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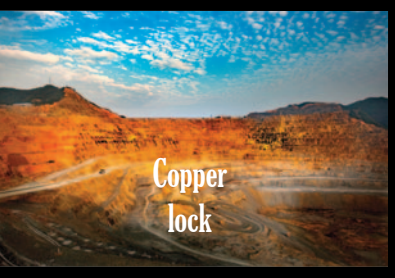
Only Natural Energy

Looking backward to move forward



Copper lock

Commodity bonds as a development tool

The role of coal power in China's energy transition

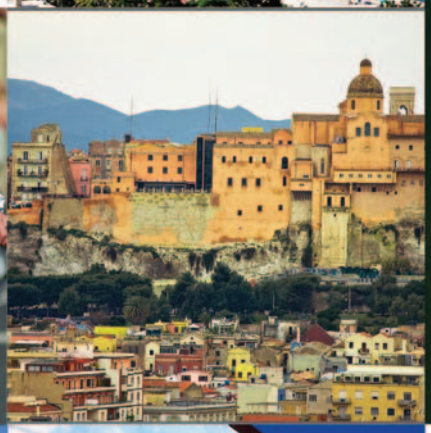
New routes for hydrogen storage

YEAR IX - NUMBER 1 - JANUARY-MARCH 2023

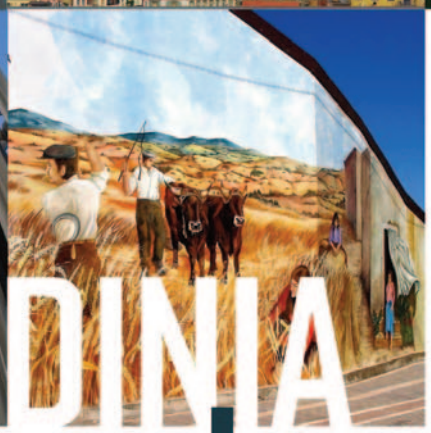








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Cover Photo:
The Old Delhi-Gurgaon road overflows with factory workers on their way to Udyog Vihar. Absence of a dedicated pedestrian walkway forces them to walk on the road along cars, rickshaws and trucks
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Dexing Copper Mine (China). Photo credit: China Xinhua News

Copper lock

GIANNI SERRA
ONE

Decarbonisation. Solar. Wind. Green hydrogen. Electric cars. Energy storage. The main keywords of EU energy policies are the same as the USA, China, India, Brazil and Australia. The difference is the strategy - if you have one or not. It's the difference between China's energy transition and the rest of the world's.

The first steps of the global energy transition have already revealed an insufficient supply of copper to meet a demand that will double within the next 12-15 years to cope with the massive growth of solar, wind, green hydrogen, electric cars, and energy storage.

Currently, around 60% of the world's copper production comes from Chile, Peru, China, Congo and the USA. But over 80% of solar panel production - which requires copper - comes from China. The top five solar panel manufacturers worldwide are Chinese, and nine are in the top ten.

China alone will have total control of the production process and will be able to balance sustainability, safety and affordability in this sector. To decarbonise its economy, the European Union is accelerating solar and electric cars and is banning coal and diesel.

If the price of the energy transition already seems high, it is still nothing. To sustain its energy transition, Brussels has carved out a subordinate role with its own hands. The EU will rely on China not only for copper extraction but for its manufacture too. It is the difference between those who think, choose and then move and those who start running and ask themselves questions afterwards. The EU needs to find out how to get out of the corner it has gotten itself into. ONE

Looking backward to move forward: sustainable alternatives to automobiles

LENORE HITCHLER
ONE

Imagine a future where private automobiles have gone the way of the horse and buggy. For everyday trips, you hop on and off community-owned bikes dispersed throughout the area to get to your nearby goal or to cheap, reliable public transportation for more distant destinations. Transitioning to new modes of transportation is very difficult. People are reluctant to make major changes in their lifestyles, and it is extremely convenient and comfortable to drive from door to door.

Walking, bicycling, and public transportation should become the pillars of local transportation and will involve changes in how people live their lives, as opposed to jumping in their cars.

Moving forward to a differently imagined lifestyle seems like an unrealistic utopian fantasy. Nevertheless, it is certainly technologically feasible and would cut down reliance on fossil fuels. These solutions

Photo credit: Paul Krueger

appear to be moving us backwards. However, it is necessary to adopt different modes of transportation if we want to move forward sustainably. Implementing new modes of transportation will involve massive infrastructure changes constructed by local and national governments.

Many would vehemently object to subsidies for expanding public transportation and making communities more walkable and bikeable. However, the US spends massive amounts of money to support automobile use and $20.5 billion yearly to subsidize the fossil fuel industry. Even people who do not drive subsidize those who do by paying taxes for streets and roads and are exposed to air pollution from other people's cars. Also, governments already regulate automobile use by mandating car and driving licenses, car insurance, speed limits, and drunk driving laws.

Governments will have to be involved in switching transportation to a system less reliant on fossil fuels. Unfortunately, governments seem reluctant to do so. Thus, massive social movements fighting climate change must push them to change their policies.

For people to mobilize to switch their transportation modes, they need to know exactly why they should do so. One way to motivate people is to remind them of how expensive car ownership is, including the high cost of car payments, including interest, insurance, gasoline, maintenance and repair. Also, higher taxes are paid for street, road, and parking space construction and maintenance. According to the American Automobile Association (AAA), the average yearly cost to own and operate a vehicle in 2022 was $10,728. Society pays for policing roads and the effects of noise, water, and air pollution.

Besides the high cost of owning cars, they also damage the environment. When vehicles burn fossil fuels, it adds to the greenhouse effect contributing to climate change. Air pollution from vehicles damages various organs, the cardiovascular, respiratory, and immune systems, and increases asthma, heart attacks and strokes, cancer, and even increases the rates of Alzheimer's and autism. According to the US Department of Energy, approximately 25 pounds of greenhouse gases are emitted per gallon of petroleum fuel consumed.

The Geneva Protocol on Air Pollution declared the petroleum industry the largest single source of worldwide air pollution. Air pollution even damages food crops. According to Terry Tamminen, author of *Lives Per Gallon—The True Cost of Our Oil Addiction*, farmers lose around a third of their crops to petroleum-based air and water pollution. Gasoline contains up to 225 toxic chemicals, some of which are carcinogenic. According to the California Air Resources Board, gasoline evaporates whether the engine is running or not. Particulate matter released from engine exhaust, brake linings, and tire wear adds to air pollution.

Air pollution is also created by the businesses and infrastructure that service automobiles. For example, ac-

Chuo Street car-free zone in Ginza, Chuo, Tokyo, Japan.
Photo credit: Volfgang

cording to the Environmental Protection Agency, around 25% of the country's approximately 623,000 gas station tanks have leaked their contents into the environment. Even all the energy used to produce and maintain parking spaces increases pollution. The petroleum industry used lead as an additive despite previous knowledge of lead toxicity. Tamminen reported that approximately seventy million tons of lead contaminated the environment.

There are various issues regarding switching to walking, bicycling, and public transportation. One large obstacle is bad weather. Sometimes it just seems too hot, cold, windy, icy, or stormy for walking, biking, or waiting for public transportation. However, these harsh conditions can be dealt with by such measures as car sharing and dial-up rides for door-to-door service for anyone unable to walk, bike, or ride public transportation.

Young children could ride in an enclosed bike trailer that protects their safety and prevents exposure to the harshest elements.

Enclosed rickshaw types of bicycles can be covered with a roof that protects from rain and snow, and leafy green vegetation could be grown on the roof in the summer to provide shade. Enclosed bicycle-driven vehicles that look like cars could also protect against wind, cold, snow, and rain. These methods would be great for the ill, the elderly, and the disabled.

Another difficulty is transporting groceries and other items. Nevertheless, walkers can use shopping carts, and bicyclists can either use baskets on their bikes or ride cargo bikes. Businesses can deliver larger and bulkier stuff.

Personal safety is another issue. However, the more people out and about, the safer the neighborhood is. Unfortunately, making poor neighborhoods more plea sant frequently leads to gentrification.

Gentrification is ironic as it pushes out the people who walked, rode bikes, and used public transportation by the classes that abandoned cities. Expressways were built for suburbanites, which tore through poor neighborhoods and exposed them to air pollution from people who didn't even reside there.

It is extremely easy to criticize the sprawl of detached single-family homes in suburbia. However, it must be acknowledged that these communities are more physically attractive and quieter than cities. In contrast, city living is noisy, and most apartment buildings are usually unattractive. Luckily, increased greenery can make urban living more peaceful and attractive. Apartment buildings could be made more appealing. Murals and other public art are visually captivating and can be scattered throughout communities to attract pedestrians.

A major advantage of walking is its positive effects on health. "Walkability and its Relationships with Health, Sustainability, and Livability: Elements of Physical Environment and Evaluation Frameworks" was published in *Frontiers in Built Environment*. The authors reported that walking is good for health and "as a low-intensity physical activity is associated with healthier populations since it contributes to lower rates of obesity, diabetes, and cardiovascular diseases. … Neighborhood walkability is also associated with lower respiratory disease rates, such as asthma in children. … The mortality rate for those above 65 years old who walked for 2,000 steps per day was found to be 78 per 1,000 as opposed to the mortality rate of 12 per 1,000 for those who walked 10,000 steps per day." The authors stated that walking in daylight is even good for the immune system because it increases vitamin D production.

A study from the *American Cancer Society* verified the health benefits of walking. They followed 140,000 older adults and found that those who walked 6 hours weekly had a lower risk of dying from cardiovascular disease, respiratory disease, and cancer than those who were not active.

It would be reasonable to assume that walkers and cyclists are exposed to more air pollution than those riding in cars. However, Damian Carrington, environmental editor at *The Guardian* reported that there is evidence that this is not correct.

A study conducted in Leeds, England, tracked rush-hour commutes of 2.5 miles. All commuters started at the same time, and the cyclists arrived at the destination in 11 minutes, half the time of car travelers. Cyclists were exposed to half the particulate matter than car riders. Walkers in the same study who took a route that avoided busy streets cut their particulate exposure by 75%.

A study in London found that green routes cut walkers' exposure by half. Carrington also reported that experiments have shown that drivers inside vehicles are exposed to far higher levels of air pollution than those walking or cycling along the same urban route. Stephen Holgate, MD, stated that air pollution "is nine to 12 times higher inside the car than outside."

