study from Africa shows

The research underscores the importance of tackling climate change impacts and conflict mitigation together because misguided climate adaptation strategies can intensify existing tensions.

MALAVIKA VYAWAHARE
Mongabay

In October 2021, the city of Guriel in Somalia's Galguduud region became the epicenter of fierce fighting between the national army and a paramilitary group that left more than 100 people dead and displaced another 100,000. In November, the government declared a national emergency as drought intensified over 80% of the country, including in Galguduud.

"You can run away from fighting, but you can't escape from the drought," Deeko Adan Warsame, head of the women's council of Guriel, told an International Committee of the Red Cross (ICRC) official.

New research from Africa shows that fighting may, in fact, follow droughts. This year, rains failed again in Somalia, the fourth time in two years. If drought conditions persist for three years, it significantly increases the risk of violent confrontations, a study in the journal Economía Política estimated. Climate change can amplify the risk of conflict by as much as four to five times in a 550-kilometer (340-mile) radius.

Somalia, a coastal nation in the Horn of Africa, is one of the most vulnerable to climate impacts. In 2019, it was ranked 181st out of 182 countries on the University of Notre Dame's ND-GAIN index, which ranks climate adaptation readiness. Of the 25 countries most at risk from climate change, most are already dealing with violent conflicts, according to the ICRC, which operates in conflict-wracked regions.

There's growing evidence that climatic change shapes the political landscape, but social scientists are still piecing together how. Researchers from Spain's INGENIO Institute, the University of Rome III and the University of Urbino Carlo Bo in Italy dug into data from Africa from 1990 to 2016 in search of answers. They mapped how far the impact of climate change on conflict reached and how the risk is spread over time.

Rainfall failures tend to impact a broader geographic area. Drier conditions cause widespread water and food shortages and sometimes force people to move. Somalia is particularly drought-prone, but severe droughts are now occurring with unrelenting frequency. In the past 15 years alone, the country was struck by three major droughts. In 2010-2011, the country witnessed its worst drought in 50 years. Then again, in 2016-17.

At the same time, climate scientists expect Somalia to receive abundant annual rainfall in the coming years, occurring in short bursts of heavy showers. This year, too, downpours dumped rain that was lost as runoff without replenishing water sources or nourishing pastures. Instead, such intense rain spells often erode the soil. Excessive rainfall, especially during the growing season, can destroy local economies. However, the analysis found that the effects of flooding are more limited. It increases the susceptibility to conflict for a shorter time and over a smaller area.
Climatic changes weigh heavily on human lives, but they aren't often at the root of discord. Rather, they

Burundi peacekeepers prepare for next rotation to Somalia.
Photo credit: Rick Scavetta (U.S. Army Africa)

deepen existing tensions. Some pockets of the Sahel, the dry arid zone on the southern fringe of the Sahara Desert, are particularly volatile because the harsh, dry conditions can quickly become unbearable. Confrontations between pastoralists and settled farmers have erupted frequently because of competition for resources like land and water.

Pastoral herding practices are molded by the availability of water and fodder. However, centuries-old traditions can falter in the face of significant shifts, like more frequent droughts and extreme, erratic rainfall. Herding routes are woven from past knowledge about water and pasture availability. When rains fail and known pasturelands wither, pastoralists are forced to venture farther from their traditional orbits.

This displacement can bring them in contact with other nomadic groups with whom they don't have long-standing ties. There are also many areas where herders and farmers live side by side. Where land rights are ill-defined, confrontations often break out. In Nigeria, tensions between Fulani herders, mostly Muslim, and predominantly Christian farmers aren't rooted in environmental crises. However, shrinking land available for farming and grazing is exacerbating age-old frictions.

The likelihood of conflicts is higher in areas where pastoralists and farmers live in close proximity, a report from 2020 found. A temperature rise of 1° Celsius (1.8° Fahrenheit) can lead to a 54% increase in the risk of conflict between farmers and herders. In areas where the two groups don't cohabit, the risk falls to 17%. In a vicious cycle, conflicts almost always reduce communities' ability to cope with climate shocks. Armed conflicts inflict lasting damage, for example by destroying institutions and infrastructure that supply basic needs like water and health care. In the October attacks, Guriel's main hospital was damaged and its second-biggest hospital destroyed. According to the ICRC, a borehole that provided water for thousands of people was left unusable.

The new research shows that climate change's toll is heavier than conventional estimates suggest. An increase in the conflict risk for sub-Saharan Africa by 2030 could lead to 393,000 additional deaths, a 2009 study reckoned. It also underscores the importance of tackling climate change and conflict mitigation together.

Some strategies to ease climate-related pressures can feed social conflicts, for example when climate finance is directed to some groups and not others, or when NGOs provide alternatives to some communities and omit others.

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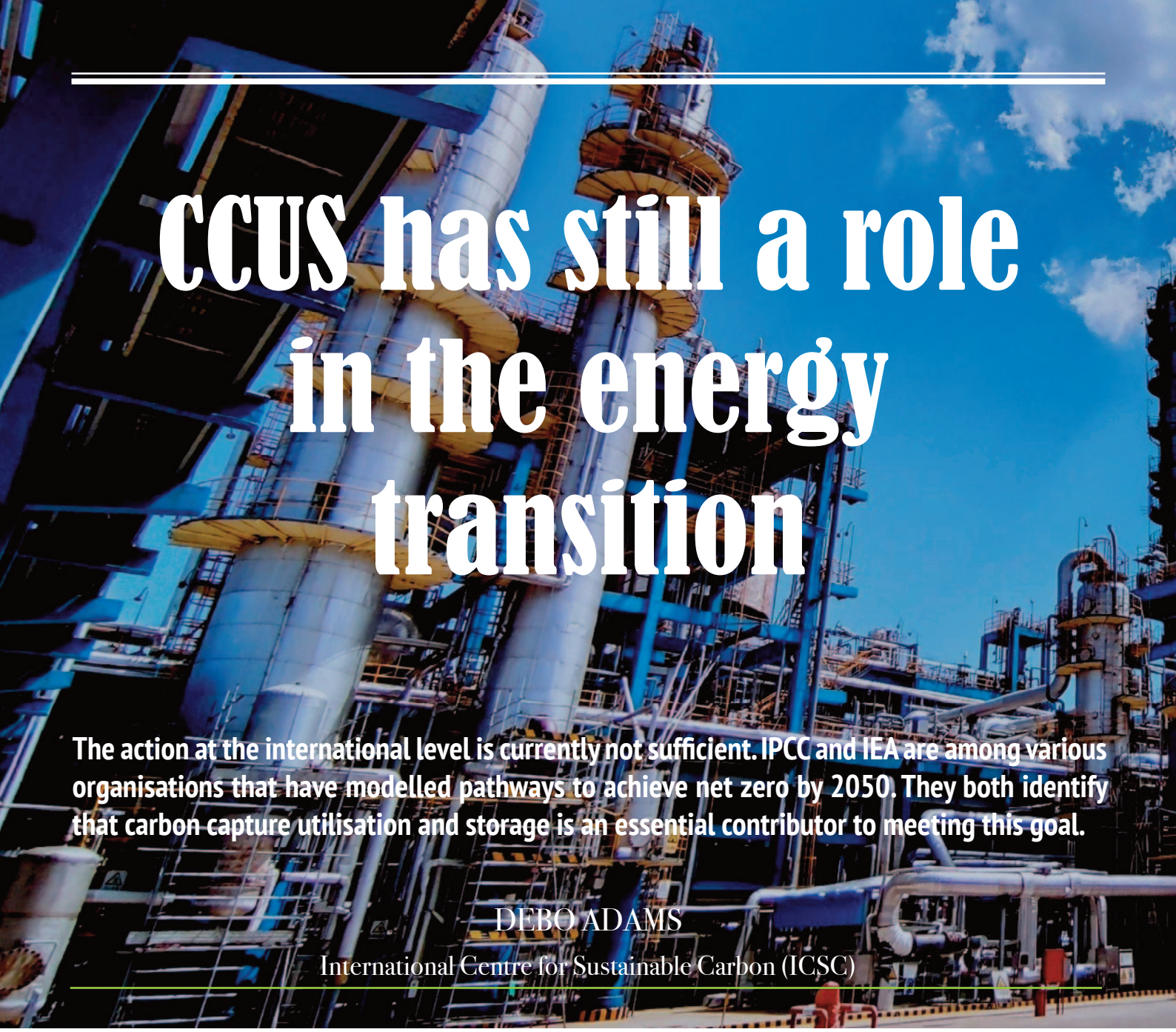


CCUS has still a role in the energy transition

The action at the international level is currently not sufficient. IPCC and IEA are among various organisations that have modelled pathways to achieve net zero by 2050. They both identify that carbon capture utilisation and storage is an essential contributor to meeting this goal.

