



**CCS and coal:
the carbon
no one wants
to capture**



Teen
air



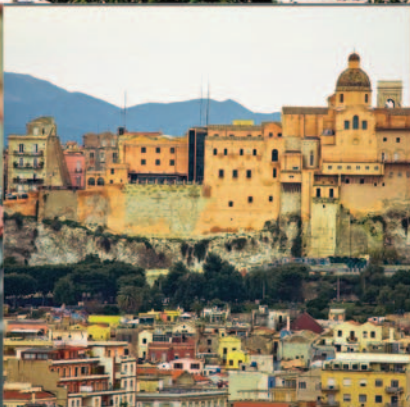
Museums
for future



The archipelagic energy structure
of the Philippines



Nuclear,
a waste of time?



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THE climate

is
changing

WHY

aren't we?



TEEN AIR

By GIANNI SERRA

ONE


Age is the difference. "For more than 30 years, science has been crystal clear. How dare you continue to look away and come here saying that you're doing enough when the politics and solutions needed are still nowhere in sight." There was an urgency in the speech delivered by 16-year old Greta Thunberg at the UN General Assembly (UNGA) Climate Action Summit on September 23, 2019.

Greta's urgency is shared by all the students filling streets and squares all over the world, whereas that urgency is utterly absent in the looks, choices, behaviour of those who observe them with contempt or paternalism. Typical of those who believe to know better, to know how the world works and consider these battles typical of age: genuine, naive, but mainly useless, as the boys will discover themselves later.

The Friday for Future regarded as a whim or, more benevolently, as teen idealism, typical of the age in which you believe you can reshape the world and change the same things you will embrace and protect with maturity. Disillusion and cynicism push, for different reasons, in the same direction: some hope to block or defuse the protest, others have stopped dreaming and believing. None of them deserves the last word in a debate that they have always avoided.

Awareness-raising and information have been useful. Today, at least in the younger generation, there is a clear perception of the problem: "No planet B". The average increase in temperatures in the last five years is 1.1 ° C; carbon dioxide emissions keep growing and only last year we arrived at the record figure of 37 billion tons of CO₂; 159 billion tons of ice lost each year in the South Pole (three times what happened in 1990); in the last half century the demand for water has doubled and two billion people live in countries that no longer have enough water to meet basic needs. Facts.

Those who have contributed to determining those situations should feel embarrassed. On the contrary, they contest the figures in words, without scientific evidence. Like the Clintef group, made up of 75 Australian businessmen, retired managers, engineers and geologists, who wrote to the Secretary of the United Nations Antonio Guterres to say that "there is no climatic emergency".

In Kabul students, defying the risk of attacks, take to the streets for the future, when the war continues to deny them even the present. Their courage tells us where the reason lies and the priorities: nothing is more urgent and global than the protection of the planet earth and its inhabitants. The irrational use of natural resources and the possibilities offered by technological progress has made what was abundant insufficient. Which is the problem? Climate or man? The man turned the climate into a problem, and he has to solve it. The boys are just reminding us of our obligations. 

CCS and coal: the carbon no one wants to capture

The coal mining companies still backing CCS as representing a clean future for their product have become somewhat isolated from the rest of the CCS community. Why?

By TOBY LOCKWOOD

ONE

Ten years ago, carbon capture and storage or 'CCS' went hand in hand with the idea of 'clean coal'. Although early efforts to capture CO₂ emissions and store the greenhouse gas deep underground had mostly taken place in other industries, coal power's enormous contribution to global carbon emissions was seen as the obvious grand prize for this ambitious climate change-mitigation technology. At the time, governments interested in CCS, such as the US, Canada, Australia, and the EU, led a host of projects aimed at developing CCS for their own coal fleets, as well as attempting to launch projects in China.

Now, following years of mostly disappointing progress, interest in CCS has reignited in several countries, but it is much less frequently linked to coal power. Many advocates for the technology argue that it should be reserved for cleaning up emitting industries, which can't be helped by renewable energy, such as steel and cement, or used to help achieve 'negative' CO₂ emissions by storing CO₂ produced from bioenergy.

This is arguably an exercise in rebranding; after years of failing to gain meaningful government support, and dogged by accusations of serving merely as a fig leaf for an irredeemable coal industry, many CCS supporters tacitly acknowledged that any association with coal was not helping the case. As a result of this shift in narrative, the coal mining companies still backing CCS as representing a clean future for their product have become somewhat isolated from the rest of the CCS community, and more subject to accusations of ulterior

motives than ever.

A recent *Financial Times* article scrutinising the CCS-promoting activities of Australian coal-mining giant Glencore is indicative of this trend. Although seeking to present a balanced view, the piece draws heavily on ardent critics of CCS, whose views are as deserving of scrutiny as those of Glencore. Coal power remains the world's single largest source of electricity, and the biggest contributor to CO₂ emissions; it is therefore inevitable that its role in our efforts to decarbonise is more nuanced. It is true that the case for deploying CCS on coal power is diminished in some regions from ten years ago.

The article cites the well-known cost reductions in wind and solar power, which have made some forms of those technologies cheaper than coal in several parts of the world. Perhaps more importantly, there has been a marked shift from coal to gas power in many Western economies, particularly in the US and the UK, driven by cheap gas or high carbon prices. In these countries, where building things is relatively costly, the capital required for large coal plants can also sometimes outweigh any fuel savings made over more compact gas plants.

However, Glencore does have some important numbers on their side. The company regularly turn their detractors to

the role of CCS in decarbonisation pathways produced by the International Energy Agency (IEA) or the Intergovernmental Panel on Climate Change (IPCC). These organisations run com-

**The coal mining companies still backing
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A plant used for testing carbon capture and storage in Tomakomai, Hokkaido.
Photo credit: JAPAN CCS CO.



puter models which seek to determine the lowest cost route to achieving targets such as limiting global warming to 2°C or 1.5°C in the next few decades.

Despite huge growth in renewable generation in all these pathways, CCS still features heavily, and a significant proportion of it is still on coal power. How does this square with its newly acquired status as a worthless anachronism?

The IEA's most recent Sustainable Development Scenario, consistent with keeping global warming to 'well below 2°C' features 210 GW of coal power fitted with CCS by 2040, mostly in China and the US, along with 169 GW of gas power with CCS. More detailed IEA analyses typically show CCS

must capture similar amounts of CO₂ from the power sector as it will from all other industries combined.

These results stem fundamentally from two basic facts: firstly, there is an enormous amount of coal power plants around at the moment, half of which are less than 15 years old; secondly, even if there were some prospect of closing these plants early (unlikely in energy-hungry countries like China and India), completely replacing thermal power plant is not so straightforward.

While the Financial Times article makes much of the decline of coal in the UK, less is said about the country's continued interest in gas power with CCS, with a few government-bac-



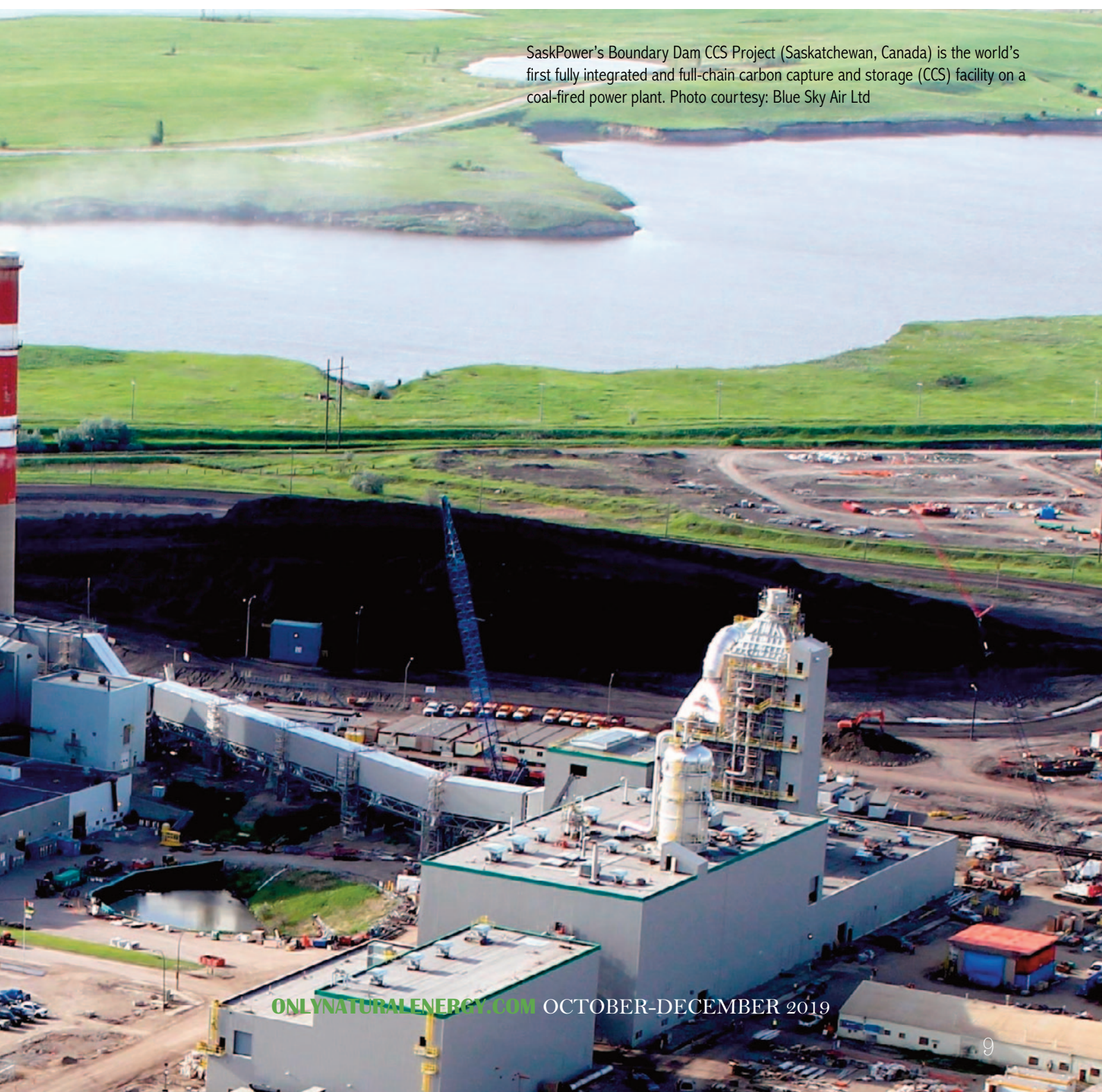
ked projects currently in various early stages of development.