Dr. Benjamin Barratt at the School of Public Health at Imperial College-London measured the exposure of people traveling by car, bus, bicycle, and walking in London in 2014. He stated, "The car driver, by a very long way, was exposed to the highest pollution level. The fumes from the vehicles in front and behind were coming into the car and getting trapped there."

Just as walking improves health, it also benefits the economy. Robert Steuteville is the editor of Public Square, a Congress for the New Urbanism publication. Steuteville wrote about the economic value of walkability. For instance, the High Line is a 1.45-mile-long pedestrian park in Manhattan, New York City. It attracts five million visitors a year, and the surrounding developments led to the creation of 12,000 new jobs.

Still another positive effect of walking is its lower carbon footprint. Walking contributes much less to climate change than driving. The LOWA website reported that walking five trips of 1.24 miles a week instead using a car for those trips can decrease greenhouse gas emissions by 189.598 pounds yearly.

Another study from the Pacific Institute found that walking 1.5 miles would generate less than a quarter of the greenhouse gases that would be emitted if the person drove the same distance. Cycling also produces only a small amount of CO2. Bicycling is also great for the health of the biker and even non-riders because less air pollution is produced.

Blue Zones is an organization that researches the characteristics of societies in which the populace has longer life expectancies. According to an article they published, bicycling increases cardiovascular fitness, improves muscle strength and flexibility, increases joint mobility, posture, and coordination, leads to stronger bones, decreased body fat, lowers stress levels, and reduces anxiety and depression.

The article in Blue Zones reported that cycling lowers the amount of money spent on health care. An article entitled "Air Quality and Exercise-Related Health Benefits from Reduced Car Travel in the Midwestern United States" was published in *Environmental Health Perspectives.* The study estimated that if residents of Minneapolis and St. Paul, Minnesota replaced half of their short car trips with bike trips in warmer months, the estimated cost savings from avoided mortality and reduced health care costs could total $146 million yearly."

Another study was co-authored by Dr. Babak Mohit of the Mailman School of Public Health at Columbia University. It reported that the 45.5 miles of bike lanes

A shared bikeway along the Black Sea coast in Burgas, Bulgaria.
Photo credit: Alicia Fagerving

that New York City built in 2015 "yielded benefits that equated to an extra year of life at full health over the lifetime of all residents of the city."

Public transportation is a major alternative to automobile use. The American Public Transportation Association [APTA] provided important economic data. For example, every $1 billion spent on public transportation creates approximately 50,000 jobs, and every $10 billion spent on public transportation operating investments yields $32 million in increased business sales.

Besides the economic importance of public transportation, it has a positive effect on riders' safety. A report entitled "Evaluating Public Transportation Health Benefits" published by the Victoria Transport Policy Institute adds that public transport has only about 1/20th the passenger fatality rate of automobile travel. The APTA reported that traveling by public transportation is ten times safer per mile than traveling by automobile.

Public transportation contributes to a healthier populace by lowering air pollution and climate change. The APTA reported that public transportation saves the country 6 billion gallons of gasoline annually and reduces carbon emissions by 63 million metric tons annually. Public transportation increases the amount of walking. The health report from the Victoria Transport Policy Institute stated that overall, North Americans daily walk about 6 minutes on average, whereas public transit riders spend a median of 19 daily minutes walking, a little less than the target of 22 daily minutes of moderate physical activity.

Just as public transportation improves health, it also provides financial savings. The Moving Forward Discourse website summarized the various costs of different transportation modes. They stated that for every dollar a car driver spends, society pays $9.20. If busing costs $1, society pays $1.50. If walking costs $1, society pays $0.01. If biking costs $1, society pays $0.08.

Fortunately, many Americans support public funding of sidewalks and bike paths. For instance, Princeton Survey Research Associates International conducted a study on this. They first informed their participants that 1.5% of federal transportation funds sidewalks and bikeways even though biking and walking make up 12% of all trips. 17% of federal transportation funds are spent on public transportation, and 80% are used for roads. 47% of the study participants supported increasing funding for sidewalks and bikeways.

Switching to walking, biking, and public transportation will seem like a catastrophe for many. However, it is an opportunity to improve health, lower air pollution, and slow down climate change. ONE

Commodity bonds as a development tool

THEO HART
ONE

Bonds with fuel pellets as the commodity are a surprisingly good example, but that is the finale of this item. First, the intro: Commodity bonds may be used as a development tool, especially by smaller countries not in the Eurozone, whose government bonds in their currency may sometimes prove difficult to sell.

Governments issuing bonds not in their own currency but in a strong one, such as the Euro, the American dollar or the Japanese Yen, do so to relieve buyers of currency exchange risk. Potential buyers of such bonds will be fine with the interest payments becoming of less value several years hence, compared to when the bonds were bought.

That naturally concerns buyers of bonds in a minor currency, whose exchange value might change considerably over time. For example, in recent years, the Turkish lira has dropped dramatically in exchange value.

But issuing bonds in a stable foreign currency shifts any currency exchange risk to the issuer. To the degree its currency weakens in the future, it will have to devote a more significant part of its revenues to paying interest on such bonds.

Commodity bonds avoid this problem because the interest is not paid in any currency but in a stated amount of the actual commodity specified — to be sold at auction, with the proceeds going to the bond owners. Or, to be more precise: to whoever holds the right to receive that special interest payment.

Avoiding currency exchange risk in the future may be the main reason buyers prefer this type of bond, though they have another major attraction. Whatever the product is might rise in value in the years to come, and believers make eager buyers.

Avoiding currency exchange risk may also be the main reason a government would choose to issue Commodity Bonds rather than the usual bonds paying a fixed interest rate.

Yet, there is another excellent reason as well: **economic development.**

Fostering industry development and job creation is likely to be cumulative. Because commodity bonds

pay in an actual product, the issuing government will be buying that product from local producers, who in turn are purchasing the inputs needed to produce whatever it is—and doing so locally.

Producers with multi-year contracts with the issuing government for a good part of their output should have little difficulty obtaining private financing. Of course, they will want to produce more than the contracts call for. Having a solid output base, anything additional should be at a lower unit cost than otherwise and thus likely profitable even at a lower price. The suppliers they use will likely be the same local ones, further boosting the local economy.

Politicians love to take credit for this sort of thing, as voters generally approve of more employment because it often results in greater consumer spending and more income for a wide array of businesses. Numerous are the voters who then benefit to some extent. Issuing commodity bonds is a good re-election strategy, though some bond commodities would be more significant than others.

Suppose that product is **biofuels**, and let's confine it to liquid furnace fuels comparable to what is currently in use. Notice how general the wording can be; it is not stated as one specific fuel only.

Similarly, was this intended for today's car engines, it would be a mistake to tie the bonds to bioethanol specifically. Instead, bond payments should be in "a biofuel suitable for a gasoline engine", which provides room for future supply contracts to be in biofuels other than ethanol. The bond term is likely for fifteen or more years, after all, and the current obsession with bioethanol will eventually end.

Liquid furnace fuels now are typically a particular cut of the output from a petroleum refinery, something which might otherwise have been made into diesel fuel. So as liquid furnace fuels become more biofuel than fossil fuel, the petroleum refineries will want to make more diesel fuel instead, but only if they can sell it all profitably.

Though hidden from sight inside the furnace, this is burning fuel with the exhaust going out a chimney.

Lignin pellet bonds: strange as it may be, fuel pellets made of lignin would encourage biofuel production even more so than buying the biofuel itself.

Burning fuel in an external combustion (EC)engine is the same, the exhaust going into the air. EC engines could replace diesel in most places. For example, in railway locomotives.

Hybrid transit buses featuring an EC engine would be cheaper than all-electric buses and require no particular infrastructure. When the burner is functioning correctly, the exhaust is reasonably benign.

Having much cleaner emissions than diesel, the air quality in cities would be much improved as EC engines are used in transit buses and certain other road vehicles. These would be Rankine cycle turbines with some energy storage, electric batteries perhaps. Hybrid cars should all have an EC engine instead of a gasoline engine.

So the biofuels meant for liquid fuel furnaces will have a much-expanded market once EC engines come into use.

Strange as it may be, fuel pellets made of lignin would encourage biofuel production even more so than buying the biofuel itself. However improbable this assertion seems, the logic involved is sound. For example, agricultural residues, such as maize cobs, have three main components, each a polymer: cellulose, xylan and lignin. Based on its dry matter, maize cobs are around 40% cellulose, 33% xylans, and 18% lignin. Other materials say sunflower stems, will differ in these proportions though the order is the same.

Cellulose is comprised of glucose molecules which many microbes utilize, once they can get at them. Glucose molecules are also what starch is made of. But the cellulose is tightly structured and difficult to break up, and the more mature the plant, the more difficult this becomes. In contrast, starch comes apart easily.

Xylan is not a linear polymer but a branched one. It is rather readily removed and broken up. The xylose molecule which comprises it is a five-carbon (C5)sugar, and while many microbes can utilize it, most would rather not, preferring a six-carbon sugar instead, especially glucose. Only when no C6 sugar is present will they begin to use a C5 one. Lignin is a messy polymer of something indigestible and presently useless, essentially a waste product, often burnt or otherwise disposed of. Imagine being paid for it instead.

Much research has been done on cereal straws to make them into a valuable feed for ruminants, and two things are clear: [one] cattle will lose weight if the straw is the central part of their feed, and [two] removing about half the lignin in straw sees cattle gaining weight slowly when that is the main part of their feed.

Since a ferment within the animals' rumen is responsible for digestion, an industrial ferment can be done using a somewhat similar mix of microbes on a substrate of farm residues having much of the lignin already removed. Various organic acids result.

These, after some processing, become biofuels of one kind or another, depending largely on the microbes involved and the type of processing. Hydrogenation is one sort, making them into a mix of alcohols.

Couple sale of those biofuels with sale of the removed and pelleted lignin to government buyers, and the revenue situation of the fermenter becomes much more positive.

In this way, issuing commodity bonds where the commodity is lignin fuel pellets can create a biofuel industry based on particular agricultural wastes. And as a bonus benefit — even a significant benefit, some would say — those lignin fuel pellets could provide a green fuel to be used in cement kilns.

After all, powdered coal has been used as the primary fuel in such kilns. This is a simple substitution, as would be replacing coal where electricity is still being produced that way. ONE

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The role of coal power in China's energy transition

In its 14th Five-Year Plan, China has demoted coal power from a mainstay to a supportive role to renewable energy. Some coal-fired power plants are being retrofitted to increase flexibility and provide faster backup responses to wind and solar.