DEBO ADAMS

International Centre for Sustainable Carbon (ICSC)

More than 120 countries have announced commitments to achieve net zero emissions by 2050, or 2060 in the case of China and 2070 in India. These are positive and ambitious statements although it is unlikely that even if these targets are reached, they will prevent the average global temperature increase from exceeding 1.5℃, which is the aim of the Paris Agreement, made at the 21st Conference of the Parties (COP) to the UN Framework Convention on Climate Change in 2015.

Many of the net zero target announcements were made to coincide with COP26 in Scotland in November 2021. Each Party to the Paris Agreement has Nationally Determined Contributions (NDCs) which spell out their individual targets to help limit climate change. NDCs are meant to be revised and strengthened every five years so that countries increase their commitment to climate change mitigation. As of December 2021, 127 countries plus the EU had submitted new NDC targets. At COP26 it was clear that the updated targets would, at most, limit warming to 2.4℃, so governments agreed to 'revisit and strengthen' their targets further in 2022. However, by August 2022 only 14 countries had submitted an updated NDC, two of which have not increased their ambitions.

This means that 179 countries have not updated their targets. And these are the main international commitments on climate change that countries make. Of the top ten greenhouse gas emitters, only Japan, Canada, the EU and the UK had legally binding net zero commitments, as of November 2021. So, although many statements of intent have been made, at the national level there are not adequate policies in place to achieve the goal of the Paris Agreement.

Although the action at the international level is cur-

China's Sinopec Corp said it has put into operation the country's largest carbon capture, utilization and storage (CCUS) facility in east China, and plans to build two more plants of similar size by 2025.
Photo credit: Sinopec

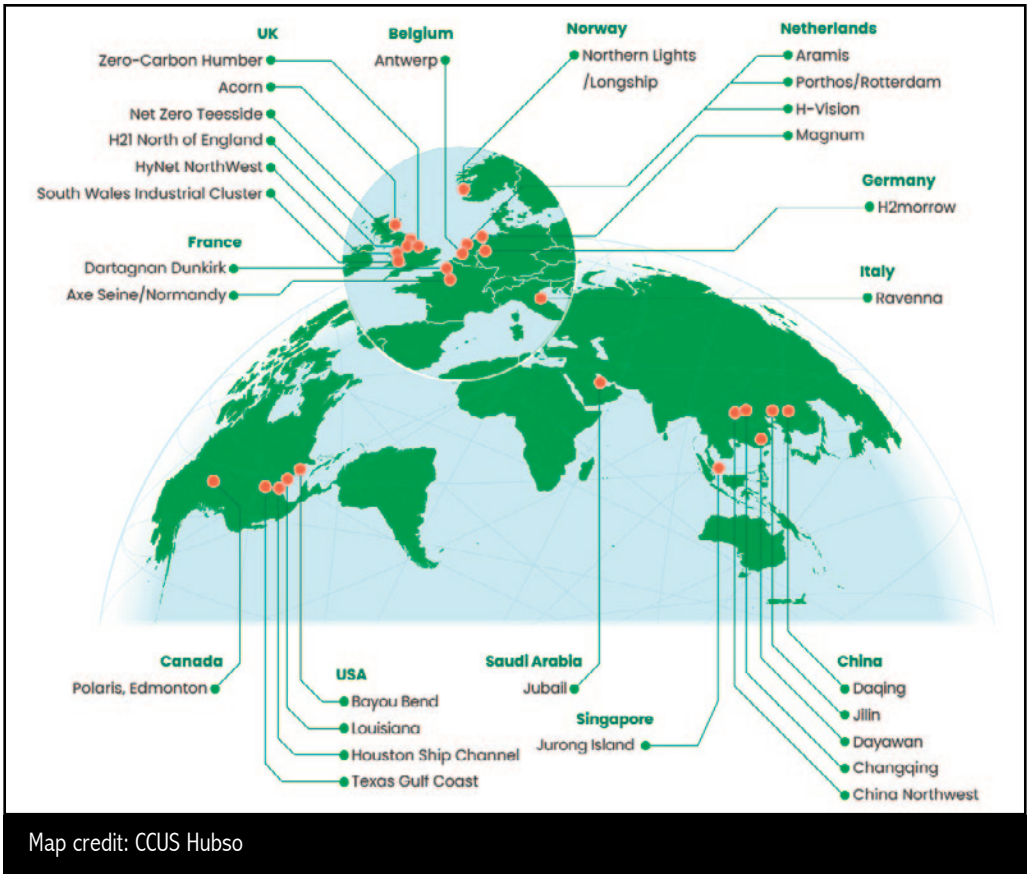
rently not sufficient, the IPCC and the IEA are among various organisations that have modelled pathways to achieve net zero by 2050. They both identify that carbon capture utilisation and storage (CCUS) is an essential contributor to meeting this goal.

In the IPCC 1.5℃ report, almost all the scenarios require CCS. Three of the four Illustrative Pathways required 348 – 1218 GtCO2 to be stored this century. And in the 4th Illustrative Pathway which does not include CCS, final energy demand needs to decline by one third by 2050, compared to 2010.

In the IPCC Pathways, there also is a 60-80% reduction in coal use by 2030 compared to 2010 and a 70-97% reduction by 2050. In the IEA NZE scenario, there is a 50% reduction by 2030 compared to 2020 and 90% reduction by 2050. But the reality is that in 2019 there was roughly 2000 GW of coal capacity installed, with more than 500 GW of new capacity planned by 2030, with 200 GW already in construction. Bearing in mind that the economic life of a coal plant is 40-50 y, this means that in all probability coal utilisation will grow beyond 2030, rather than fall. So, CCS must be added to coal-fired power generation.

Work at the International Centre for Sustainable Carbon has shown that not only is 36% of electricity currently generated from coal, major industries also rely on this fossil fuel. They include iron and steel production, cement, aluminium and chemicals production, which are essential to economic

growth and development. Emissions from these sectors can be reduced dramatically by efficiency measures and fuel substitution, but to approach net zero, CCUS must become more widely used. For example, of the 7.8 GtCO2 emitted from industry in 2017, around 1.9 Gt CO2 are process emissions. This means they are an inherent part of the production process, and so cannot be eliminated, making CCUS the only feasible option. According to the GCCSI, CCS must deliver 29 GtCO2 of emissions abatement in industry between 2017 and 2060 to meet the Paris Agreement objectives. CCS is also the most practical abatement method in various industries. For example, most steel is produced in blast furnaces in China which are around 12 years old. Considering the typical lifetime of a steel plant is 40 years, there is too much productive life in these units for them to be wound down. This is another reason to append CCUS to the plants, so they can continue steel production, but in a low-carbon manner.



Map credit: CCUS Hubso

Similarly in the chemical industry, the average age of plants worldwide is around 10-12 years, and they have a typical life of 30 years. CCS is proven. It has been used for 50 years for enhanced oil recovery (EOR) and dedicated storage has been in place for 27 years at the Sleipner facility in Norway. Investment in CCS is increasing rapidly. For example, in 2017, there was only about 60 Mt CO2/y capacity in operation, construction, or in early or advanced development. Whereas in September 2021, there were 27 projects operating, 4 in construction and 102 in various stages of planning, making a total of almost 150 Mt CO2/y CCUS capacity. Since 2021, more than 100 new projects have been added.