This is illustrative of the difficulty in achieving a zero-carbon energy sector with renewables alone, as wind and solar power do not generate all the time, and require some kind of back-up for when they do not.

And while gas power with CCS is now more economical in much of the West, for Asian countries, where gas is expensive and capital cheap, coal power with CCS comes out on top. Climate models do not care that the gas plant started off slightly cleaner than the coal plant: once fitted with CCS, they produce equivalent low-carbon energy.

This kind of argument for retaining some form of 'dispatchable' back-up power plant is usually met with appeals to the rise of energy storage technologies, and the falling cost of batteries in particular. To make this point, the Financial Times article, unfortunately, refers to dubious cost figures from a US-focussed 2018 report on CCS by the Institute of Energy Economics and Financial Analysis (IEEFA) – a group with a mission to accelerate a specific form of energy transition rather than the academic institute that their name suggests.

The report cites bids made in recent US auctions for power purchase agreements (PPAs) for new 'solar and storage' (\$35/MWh) and 'wind and storage' (\$21/MWh) projects in Indiana and Colorado respectively. Such low bids are impres-



SaskPower's Boundary Dam CCS Project (Saskatchewan, Canada) is the world's first fully integrated and full-chain carbon capture and storage (CCS) facility on a coal-fired power plant. Photo courtesy: Blue Sky Air Ltd

sive and positive news, but these projects are not equivalent to a CCS power plant. They typically relate to a renewable plant with some battery capacity to help with grid stability and to better match generation to peak demand. This does not mean that power is available whenever required. Such competitive prices are also based on projects receiving capacity payments and federal subsidies for wind and solar, such as production and investment tax credits.

In its latest 'World Energy Outlook' the IEA cautions against the use of PPA auctions as a general indicator of renewable costs, and gives a figure of around \$80/MWh as a 'world average cost' for solar power with favourable financing conditions. Perhaps most telling in the US context is the fact that conventional fossil plant is still very much alive, in the form of natural gas power plants which represented over 60% of new generating capacity in 2018.

Several of the contributors to the Financial Times article appeal to a widespread but rather circular argument that CCS should not be pursued because it has so far been deployed at such small scales. There are only two coal plants currently operating with the technology, and even these are decried for being smaller than the largest power plants.

The piece strikingly illustrates the poor progress with a graphic contrasting the emissions captured in one year by the existing Boundary Dam CCS coal plant in Canada (626 thousand tonnes) with the 10 billion tonnes emitted annually by coal power worldwide (nearly a third of all CO₂ emissions).

Leaving aside the puzzling omission of a second, much larger CCS coal plant operating in Texas, this comparison should serve only to remind us that most efforts to reduce CO₂ emissions appear a drop in the ocean compared to the immense scale of the challenge the world faces, even for comparative success stories like the rapid growth in solar power.

In 2017, there were 460 TWh of solar power generated worldwide; if we assume that this renewable power has replaced the same amount of gas-fired generation, it has avoided only around 180 million tonnes of CO₂ (or around twice this amount if we assume coal is replaced). This is less than five

times the total emissions captured by the handful of CCS plants currently operating in all industries – remarkably similar figures for technologies with ostensibly such varying fortunes. In reality, the failure of CCS deployment to snowball in the same way as wind and solar power is evidence of nothing more than the lack of money to be made in storing CO₂. The two technical demonstrations in Canada and Texas, have shown that it is entirely feasible to capture and store CO₂ from coal plants, but both rely on using the gas to boost oil-field production for it to make some kind of commercial sense.

IEEFA condemns this practice in the Financial Times piece, yet it is merely filling a gap where government incentives would normally have to play a role. The remarkable growth in wind and solar power has thus far been driven not by their low cost, but by government subsidies which have then been

rewarded by falling costs. This kind of positive feedback can also occur for CCS, and may do so in the US now that the government has introduced a new tax credit for storing CO₂.

Arguably, opponents of the use of CCS on coal power specifically are

left with a more problematic position than those who oppose the technology outright. If one accepts the models showing an urgent need for CCS, then one must also accept the important role shown for it in the coal sector, regardless of any personal distaste for the black stuff. And if the – admittedly formidable – task of building a large-scale infrastructure for collecting and storing CO₂ is to be embarked upon, it would be odd not to use it to address power plants.

The shift in CCS dialogue away from coal can be partly attributed to a Western-centric view that gas is visibly replacing coal anyway, but in Asia and many other parts of the world, coal continues to dominate and other approaches are needed.

While Glencore's motivation for backing CCS is doubtless not purely motivated by concern for the planet, this does not in itself mean that the arguments they present are without merit. Reducing our carbon emissions to the levels required is a gargantuan task, and will require much greater use of all the options available to us if we are to have any chance of succeeding. **ONE**

Several of the contributors to the *Financial Times* article appeal to a widespread but rather circular argument that CCS should not be pursued because it has so far been deployed at such small scales.

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When rich economies cut emissions, poor ones stand to benefit, study says

By ASHOKA MUKPO
News Mongabay

If higher and middle-income countries cut their greenhouse gas emissions in half by 2050, reduced demand could lower oil costs and boost economic growth for low-income countries, according to a study published in the journal *Climatic Change* in April. To benefit from that cheaper oil, low-income countries would have to be exempted from emissions requirements until they reach middle-income status.

However, emissions last year hit an all-time high, and without drastic emissions reductions, low-income countries currently face economic, social and environmental catastrophe. The world is currently on course to be 3 to 5 degrees Celsius (5.4 to 9 degrees Fahrenheit) hotter by 2100, leading to food crises, natural disasters, and disease outbreaks that will disproportionately affect the poorest people.

When Cyclone Idai hit the coast of Mozambique in March, it tore through towns and neighborhoods, flooding fields of maize and killing hundreds of people while displacing thousands more. An official of the World Meteorological Organization said the storm was “one of the worst weather-related disasters” ever to hit Southern Africa. Just over a month later, a second storm hit, causing another wave of destruction. This one, Cyclone Kenneth, was said to be the strongest ever recorded in the region.

“What used to be rare is not rare anymore,” said Sudanese meteorologist Abubakr Salih Babiker from the Intergovernmental Authority on Development’s (IGAD) Climate Prediction and Applications Centre. “Climate is changing and we really need to do something about it.”

Three-quarters of the countries the World Bank classifies as “low-income” are in Africa, and the worst impacts of the climate crisis will fall squarely on them. Reducing emissions is a matter of life and death; in fact, according to a study published in the journal *Climatic Change* in April, getting global emissions under control might do more than just spare those countries the worst impacts of climate change — it could also be a boon to their economies.

A 50 percent reduction in emissions by 2050 would cause oil prices to fall, the study says, which would boost economic

growth in the world's poorest countries if they're allowed a longer timetable to transition off fossil fuels.

Drier, hotter weather spells danger for agriculture

The study uses an advanced computer model to analyze the impact of temperature increases on three countries in Southern Africa's Zambezi River Basin: Mozambique, Malawi and Zambia. On the world's current emissions trajectory, by 2050 all three are predicted to suffer significant economic damage from severe weather patterns, including flooding and drought. The study suggests a high likelihood that growing seasons will become hotter and drier, which could mean failed harvests and food shortages.

Under this “unchecked emissions” scenario, all three countries are also expected to have GDPs that are substantially lower by 2050 than they would have been without the effects of climate change. In Mozambique, the model predicted a GDP that could be as much as 11 percent smaller than it might otherwise have been.