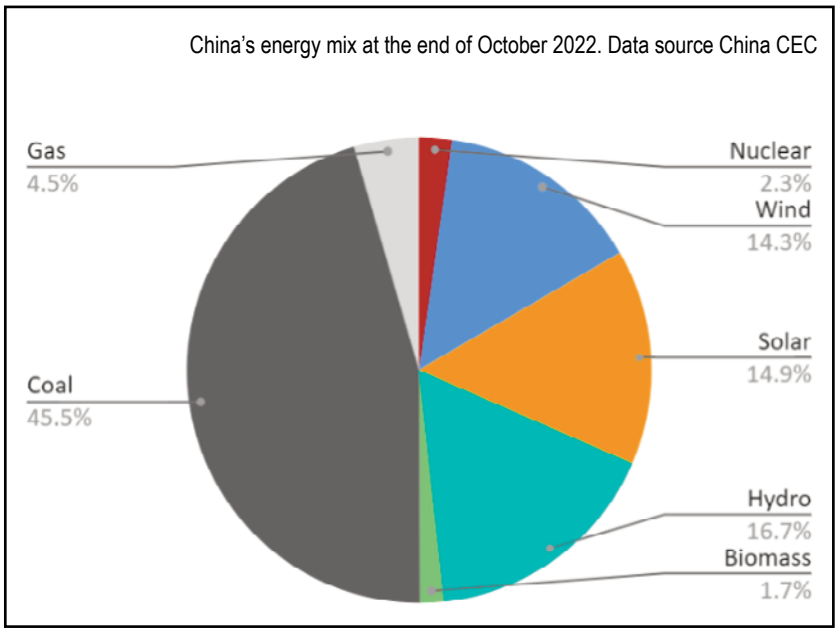
XING ZHANG*

ONE

China is the leader and continues to lead the world in renewable energy, especially wind and solar installation. According to the China Electricity Council (CEC), by the end of October 2022, China's renewable energy installation saw a remarkable 97GW rise, accounting for 76% of total power generation additions. The share of renewable energy in the entire energy mix has reached 47.6%, overtaking the share of coal (see figure below). The total wind power generation capacity had reached 350GW, a year-on-year (YoY) increase of 16.6%, and the whole solar installed capacity had reached 360GW, a YoY growth of 29.2%.

However, similar to the end of 2021, autumn 2022 has also seen another surge of new coal-fired power plants granted permission to build. Guangdong province alone permitted almost 16GW of new coal-fired power plants since September. One way new coal power projects are justified is by framing them as part of a clean energy programme, such as the 2 x 1000MW Lufeng Jiahuwan power plant. The plant is conceived to run at 30% designed efficiency to support wind or solar power generation variation. The other reason to justify adding new coal-fired power plants is to secure the local electricity supply, as explained for the rest of the Guangdong newly permitted coal plants. In the second half of 2021, China experienced the worst power crisis in a decade. Coal and coal power shortage combined with drought across southwest China and windless weather in the northeast led to electricity rationing in more than half of the country's provinces at its peak in September.

China's energy mix at the end of October 2022. Data source China CEC



In the summer of 2022, the record-breaking heatwaves and droughts have once again underscored the vulnerability of China's power generation system to climate change and extreme weather. High temperatures pushed up the demand for air conditioning, using more electricity. The Central China grid region, where much of the country's hydropower capacity is located, was affected by scant rainfall. August is usually a part of the rainy season with an abundant water supply.

However, some rivers dried up in Sichuan province, and the rainfall was 60% lower than the seasonal norm. At the peak of the drought, Sichuan's daily hydropower generation plummeted from about 900 million kWh in the same pe-

In the summer of 2022, the record-breaking heatwaves and droughts have once again underscored the vulnerability of China's power generation system to climate change and extreme weather.

riod to 440 million kWh. As China's largest hydropower-producing province, the weak hydropower output led to a severe power shortage in Sichuan. Factories were ordered to either shut down entirely or limit production, and households and services were urged to save power. Both power crises resulted from extreme weather conditions and exposed weaknesses and rigidities in China's power system management.

The 2021 crisis was caused by government efforts to lower electricity costs as part of a COVID-19 recovery policy focused on supporting industrial output, along with anti-corruption and safety campaigns affecting coal mine output. The government's immediate response was to shore up the profitability of coal-fired power generation by increasing the tariffs paid to generators. Pro-coal interests also successfully utilised the crisis to rewrite the country's energy policy, paradoxically resulting in policy shifts that perpetuate the country's dependence on coal.

Despite the lack of hydropower contribution, the Central China Grid region would have been able to meet local power demand comfortably in the Summer of 2022, but for one factor: the region continued to export enormous amounts of hydropower to eastern provinces under inflexible, fixed contracts.

There are also indications that coal and gas power plants failed to operate at full capacity during the shortage due to the high fuel prices, contributing to the scarcity. On both occasions, the lack of flexible grid management perpetuates the reliance on coal power and creates a perceived need to build more of it. Adding more to its already massive coal power fleet will pose a significant challenge for China to achieve its dual-carbon goals - peaking its carbon emissions by 2030 and achieving carbon neutrality by 2060. China needs to decarbonise its power sector and rebuild it around clean energy to attain its carbon commitment. China's impressive wind and solar development pose an urgent need for its energy system to transform as it was not built to accommodate large amounts of variable clean power.

In its 14th Five-Year Plan, China has demoted coal power from a mainstay to a supportive role to renewable energy. Some coal-fired power plants are being retrofitted to increase flexibility and provide faster backup responses to wind and solar. However, some new coal power plants are being added for the same reason.

Operating higher-cost coal power generators at very low utilisation results in significant losses of revenue and should only be a transitional option. China needs to invest heavily in developing battery storage and pumped hydro systems, as well as more innovative and flexible grid operation and planning. It must reform the electricity markets and incentives for more active demand-side responses. Emerging technologies, such as hydrogen and thermal energy storage, must also be promoted.Electricity shortages experienced in the autumn of 2021 sped up grid reforms that had been delayed for a long time. This summer's power crunch is likely to accelerate this process further.

China's energy planners have to balance the country's energy security and climate commitment. Making grid operation more flexible is the key to avoiding electricity shortages, reducing the need for coal-fired power as a backup and transitioning to a clean energy grid. Using coal power as a supporting pillar to provide a flexible energy supply should only be a short-term solution. A long-term plan should be made to promote the uptake of clean flexibility technologies. ONE

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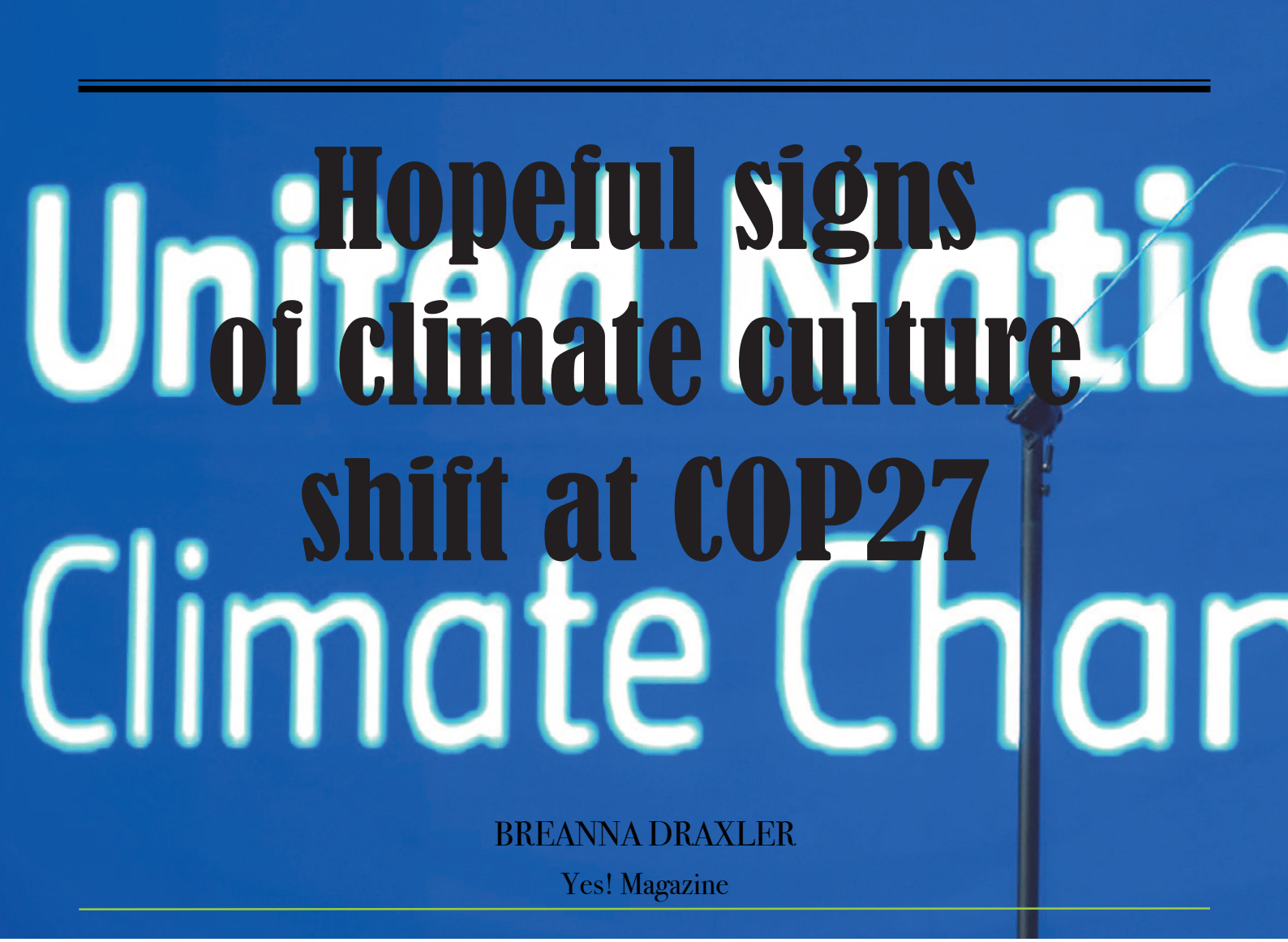


Hopeful signs of climate culture shift at COP27

BREANNA DRAXLER

Yes! Magazine

This month, the United Nations hosted its annual "Conference of the Parties" (COP) in Egypt to discuss how to move the global community forward in the face of climate change. Now in its 27th year, the international meeting attracted familiar critique—of the growing presence of fossil fuel reps and the wide gap between leaders' words and actions. The 12-day conference was extended by two days to allow the parties to reach an agreement to create an international fund to pay for "loss and damage" experienced by the victims of climate chaos.