This increased momentum is due to several drivers, which can include the growing number of net zero commitments from both countries and companies, as mentioned at the start of this article, strengthening policy support for CCS, a growth in CCS networks known as hubs and clusters, the development of low-carbon hydrogen projects, technology-based CO2 removal and the creation of strategic business partnerships. For example, there are more than 30 hub and cluster CCS networks in development. They offer the advantages of unit costs reductions through economies of scale, a reduction in the attendant risks through multi-party business ecosystems and also make smaller sources of capture feasible. CCUS is one part of the energy transition. There is also fast-growing interest in low-carbon fuels such as ammonia, methanol and hydrogen.

These can be produced from renewable electricity, or fossil fuels with CCUS. Due to the massive demand for renewable electricity, there may not be much to spare for the production of chemicals such as these. In addition, the chemicals are already in demand and produced at scale with fossil fuels.

So, at least in the interim, it will be more viable to produce them in a low-carbon manner, from fossil fuels with CCUS. It is certain that that the lowest cost and lowest risk pathway to net zero emissions will involve every emissions abatement technology including CCS. ONE

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CCUS

CARBON CAPTURE, UTILIZATION, AND STORAGE

SPRING 2023 • HOUSTON, TEXAS

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Submission Deadline: 3 November 2022

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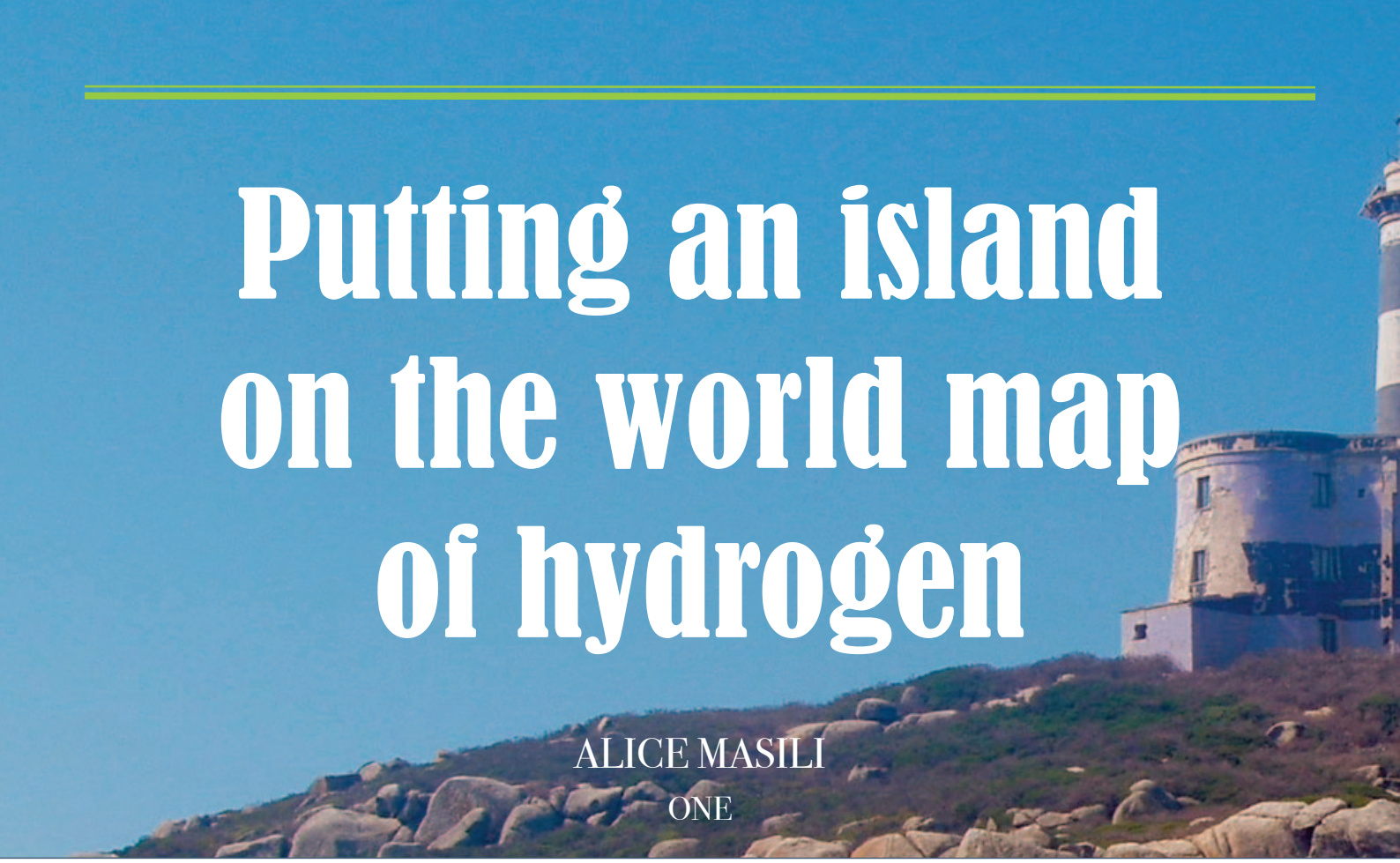


Putting an island on the world map of hydrogen

ALICE MASILI
ONE

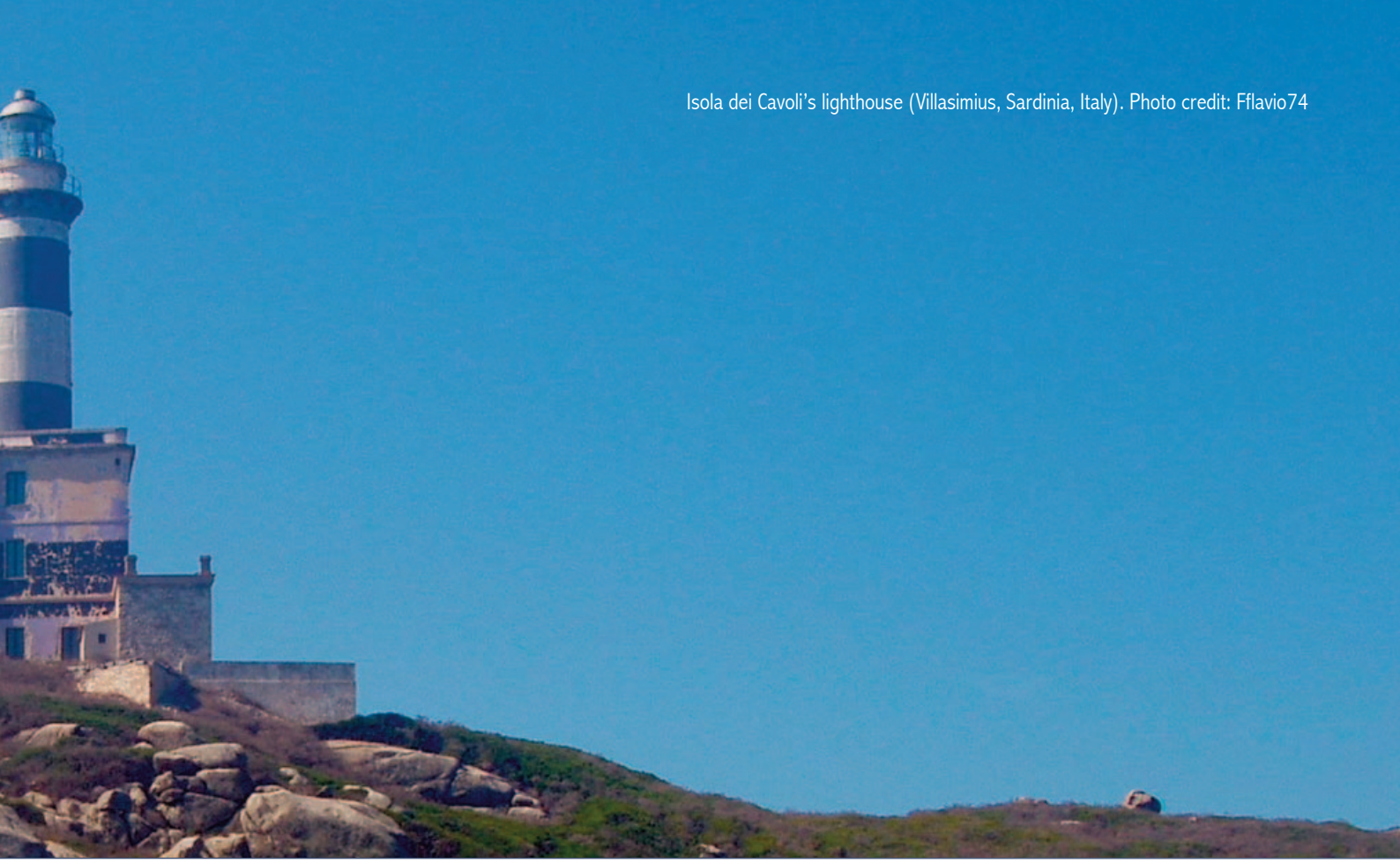
Thanks to green hydrogen Cavoli Island will be the first energetically independent site in the world, served only with zero-emission technologies and utilities. We are talking of a tiny island, just 43 hectares, located in the southeast of Sardinia, within the protected marine area of Capo Carbonara, accessible only by private boats or organised excursions from the port of Villasimius.