“We were motivated to see how much of a difference we really get in temperature and precipitation and how much that reflects back into economic outcomes, and it was more distinct than any of us would have guessed,” said Channing Arndt, the study's author and a director of the International Food Policy Research Institute in Washington, D.C.

Fossil fuel exemption for low-income countries

Last year, the Intergovernmental Panel on Climate Change warned that limiting warming to 1.5 degrees Celsius (2.7 degrees Fahrenheit) above pre-industrial levels would require “net-zero” emissions by 2050. Arndt says his team chose to illustrate a scenario where emissions were only cut by half because it's a “gradual decline that's much easier than net-zero by 2050.”

According to the study's model, if the world halves emissions by 2050, low-income countries could see sizable economic gains. As developed and middle-income countries curb emis-



Household takes refuge from the rain in central Malawi.

Photo credit: ILRI/Stevie Mann

sions, they would have to cut back on fossil fuel consumption, which would sharply lower the price of oil on world markets. If low-income countries were allowed to benefit from those low oil prices by being granted a temporary exemption from restrictions on their emissions, they could see higher GDP growth than they otherwise would have experienced.

In Mozambique, the study predicts low oil prices could mean a GDP that's around 2 to 3 percent higher than it would have been even under a hypothetical scenario where its climate didn't change at all, and much larger than the contracted economy it's on course for now.

Arndt says the benefits of cheaper oil would extend to nearly all of the 31 low-income countries. But to benefit from those low prices, they would need wealthy and middle-income countries to agree to allow them to be initially exempted from a global emissions reduction plan.

That isn't a far-fetched scenario, says Timmons Roberts, director of the Climate and Development Lab at Brown University. The 2015 Paris Agreement, for example, already contains language acknowledging the "special circumstances" low-income countries face in joining mitigation efforts. "I think it's fairly non-controversial that they would have a right to keep burning fossil fuels longer than anyone else," he said.

Roberts says transitioning to green energy is politically challenging, and wealthy nations should prioritize efforts to finance that transition in low-income countries sooner rather than later. But in the absence of that assistance, for those countries "it probably is cheaper to keep burning fossil fuels."

Altogether, the 31 low-income countries in the world generate only 0.67 percent of global GDP. Arndt says this means that even if they are exempted from emissions regulations until they graduate to middle-income status, they'd still be "hard pressed to come to more than 1% of current global emissions."

For those countries to benefit from low oil prices caused by a reduction in global emissions, however, the world would have to dramatically shift course and wean itself off of fossil fuels. For the moment, that seems unlikely, with emissions hitting an all-time high last year. The study is part of a growing body of work that uses data to illustrate the links between carbon emissions and economic development in the global south. In April, researchers at Stanford University published a paper showing that warming trends have already made inequality between the world's richest and poorest countries worse than it would have been without today's higher temperatures.

For Anabela Lemos, director of the Mozambican environmental organization *Justiça Ambiental*, the two cyclones that hit her country in March and April were a grim sign of Southern Africa's vulnerability to the impacts of climate change, and the need for wealthy nations to take the problem seriously.

"What developed countries owe not only to Mozambique but to the rest of the planet is to stop emissions," she says. "People will feel the effects of these cyclones for years. They lost everything."

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When fracking companies own the gas beneath your land

By MAYETA CLARK*

ProPublica

When Beth Crowder and David Wentz bought their 351-acre property in West Virginia in 1975, they knew that they would only own the surface land, not the minerals beneath it. But it didn't bother them.

"They showed us gas wells, which were these two tracks in a field where a vehicle would go to, to check on them monthly or even less often," Crowder recalled. "They were really very, very innocuous."

At that time, Crowder and Wentz did not envision what future drilling technology might entail and the scale of disruption it would bring to their lives. (They subsequently divorced, but both continue to live on the land.)

Since the mid-2000s, however, drilling companies have crisscrossed West Virginia using a technique that allowed them to drill horizontally from one property into gas deposits across a wide area. The boom is reshaping how West Virginia looks and sounds, as the Charleston Gazette-Mail and ProPublica documented last year.

Before 2007, West Virginia issued only a few dozen permits for horizontal drilling. Over the last decade, the state has issued nearly 5,000.

A new documentary released today by ProPublica and CBSN Originals shows how Crowder and Wentz found themselves right in the middle of this boom.

In late 2010, Crowder ran into a survey crew on the dirt road leading to her home. She learned of plans for a large well site on the property, which would include a 13-well "pad." Crowder and Wentz fought back against the gas driller on their property, Pittsburgh-based EQT. They hired a lawyer and sent letters telling EQT that it did not have the right to build the pad site.

EQT went ahead anyway, clearing 42 acres of forest, some of which Wentz had cultivated for years for timber. The company put in a road, a 20-acre well pad and a storage pond.

Drilling and fracking just one of the wells that EQT built on Crowder and Wentz's property required almost 11 million gallons of water and 1.8 million pounds of sand, all of which had to be trucked to the site. By comparison, vertical wells drilled on the property previously used just 305,000 pounds of sand in total.

West Virginia law states that mineral owners have the right to do what is "reasonably necessary" to access their minerals. But the legal concept of "reasonably necessary" was developed at a time when gas wells were a few pipes sticking out of the ground.

The majority of gas that EQT extracted from the well site on the property did not come from beneath Crowder and Wentz's land, but rather from neighboring properties. The 1901 lease gave the company the right to produce gas from beneath the land owned by Crowder and Wentz, but it did not give them permission to use their land to drill into neighboring tracts.

In 2014, they sued EQT for trespassing. In 2017, they won a \$190,000 victory in Doddridge County Circuit Court. EQT later appealed to the West Virginia Supreme Court.

Filing a lawsuit against a gas company in West Virginia is a difficult decision. Judges are elected in the state and some, including Supreme Court justices, receive donations from the industry for their election campaigns. Natural gas companies are also valued in communities where work is scarce.

In the last decade, the number of jobs provided by the sector has risen from around 8,000 to over 18,000, with average sa-



West Virginia law states that mineral owners have the right to do what is “reasonably necessary” to access their minerals. Photo: Pxhere.com

laries ranging from \$67,000 to more than \$117,000, compared with \$45,000 for most private-sector jobs in West Virginia, according to an analysis of data collected by Workforce West Virginia.

In 2018, more than half of the natural gas jobs were in the highest paid category, pipeline construction. But those jobs will likely decline in the next few years as the need for new pipelines diminishes.

On June 5, the West Virginia Supreme Court unanimously ruled in favor of Crowder and Wentz. The court said that natural gas companies must get permission from surface owners to use their land to drill into minerals under neighboring properties. “The right must be expressly obtained, addressed, or reserved in the parties’ deeds, leases, or other writings,” Justice John Hutchison wrote.

For Crowder, Wentz and their lawyers, the decision was grounds for celebration. “The short answer is, we won. And we won big time,” David McMahon, the couple’s lawyer, told them over the phone. “It isn’t April Fool’s Day, is it?” Crowder asked, while

Wentz, usually taciturn, cheered.

Joshua Fershee, a West Virginia University law professor who followed the case, said that the decision is not going to stop the drilling, but it will cost drillers more. “This is just really about making sure that people are compensated for giving up their rights,” he said.

A representative from EQT said in a statement last month that since November 2018, a new management team has been in charge of the company, and it has undergone a “cultural transformation.” The company now seeks “to maintain more cooperative relationships with landowners and the residents of the communities in which we operate.”

**(Charleston Gazette-Mail staff writer Ken Ward Jr. and ProPublica news applications developer Al Shaw contributed to this report.)*

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Museums for future

Museums, science centers, zoos, aquariums, and similar institutions, can be a valuable resource to disseminate knowledge about climate change.

By LENORE HITCHLER
ONE

Droughts, fires, severe storms, floods, and other calamities are increasing dramatically because of climate change. Humanity is charging into its human-made disasters caused by increased levels of greenhouse gases which are produced when burning fossil fuels. And there are still millions who deny that climate change exists. To increase support for initiating stronger measures to stop climate change, it is evident that more people need to become educated about it.

Museums, science centers and similar institutions, including zoos, aquariums, and planetariums, are excellent places to disseminate knowledge about climate change. The American Alliance of Museums reports 98% of Americans, across all ages, races, and geographical locations, consider museums to be educational.

Museums have great potential to reach many people. According to the American Alliance of Museums, there are 850 million visits each year to museums. According to the book, *Museums of the World*, by De Gruyter Saur, there are 33,000 museums in the US and 55,000 museums globally. These are a lot of popular venues for reaching the public.

Historically, museums have not adequately reached out to the general public, especially the poor and minorities. Since climate change particularly harms the poor, minorities, and women in the third world, museums have an excellent opportunity to attract these groups by designing exhibits to show how climate change will mainly affect them. In turn, these new museum visitors will be more likely to support museums.

Being able to trust sources of information is very important in convincing the populace that climate change exists. In a

study regarding which sources are trusted by people, a majority of the respondents didn't trust governments as regards to climate change.