Nevertheless, "failure" was a consistent description of the outcome of COP27 in the popular press and on social media, especially among climate justice activists. But Favianna Rodriguez, who attended COP this year and last, sees it differently.

The California-based artist, cultural strategist, and social movement leader agrees that the political jockeying may indeed have failed to make meaningful or lasting change for those most affected by the climate crisis. And even if the fund pans out, the parties may not have achieved real justice. But, she says, the real value of the conference happens outside the negotiating rooms, and in that respect, the conference was a success.

"COP becomes a place for us to reconvene as people throughout the world who are committed to climate justice," Rodriguez says. It serves as a central gathering place for those "who understand that colonization and white supremacy are huge contributors to the climate crisis, who recognize that people of color and people from the Global South are the most impacted and therefore deserve a seat at the table."

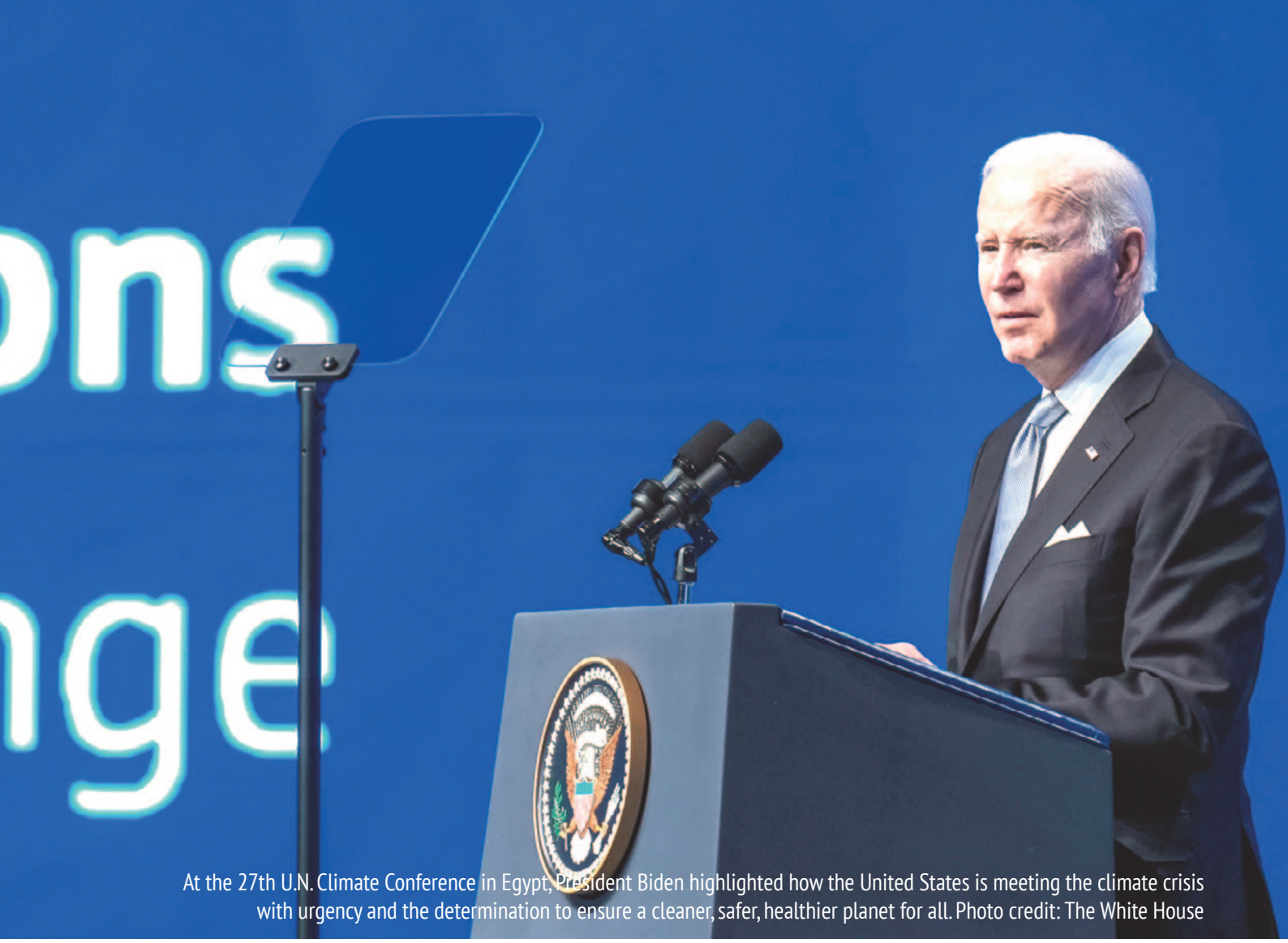
"Even though some of these folks are not at the decision-making table, they are influencing the conversation at COP," Rodriguez explains.

The Real Purpose of the Climate Summit

Cultural shifts are the heart of Rodriguez's work. As the president and co-founder of The Center for Cultural Power, she believes artists and storytellers are powerful agents of positive social change.

Rodriguez was a featured speaker at COP27 on a panel about culture and entertainment, and she and her organization hosted several cultural events for organizations, influencers, and leaders committed to climate justice. She says her primary function was to advance the role of arts and culture at COP, which she sees as an integral tool in the fight for climate justice.

"There's political wins," Rodriguez says, "but there's also cultural wins that need to happen in order to win on cli-



At the 27th U.N. Climate Conference in Egypt, President Biden highlighted how the United States is meeting the climate crisis with urgency and the determination to ensure a cleaner, safer, healthier planet for all. Photo credit: The White House

mate."

"I don't want to sound cheesy, but I feel like … the Earth warriors of climate resistance are all convening" at COP, she says. "There's no other space like that."

Even so, Rodriguez says COP27 differed from last year's gathering in Glasgow, Scotland, in many ways.

In Glasgow, she says, many of the events were open to the public, providing ample opportunity for participation from civil society. Rodriguez and The Center for Cultural Power were able to host film screenings and conversations.

But Egypt was a very different story, she says. Hosting COP27 in the resort city of Sharm El Sheikh made attendance prohibitively expensive for many. And the Egyptian government outlaws public protest, which denied climate activists access to a historically effective communication and bargaining tool at the conference. Whether or not this was the intention of the event organizers, "they are making it very hard for people to go to COP," Rodriguez concludes.

Still, the underlying goal of cultural leaders like Rodriguez remains the same: build relationships. And because the conference forced them to meet with intention in uncommonly intimate spaces, that aspect was a great success.

Even with the decreased presence of civil society leaders, Rodriguez says she was excited to see the growing number of change-makers pushing back on these world governments, at COP and beyond.

"They look very different than the people in the room, right? But they're there," she says. "It tells me that there's a cultural shift already happening that's shaping the conference."

The Twofold Goal of COP27

The political negotiations themselves at the conference are often frustrating and demoralizing, with copious amounts of posturing and presenting false solutions, Rodriguez says. Looking at the leaders who make global climate decisions, Rodriguez acknowledges that COP is "a patriarchal, white supremacist, male-centric, multinational operation that gets very little done."

Those world leaders, let alone COP leadership, "[don't]

Favianna Rodriguez. Photo credit: Jami430

reflect the growing constituency of people who are demanding more from COP," she says. And yet, "it was also really powerful to just see the growing number of young people who are taking up more space."

That space includes a coming-together of grassroots communities, impacted communities, and Indigenous communities from throughout the world, who show up to apply pressure so world governments take action on climate.

Rodriguez adds that COP does provide critical space for building alignment among those within the movement about how to talk about climate. That space is about gathering those most impacted by climate change and then strategizing and coming up with shared messaging, she explains. It's about coming together as a united front to create momentum for real change.

"Movement leaders are being effective in really pushing forward a frame of reparations," Rodriguez says. "Now that's different than … the political outcomes of the negotiations, but the fact that they're getting on the agenda and even that that 'loss and damage' is something so central to the agenda, that to me is signaling a cultural shift."

Indeed, "loss and damage" was language that was entirely absent from last year's COP26, but played a defining role in this year's negotiations.

Rodriguez also sees each COP as an opportunity to increase conversation and understanding between political leaders and communities most impacted by climate change. By attending COP, she and other community leaders are able to report back and help their communities digest the takeaways and participate more meaningfully.

"My hope is that more and more people from the broader public, especially from impacted communities, get to understand, 'How does this thing work? Why is it important that our voices are represented there?'" Rodriguez says.

Ultimately, the goal is "about Indigenous people having more control and power over climate solutions," Rodriguez says. That's in direct contrast to what she calls "false solutions" that all too often come from these kinds of meetings. "We don't want greenwashing," she adds. "We don't want fossil fuel companies proposing solutions."

Cultural Climate Challenges Remain

Rodriguez says she left COP27 with a clear pathway toward what can be done in the U.S.—which she calls a center of global culture—in a way that centers those most impacted.

But the job doesn't stop at COP, she adds. The next step is translating these messages into pop culture and cultural norms. And that's a heavier lift.

"We're not winning on climate when it comes to culture. We're just not," Rodriguez acknowledges. "More has to be done. And I think part of the problem is that climate has kind of stayed in this very scientific, politically wonky arena, and we have to make it more accessible and help people feel that it's important to them. But in order to do that, we need to have the cultural strategy."

She points to social media influencers who are creating new conversations and setting the tone, especially among young people, who will continue to experience the worsening effects of climate change.

"They're shaping politics," she says. And these influencers and activists know full well that mass audiences don't engage with political back-and-forth. They engage with stories. And that's why she puts so much of her energy and effort into telling stories of climate solutions.

Rodriguez is hopeful about shifting the culture around climate to center climate justice, though she knows it requires perseverance, resilience, and fortitude. She sees successful models for this kind of cultural shift in the growing embrace of The Movement for Black Lives, as one example.

"At some point, there has to be a power shift," Rodriguez says. "The power shift hasn't happened yet. But the cultural shift is moving."