An authentic flora and fauna jewel. The need to preserve such a natural paradise is one of the main reasons to pick this place for "Green Hyland". This project, which integrates the most innovative technologies to mitigate climate change, is designed by the Sardinian start-up H2D Energy and the Protected Marine Area of Capo Carbonara, with the support of the University of Cagliari and Sardegna Ricerche.

Since the 80s, the University of Cagliari has been developing a project for Biodiversity Conservation on the island. For the last 15 years, the project has been led by Gianluigi Bacchetta, Professor of the Department of Botanical Sciences and Director of Cagliari's Botanical Garden. After the Capo Carbonara Marine Protected Area creation, the University of Cagliari, Villasimius Municipality and the Marine Protected Area continued to develop this project together. The primary mission of Mr Fabrizio Atzori, Director of the AMP Capo Carbonara, was to combine island biodiversity preservation with sustainable development. Two years ago, Carlo Manconi, CEO of H2D Energy, met Prof. Bacchetta and Mr Atzor-they came up with the idea to sustainably enhance tourism on the island. H2D Energy proposed to create a 100% renewable system using the 14 kW of photovoltaic panels already in place to power the services on the island. "We also financed a post-graduate scholarship to the University of Cagliari, which will support the development of mathematical models and the experimentation phase at the Sardegna Ricerche laboratories," Manconi said.

All energy comes exclusively from 100% renewable sources in the Green Hyland project, and zero-emission technologies deliver all services. "Our she system is made of different technologies that H2D Energy has chosen, assembled, integrated and engineered to give life to what it has called *Hybox*," Manconi explains. "Hybox is a power-to-gas-to-power "plug & play" system, the least bulky possible, which accumulates electricity produced by a photovoltaic system in the form of hydrogen, reconverted into current when necessary. When the sun does not shine, and the photovoltaic does not produce energy, the accumulated hydrogen is converted into electricity". The intent is to create a marketable device applicable to other contexts, including the domestic one.

The Hybox system, powered by the island's photovoltaic energy, includes a 2.5 kW electrolyser capable of producing and storing hydrogen to have 12 kWh for night use and 138 kWh for seasonal use. This way, the island will have the necessary energy to serve the microgrid autonomously and continuously, day and night, 365 days a year.



Isola dei Cavoli's lighthouse (Villasimius, Sardinia, Italy). Photo credit: Fflavio74

This system avoids energy dispersion over time and overcomes the inefficiency of traditional batteries, allowing storage for prolonged times, even for years. In addition to protecting the environmental heritage, hydrogen production does not use any polluting component, either in the accumulation phase or energy release phase. Therefore it does not require any waste disposal process or by-products.

The needed water for hydrogen production will come in part from a moisture condensation system, known as Awg (Atmospheric water generator) called "hydropanel" and manufactured by Source Global, which is a partner of H2D in this project, and in part recovered from fuel cells during the conversion of hydrogen into electricity. The hydropanel system was designed to combine electricity consumption and occupied surface better. The choice of preferring an AWG system over a seawater desalinator is logically linked to environmental protection goals due to the generation of drinking water with hydropanels through the sun and the air in a fully sustainable design. The withdrawal of water from the sea would involve a modification of the marine ecosystem, in addition to generating the brine residue of desalination that requires disposal. The hydropanel reproduces exactly the rain natural process.

There is already a reverse osmosis system on the island to purify wastewater. "To ensure sustainable and environmentally friendly tourism, the project involves purchasing an electric motor boat, made of wood or recycled materials, in which, instead of the battery, there will be a hydrogen fuel cell".

The protected marine area already has an electric vehicle, which will be modified with a hydrogen fuel cell, allowing disabled people to visit the island. Two hydrogen-charging stations will be built. One will be placed on the island and powered by the system described. The other will be built in the Villasimius quay - a similar design powered by a 20 kW photovoltaic system.

This project could open the door to more opportunities to support sustainable navigation and create areas reserved for ecological boats. The work has already begun. After assessing the physical sizing of the components and the purchase of materials for their construction, the performance assessment of all the features and the feasibility of the integrated system will start at Sardegna Ricerche's Renewable Energy platform. Then the system will be moved to the island. It should be operative in less than a year.

For the first time in a manufactured system, energy, sanitary water, wastewater, and land or marine mobility are combined and provided through technologies with zero emissions and no environmental damage—a real jump into a sustainable future for humanity. ONE

Net zero: Copenhagen's failure to meet its 2025 target casts doubt on other major climate plans

KRISTINE LUND CHRISTIANSEN and INGE-MERETE HOUGAARD
The Conversation

The city of Copenhagen, often celebrated as one of the world's greenest for its cycling culture and other initiatives, recently defaulted on its pledge to become carbon-neutral by 2025. This early failure in the global race to net zero emissions (a balance between CO_2 emitted and absorbed) may foreshadow backtracking by other target-setters, indicating that pledges to cease contributing to climate change demand greater scrutiny.

Since 2012, when Copenhagen launched its plan to become the first carbon-neutral city in the world by 2025, the city has enjoyed international recognition and a significant branding boost. It expects to reduce emissions by 80% by, for instance, switching its power and district heating systems to biomass, wind and solar, renovating buildings to make them energy efficient and improving public transport.