For example, 66% of Australians, along with 73% of polled residents in New York State, New York City, and New Jersey lacked confidence in national governments. Furthermore, 81% distrusted industry and corporations as informative sources on climate change. By contrast, 66% in Australia and 56% in the US trusted museums. They are considered the most trustworthy source of information in the US, and they are rated higher than local newspapers, nonprofits researchers, academic researchers, and the US government. The American Alliance of Museums asserts that museums are considered a more reliable source of historical information than books, teachers or even personal accounts by relatives.

Respondents in museum surveys feel that museums should include information on climate change. An Australian online survey dealing with the role of museums and science centers found that 76% felt that they should communicate leading-edge climate science.

The idea that museums should provide information on how individuals can change their lifestyles and make consumer choices to reduce greenhouse emissions was supported by 71%. The assertion that these institutions are in a unique position to challenge people's ways of thinking and shift people's point of view was supported by 80% of respondents.

There are several roles that museums could fill in changing attitudes and behaviour about climate change. First of all,



they should provide evidence to refute the claims of climate deniers. They can provide information to those with little knowledge of climate change. Besides, those already concerned might become motivated to become personally involved in the climate change movement.

Additionally, the media is not adequately covering climate change, and this is another reason for museums to do so. For example, in 2018, the major television network nightly news and Sunday morning political shows (ABC, CBS, NBC, and the Fox News Sunday morning show) spent merely 142 minutes on climate change.

Unfortunately, exhibitions about climate change might cause difficulties for museums. Individuals might jeopardize their employment if the institution is challenged by powerful government or private leaders. The institution itself could

lose critical funding and acquire new political enemies.

However, countering this dilemma is the fact that current conditions of life on the planet are in jeopardy. Climate change in the past led to massive extinction rates. Therefore, those who can reach the public should be expected to stand up for science and the future of species now inhabiting the planet.

Museums of natural history are great places to teach about climate change as they already include botany, zoology, biodiversity, and geology. Climate change exhibits can be based on what these museums have previously collected and studied.

History museums are also important venues to educate about climate change. For example, the Little Ice Age is a

good topic for European museums. The climate was greatly disrupted during this time with many scholars seeing a direct relationship between the Little Ice Age and plagues, famines, witch trials, and social upheavals. And all this occurred because of a mere 2 degrees change in the temperature! US museums could examine the relatively new theory that during early colonialism there was a high death rate of Native Americans, especially from European diseases. Their former lands reverted to forests leading to cooling temperatures.

Along with natural history museums, botanical gardens, zoos and aquariums are great places to learn about the effects of climate change on plants, fish, other animals, biodiversity, and entire ecological systems.

The World Association of Zoos and Aquariums found that more than 700 million people visit zoos and aquariums worldwide per year. An article in Scientific American reported that annually 183 million Americans visit a zoo or aquarium.

According to the American Zoo and Aquariums Association (AZA), there are over 10,000 zoos worldwide with 2400 in the US. Thus, these venues offer many opportunities to provide information on climate change.

The AZA states that: *By communicating about the impacts of climate change on wildlife and habitats, AZA and its member institutions can play an important role in inspiring people to take personal and civic action that will help decrease atmospheric CO2 concentrations to protect humankind's wildlife heritage.*

Thus, zoos and aquariums are excellent places to educate many about climate change. An excellent example of a zoo exhibition is the "Journey to Churchill" located in Winnipeg Canada, which connects visitors with the impacts of climate change on the animals and people of the Arctic. On ten acres there are animals including caribou, foxes, wolves and polar bears plus lots of multimedia information presented in various buildings.

The Monterey Bay Aquarium in California is a great example of how aquariums can contribute to knowledge about climate change. Sarah-Mae Nelson is the Climate Change Interpretive Specialist there. The organization "Climate

Interpreter" has around 500 members and is involved with US educators at aquariums, zoos, museums, parks and marine sanctuaries. In an interview, she gave a frightening example of climate change already occurring. She said that twenty years ago, an exhibit contained five rocks that were covered with cobalt blue sponges, which is a sponge which lives in cold water. Now because of rising sea temperatures, not one rock has that sponge living on it. In 2010 the aquarium hosted one of the first aquarium exhibits in the country, entitled "Hot Pink Flamingos," to focus specifically on climate change.

"Narrative—whether in words, pictures, or film—is the best technology we have for making the inhuman scale of climate change understandable."
Jeffrey Cohen

Botanic gardens, numbering 1775 worldwide, are also good venues for climate change education. According to the Botanic Gardens Conservation International 300 million visitors visit botanic gardens yearly.

An example of a botanical garden exhibition on climate change is "Klimagarten 2085" which is co-sponsored by the Botanical Garden of the University of Zurich.

One greenhouse will be set at 2 degrees centigrade above the current annual summer temperatures, whereas the second greenhouse will be 4 degrees higher. Therefore, the rates of plant growth will enable comparisons between what the Swiss currently produce and consume and what may happen to these crops in the future.

Art museums are also appropriate venues for climate change as shown from the following quote by Jeffrey J. Cohen, professor of environmental humanities: *Narrative—whether in words, pictures, or film—is the best technology we have for making the inhuman scale of climate change understandable. The data that environmental science generates isn't always compelling because it isn't storytelling. The arts and the humanities know how to change hearts as well as minds.*

College and university art museums are excellent venues for climate change exhibits. In 2010, art museums at Bowdoin College, Brown University, and the Universities of Colorado Boulder, Maryland, Michigan, Utah, Yale and Princeton were all sites of climate change exhibitions. Children's museums provide excellent venues for reaching our future leaders. The Scarborough Rotunda Museum in England hosted an interactive exhibit entitled "Future Fossils" in September

2019. Visitors were met by the “Chief Investigator from the Future Fossils Federation” who led them to a “secret place” where they heard voices of Scarborough’s young climate activists and were invited to make pledges to combat change. In the “research lab” they “looked at the current climate crisis in a vibrant and theatrical way.”

The Tel Aviv Museum of Art is currently hosting a climate change exhibit entitled “Solar Guerilla: Constructive Responses to Climate Change.” It includes various projects from around the world that deal with climate change in new and innovative ways.

The following are a few museum exhibitions that show ways in which museums are responding to climate change. They show the possibilities of what all museums could do to educate and motivate members of the general public.

The Smithsonian National Museum of Natural History has recently reopened its fossil hall. Every fossil is presented in the context of past climate change and helps to explain current climate change. Besides exciting dinosaur fossils, there are other fascinating fossils, such as a fossil palm leaf originally from Alaska.

Kirk Johnson, director of the museum, points out that at one time the North Pole had no ice, and fossilized crocodiles, turtles, and palm trees have been discovered there. An interactive game teaches about the effects of climate change on such popular things as chocolate, flowers, and beaches and also shows ways people can lower their contribution to greenhouse gas production. Johnson states: *“The cumulative effect is that no person will be able to walk through the hall ... [which] is the most visited room at the most visited science museum in the world, without contemplating climate change and humans’ role in it.”*

The American Museum of Natural History is located in New York City and is visited by five million people annually. It includes a permanent exhibit entitled “Our Changing Climate.” This museum also collaborated with the Museum of Samoa in an exhibition entitled “Rethinking Home: Rethinking Climate, Linking Samoa and New York.”

It dealt with both the aftereffects of Hurricane Sandy in New York and Cyclone Evan in Samoa. One of the goals of the joint venture was to help people from different backgrounds respond to impacts from climate change, and it is an excellent example of museum contributions to climate justice.


The Jockey Club Museum of Climate Change is located at the Chinese University of Hong Kong and was the first museum solely dedicated to climate change. Travelling exhibits are very useful as they reach people not able to attend traditional museums. Portable displays are also great for museums as they can share both the cost and the benefits of specific exhibits.

Various universities have produced traveling climate change exhibitions. The Yale Peabody Museum of Science presented an interactive traveling exhibition that showed how New England is affected by climate change. The Oregon Museum of Science and Industry produced an exhibit on permafrost, which is soil that is frozen the whole year. This is an essential exhibit because one of the major effects of climate change is to melt the permafrost, which then releases methane, a potent greenhouse gas, previously trapped in it

Sweden has already produced several traveling exhibitions on climate change. Lund University in Sweden created a traveling presentation which portrays an imaginary exhibit from 2053 and in this futuristic exhibit the Swedish government has opened a museum named FOSSIL.

The exhibition is called “Carbon Ruins” which celebrates that global net-zero carbon dioxide emissions were reached in 2050. The aim of “Carbon Ruins” is to make visitors feel that they are in the period where the transition to post-fossil society has already occurred. Exhibit visitors see many relics from when humanity was dependent on fossil fuels, including plastics, frequent flyer forms, and remnants from the fast-food industry. Another traveling exhibit in Sweden presents significant threats of climate change and also promotes hope.

More museums dedicated solely to climate change are planned for the future. The Climate Museum will be located in New York City. It will use both science and art to respond to climate change. The Climate House will open at the botanical garden in Oslo, Norway in 2020.

Thus, natural history, science centers, historical and art museums, and other similar institutions, such as zoos, aquariums and botanical gardens have a significant role to play in stopping climate change. There are millions of museum visits to thousands of museums, and museums are considered to be both educational and trustworthy by the general public. Now the challenge is to reach new audiences to order to save our current environment. 