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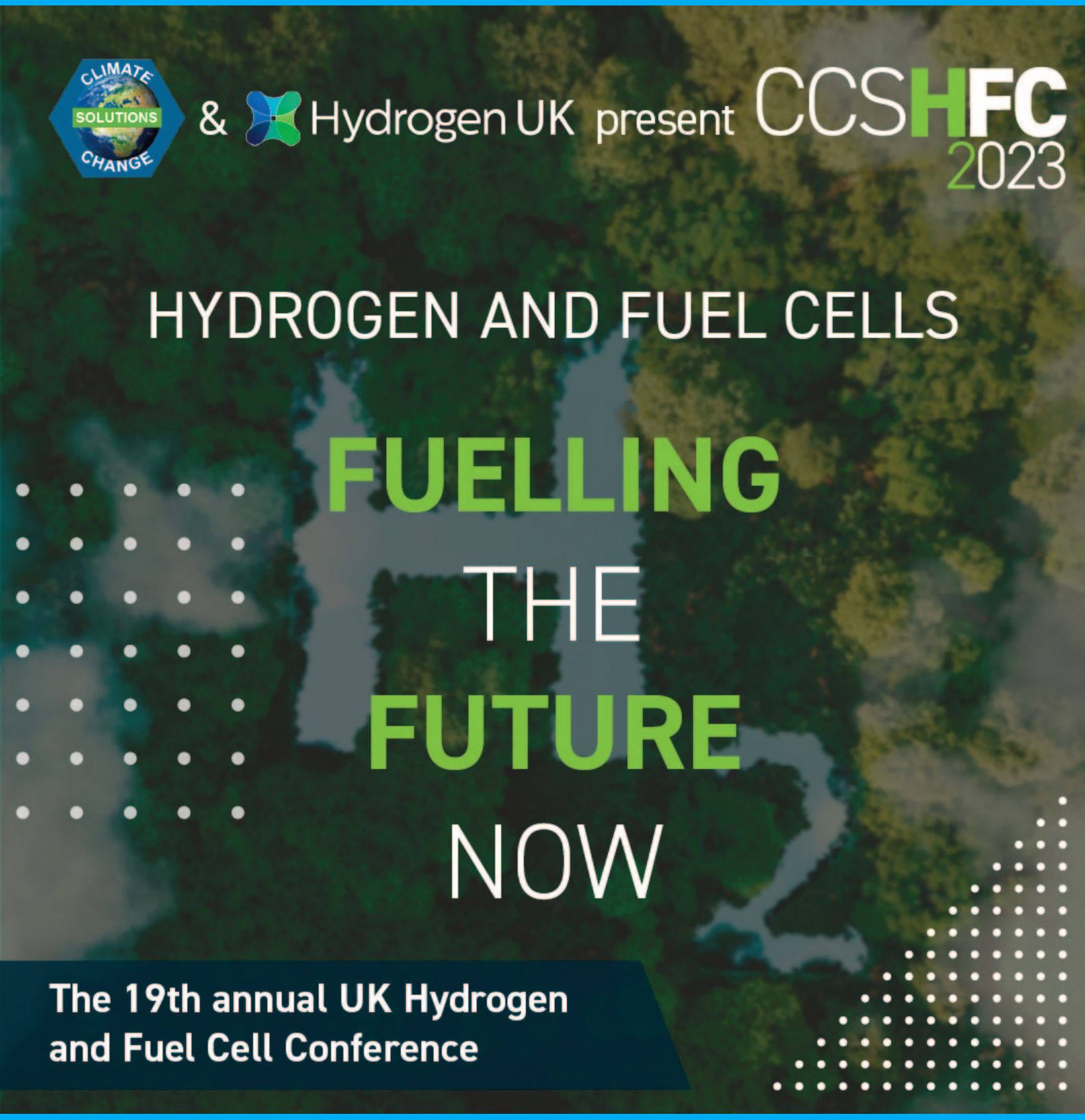
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New routes for hydrogen storage

ALICE MASILI
ONE

Hydrogen is the primary candidate to take on the long-term role of energy storage in a system that relies heavily on non-programmable renewable sources such as solar and wind. But even though hydrogen is environmentally friendly, produces no emissions and has a high energy density compared to other fuels, it is more challenging to store. Unless, of course, it turns to dust.

While production remains a priority, safe and successful storage options are critical to meet demand and deliver fuel efficiently.

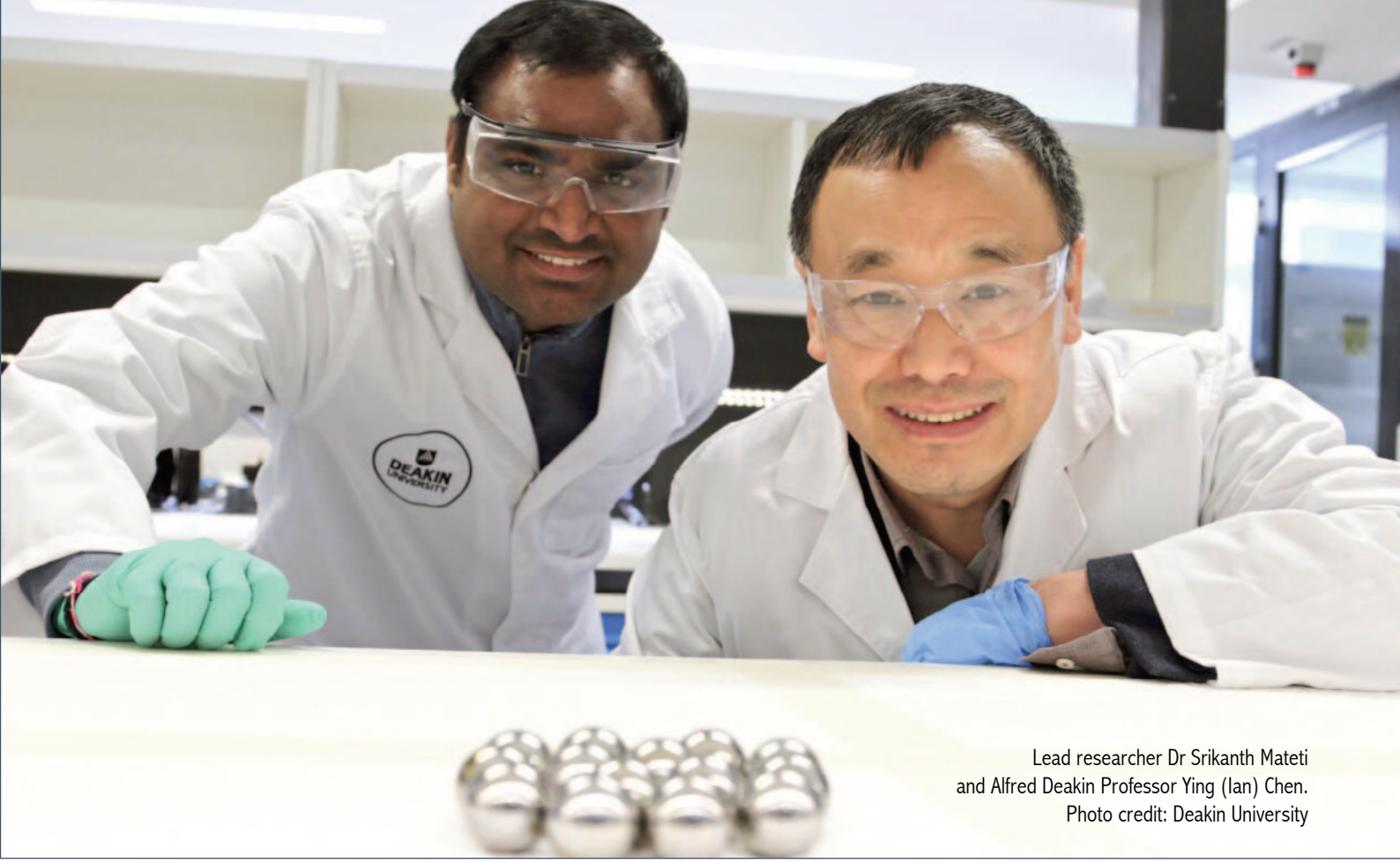
Storing hydrogen has proven to be a challenge. Conversion to liquid is the most used because it allows storing larger quantities in smaller spaces. Still, it requires extremely high pressures and usually low temperatures. For this reason, research has developed new methods to make it easier to manage and transport this clean fuel.

Some researchers at the University of Turin (Italy) focus on this issue. They are working on solutions for using solid-state hydrogen as an energy source. Their report, "Solid-State Hydrogen Storage Systems and the Relevance of a Gender Perspective," provides an overview of the available vectors for solid-state hydrogen storage. The report highlights the challenges they face to become critical technologies for the energy transition, improving energy storage efficiency and smart grids.

According to the study, hydrogen storage by physisorption in metal-organic frameworks (MOFs), nanotubes, and graphene is possible. However, it has yet to be tested in larger prototypes. A more rising method is to use pure metals or inorganic compounds to form metal and complex hydrides. As the case may be, certain pure elements and intermetallic compounds form a hydride phase once the hydrogen has been absorbed.

Conversely, hydrogen can be absorbed and released in solid solutions without changing the crystalline structure of the compound but only by increasing the lattice parameters.

Metal hydrides, in particular, can store large amounts of hydrogen, which can be easily removed at low pressure and near ambient temperature. Magnesium, for example, forms MgH2, a material with a high hydrogen storage capacity (volumetric density of H2 of about 130 kg H2·m-3 and gravimetric density of H2 of about 7.6 wt%). Trapped hydrogen can be quickly released by adding as much heat as is generated during absorption or by changing the pressure. The most used metals are titanium, iron, manganese, nickel and magnesium. Adding small percentages of rare earths improves the conditions for formation and decomposition. It reduces the temperature or rate at which hydrogen is fixed and released. These compounds have been extensively researched in recent years. They are the subject of experimental studies such as the European HyCare project. The project envisages the storage of about 50 kg of hydrogen on a solid carrier using metal hydride. The storage tank will



Lead researcher Dr Srikanth Mateti
and Alfred Deakin Professor Ying (Ian) Chen.
Photo credit: Deakin University

be part of a renewable energy plant using H2 as an energy carrier for stationary energy storage. The recovered heat is used to desorb the hydrogen from the metal hydride. Finally, the released H2 powers a fuel cell that generates electricity.

There are only a few commercial applications. GKN Hydrogen has developed a hydrogen storage system based on an intermetallic alloy. GKN is launching small, medium and large hydrogen storage systems based on this technology. One example is the Arieshof of San Lorenzo in the Pusteria Valley (Italy), where GKN has implemented the solution for a self-sustaining organic farm.