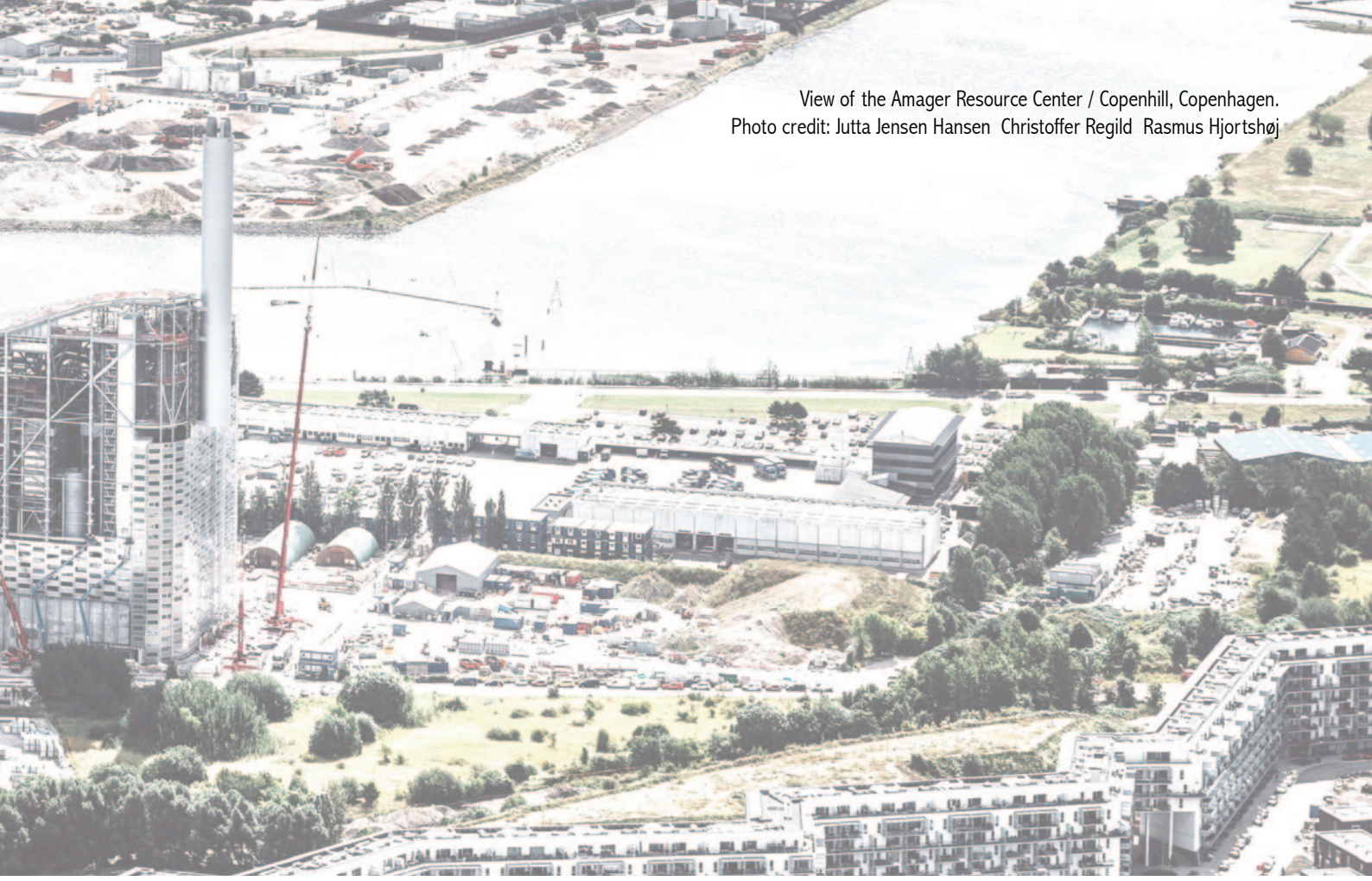
The remaining emissions were supposed to be mopped up by installing carbon capture and storage (CCS) technology at the local waste-to-energy plant. This would remove CO_2 from the smokestack before it is emitted to the atmosphere, isolating it for later underground storage.

But at the beginning of August 2022, the semi-public utility Amager Resource Center (ARC) which manages the plant announced it was ineligible for national CCS funding. This funding, it argued, would otherwise have enabled them to capture CO_2 generated by burning the city's waste. And so, Copenhagen has given up on its pledge.

Cities such as Glasgow and Helsinki, countries like Sweden and the UK, and companies including IKEA and Apple have made similar pledges to be net zero by 2030, 2045 or 2050. This gives the impression that sufficient measures to address climate change are in the pipeline.

Yet various reports and studies suggest that these pledges often skimp on important details, by failing to include progress reports or specify the emissions they target. Critics have warned that the idea of net zero may only serve to greenwash reputations and diminish the urgency around decarbonisation.

Copenhagen is unlikely to be the last to renege on its net zero pledge. The city's example of relying on immature technology and external funding indicates how similar climate plans might disintegrate in future.



View of the Amager Resource Center / Copenhill, Copenhagen.
Photo credit: Jutta Jensen Hansen Christoffer Regild Rasmus Hjortshøj

Faith in technology

Copenhagen's experience highlights two problems which could scupper other net zero strategies. First, the city's reliance on immature technology.

Copenhagen's plan to reach net zero emissions did not always include CCS. When the city announced its 2025 goal in 2012, the Danish parliament had just rejected an application from Swedish energy company Vattenfall to deploy CCS at its coal power plant in northern Jutland. Danish politicians wanted to monitor experiences with CCS abroad before allowing it in Denmark.

Instead, in 2012 Copenhagen's net zero plan relied on the expectation of reducing the energy-to-waste plant's emissions by recycling more plastic waste and increasing the ratio of organic waste (since it would count as carbon neutral). But when the third and final road map for Copenhagen's transition was presented in 2021, it included a shortfall of 430,000 tonnes of CO_2.

Alongside other measures, CCS was – in line with new national policy – supposed to be installed at the plant to bridge the gap by cutting 390,000 tonnes of CO_2. The utility managing the plant suggested the technology could capture up to 500,000 tonnes.

Copenhagen is not alone in including CCS in its climate strategy. Neighbouring capitals Oslo and Stockholm expect to reach net zero with it too. Denmark's national climate strategy expects CCS to cut between 3.5 million tonnes and 8 million tonnes of CO_2 by 2030.

Despite the faith invested in it, carbon capture technology has a poor track record. A new study by the Institute for Energy Economics and Financial Analysis think tank found that CCS projects tend to underperform on their emission reduction targets.

Dedicated investment in carbon storage technology has been sluggish too. As a result, CCS is largely used to extend the shelf life of fossil fuels, as captured CO_2 can be injected into oil wells to extract additional oil. These and other issues were reported to municipal leaders in Copenhagen as substantial risks to the 2025 goal.

Copenhagen.
Photo credit: GuoJunjun

Lack of accountability

The second problem concerns the question of accountability. Who is ultimately responsible for Copenhagen's failure to meet its net zero target? When the utility ARC first announced its plan to deploy CCS at its waste-to-energy plant in 2021, it counted on external funding and a supportive policy framework to do so.

Now, the head of the city's technology and environment committee criticises national politicians for knowingly setting financial criteria which the utility cannot meet, hindering the city's road to climate neutrality. And so, the baton of responsibility is passed.

Emissions targets must be based on credible measures which are within the powers of those pledging them. There must be clear ways to assign accountability if those plans fail. When organisations boast of pledges which ultimately depend on the actions of others to succeed, the public is right to question their validity.

Copenhagen's mayor suggested the city may still reach climate neutrality in 2026, 2027 or 2028. Yet this case shows how easily net zero plans can fall apart.

It reveals the dangers of the current uncoordinated approach to reaching net zero, in which every organisation is free to set its own eye-catching pledge without fully accounting for its success. What we need is for political and corporate decision-makers to present credible plans for the necessary deep decarbonisation of society.

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Sydney, Australia
February 17-19, 2023

ICSEE 2023

2023 7th International Conference on Sustainable Energy Engineering

2023 7th International Conference on Sustainable Energy Engineering (ICSEE 2023) will take place in **Sydney, Australia** on **February 17-19, 2023**, **co-sponsored by University of Tasmania, Australia.** It aims to provide a high level international forum to bring together industry professionals, academics, and individuals from institutions, industrials and government agencies to exchange information, share achievements, and discus the advancement in the fields of Sustainable Energy Engineering, etc.

Notice

The safety and well-being of our participants is of paramount importance to ICSEE. On 11 March 2020 the World Health Organization (WHO) declared Covid-19 a pandemic. Governments around the world are now issuing restrictions on travel, gatherings, and meetings in an effort to limit and slow the spread of the virus. The health and safety is our first priority and we are supporting these efforts. Therefore, if the author has difficulty to attend the event physically, online/video presentation is acceptable.