How Islamic finance can build resilience to climate change

By MARAM AHMED
World Economic Forum

In arid and semi-arid lands (ASALs), extreme weather manifestations such as droughts caused by prolonged dry spells, among other climate stressors, put ASALs at risk and intensify conflicts.

Worsening climate change impacts such as extreme rainfall fluctuations and temperatures are having a negative impact on agricultural food production, livestock value chains and livelihoods.

To tackle Sustainable Development Goal number 13 ("take urgent action to combat climate change and its impacts"), financial inclusion can be used as a tool to provide much-needed access to financial services for ASALs. This in turn can help vulnerable communities break a vicious cycle to better prepare and cope with climate change shocks such as droughts or floods.

Given that a significant proportion of those in ASALs are Muslims, Islamic finance can be a stimulus for that financial inclusion. It creates the opportunity to include those with little to no access to financial services without compromising their religious beliefs.

Islamic finance as a catalyst

The connection between financial services and climate adaptation and resilience is clear. A growing body of research suggests that greater access to financial services allows people to manage risks, plan and mitigate shocks – through savings, borrowing, remittances and digital payments.

Take the Kenyan county of Wajir, situated in an arid part of northern Kenya: 90% of its population is Muslim, who are financially underserved making it difficult to save for a rainy day – or lack of rain in this context. In its latest report, the National Drought Management Authority warned that in the current crop season Kenyan counties

in arid and semi-arid lands will see a 50% decline in food production as a result of erratic rains.

In such instances, enhancing financial inclusion can help people prepare for environmental irregularities and provide a financial safety net in the face of climate change shocks.

A project set up by international humanitarian agency Mercy Corps aims to do just that: Crescent Takaful Sacco, a microfinance institution, established a Wajir branch in 2016 as the county's first private cooperative to offer Islamic financial products. The initiative was led by Mercy Corps with a big proportion of the clientele being pastoralists (typically nomadic, livestock farmers).

Underbanked and financially underserved, there is a dearth of financial products and services that adhere to Islamic principles available to pastoralists. The aim of the initiative was to "try to fill a gap that banks and traditional institutions are not able or willing to fill" given that a significant number of the pastoralists and farmers are Muslim.

Expanding access to Islamic financial services for climate adaptation

While the experiences of the north-Kenyan county are distinct, there are some lessons that can be learned by ASALs in member states of the Organisation of Islamic Cooperation (OIC).

Firstly, Islamic microfinance institutions can fill a vital gap not met by conventional microfinance institutions by targeting pastoralists – the majority of which are underbanked with enormous untapped potential.

Pastoralism is the backbone of Wajir county and a crucial source of income. Livestock production accounts for more than 12% of Kenya's GDP, 60% of Kenya's livestock

herd are found in ASALs, and an estimated 13 million pastoralists rely on livestock.

Access to credit can help pastoralists mitigate the loss of livestock and cope with frequent droughts, as in times of drought, they are at risk of their livestock dying. Credit can provide this group with a financial safety net and give them the ability to feed their animals in dry periods. The second lesson to learn is that trust is an important component that can be used as a guarantee for those with little to no collateral.

A social collateral approach is taken by Crescent Takaful Sacco. The microfinance institution lends money to groups instead of individuals and "the group's cohesion and reputation acts as a guarantee".

This group-based lending approach is similar to the concept of asabiyah, otherwise known as social solidarity,

first coined by philosopher Ibn Khaldoun. A collateral substitute method can be a viable way to integrate financially underserved groups, such as pastoralists, into the formal financial system.

Financial inclusion will only become more essential in the face of growing climate change impacts such as prolonged droughts and erratic rainfall.

Given the principles of social justice and inclusion, Islamic finance can help boost resilience to climate shocks. It should be employed to enhance financial inclusion especially in arid and semi-arid lands where climate change is increasing instability and conflicts.

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A Saba Islamic Bank branch in Djibouti.
Photo credit: Abass Chirdon

Nuclear, a waste of time?

By ALICE MASILI

ONE

One kilogram of Uranium 235 generates the same amount of energy derived from the combustion of 2 million kilograms of coal. Thermoelectric power plants rely on coal, oil, hydrocarbons, whereas nuclear power plants use Uranium 235 bars, whose fission produces heat converted into electrical energy.

From any economic but also emission reduction policy perspective, there is no competition between nuclear power plants and all other types of power plants — nuclear wins. But there is also the other side of the coin.

Presented as one of the possible answers to the CO2 emissions problem, the exploitation of nuclear energy involves severe potential risks, first of all the disposal of radioactive wastes and the dispersion of harmful radiation.

As reported by the 2019 Greenpeace report "La crise mondiale des déchets nucléaires" (The global nuclear waste crisis), nuclear wastes are still in need of a permanent solution. The study analyses the situation in Belgium, France, Japan, Sweden, Finland, Great Britain and the United States and concludes that none of those countries has a detailed long-term plan to manage nuclear wastes.

According to Greenpeace, in the world, there are 250 thousand tons of highly radioactive waste, concentrated in fifteen countries. The biggest part is stored in cooling pools within each power plant area. A considerable quantity, if we consider that such waste cannot be treated or kept, without enormous precautions. This inevitably also entails very high costs, but none of the seven countries, Greenpeace says, produced a credible estimate of the total expenditure required in the future decades.

In Europe, nuclear wastes are generally stored near the four plants or in surface storage centres. The main European storage centres, all no-geological, are Le Hague (France), Sellafield (Great Britain), Oskarshamn (Sweden) and Olkiluoto (Finland). All European storage centres have a temporary nature to respond to the reversibility criterion - the wastes

transfer to other places is always possible, which makes them more flexible in case of problems. A plan b is on the cards. Such a flexibility is absent for the materials hosted underground in the geological sites permanently - buried for good.

Nevertheless, the first permanent deposit of nuclear waste is almost completed. Thanks to engineering solutions and advanced safety devices, Finland will become the first state in the world to have a radioactive waste warehouse, designed to withstand hundreds of thousands of years. The Onkalo tunnel, camouflaged in the dense vegetation of the forest of Olkiluoto, goes down over 450 meters deep. The structure ramification includes 137 more underground galleries. When the deposit is working, the slag will be placed in cast iron bins of 25 tons of capacity, covered with a layer of pure copper. Each will be housed in a custom-built slot lined with bentonite (a type of clay that swells on contact with water, also used in cat litter).

The local rock in which the tunnel was dug, the gneiss, is geologically stable, and it should keep the water away. Bentonite can absorb all traces of residual moisture, and the deep groundwater, below the deposit, is low in oxygen and not acid. Copper is one of the most stable substances on earth, and even if water reaches the bins, it will take millions of years to erode the coating.

Meanwhile, the waste inside it would be degraded to materials no longer dangerous for the environment and humans. The Onkalo storage centre will start operation in 2025. The depot will host over five thousand tons of waste and count seventy kilometres of tunnels. By 2080 it will be able to hold 6500 tons of radioactive waste for a time corresponding to the life of four thousand human generations.

The United States was trying to do something similar with the Yucca Mountain depot but the federal funding ended in 2011 under the Obama administration.

The underground Exploratory Studies Facility at Yucca Mountain in Nevada built by the US Department of Energy to determine whether the location was suitable as a deep geological nuclear waste repository.
Photo courtesy: US Department of Energy



In the Trump administration's view, it still makes sense to have a central repository. "But it is difficult to imagine that the shipment of over 5,000 barrels of high-level nuclear waste trucks over 50 years does not involve at least one radiological release," Nevada Democratic Senator Jacky Rosen said.

Yucca Mountain is near the most extensive munition Air force testing area, which increases doubt and fears. In the end, the U.S. House Appropriations Committee discussed the issue and decided not to fund the Yucca Mountain project again. However, the Senate is still considering it, and both supporters and opponents claim that the fight is not over yet.

In the USA, the WIPP (Waste Isolation Pilot Plant), a pilot plant for the disposal of long-life plutiferous waste produced in the centres of the federal government (the so-called defense wastes) is in operation since May 1999. The WIPP is the first and only deposit of geological disposal in the world, even if its aims are particular and it is not intended for high activity radioactive waste of classic type and commercial origin (vitrified waste or irradiated fuel).

Underground experimental laboratories are under construction or in operation in France, Germany, and Sweden. While waiting for a geological disposal site to be available, radioactive wastes with a long-term condition are still kept in plant systems suitable for a few decades storage.

The Chernobyl disaster in 1986, which had lethal consequences for humanity, flora and fauna, irreversibly shook confidence in atomic energy and showcased its limits and weaknesses.

Chernobyl is still a focus of world attention. Recently, to verify the situation of the area, few drones were sent to inspect more than 15 km of territory.

Each drone was provided with a gamma-ray spectrometer, in conjunction with a precision Lidar. The results were alarming: no one thought that after decades, the situation was still so out of control and dangerous. The area around the reactor has been uninhabited for thirty years due to radiation, and it will continue to be so in the next decades due to the high level of contamination.

