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The not-so-distant future of energy storage

Protecting biodiversity has paid off for Costa Rica

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Only Natural Energy

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Michael Bloomberg, U.N. Secretary General's Special Envoy for Climate Action at the Global Climate Action Summit 2018. Photo credit: Nikki Ritcher

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The U.S. Supreme Court.
Photo credit: Hydetim

Supreme Coup

GIANNI SERRA
ONE

The intention was to tell the story of Dom Phillips and Bruno Pereira, a British journalist and an Indigenous expert. Both were killed last June in the Amazonas. A beautiful corner of Brazil turned into an oasis for illegal gold miners or fishers catching protected species. Phillips was there researching for a book on sustainable development.
Not an isolated case. A couple of months earlier, Cambodian journalists Hang Serei Oudom and Chut Witty were murdered after writing several articles about deforestation and other related crimes.

The risks faced by reporters investigating environmental issues are enormous. Plus, fake news, conspiracy theories, and hate speech make reporters' jobs to enlighten public opinion on complex topics like climate change and energy policies even harder. A mission less and less appreciated by the general public, apparently happy with the unsubstantiated but abundant information any blog or social media can provide. This is why accurate reporting is more crucial than ever.

Ill-informed and kept-in-the-dark citizens are a recipe for a weak democracy. Paradoxically, it is in the name of democracy the U.S. Supreme Court has ruled in the West Virginia vs EPA case. Without a new ad hoc legislation from Congress, the environmental agency has no legal authority to regulate climate change issues or impose specific measures on power plants. In the name of representativeness, the Court ruling empties the legal foundation of institutions operating for over a century. Agencies set up and authorised by representatives of the people democratically elected are legitimate. Unless all congressmen are equal but some are more equal than others.

Denying the executive agencies' rule-making power on areas of expertise and specialised knowledge brings the ball back on the Congress pitch. Where the scientific argument makes a step backwards and allows lobbyists to retake the reigns.

All you need is six people in a room to crush in one go creditable years of journalists' reporting, a country's administrative system, and any hopes of progress on climate issues. If the nation is the United States of America, not only American citizens have to worry. ONE

Is philanthropy (really) good for climate and democracy?

LENORE HITCHLER
ONE

The American multibillionaires Bill Gates and Michael Bloomberg have recently published books about how to fight climate change. It is always commendable when people seek to make the world a better place. There are both good qualities and bad aspects to these books. Gates advocates for high-tech solutions, while Bloomberg provides a more complex analysis.

To be fair, honest, and in the interest of full disclosure, I'm not too fond of Bill Gates. Many unpleasant experiences with various Microsoft programs, such as Windows, Outlook, and Word, led to my distrust of Gates. The difficulties that I had with Microsoft were never repaired. Therefore, if Gates was not able to correct errors within the high-tech company that he was responsible for, how can we trust his high-tech solutions to climate change?

On 19 July 2021, Ursula von der Leyen, President of the European Commission, received Bill Gates, Chairman of Breakthrough Energy Ventures.
Photo credit: Lukasz Kobus/European Commission

Besides my lack of confidence in Gates' technological capability, I do not have faith in his ethical standards. His personal improprieties and scandals have recently been made public. In 2000, a district court judge ruled that Microsoft violated multiple sections of the Sherman Antitrust Act. In the same year, the Bill and Melinda Gates Foundation was formed. I find it quite coincidental and convenient that right after losing his court case, he launched his philanthropical career.

Additionally, it is reasonable to expect multibillionaires to pay their fair share of taxes. Michael Edwards, who has worked for the Ford Foundation, explained the negative consequences of not paying one's share of taxes. He stated, "Philanthropy of all kinds saves you money on your tax bill but reduces the resources that governments have to pursue the public interest (to the tune of $40 billion in the U.S. in 2006 alone)."

In addition to breaches of legal and ethical norms, Bill Gates has excessive power in fields in which he has no qualifications. Through his influence and financial contributions, he is a strong power in the movement for replacing public schools with private education. Instead of working to improve water and air supplies and promoting healthy immune systems, he merely provides vaccines.

His most recent cause is to promote fertilizers, pesticides, irrigation, the monopolization of seed crops, and monoculture in Africa as opposed to a more ecological agricultural system. He dropped out of college and never graduated. Therefore, he does not have the proper credentials to decide medical, educational, energy, and agricultural policy. However, the media treats him as a scientific expert, and governments throughout the globe are allowing him to make decisions that affect their countries. Despite never being elected to any position of power, he has great global power. However, it is reasonable to assert that citizens, through their elected officials, should make the decisions that affect their environment and lives.

There are also some discrepancies between the Gates foundations' goals and their investments. Sociologist Linsey McGoey wrote a book about the Gates foundation. She stated that "Investigative reporters from the *L.A. Times* were the first to report widespread dissatisfaction with the Gates Foundation's endowment investments in companies, such as Exxon Mobil, pointing out that flares from oil plants mushrooming across the Niger Delta [located in Nigeria, Africa] are widely believed to have caused epidemics of bronchitis in adults and lowered immunity in children – increasing their susceptibility to measles and polio. Local physicians told the L.A. Times that they felt that unregulated oil extraction was a prime cause of the poor health they faced daily."