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All accepted papers must be written in English, all papers submitted to the conference will be subjected to the rigorous peer-review process, after registration and presentation,which will be published into **Springer Book Series-Green Energy and Technology**. Which submitted for **Ei Compendex, Scopus**, et al.

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The risks and rewards of the minerals required for the energy transition

As renewable energies proliferate, the need for minerals increases, along with socio-environmental risks. What are they, and what are the possible alternatives?

ALEJANDRA CUELLAR and ANDREA FISCHER
Dialogo Chino

In order to limit global temperature rises, the world will have to undergo an urgent energy transition that will leave the fossil fuel era behind. Yet, the technologies that support this, such as solar and wind power, or electric cars, require the extraction of large quantities of the various minerals used in their production. An electric vehicle, for example, requires six times more mineral resources than a conventional one, while an onshore wind power plant requires nine times more mineral input than a gas facility.

As the world advances in climate-friendly energy, demand for certain minerals that are found in the subsoil throughout Latin America will increase, begging the question: are there enough resources to meet the needs of a new energy era? What negative impacts will extraction cause for the environment, and how can we mitigate them? This is what we know so far.

What minerals are required for the transition and how are they used?

While lithium and rare earth elements have attracted newfound attention for their transformative potential for energy storage, traditionally mined metals such as copper, nickel, manganese, graphite, and zinc also have an important role to play – and their demand will also increase. These metals and minerals are key components in electric vehicles (EVs), wind turbines and other emissions-free energy sources that mitigate global temperature rises.

All new energy technologies use these minerals in different proportions, but EV batteries are the most demanding, particularly for lithium, which enables strong battery performance and longevity.

Demand for lithium is estimated to increase 40-fold by 2040. Demand for graphite, cobalt and nickel is expected to grow by between 20 and 25 times. Charging networks for EVs consist of numerous cables that require a large amount of copper, demand for which is expected to double over the same period. In 2021, demand for copper from Chile, the world's largest producer, already increased by around 80% compared to the previous year, according to BBC Mundo.

In terms of electricity generation, wind power is the most mineral-intensive renewable source, especially when turbi-

An EV charging station in Mexico City, which has more points than any other Latin American city. Photo: Alamy

nes are installed offshore, where they can require up to three times more copper to transmit energy along cables than onshore plants: in 2020, the volume of copper required worldwide for offshore wind power generation was around 8,000 kg per megawatt of energy produced, compared to 2,900 kg per megawatt for onshore wind. Construction also requires aluminium, zinc and rare earths.

Wind turbine towers and drivetrains are made of steel, zinc and aluminium and account for about 80% of the total weight. Some turbine designs use direct-drive magnetics, which contain the rare earth metals neodymium and dysprosium. It is estimated that about 20% of all installed wind turbines use rare earth magnets. Wind turbines also contain copper in the generators, and carbon fibre and fibreglass in the blades, not to mention the concrete used to construct the towers.

Solar energy requires storage units both in the form of individual batteries for private use and on a large scale in power grids. This requires the various minerals used in lithium-ion batteries, which include cobalt, lithium, manganese, nickel and graphite.

Batteries consist of two electrodes, or electrical conductors, called a cathode and an anode, and an electrolyte through which they exchange ions, delivering a charge or discharge. Different minerals can serve these purposes. Lithium's high electrochemical potential makes it a valuable component of high energy-density rechargeable lithium-ion batteries.

Most lithium-ion batteries use graphite as the anode, which means graphite will be the most sought-after mineral in energy storage. Cathodes vary more widely: most frequently they use nickel, but various mixes of cobalt, lithium, and manganese are also common.

The environmental impact of minerals for the energy transition

Yet, in the shadow of the promise of clean energy lies the threat of unsustainable damage to the environment caused by obtaining and processing the requisite minerals. Every tonne of lithium that is extracted, for example, requires up to 2 million litres of water, depleting groundwater resources. This affects availability for communities, flora and

The iconic Uyuni salt flats in Bolivia, where lithium production is expected to ramp up, given its role as one of the key minerals for the global energy transition. Photo: Alamy

fauna, and operations can affect water quality.

Researchers at Boston University have recommended that the countries of the lithium triangle (Argentina, Chile and Bolivia) strengthen their institutional capacity to generate a more responsible mineral boom in partnership with greater participation by local communities.

Rare earths are a group of 17 light metallic elements that are a key part of the transition, and which we unknowingly interact with every day. Smartphones, tablets and other devices with touch screens depend on them. They are valued materials for the energy transition because they are very good electrical conductors and have magnetic properties that are useful in battery technologies used in electric cars.

Rare earths – neodymium, scandium and yttrium, to name a few – are especially difficult to extract, since they are embedded in certain other minerals and alloys. And although they are actually abundant, it is very rare to find them in their pure form and they tend to occur in low concentrations. Elisa Fabila, a chemical engineer from the National Autonomous University of Mexico (UNAM), who specialises in the study of metallurgical chemistry, says that the extraction process is complicated and invasive.

"To separate the mineral [from the other compounds] an ionic reaction is needed and the residues of this reaction are what become so polluting," Fabila says.

"The water that is used can no longer be reused, due to all the toxic and radioactive waste that remains. And although these alternatives [to fossil fuel inputs] do not produce emissions, they are not as clean as we thought," she adds.

Other non-rare earth minerals essential to the energy transition also have damaging extraction processes. Copper, for example, is extracted by detonating explosives in cracks in the ground in open-pit mines. On average, 300 square metres of soil are lost for each explosion, explains Fabila. All properties of the earth are washed away, as the blasting needs to break down the components of the soil in order to

bring out the metals.

China stars in the extraction of rare earth metals. According to data from Statista, in 2021, the country accounts for 60% of global rare earth production. It has in recent years limited its production and export to other parts of the planet, and brought rare earths to the fore in a trade dispute with the USA. The largest of all its mines is at Baiyun Obo in Inner Mongolia, which, according to NASA, is home to almost half of the world's production of rare earths.

It is estimated that the demand for rare earths may grow by three to seven times by 2040, depending on advances in battery technology and electric turbines.

Scarcity, concentration and quality

As the world requires more minerals, questions have been raised as to whether there are sufficient resources to meet global demand. Several factors will influence this and it will largely depend on the developments in battery chemistry.

According to a report by the International Energy Agency, a mixed scenario is expected in which some minerals, such as lithium raw material and cobalt, are likely to have a short-term surplus, while processed lithium, battery grade nickel and key rare earth elements such as neodymium and dysprosium could experience supply shortfalls in the coming years as it fails to keep pace with demand.

The geographical concentration of minerals presents other problems. More than 60% of global cobalt production is concentrated in China and the Democratic Republic of Congo, according to a *New York Times* report that documented the ongoing battle for new technology metals. If there were supply chain problems in producing countries, this would directly affect battery prices and production.

However, short-term supply problems would only affect the development of new products such as electric cars and wind turbines. Unlike combustion vehicles, for example, EVs that already operate can do so for the shelf-life of the battery, which can range from 10 to 20 years, and are not affected by a lack of new mineral supplies.

Solutions

IEA experts recommend a series of measures to ensure the future availability of key minerals. Awareness raising on the need to invest in sustainable mining developments in countries with significant reserves is essential.

It is also crucial to develop technologies that are more efficient with the use of critical minerals. And instead of relying on them, explore the wider rollout of alternatives that are potentially less damaging for soil and water, such as biomass.

Recycling is also an important factor in relieving pressure on primary supply. Harald Gottsche, President and CEO of the BMW Group's San Luis Potosí plant in Mexico, told Diálogo Chino that the company wants to reduce its impact on the entire distribution chain.

"Circularity starts from product design, with the use of secondary materials in our value chains, as well as with the recycling of BMW Group vehicles at the end of their life cycle," Gottsche says. For example, the company plans to reduce the use of cobalt in the cathodes of its current generation of batteries to less than 10% by the end of this decade.