The nearby town of Prypyat has been deserted since 1986 and, as documented in various photo shoots, nature has slowly transformed the area, with creepers and trees that have returned to grow between the cracks of cement and asphalt. Last July, the new shield of the reactor number 4 was inaugurated due to the collapse of the old protective shell. A special project financed by the European Bank for Reconstruction and Development and sponsored by 45

countries. Even the concrete dome of the Marshall Islands in the Pacific Ocean is beginning to show signs of abating. The structure built by the United States in 1979 to contain the remains of nuclear tests carried out on two Bikini and Enewetak atolls, covers an artificial crater with about 85,000 cubic meters of radioactive waste generated between 1946 and 1958 and stored after 67 atomic explosions.

According to the experts, the foundation situation is particularly worrying. The bottom of the dome is precisely the one left by nuclear weapons, and it is a porous and highly unstable floor. The official report of the Republic of the Marshall Islands warns that marine sediments are polluted by nuclear waste. Another slag from the bottom can threaten the population of the island, especially after a storm. Several tests indicate that coconut palms already present the radioactive isotope Cesium-137.

Last 8 August an accident happened on a marine platform in front of the missile base of the Russian Ministry of Defense of Nyonoska. The missile exploded in the test phase caused 7 deaths and 15 wounded, releasing a radioactive cloud in the air. It did not get the same coverage of Chernobyl and Fukushima, but it rekindled the fear. A report by the French research centre Criirad pointed out that the clear but limited gamma-ray peak found could hide much wider contamination from plutonium 238.

"Nuclear energy is perhaps the best energy solution for the future, but not before having resolved problems of radioactive waste," says Gerard Mourou, in an interview with *Bloomberg*.

The 2018 Nobel Prize for Physics has been engaged in a particularly ambitious project. "The idea is to eliminate radioactivity from waste through a process of transmutation of atoms, which involves a change in the nucleus."

The transmutation would be obtained by "shooting" a beam of protons inside a nucleus through a high-power laser beam, for a very short time. The protons would go to join the core, rebalancing the situation, because a radionuclide is an atomic nucleus that has lost its stability.

A valid idea from a purely theoretical point of view, it needs to overcome quite a few challenges before it can be applied to everyday reality. The rest of the academic world seems not impressed with Mourou's project feasibility. The idea could still take decades before it can be put in practice. Scientists are not alone in their scepticism. Also, public opinion resonates that the same amount of money can be more effectively spent on renewables to achieve better results.

Nuclear wins? Not yet. **ONE**

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Marcin Korolec, Head of Electric Vehicles

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Inching towards abundant water: new progress in desalination tech

By VANESSA BATES RAMIREZ

SingularityHub

In early 2018, Cape Town, South Africa came dangerously close to being the world's first major city to run out of water. People lined up for blocks to collect spring water. Stores sold out of receptacles like buckets and bowls. Bottled water was rationed in tourist-heavy parts of the city. April 12 was designated "Day Zero"—the day the water was expected to dry up. City officials prepared for riots, keeping army and police ready to be deployed to water collection sources.

Rainfall in the region had been low for three years straight, prompting a drought. Thanks to a massive effort by city officials to enforce water conservation—including tariffs, heavy restrictions, and a new water pressure system, plus redirecting agricultural water to the city—Day Zero never came, and rainfall returned to normal shortly thereafter. The city breathed a collective sigh of relief; crisis averted. But the scare was a wake-up call, not only to Cape Town but to water-stressed cities around the world. Mexico City, Sao Paulo, Cairo, and many others are facing water shortages. As the world's population grows and climate change pushes temperatures up, water is set to become even scarcer. If only there was a cheap, easy way to take the salt out of the billions of gallons of seawater sitting within a few hundred miles of all these cities. As it stands, desalination is expensive and energy-intensive.

Getting the technology to a point where desalinated sea water is a viable option for water-starved cities is going to take years, if not decades—but teams of scientists around the world are making incremental progress, slowly moving us towards a water-abundant world.


Desal Tech as it Stands

The most common desalination methods are thermal distillation and reverse osmosis. In thermal distillation, water is heated until the pure vapor separates from the salt and other components. In reverse osmosis, high amounts of pressure push water through a filter to separate it from salt. According to the International Desalination Association, there are 20,516 desalination plants across 150 different countries, providing water to 300 million people.

The biggest existing facilities are Saudi Arabia's Ras Al Khair, which uses both thermal distillation and reverse osmosis, and Israel's Sorek, hailed as the largest and cheapest reverse osmosis plant in the world when it opened in 2015. The Middle East is by far the dominant region in the world when it comes to desal (unsurprising given its hot climate and oceanside locale); the West's largest plant is located near San Diego and produces 50 million gallons of fresh water per day. The biggest problem keeping desalination from becoming an even more widespread source of water is its costs, both environmental and financial. Thermal distillation and reverse osmosis require huge amounts of energy (the former more than the latter), and are still expensive relative to other sources of fresh water. Three recent developments may help.

Graphene-Based Membranes Get Better

At just one atom thick, graphene—a material made of carbon atoms arranged in a hexagonal lattice—has been widely hyped its strength and conductivity, but thus far it's proved difficult to scale its manufacture. Graphene holds promise for water filtration, but the technology is far from ready for use in large-scale de-



salination. It's slowly getting closer, though. Last week an international research team from the US, China, and Japan published a paper in *Science* detailing their work to reinforce graphene membranes for filtration purposes. Graphene could be useful in filters because it acts as a molecular sieve, with holes large enough for water but not salt molecules to pass through, and is more permeable than the polymer-based membranes currently in use, which means separated water flows through faster. A faster flow means less energy, which means lower cost. However, graphene-based membranes are fragile and prone to damage, especially as their surface area increases; effective membranes thus far have been limited to micrometer-scale dimensions. The research team created a graphene-nanomesh/single-walled carbon nanotube hybrid membrane. The nanotubes act as a microscopic framework to support the graphene and increase its structural integrity. The result was a centimeter-sized mesh with a honeycomb appearance, and when tested as a membrane in a filtration system it rejected 85-97 percent of the salt from saltwater.

A New Way: Solvent Extraction

A team from Columbia University's engineering department published a study in *Environmental Science & Technology Letters* in April detailing what they call a "radically different desalination technology" not dependent on filters or distillation. Called temperature swing solvent extraction (TSSE), the method works as follows: a solvent whose water solubility varies with temperature is added to saltwater, and at room temperature the solvent draws in water molecules (but not salt). The solvent (and its newly-absorbed water) is then drawn off and heated. The heat causes the solvent to separate from the water, which can then be collected, salt-free.

"We think TSSE will be transformational for the water industry. It can displace the prevailing practice of costly distillation for desalination of high-salinity brines and tackle higher salinities that RO cannot handle," said Ngai Yin Yip, who led the study. "This will radically improve the sustainability in the treatment of produced water, inland desalination concentrate, landfill leachate, and other hypersaline streams of emerging importance. We can eliminate the pollution problems from these brines and create cleaner, more useable water for our planet."

In the study, the method was shown to remove up to 98.4 percent of salt, not only for seawater but for sal-

tier solutions called hypersaline brines; the authors claim TSSE can handle approximately twice the seawater salt concentrations as reverse osmosis. And since it requires far less heat than thermal distillation, TSSE could be cheaper to scale, perhaps using industrial waste heat or low-concentration solar collectors.

Speaking of the Sun...

It turns out sunlight isn't only good for solar energy—it can help with desalination too. In fact, the US Department of Energy gave out \$21 million in grants for solar-thermal desalination research last year. Solar-thermal power holds promise for smaller-scale desalination, including portable and off-grid systems. A study published this week in *Proceedings of the National Academy of Sciences* found that using nanoparticles to focus sunlight onto a photothermally active membrane increased the flow of distilled water by more than 50 percent. Concentrating light on a small spot on the membrane results in a linear increase in heat, but the heating produces a nonlinear increase in vapor pressure, which forces more purified steam through the membrane in less time.

"The typical way to boost performance in solar-driven systems is to add solar concentrators and bring in more light," said Pratiksha Dongare, co-lead author of the paper. "The big difference here is that we're using the same amount of light. We've shown it's possible to inexpensively redistribute that power and dramatically increase the rate of purified water production."

A Solution With Its Own Problems

Despite its promise (and eventually, its necessity), desalination likely won't be a silver bullet for the world's water problems. Even once the technology becomes more energy-efficient and affordable, there will still be environmental impacts to consider; the waste product from desalination, a concentrated mix of salts and chemicals, is mostly dumped back into the ocean, where it can harm marine life and increase the toxicity of coastal waters. Opponents have also pointed out that desalination's energy demands produce high carbon emissions; so we're getting more clean water at a price of less clean air. Despite these drawbacks, progress in desalination will continue to inch forward. By the time the world really needs it, hopefully those inches will add up to miles (er, gallons).