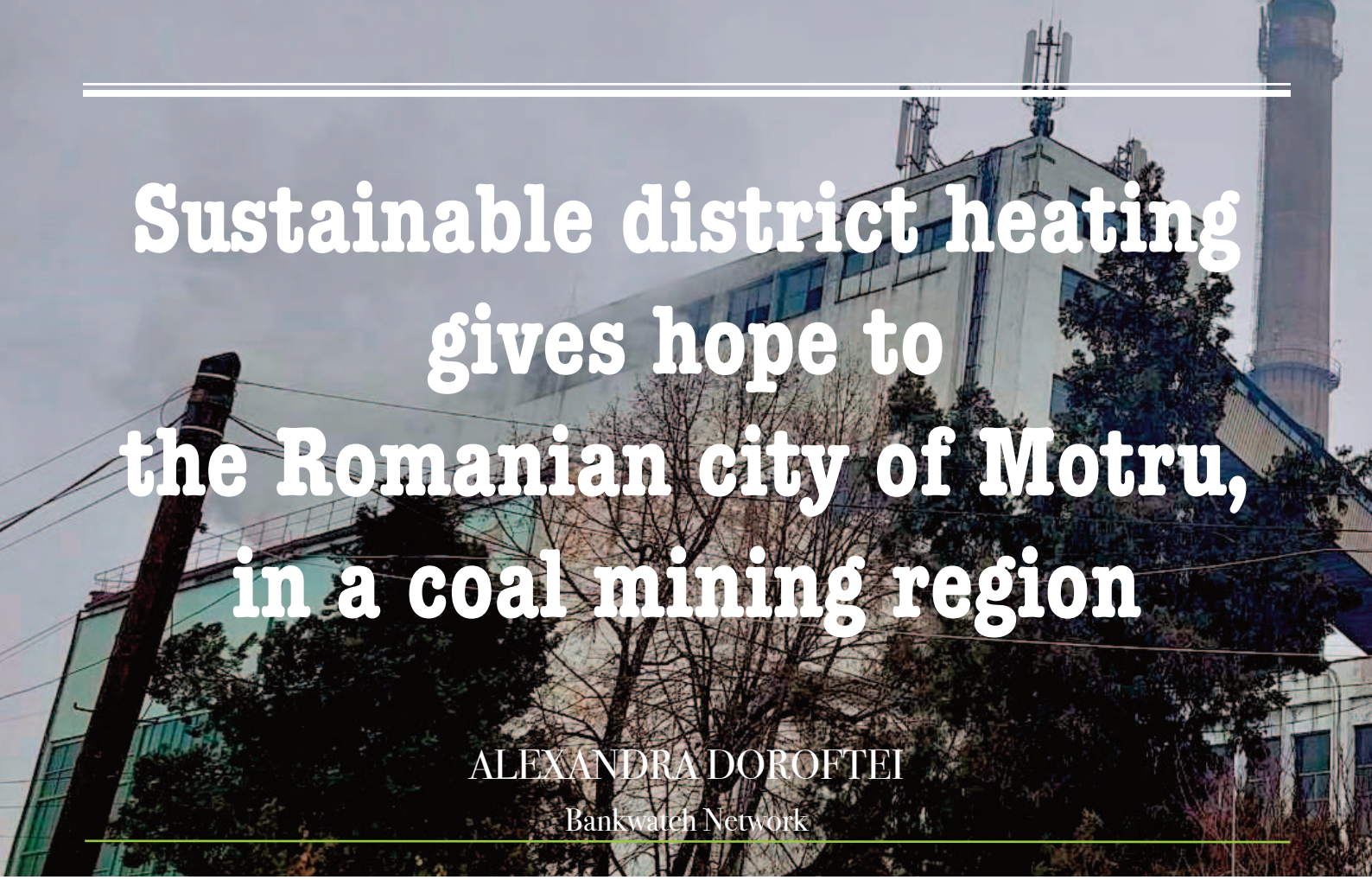
Another possible way to store hydrogen is from Deakin University in Australia. Their scientists have developed a safe, environmentally friendly and energy-efficient method of storing gas. The study, published in the scientific journal *Materials Today*, describes the process used to preserve the gas in solid form.

The particular component of the process is boron nitride powder, which is mixed with gases in a ball mill, a grinder with stainless steel balls inside. As the mill rotates, the collision between the steel balls and the boron nitride powder triggers a mechanochemical reaction that allows the powder to absorb the gas. The gas absorbed before is separated from the others by removing the dust from the mill. The process continues with the remaining gases. There is no waste. The process requires no harsh chemicals, and it generates no byproducts. Boron nitride itself is a non-hazardous chemical compound. It means you can store gases anywhere and use them as needed. The powder can be transported easily and safely. To recover the gas, heat the boron nitride powder in a vacuum, which can then be reused up to fifty times.

The Australian team's report claims that this method has a very high gas storage capacity because the milling process does not break down the gas molecules. The energy consumed to store and separate 1000 litres of gas is 76.8 KJ/s, almost 90% less than the energy consumed by the current separation process.

This discovery addresses the critical challenge of hydrogen storage by allowing large quantities of green hydrogen to be stored and safely transported in a solid state at a fraction of the energy cost.

So far, Deakin's team has only been able to test their process on a small scale, separating about two to three litres of material. They hope to get industry support to scale up the discovery to a whole pilot plant. Moving from the lab to a larger industrial scale is the next challenge for a method of gas separation and storage faster than the traditional ones. A provisional patent application for their process has already been filed. ONE



Sustainable district heating gives hope to the Romanian city of Motru, in a coal mining region

ALEXANDRA DOROFTEI
Bankwatch Network

It's not often that a town in a coal dependent region leaps to a fully renewable district heating system. Sometimes it is not even technically possible; other times, decision makers are just too rooted in 'how we've always done things around here' and keep old polluting heating systems on life-support because it's the easier political decision. But the city of Motru in Romania benefits both from political will and from diverse sources of sustainable energy and can be a leading example for other municipalities in the country in their efforts to decarbonise the heating sector.

On 17 November, the study Heating from renewable and alternative energy sources for the city of Motru. Solutions and recommendations was launched in Motru, Gorj County, with the support of the mayor and representatives of the local council. The study, which presents five alternative scenarios to the current coal-based district heating system, was carried out by the *Institute for Studies and Power Engineering (ISPE)* at the request of Bankwatch Romania. Its goal is to assess whether the need for heating and hot water of the 5,000 homes connected to the system can be met in a sustainable way, using renewable energy sources, with minimal negative impact for residents' health and the environment.

The coal-based district heating plant is managed by the local council and has been providing hot water and heating to Motru's residents since 1970. Currently, it supplies 86 per cent of Motru's population, 8 per cent of the public institutions and only 6 per cent of the private ones.

The end of an era?

In recent years, the increasing costs of CO_2 allowances – up from EUR 7 per tonne of CO_2 at the end of 2017 to over EUR 70 per tonne of CO_2 now – and the health-damaging pollution caused by the aging power plant, have made it increasingly difficult to operate it. The wear and tear on both the thermal power plant and the hot water distribution system also results in a lot of lost heat: the system's registered thermal energy losses in 2021 stood at an eye-watering 46.8 per cent.

At the end of 2021, the company running the plant just barely managed to get out of the insolvency process it had been mired in since 2016. To continue providing heating and hot water for the residents of Motru, the operator received at least EUR 6.5 million in financial aid from the local budget.

Motru. Photo credit: Bankwatch.ro

Because the financial problems were projected to deepen month after month, the mayor of Motru and Bankwatch Romania decided to look for sustainable, financially viable and non-polluting solutions.

A fully renewable energy scenario is possible, even in a coal dependent town

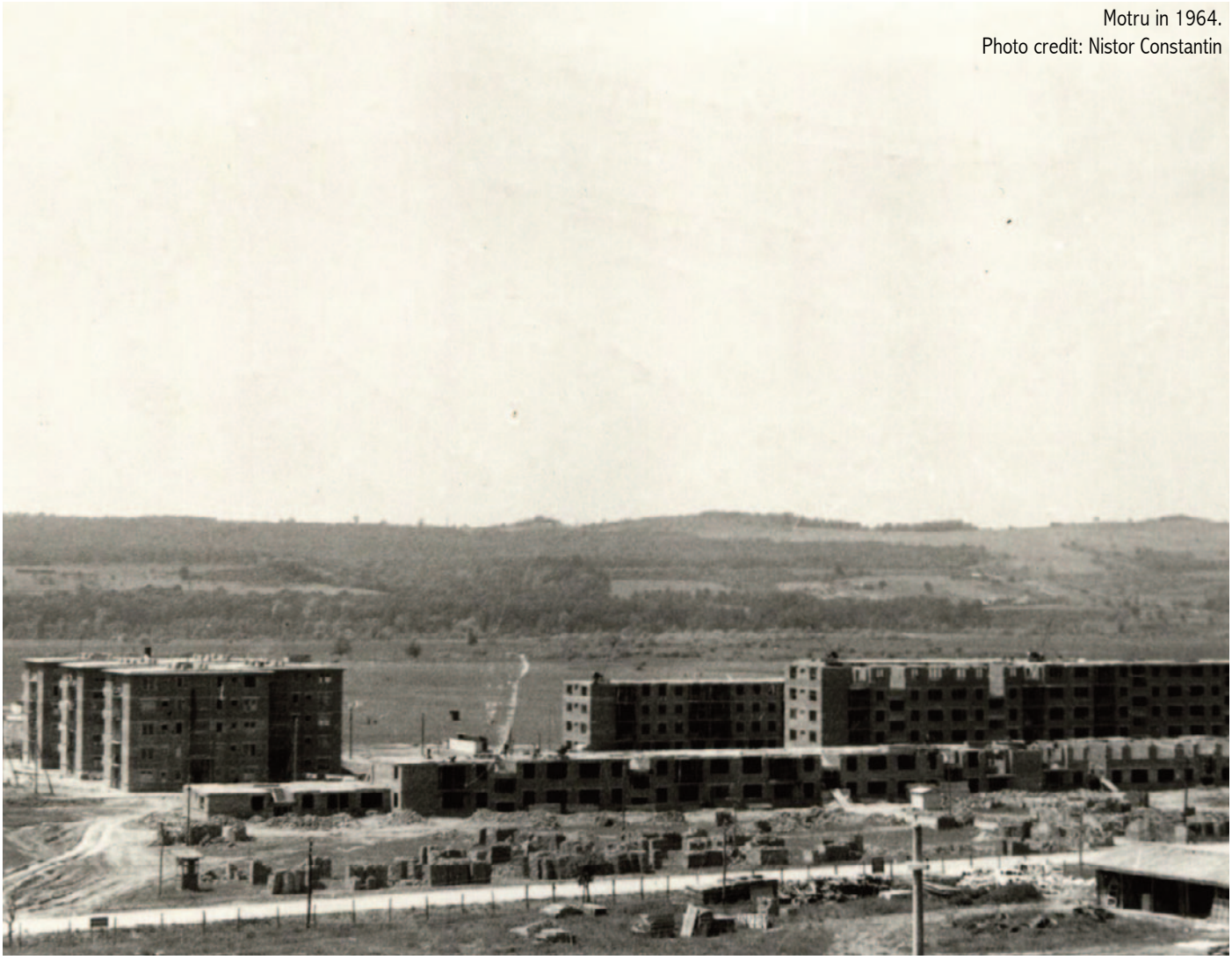
The study includes the analysis of five scenarios with different technologies for the production of thermal and/or electrical energy. These technologies range from conventional ones, which are expensive to operate and have considerable environmental impacts (such as fossil gas boilers, a municipal waste incinerator), to a biomass cogeneration plant, to photovoltaic (PV) panels on the ash deposit and heat pumps.