"Our latest generation of electric motors is built without using rare earths," Gottsche says. Other big companies like Samsung and Tesla are choosing to ditch cobalt batteries.

Renewable energies are essential to keep dangerous global temperature rises at bay. Otherwise, according to the latest report by the Intergovernmental Panel on Climate Change on climate mitigation, parts of the planet will be uninhabitable by 2050. The use of alternative fuels, such as hydrogen, that are less dependent on minerals must also significantly increase, according to the UN.

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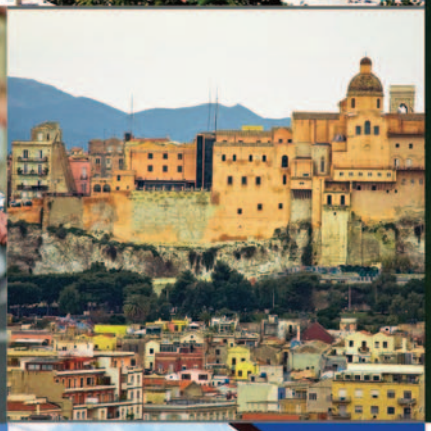



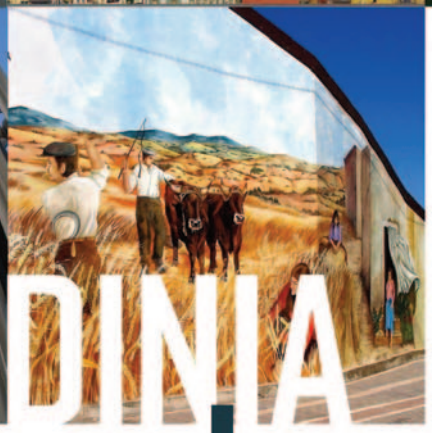


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Mexican Farmers and Scientists Share a Mission: Saving a Wetland

LOURDES MEDRANO

Undark

On the southern edge of Mexico City, on a patch of land surrounded by water, a farmer and a scientist recently inspected rows of small cubes of mud that had sprouted seedlings. They were crouching on a chinampa, an island that appears to float in Lake Xochimilco, part of a complex ecosystem where the Aztec Empire once flourished.

The farmer, Dionisio Eslava, expects a good harvest of the mix of crops he planted this year. On this spring day in May of last year, he showed the agricultural scientist, Carlos Sumano, the sowing cubes he created with mud he scooped up from the bottom of canals, a Mesoamerican farming technique called chapín. "They're just about ready for transplanting," said Eslava, carefully pulling a single cube from the ground and, after a closer look, returning it to its place with other chili pepper plants.

Eslava and Sumano are working together to preserve the region's chinampas, remnants of the branch and reed rafts that Mesoamerican farmers covered in nutrient-rich lake mud to grow fruits, vegetables, and flowers. They are part of a conservation partnership that is tapping Indigenous agricultural knowledge and scientific expertise to prevent the demise of Xochimilco, an ecosystem of more than 6,000 acres of protected wetlands that provides multiple environmental benefits, including food production, groundwater recharge, and carbon sequestration.

Dionisio Eslava tending to the crops he grows on a Xochimilco chinampa using ancient farming methods. Photo credit: Lourdes Medrano

The traditional farmers, known as chinamperos, and scientists from the National Autonomous University of Mexico, also known by its Spanish acronym UNAM, are seeking to encourage sustainable and pesticide-free ancient farming to restore areas degraded by rampant development, pollution, and over-exploitation of groundwater. Though they haven't always seen eye to eye over the years, the farmers and scientists agree that a healthier ecosystem will not only ensure continued food production but also the survival of the remarkable salamander called the axolotl, which is on the brink of extinction.

So far, the project involves some 30 farmers, including Eslava, who rely on ancient agricultural methods that include extracting a mix of rich soil and decaying vegetation from the marshy lakebed to grow crops. Among other things, they are digging narrow canals adjacent to chinampas to act as a refuge for the critically endangered axolotl and other threatened species. Rustic filters made from aquatic plants are placed in the canals to absorb contaminants and increase water transparency.

Ahuejotes, a type of willow trees, and other vegetation contain a chinampa in Xochimilco. Photo credit: Lourdes Medrano

Chinamperos maintain the canals, irrigate crops with cleaner water from restored waterways, and replace pesticides with organic fertilizers. Scientists evaluate species development and changes in water quality. They collect samples of water and soil to test in the laboratory for the presence of bacteria, heavy metals, and other pollutants. When the canals are free of contaminants and have reduced salinity, the water quality is better prepared to sustain the axolotl and other native species. Sumano and his colleagues also hold workshops on organic fertilizers and water and soil quality.

The farmers, meanwhile, provide the project with a wealth of knowledge that has been passed down from generation to generation, Sumano maintains. "We're working with people who know how to get results on their chinampas," he said. "It's not like the institution is here to tell them what needs to be done."

Eslava views the exchange of knowledge as a boon for one of the last vestiges of a centuries-old lake culture facing major threats to its survival. For years, he has worked on his own and with other chinamperos to clean up garbage from the shallow waterways he has navigated in wooden canoes since he was a youngster. "We contribute what our ancestors taught us about the richness of the chinampas," he said. "Scientists bring resources, they monitor the quality of the water and the nutrients in the soil."

Still, some farmers remain wary of scientists because over the decades researchers from various institutions have studied Xochimilco in isolation, neglecting to tap the deep local understanding of chinamperos. "They didn't want to hear what we had to say, just like the authorities didn't want to hear what we had to say, because we are farmers," Eslava said.

When he accepted Sumano's invitation to join the project in 2020, Eslava was already relying on traditional farming methods without pesticides. But he hoped that scientific expertise and resources could help expand Xochimilco's sustainable agriculture and improve habitat for the axolotl, or ajolote, and other native species like the freshwater crayfish acocil and the minnow-sized charal.

Eslava said he believes more farmers, as well as more people in the region, are coming to realize the importance of preserving Xochimilco (pronounced so-chee-meel-koh) and its biodiversity. "If we all do our part," he added, "we can leave something much better here for future generations."

Despite the environmental pressures, the ecosystem remains a striking green space on the southern shore of Lake Xochimilco. Though it's technically part of a metropolitan area of 21 million people, it retains a tranquil atmosphere. Rows of its most emblematic tree — the ahuejote, or willow — border chinampas in showy formation, its intertwined roots anchoring the plots. Xochimilco's name in the Nahuatl language, "field of flowers," is reflected in a landscape bursting with flowers like purple bougainvilleas and yellow floripondios, or angel trumpets, and rich with birds like white pelicans and egrets.

Xochimilco, which UNESCO recognized as a World Heritage site in 1987, was once part of a vast network of lakes and canals that stretched through the Valley of Mexico, where various Nahuatl-speaking Indigenous com-

munities thrived long before Spanish colonizers arrived in the 16th century. The Spanish eventually drained the waterways as a new city replaced the conquered Aztec capital of Tenochtitlán, and urbanization over the centuries has further degraded the chinampas, despite multiple efforts to protect the area.

As the deterioration has worsened, concern has grown over the fate of the axolotl, which has profound cultural significance in Mexico as a symbol of the country's pre-Hispanic history. A grinning image of the creature in the waters of Xochimilco graces Mexico's new 50-peso bill.

Luis Zambrano, a biologist at UNAM who oversees the chinampas project with the farmers, arrived in Xochimilco in the early 2000s to research the axolotl, or Ambystoma mexicanum. Researchers have long studied the small salamander's extraordinary regenerative abilities in hopes of uncovering biological secrets that could one day help renew human tissue. The axolotl, which retains its juvenile characteristics throughout its life cycle, can grow new limbs and other missing organs.