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The costs and benefits of a clean economy

By TOM KOMPAS
University of Melbourne

Business leaders, politicians and policymakers have spent years asking if we were to cut emissions, how much would it cost in lost income or Gross National Product (GDP) in Australia? How much worse off would we be? If countries around the globe also cut emissions how badly would Australia's exports of coal and natural gas suffer? While once framed purely as an environmental issue, the Deputy Governor of the Reserve Bank of Australia Guy Debelle noted earlier this year that the risks that climate change poses to the Australian economy are "first order" and have knock-on implications for macroeconomic policy. So using recent work by Melbourne Sustainable Society Institute (MSSI) at the University of Melbourne, we have compared the cost of damages from climate change, with the cost of reducing emissions from the recent Climate Council Report for economic damages under current or continued increases in emissions.

COST OF EMISSIONS REDUCTION IS NEGLIGIBLE

We know that climate change can have potentially disastrous effects, and the list is long; pollution, heat stress and its impact on human health, falls in agricultural productivity and permanent losses in biodiversity. As well as damage to environmental assets such as the Great Barrier Reef, sea level rise and resulting infrastructure damage, the increased likelihood of floods and bushfires, possible increased frequency and severity of tropical storms, and severe migration pressure from countries most affected by climate change are only part of the list.

But the relative costs of emissions reduction to avoid these damages, can be hard to measure in dollar terms, given our complex and uncertain future. As a first step, we use a large dimensional global trade and climate

model, an extension of other recent work, to determine the cost of meeting Australia's minimum target of a 26 per cent reduction in emissions by 2030, compared to 2005. We also assume that all other countries do reduce their emissions by more than double the current unconditional 'Nationally Determined Contribution' in the Paris Accord, or a 12 per cent reduction in emissions on average. There are two major cost effects for Australia here; the cost of transition from fossil fuels to renewables, resulting in relative and variable price changes for energy, across all sectors, and the effect of falls in net exports of fossil fuels on national income.

For the 26 per cent target, we find only negligible effects on national income. The total cost is only \$A35.5 billion in the cumulative fall in GDP from now until 2030 in Australia – a measure much lower than previous other estimates, which range from more than \$A82 billion to nearly \$A300 billion, using the exact same target.

Why the difference?

One good reason, among many in our modelling, is that we use the most recent estimates on the cost of energy, what is termed the LCOE or the Levelised Cost of Energy. The LCOE allows for a clear comparison across different technologies (solar, wind, gas, thermal coal etc), allowing for the effects of different project lifespans, capital costs, risk levels, expected rates of return and the ability to generate capacity.

COST OF RENEWABLES IS FALLING

The story here is nothing but positive. The cost of renewables is falling very rapidly around the world and the



Smog in Tokyo.
Photo: Wilhelm Joys Andersen

LCOE of renewables, also falling rapidly, is already less than the cost of fossil fuels in Australia. There will still be costs of transition to renewables, of course, especially in the transport sector, along with losses in net exports. But projected increases in resource efficiency, an efficient emissions trading scheme and the fall in the price of renewables act much like technological change in Australia they give added output from a different energy mix of inputs, generating very little net fall in GDP over the coming decade. What about damages from climate change under current policy and ‘business as usual’ globally? These are estimated at \$A584.5 billion in 2030 for Australia and blow out to over \$A5 trillion in 2100 in the Climate Council Report. Although not large amounts in terms of the percentage of GDP (roughly 2.5 to 4 per cent in 2100 depending on assumptions on GDP growth going forward), someone has to pay the cost.

That cost is roughly \$A14,000 for every Australian in 2100, each year and every year after, or \$A61,000 in the cumulative cost per person from now until 2100.

The longer we wait to act and bear any of the costs, or the more we pass on to the future, the larger this per person cost becomes. The younger generation is right to be protesting. However, the striking point here is that these damage measures are very limited in scope. They cover only infrastructure damage, some human health effects and losses in agricultural and labour productivity in Australia. A great deal indeed is missing.

THE BOTTOM LINE

Do the costs of emissions reduction to 2030, the \$A35.5 billion, compare to the losses in 2030 in Australia of \$A584.5 billion? Not exactly, since a 26 per cent target in Australia and the 12 per cent reduction globally will clearly miss the “less than 2 degrees warming by 2100” target, meaning there will still be profound damages from climate change. Only part of the damages from climate change, in other words, are avoided with such a relatively mild target. But it does give us a good idea of the order of magnitude.

The 26 per cent reduction in emissions should be relatively easy for Australia to achieve, with very little cost. It follows that we can and should do even much better. Indeed, our preliminary modelling shows that the costs of emissions reduction are far less than the damages of inaction in all scenarios that we have examined.

Even the case of a net zero emissions target by 2050 is not only possible but desirable – the costs of emissions reduction are also far less than the avoided damages from climate change, even under this more aggressive target. This, without even acknowledging that our measure of damages from climate change is vastly underestimated, shows that transition from fossil fuels to renewables makes sound economic sense.

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The archipelagic energy structure of the Philippines

By EUSEBIO LORIA

ONE

Oversupply-solar displaces geothermal; renewables displace renewables - that's the paradox. In the Philippines, renewable energy development to transition out of a fossil fuel-based economy is attractive, but the regulatory framework is not yet stable and well-established. Laws and institutions, besides technologies, allow energy to be produced and (mostly) transported to consumers.

The country needs to address the economic and political issues that could prevent a successful transition to any low carbon and long-lasting energy mix. Over the years, the priorities of each administration have been reflected in numerous energy plans, highlighting the lack of a single, coherent, long-term perspective. Large developing countries in Asia are working on decreasing their import dependence through an increase in renewable energy sources.

Last year the Philippines received the top score in environmental sustainability by the World Energy Council for its renewable energy potentials, but their ranking is 63rd in energy security and 95th in energy equity. The main challenge for the country is

to avoid over-reliance on fossil fuel or weather-dependent energy resources. However, there is no "one-size-fits-all" energy transition.

Citing the International Energy Agency "the global transition to an environmentally sustainable economy will require radical reorganization in the structure of energy systems. Since energy production and consumption are substantial sources of greenhouse gases, contributing about 65% of global emissions, energy policy changes are critical to achieving environmental sustainability."

Energy sustainability weakens the affordability component of energy equity. Subsidies encourage investments in renewable energy sources, particularly solar, but government guarantees must ensure subsidies, collected from consumers in the form of taxes, which eventually raise overall electricity prices. It seems there is no way out of this vicious circle.

Policy revision is mandatory in all the countries that attempt



Sambawan (Philippines). Photo credit: Xivjericho

energy transitions. Germany's Energiewende includes a massive change in its nuclear strategy and the creation of an aggressive policy for renewable energy. China has begun shutting down its coal power plants and has heavily invested in solar, hydropower, and nuclear technologies. Each country selects its priority policy and works for it. On one side, the Philippines show fossil fuel dependence and, on the other side, high potential for renewables, despite no clear requirement by the law.

So, which is the most critical challenge for a rapidly growing nation on its way to a low-carbon future?

The social, political and economic factor

The Philippines are an archipelago of 7,641 islands in the Western Pacific Ocean, with a population of 104.9 million. The population grows at an average of 1.5 % per year, higher than the world average of 1.07 %. Despite being a lower-middle-income country, Philippines are one of the fastest-growing economies in Asia. Over the past six years, their economy grew by an average of 6.4%, with growth pace expected to continue at 6.5–6.7% in 2019. The Asian Development Bank expects the Philippines to become an upper-middle-income country by 2020.

To support the growing population and economy, the Philippine Department of Energy (DOE) expressed the need for total installed capacity addition of 43,765 megawatts (MW) by 2040. Currently, the Philippines' installed capacity is 20,055 MW, of which 26% from renewable energy, 42.8% from coal, 7.4% from oil, and 24.2% from natural gas. Obviously, on the road of its energy transition, the Philippines aims to increase the share of renewables in its energy mix.

Climate framework

The Philippines are vulnerable to extreme weather events such as typhoons, floods, and rising sea levels. The Global Climate Risk Index 2017 ranks the Philippines as the world's fifth-most affected country by extreme weather events and other natural hazards like earthquakes, even

while global average temperature increase is still at +1 °C above preindustrial levels. Thus, the Philippines are forced to face climate change dilemmas.

Legislation

Unstable energy supplies in the late 1990s encouraged the government to liberalize its electricity sector with the Electric Power Industry Reform Act, which remains at the core of the national legal framework on energy. The 2008 law on renewable energy (called RE-Act, Renewable Energy Act) attempted to mitigate EPIRA, through the promotion of renewables.

The goals for the renewable energy sector included: increasing renewable energy capacity by 15 GW by 2030 (roughly 50% of total installed capacity); becoming the "number one" geothermal energy producer in the world (currently second); becoming the "number one" wind energy producer in South East Asia; and expanding the contribution of hydropower, biomass, solar and ocean energy by 131 MW.

Whereas EPIRA provided the general framework for the power industry, the RE Act provided the direction for the use of renewable resources. These two acts were supposed to complement each other. A well structured energy mix needs to be diversified and should prioritize indigenous energy sources. Escaping from fossil fuels dependency requires a stable long-term energy plan to rationalize and diversify energy sources. It is thus the responsibility of the national government to stimulate low-carbon investment while balancing the needs for energy security, equity and sustainability.