Out of all five scenarios, the 100 per cent renewable one stands out as the best choice for modernising the thermal power plant. It involves the use of heat pumps powered by solar PVs mounted on the heating substations and on the ash disposal sites. The electricity required to power the heat pumps when the solar PVs cannot provide it will be taken from the national grid. Along with a deep renovation of the apartment buildings stock, and the rehabilitation of the distribution system, the scenario is possible, viable from a technical-economic point of view and 'easier to manage and safer from the point of view of continuity and safety of supply', according to the authors of the study.

The income from the system's operations fully covers the annual operating expenses. The EUR 23.5 million original investment is estimated to be recovered eight to nine years after the new heating system is put into operation. After the ninth year of operation, the new district heating system would begin making profits. An important part of the cost cuts is because the plant will no longer have to buy CO_2 allowances. In 2022 alone, the plant operator had to buy over 45,000 CO_2 allowances, with a cost burden of approximately EUR 2.5 million.

The 100 per cent renewables scenario will also significantly improve the local air quality, as current emissions from the district heating plant (sulphur dioxide, nitrous oxides and dust particles) would disappear altogether.

The fully renewable scenario ensures the district heating sy-



Motru in 1964.
Photo credit: Nistor Constantin

stem will be independent from potentially unreliable, unavailable or expensive fuel sources such as gas, waste or biomass. The fully renewable solution eliminates the risk of having production outages and it gives more predictability to consumer prices.

Funds exist – Motru just has to go for them

The investment needed for a 100 per cent renewable district heating system in Motru is estimated at EUR 23.5 million, which the local administration must fundraise. Fortunately, the palette of available sources of funding is wide, and it ranges from grants to low-interest loans. The Modernisation Fund, the Just Transition Fund, Romania's COVID-19 recovery plan, and its operational programmes all prioritise investments in renewables, especially in district heating. Motru is a just transition region and has a Territorial Just Transition Plan, so it ticks all the boxes to qualify for this funding. International financial institutions (such as the EBRD) would gladly lend to such projects as well, but when grants are available, they should be the municipality's preferred option. We can only hope the local council sees all these benefits and opportunities and approves Motru's way forward on its sustainable path.

The city of Motru is the first town in one of Romania's coal regions to take such a step towards the use of renewable sources and thus towards decarbonising thermal energy production. The initiative is in line with EU policies and the commitment to increase renewable energy production and improve energy efficiency. Moreover, it will set an example for other towns in similar situations. The well-being of Motru's citizens will depend on the modernisation of its heating sector.

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The fight against deadly soot

The health risks from tiny airborne particulate matter may soon face stricter federal regulation. But improving air quality remains a complex challenge.

TIM LYNDON
The Revelator

This September a Louisiana judge derailed Formosa Plastic's Sunshine Project, the largest industrial development ever proposed in the state's heavily developed "Cancer Alley" region, where more than 200 industrial facilities already crowd the banks of the Mississippi River.

The ruling found that the plastics complex would emit so much soot that it would further endanger nearby communities – reason enough to cancel its previously approved air-pollution permits.

Louisiana citizens, who already suffer health problems from high pollution levels, had fought Formosa's plans for years. While their court victory may sound like a David vs. Goliath story, the soot at the heart of the Sunshine ruling – tiny particles less than 1/30th the diameter of a human hair – still cause sickness and death nationwide, especially in low-income communities.

Experts say addressing the threats of soot pollution on a national level is long overdue. "Particulate pollution can cause lung cancer, asthma and other diseases," says Gianna St. Julien, clinical research coordinator at the Tulane Environmental Law Clinic in New Orleans, which joined the case against Formosa. The pollutant's size is the problem, St. Julien explains. When inhaled, soot measuring 2.5 microns and smaller – officially known as particulate matter 2.5 – can penetrate the lungs and enter the bloodstream, where it can cause stroke, heart disease, reproductive complications and much more. While natural sources of PM2.5 such as pollen, dust and ocean spray have remained steady over time, the particles from burning fossil fuels and other industrial activities have risen sharply in recent decades, driving health concerns. Recent research estimates that PM2.5 causes 4.2 million deaths each year worldwide, including 50,000 in the United States.

In her September decision against Formosa, Judge Trudy M. White wrote that PM2.5 emission estimates provided by the company – and permitted by Louisiana's environment agency – would violate the Clean Air Act and compound health risks already faced by communities in Cancer Alley.

Judge White also faulted the state for inadequately analyzing environmental justice impacts from the proposed plant, which would be built in a part of St. James Parish that is 87% African American. Residents include descendants of emancipated plantation slaves who in the 1800s purchased and worked the

Smoke From Canadian Wildfires Drifting Down to U.S.. Photo: NASA

Marathon Petroleum in St. John the Baptist Parish. Photo credit: Peter G. Forest

land so future generations could inherit "untainted" agricultural lands. To some, these lands are sacred.

These are important points to St. Julien, who in January co-authored research linking high cancer rates in Louisiana's poor neighborhoods and communities of color with high exposure to pollutants like PM2.5. Her research adds to a large body of work showing poor and minority communities across the country bear an outsized burden from air pollution. St. Julien and others attribute the disparity to decades of housing, zoning and other policies that make it easy for polluters to move into disadvantaged communities.

"Wealthier White communities are able to fend off proposals like Formosa's more successfully because they have greater financial resources and political access," says St. Julien. Additional Tulane clinic research published in 2020 supports the claim.

St. Julien applauds the Formosa decision but says more work is needed, especially in understanding the cumulative impact of the "cocktail of chemicals" breathed by residents near industrial sites. Additionally, she points out, the EPA monitors that track PM2.5 and other contaminants have historically been positioned away from the communities experiencing the worst air pollution, which puts residents at a further disadvantage. "That's why we did this study," she says, "so residents already fighting for their lives wouldn't have the added burden of trying to prove they're impacted by these pollutants."

The work by St. Julien and others is having an effect. Earlier this year, after visiting St. James Parish and other Cancer Alley neighborhoods, EPA chief Michael Regan announced plans to deploy mobile air-quality monitors to the communities.

A Lagging Regulatory Atmosphere

While Louisianans resist new polluters, others are taking the fight against PM2.5 to the national level. For years scientists have warned that national standards under the Clean Air Act provide inadequate public health protections. Last year Harvard researchers connected thousands of premature deaths in the U.S. to coal, biomass, natural gas and other energy-related combustion sources, while a 2022 Health Effects Institute report found that exposure to PM2.5 concentrations below current standards causes mortality in older Americans.

The Clean Air Act requires EPA to revisit its standards every

five years to ensure they keep pace with science. But the last change came back in 2012, when the Obama EPA lowered the acceptable limit of ambient PM2.5 from 15 to 12 micrograms per cubic meter.

In 2019, after the Trump administration took office, EPA scientists recommended lowering the standard again, saying that a range of 8-10 micrograms could save up to 12,000 lives each year.

"But the Trump administration blasted forward with their review," says Seth Johnson, a senior attorney with Earthjustice. Ultimately, the Trump administration declined to toughen standards. Coal industry backers lauded the Trump decision.

Earthjustice, meanwhile, sued the EPA on behalf of a coalition of groups that included the American Lung Association and Union of Concerned Scientists. "All these groups said the science shows that people die at current PM2.5 standards," says Johnson.

Soon after the Biden administration took office, the new EPA leadership announced a course change and in 2022 published a supplement to the scientific reports used under Trump. It further supported strengthening PM2.5 standards, which the Biden EPA hopes to finalize next year. The administration has also proposed new rules to reduce PM2.5 and other pollutants from heavy duty trucks beginning in the 2027 model year. To Johnson, addressing both transportation and stationary sources such as power plants will help attain lower PM2.5 levels.

Johnson also sees the environmental justice angle highlighted by St. Julien. "It's a really big deal," he says, noting that the Clean Air Act is supposed to protect outdoor air for all groups, but that it obviously falls short for certain communities. But Johnson says he sees building awareness of the dangerous inequality. The Biden administration also sees the problem.

A 2022 policy assessment conducted as part of the current PM2.5 changes acknowledges strong evidence of racial and ethnic disparities in PM2.5 exposure, EPA spokesman Tim Carroll says by email. He added that in 2022 EPA identified

strategies to ensure PM2.5 standards are met in communities with low socio-economic status. Meanwhile a new source of soot has emerged.

The Climate Wild Card

Over its 52-year history, the Clean Air Act has had a remarkable record of reducing particulate pollution. As the EPA tracked the science through the five-year reviews required by the law, it went from only regulating particulates of 25-40 microns in the 1970s to then including 10-micron pollutants (PM10) in the 1980s and eventually PM2.5 in the 1990s. It has also gradually lowered the PM2.5 threshold.

As a result, EPA estimates, we've seen a 37% decrease in ambient PM2.5 in the past two decades.

But today scientists warn that wildfire smoke tied to climate change is erasing the gains. In September researchers at Stanford University showed millions of Americans now experience extreme levels of PM2.5 across areas affected by wildfire smoke, which can drift thousands of miles.

"We observed enormous increases in the number of days with smoke and the number of days with extreme smoke," says Marissa Childs, who contributed to the study as a Ph.D. student at Stanford and is now a fellow at the Harvard University Center for the Environment.