A restored canal next to a chinampa. Chinamperos and scientists are working together to improve water quality for the mutual benefit of the farmers and the endangered axolotl.
Photo credit: Lourdes Medrano

When Zambrano began to study the animal, with its unusual flat head and crown-like gills, it was under siege in the canals where it had lived for centuries. Poor water quality and invasive carp and tilapia introduced in the 1970s and '80s to promote fishing devour axoltl eggs and feed on the insects, small fish, and crustaceans crucial for the salamander's survival.

Wild axolotl sightings are rare, but Zambrano says a survey of the population is pending. The last count conducted by the university, in 2014, estimated the presence of axolotls at 36 per square kilometer, or about .386 square miles. A survey conducted by the Autonomous Metropolitan University (UAM) in 1998 put that number at 6,000 per square kilometer.

Zambrano's initial research has gradually expanded to include exploring the mutually beneficial union of salamander and chinampa. In 2017, his team received about 7 million pesos, or more than $370,000, for the project. The federal funding, made available for UNESCO designated sites, kicked the project into high gear. In later years, Zambrano said, the funds decreased to 5 million pesos — including a portion provided by the local government.

The waterways of Mexico are the only natural habitat of the axolotl — "water monster" in Nahuatl — although the amphibian is abundant in captivity and a popular pet in various corners of the world. But Zambrano says that differences between wild and captive-bred creatures are considerable because captive axolotls experience losses in physiological and behavioral capabilities.

While Zambrano's original idea was for surviving axolotls to wiggle on their own into the restored canals or refuges, researchers are also looking into the possibility of introducing captive-bred creatures to these spaces themselves. Before that can be done, however, Zambrano said they need more information about the salamanders' genetics and reproductive capabilities, among other things. It's known that farmers sometimes release axolotls into canals after raising them in aquariums, but the researchers say this is generally frowned upon due to environmental regulations.

If the axolotl goes extinct in the wild, it would be a tremendous loss to Mexico and the world, he said. "It's not only one of the most researched species in terms of genetics, but it's an animal that's closely connected to our Mexican culture."

In Aztec mythology, the creature is the last incarnation of Xólotl, the god of fire, who transformed himself several times after refusing to die in sacrifice for the launch of a fifth cycle of creation. It's a story passed down among generations, and Eslava knows it well. "When Xólotl was discovered, he was condemned to stay a salamander fo-

rever, and was told that when his body of water was no longer useful, he and the human race would disappear," he explained.

The ancient tale seems particularly relevant nowadays, Eslava maintains: "We are experiencing enormous pollution worldwide and many species are becoming extinct. Here in Xochimilco, we are putting a lot of pressure on the axolotl area and the water that's so important to us."

On another spring day, Eslava paddled in the shallow waters of Xochimilco toward the chinampa where he grows his crops. Although he was away for years when he worked for the government and when he retired, he returned to his childhood home some years ago to find another Xochimilco. Houses had replaced vegetables in chinampas; plastic bags of trash piled high in the waterways; and treated water flowed in canals once awash with natural spring water.

As Mexico City's population has grown, intensive water pumping has depleted much of the underground sources that used to feed the maze of canals. They now get treated wastewater from nearby plants, which has contributed to the decay of waterways and chinampas. "Things were different when I was growing up," Eslava said. "It was cleaner, there was no plastic at all. The scent of flowers was intense in the morning, and there were still many beautiful chinampas and canals."

Many farmers have abandoned their chinampas, either because they're not interested in farming or because they can't make a living at it. Some rent out their plots and, instead of growing crops, tenants build houses or turn them into soccer fields or other unauthorized sites.

"We contribute what our ancestors taught us about the richness of the chinampas," one farmer says. "Scientists bring resources, they monitor the quality of the water and the nutrients in the soil."

Meanwhile, crowds of visitors roam the waters of Xochimilco in colorful, flat-bottomed boats called trajineras, injecting money into the local economy but also straining the ecosystem.

Eslava was already involved in clean-up projects and restoration efforts with other Xochimilco residents when Carlos Sumano came calling in 2020. He relished the idea of the project because the university's sponsorship would help provide funding and resources to assist chinamperos to reactivate dormant chinampa agriculture.

"All the fertilizer we need is down there in the water," he said. "All the vegetation that disintegrates there is a very rich material, it's what our ancestors used. That's why chinampa farming was so rich. There was an enormous diversity of crops and everything was done using traditional methods like mud and native seeds."

Underground Salamanders and More Face Extinction
Those traditions had gradually succumbed to new agricultural practices that were ushered in starting in the 1940s with the promise of greater yields. "The 'green revolution' was this vision of increasing agricultural productivity as fast as possible, as best as possible, and that's when the use of pesticides and fertilizers started to grow,'" Zambrano said. "But the quality of the water is reduced a lot when you put in pesticides and fertilizers, because they kill everything, including the axolotl."

Narciso Alvarado is another chinampero who has stopped using pesticides and is participating in the project. He spends most of his days tending to such crops as cauliflower, onions, and radishes in his chinampa. The idea of being able to sell his crops at a fair price with validation from the university, while helping to restore the ecosystem, appealed to him. "I've been farming for a long time, and I want to keep doing it here, in Xochimilco," he said in a recent interview. "I don't want chinampas to disappear."

Neither does Eslava, who spends much of his time improving plots. He and Sumano recently brought six very young axolotls bred in aquariums to a narrow, restored canal. The minuscule creatures, which resembled tadpoles, wiggled out of a bucket and into the water. Sumano explained that the axolotls were placed there to be monitored for a few days, after which Eslava took them back out.

Zambrano believes the project has already started to reap benefits, like healthy species in some canals and growing interest in reactivating abandoned chinampas, though he notes that ambitious restoration projects such as this one take time and effort. But "reactivating chinampas, restoring Xochimilco, implies improvement of biodiversity, improvement of the city's water management, improvement of microhabitat changes," he said. "It implies more resiliency in terms of climate change and conservation of an iconic species like the axolotl, as well as a significant increase in local food production."

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Photo credit: Thomas Wolf, www.foto-tw.de

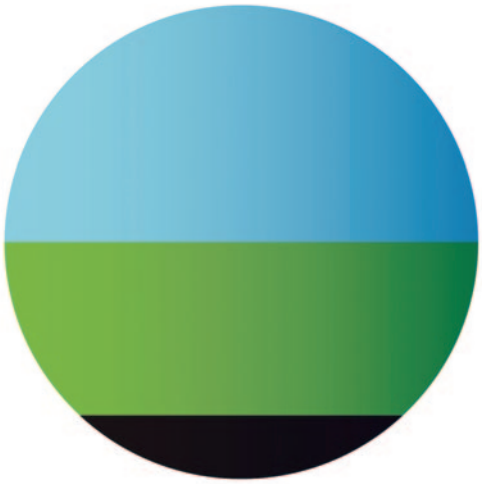
ZOLLVEREIN

The Zollverein XII Coal Mine Industrial Complex is an important example of a European primary industry of great economic significance in the 19th and 20th centuries. It is in the UNESCO World Heritage list and consists of the complete installations of a historical coal-mining site: the pits, coking plants, railway lines, pit heaps, miner's housing and consumer and welfare facilities. The mine is especially noteworthy of the high architectural quality of its buildings of the Modern Movement.

Zollverein XII was created at the end of a phase of political and economic upheaval and change in Germany, which was represented aesthetically in the transition from Expressionism to Cubism and Functionalism. At the same time, Zollverein XII embodies this short economic boom between the two World Wars, which has gone down in history as the "Roaring Twenties." Zollverein is also, and by no means least, a monument of industrial history reflecting an era, in which, for the first time, globalisation and the worldwide interdependence of economic factors played a vital part.

The architects Fritz Schupp and Martin Kemmer developed Zollverein XII in the graphic language of the Bauhaus as a group of buildings which combined form and function in a masterly way. The authenticity of the important group of industrial buildings designed for Zollverein XII by Fritz Schupp has been carefully conserved, as it is a listed industrial monument according to the German Protection Law.

SOTACARBO



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