Fuel mix

The higher the dependency is on a particular fuel, the more challenging it is to eliminate its dependence. Coal-fired power plants primarily serve the baseload demand of the Philippines. Around 68% of the country's coal comes from abroad, and 95.80% of the import is from only one country: Indonesia. These figures highlight the exposure of the Philippines' electricity prices to interna-

tional market fluctuations. Renewables are attractive to the Philippines because they are indigenous and environmentally sustainable sources. Conventional renewables, such as geothermal and hydropower, are cheaper to generate than emerging renewables such as wind, solar, biomass, run-of-river hydro, and ocean. Also, conventional renewables can serve as baseload and, with hydropower, also as peak load.

Natural gas plants are used in the Philippines as baseload and mid merit plants because they have more flexibility than coal plants, which makes natural gas the best complement to address renewables' intermittency. However, the price of natural gas is still subject to international market volatility and indigenous gas fields depletion. An oil-fired power plant is quicker than natural gas plants, but oil is the most expensive among the fossil fuels, and its price is extremely volatile because of international market fluctuations.

Promoting renewables

The RE-Act provides specific mechanisms to promote renewables and create a way out of fossil fuel dependency. Re-Act offers the option to purchase electricity from renewable energy sources; and the must-dispatch rule as a tool to allow all intermittent renewables to be dispatched immediately to the grid.

The must-dispatch rule is also the reason behind the grid instability, and therefore there is the continuing need for fossil fuels to address renewables' intermittency. Hydropower and battery storage can not be the answer yet, as the former capacity is dependent on hydrologic conditions, while the latter has not reached the commercial-stage yet. Then there is also the paradox where renewables displace renewables, as in Negros Island where the oversupply of solar power has displaced geothermal power.

Instability and uncertainty

In 2014 the Department Of Energy focused on formulating an optimal energy mix for the energy sector. After


the national elections in 2016, the new administration moved away from an optimal energy mix policy and instead focused attention on the need to meet the country's capacity requirements, thus prioritizing energy security, regardless of technology and energy sources involved.

Renewables sources also face another peculiar local barrier. Many renewables areas in the country are in lands of indigenous peoples to whom the Philippine Constitution has granted exclusive rights. Any activity on the land needs the consent of all indigenous inhabitants. Thus, even if only one out of ten indigenous tribes refuses, no free consent certificate can be issued – a sensible policy that can backfire as it discourages many greenfield renewables generators from entering the complex Philippine market.

Technical challenges

Limited investment in renewables can be attributed even to the insufficiency of the grid infrastructure and difficulties to see rapid technological developments.

Grid infrastructure has to be enhanced. The Philippines have two main unitary grids: the Luzon-Visayas grid, and the Mindanao grid. Currently, there is supply in excess from solar power in Panay, Negros, and Cebu that cannot be dispatched to neighbouring areas because of the line capacity restrictions. A sign of the inadequacy of the current grid to accommodate the increasing energy supply. Considering the Philippines' archipelagic nature, both the EPIRA and the RE-Act law have promoted off-grid solutions to address "energy isolation barriers" arising from the geographic and economic remoteness of these areas. Off-grid areas, numbering 238, are primarily served by bunker-fired diesel generators and are subsidized by on-grid customers.

The Philippines are the only country in Southeast Asia still waiting for a law on energy efficiency and energy saving. It means there is no impulse for businesses to develop energy-efficient technologies. Reaching the Paris agreement commitments without it is impossible. 

Satellite view of the Philippines.
Photo credit: Jacques Descloitres
(MODIS Land Rapid Response Team, NASA/GSFC)

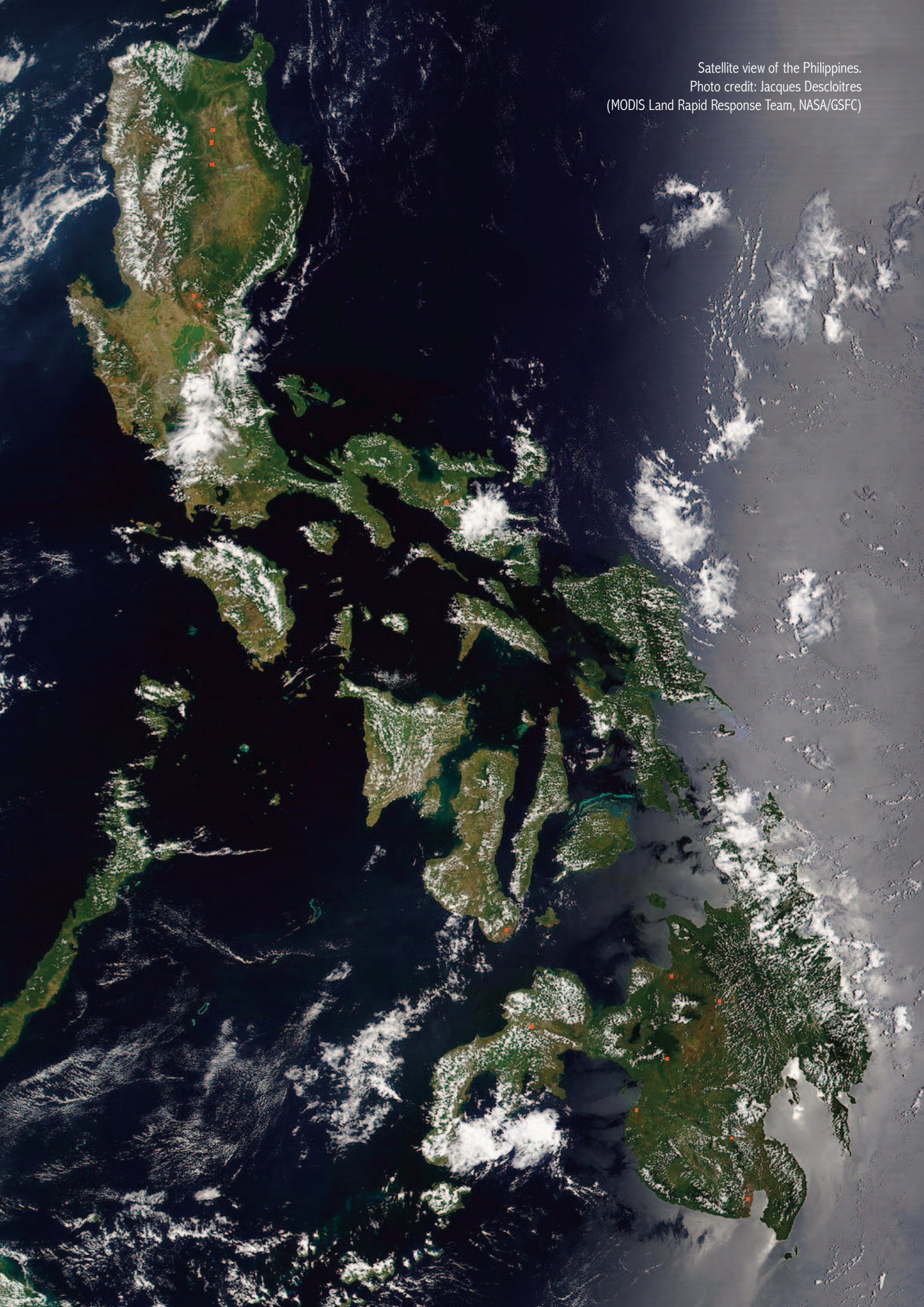


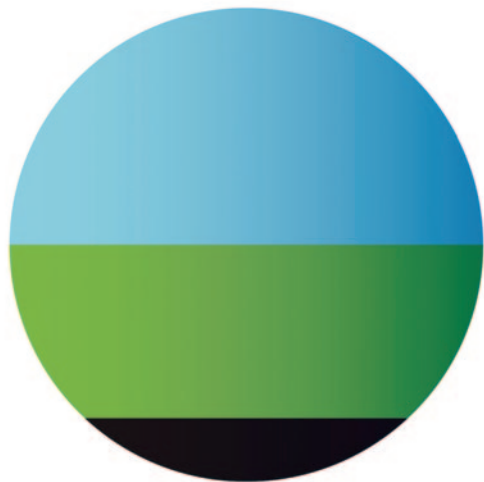
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MEIDERICH

Built in 1901, Meiderich Ironworks was a coal and steel production plant that operated until 1985. The site followed the typical curve of any coal plant in the twentieth century. The difference here is the many u-turns experienced in this site: the 1929 economic crisis that nearly shut down the plant, was followed by an 80-90 % production capacity increase. At the end of the Second World War Meiderich was not included in the list of industrial facilities to be dismantled by the Allies as compensation for the destruction caused by the Germans. Allies granted permission to resume production with the recommissioning of two blast furnaces. The end of the coal plant activity arrived in 1985. It took only a few years to make of Meiderich a symbol of the German industrial past. In 2008, Landschaftspark, as it is called now, became a founding member of the European Route of Industrial Heritage (ERIH). **ONE**

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