The researchers used satellite imagery from 2006 to 2020 to track drifting smoke, which they then correlated with spikes in PM2.5 detected by regional EPA air monitors. They used artificial intelligence techniques to apply the results over the broad areas between air monitors across the contiguous 48 states.

The work showed that swaths of Americans now experience at least 100 micrograms of PM2.5 every year, many times above the current standard and a 27-fold increase over the last decade. It also showed a whopping 11,000-fold increase in people experiencing days of at least 200 micrograms of PM2.5, which Childs says used to be exceedingly rare.

"It's really bad," she says, pointing out that particulate matter from smoke poses many of the same health dangers as other pollutants. But Childs says the soot from these events are "completely unregulated" because they fall under the Clean Air Act's Exceptional Events Rule, which exempts rare or unique emission sources such as fires. But the events are becoming more common, she says, as wildfires increase in severity, duration and the number of acres burned.

A spate of recent research agrees. UCLA researchers found that a combination of wildfires and increasingly hot and stagnant air patterns raises levels of PM2.5 and ground-level ozone in Los Angeles, Denver and other cities. The findings come as residents of Seattle and Portland, Oregon, have breathed record wildfire smoke in recent years.

The Stanford work found the increase in smoke-related PM2.5 affects wealthier populations and communities that census data show are predominantly Hispanic, which they attributed to demographics in western and southwestern regions.

Childs also recognizes that the effects may be disproportionately felt in disadvantaged communities, where the added PM2.5 comes atop already high pollution levels. Research also shows that PM2.5 and larger particles interact with climate change in complex ways. Scientists have long shown that black carbon, which can be included in PM2.5, accelerates melting of glaciers and sea ice around the world, contributing to climate tipping points.

As soot from wildfires settles to the ground, it also accelerates snowmelt in the West's mountainous areas, compounding droughts tied to climate change.

And just as St. Julien and others have noted for PM2.5 pollution, the effects of climate change are also known to put the heaviest burden on disadvantaged communities.
For St. Julien, the EPA's reconsideration of its PM2.5 standards are an overall step in the right direction.

But that's not enough, she cautions. More work is also needed to protect frontline communities and ensure that states comply with EPA standards in the first place.

In the case against Formosa, the courts agree.

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Salt and a battery – smashing the limits of power storage

CALEB DAVIES

Horizon - The EU Research and Innovation Magazine

We have all been there. The rectangular icon in the top right-hand corner of the screen turns red and flashes to indicate you're almost out of battery. But the problems with batteries go far beyond this kind of minor inconvenience. Batteries are a crucial part of our green energy future but also an imperfect one.

In future, a large portion of our energy will come from renewable sources such as solar and wind. But there are times when the wind does not blow and the sun does not shine. To even out supply, we need to store the surplus electricity generated by renewables, until we are ready to consume it. One important means of doing so is with better batteries. We also need huge numbers of batteries if we are to power the envisioned fleets of electric cars and mobility devices.

The trouble is, even the best batteries have problems. One big sticking point is that lithium-ion cells use lithium as a key component. This is mined as salt.

Europe does not presently have any large reserves, so relies on imports from only a small number of places, such as Australia and Chile. Lithium batteries are also expensive, have a limited storage capacity, and lose performance after repeated charging. If we are to make them better, first we need to understand how they work.

Traditional lithium-ion batteries have three key components. There are two solid components called electrodes – the anode and the cathode – and a liquid called the electrolyte. When the battery discharges, electrons stream out of the anode to the cathode to power whatever device it's connected to. Positive lithium ions diffuse through the electrolyte, attracted to the negative charge of the cathode. When the battery is being charged up, this goes in reverse.

Energy density

The whole process is a reversible electrochemical reaction. There are many flavours of this basic process with different kinds of chemicals and ions involved. A particular option being explored by the ASTRABAT project is to do away with the liquid electrolyte and make it a solid or gel in-

Li ion battery from a laptop computer. Photo credit: Kristoferb

stead. In theory, these solid-state batteries have a higher energy density, meaning they can power devices for longer.

They should also be safer and quicker to manufacture, since, unlike typical lithium-ion batteries, they don't use a flammable liquid electrolyte.

"We need to continue to invest in research to validate the next generation of batteries."
Dr Sophie Mailley, ASTRABAT

Electrochemist Dr Sophie Mailley at the Atomic Energy and Alternative Energies Commission (CEA) in Grenoble, France, is the ASTRABAT project coordinator. She explains that lithium-based solid-state batteries do already exist. But such batteries use a gel as the electrolyte and only work well at temperatures of about 60 C, meaning they are unsuitable for many applications. 'It's clear that we need to innovate in this area to be able to face the problems of climate change,' said Dr Mailley.

She and her team of partners have been working on perfecting a recipe for a better solid-state lithium battery. The job involves looking at all sorts of candidate components for the battery and working out which ones work best together. Dr Mailley says they have now identified suitable components and are working out ways to scale up manufacturing of the batteries.

One question she and her team plan to investigate next is, whether it will be easier to recycle lithium and other elements from solid-state batteries compared to typical lithium-ion batteries. If it is, that could increase the recycling of lithium and to reduce dependence on imports.

Dr Mailley estimates that if the research goes well, solid-state lithium batteries like the one ASTRABAT is working on could be entering commercial use in electric cars by about 2030. 'I don't know if it is these solid-state batteries that will be the next important battery innovation,' said Dr Mailley. 'There are a lot of other possible solutions, like using manganese or sodium (instead of lithium). Those might work out. But we need to continue to invest in research to validate the next generation of batteries,' she said.

Positively charged

When it comes to storing energy for the purposes of smoothing out supply to electricity grids, batteries need be reliable and high capacity, which means expensive. Scarce lithium isn't the best choice. Instead, the HIGREEW project is investigating another different kind of battery, known as a redox flow cell. The main components of redox flow batteries are two liquids, one positively charged, one negatively charged.

When the battery is in use, these are pumped into a chamber known as a cell stack, where they are separated by a permeable membrane and exchange electrons – creating a current.

The project's co-ordinator is chemist Dr Eduardo Sanchez at CIC energiGUNE, a research centre near Bilbao in Spain. He explains that plenty of large-scale redox flow batteries are already in operation around the world and they are designed to be stable, lasting about 20 years. But these existing batteries use vanadium dissolved in sulfuric acid, which is a toxic and corrosive process. Safety requirements mean these batteries must be manufactured at great expense.

"I would say we have a bloom here in Europe, with a lot of companies working on flow batteries."
Dr Eduardo Sanchez, HIGREEW

'Vanadium has lots of strengths – it's cheap and stable,' said Dr Sanchez. 'But if you have a leak from one of these batteries, that's not nice. You must design the tanks to be extremely durable.'

Less toxic

The HIGREEW project is planning to create a redox flow battery that uses far less toxic materials such as salt solutions in water which stores carbon-based ions. Sanchez and his team of colleagues have been working on developing the best recipe for this battery, screening many different combinations of salts and chemical solutions. They have now come up with a shortlist of a few prototypes that perform well and are working on scaling these up.

Work on one huge prototype battery is ongoing at the CIC energiGUNE centre. 'We have to ensure that they maintain their good performance at scale,' said Dr Sanchez.

His team have also been investigating a method of dipping commercially available battery membrane materials so as to chemically alter them, making them last longer.

Dr Sanchez sees a bright future for redox flow batteries. 'I would say we have a bloom here in Europe, with a lot of companies working on flow batteries.' He predicts that manufacturing redox flow batteries could bring abundant employment opportunities to Europe in the coming years.

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Photo credit: WinterforceMedia

ROSSDALE

The Rossdale Power Plant is one of the most important pieces of industrial heritage in Alberta (Canada). Power was first generated on the site in 1902. The Rossdale plant was the only electrical facility in Edmonton until 1970, when it generated one quarter of Alberta's power. The plant stopped producing electricity in 2008 and was decommissioned in 2011-12. The buildings that have been preserved on the site - a Low Pressure Plant and 2 pumphouses - are historically significant.

The Low Pressure Plant was built in phases between the 1930s and 1950s to meet the growing demands of an expanding city. Maxwell Dewar, who later became Edmonton's City Architect, designed portions of the building and ensured its architectural coherence. The Low Pressure Plant includes: a Switch House which is two-storeys in height and interconnected with the Turbine Hall; a Turbine Hall about 11 meters in height with a sunken, cast-in-place concrete structure that supported the turbines which generated electricity; a Boiler Hall, the largest of the elements in the Low Pressure Plant, featuring internal industrial steel framing that supported the boilers which powered the turbines. The boilers (removed along with the turbines during decommissioning) were originally coal-fired. Coal was delivered to the plant by a rail spur connecting to the Edmonton Yukon and Pacific Railway. The plant was converted to natural gas by 1955. Pumphouse No. 1, immediately south of the Low Pressure Plant, was built in 1937 and still houses its original machinery. The pumphouse's engineering was the first design project John Poole, future Edmonton businessperson and philanthropist, did after graduating from university. Pumphouse No. 2, which sits along the river between the Low Pressure Plant and Walterdale Bridge, was built in 1955. It features a small control room above a larger operating floor. In 2001 the Government of Alberta designated the Low Pressure Plant and Pumphouse No. 1 as Provincial Historic Resources. Those same buildings, as well as Pumphouse No. 2, are also on the City's Inventory of Historic Resources.

The Rossdale Power Plant is owned by EPCOR Utilities Inc. As part of the River Crossing initiative, the City of Edmonton is working with EPCOR on a transfer of land in Rossdale that would see the power plant come into City ownership. This would be a step towards bringing new life to the power plant complex as part of a broader activation of this culturally and historically significant portion of the river valley.
(Thanks to: edmonton.ca)

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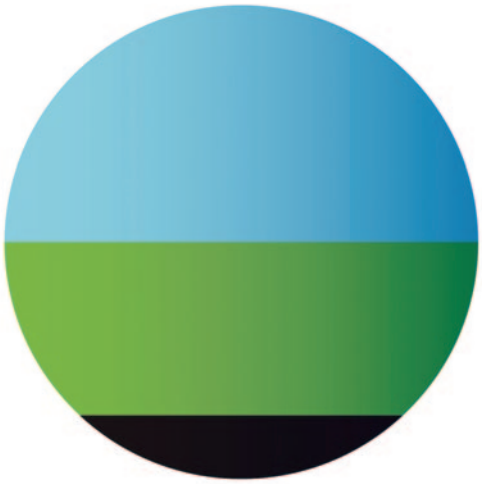

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