This is ironic as Gates spent money to prevent polio and other diseases in Africa while at the same time investing in a company that harms health. Exxon Mobil is a major petroleum producer that contributes to the greenhouse effect, which in turn causes climate

The Indian Prime Minister, Shri Narendra Modi meeting with Mr. Bill Gates, in Glasgow, on November 2, 2021.Photo credit: Government of India

change.

Another example of Gates' conflict of interests concerning climate change is his relationship with Coca-Cola. According to McGoey, "Through its shares in Berkshire Hathaway, the Gates Foundation is heavily invested in Coca-Cola."

As shown by a *Wall Street Journal* news report, he also personally invested in the company that Bill Gates transferred about $121 million worth of stock in Coca-Cola to Melinda Gates, his ex-wife. Nicoletta Dentico, director of the global health program of the Society for International Development, reported that the Gates Foundation Trust's investments include $466 million in Coca-Cola factories operating south of the U.S.

Coca-Cola is a heavy contributor to climate change. An article in the Wall Street Journal reported that the production of one liter [33.81 ounces] of Coca-Cola sold at the supermarket produces 346 grams [12.20 ounces] of the greenhouse gas carbon dioxide. Statista is a company specializing in market and consumer data, and it reported some alarming facts regarding Coca-Cola and climate change.

In 2020, Coca-Cola's global manufacturing sites produced approximately 5.24 million metric tons of greenhouse gas emissions. Petroleum is used in plastic production, and Coca-Cola produces around three million metric tons worldwide of plastic packaging per year. The disposal of plastic containers produces even more greenhouse gases. For example, annual emissions from mismanaged plastic waste produced in just six countries were estimated to be 2.5 million metric tons.

Besides Coca-Cola, the Gates Foundation has associated with organizations whose actions lead to climate change. The Gates Foundation joined the Rockefeller Foundation to initiate the Alliance for a Green Revolution in Africa (AGRA). AGRA promotes agricultural practices such as irrigation, fertilizer, and pesticides that use a lot of fossil fuels for ingredients, manufacturing, application, and transportation. AGRA policies also lead to monoculture.

However, adapting to climate change requires biodiversity. The practices of Monsanto, which is a major producer of seeds for the green revolution, contribute to a more monocultural form of agriculture. In 2010, the Gates Foundation bought $23 million worth of Monsanto's shares. In other words, biodiversity is needed to fight climate change, and the Gates Foundation has invested in businesses that lead to biodiversity loss.

Even though Gates had invested in companies that contribute to the greenhouse effect, he eventually became interested in climate change. He published *How to Avoid a Climate Disaster—The Solutions We Have and the Breakthroughs We Need*. The good news is that Gates recognized that climate change is a real phenomenon and that steps must be taken quickly to reverse it. It is admirable that he took a lot of time to educate himself by reading books and scientific reports and discussing the subject with experts.

He did a good job of educating his readers about various aspects of climate change. For example, he did an excellent job correlating slight temperature changes with massive environmental changes. He stated, "During the last ice age, the average temperature was just 6 degrees Celsius lower than it is today. During the age of the dinosaurs, when the average temperature was perhaps 4 degrees Celsius higher than today, there were crocodiles living above the Arctic Circle."

In other words, only ten degrees Celsius mark the difference between an ice age and a vast increase in tropical weather.

Gates also did a tremendous job of discussing some of the causes of climate change, including manufacturing such products as cement, steel, and plastic, the generation of electricity, heating and cooling buildings, and the agricultural and transportation systems.

Unfortunately, the bad news is that Gates omitted many other causes of climate change. For example, preparing for and engaging in warfare uses a tremendous amount of fossil fuels. Planned obsolescence, in which goods are deliberately designed to have short lifespans, also wastes energy. Printed advertisements, the fashion industry, pet care, and lawns use large amounts of fossil fuels.

Not only did Gates neglect deforestation, one of the main contributors to climate change, but he failed to mention that he has invested in biofuels. Growing the crops to produce biofuels has caused worldwide global rainforest deforestation.

Gates also neglected alternatives such as public transportation and various agricultural alternatives such as agroecology, regenerative and sustainable farming, forest farming and permaculture, and local food production, including gardens and innovations such as vertical farming.

Also, Gates excluded many accessible, relatively low-cost technologies. For example, he noted that women

and girls in Africa spend hours collecting firewood for cooking. Gates also observed children doing their homework by candlelight. He did not mention solar ovens and solar lights, which are low-tech alternatives. Just as Gates published a book about fighting climate change, multibillionaire Michael Bloomberg co-authored *Climate of Hope—How Cities, Businesses, and Citizens Can Save the Planet* with Carl Pope. Most chapters were individually written by Bloomberg or Pope except for the few chapters they wrote together.

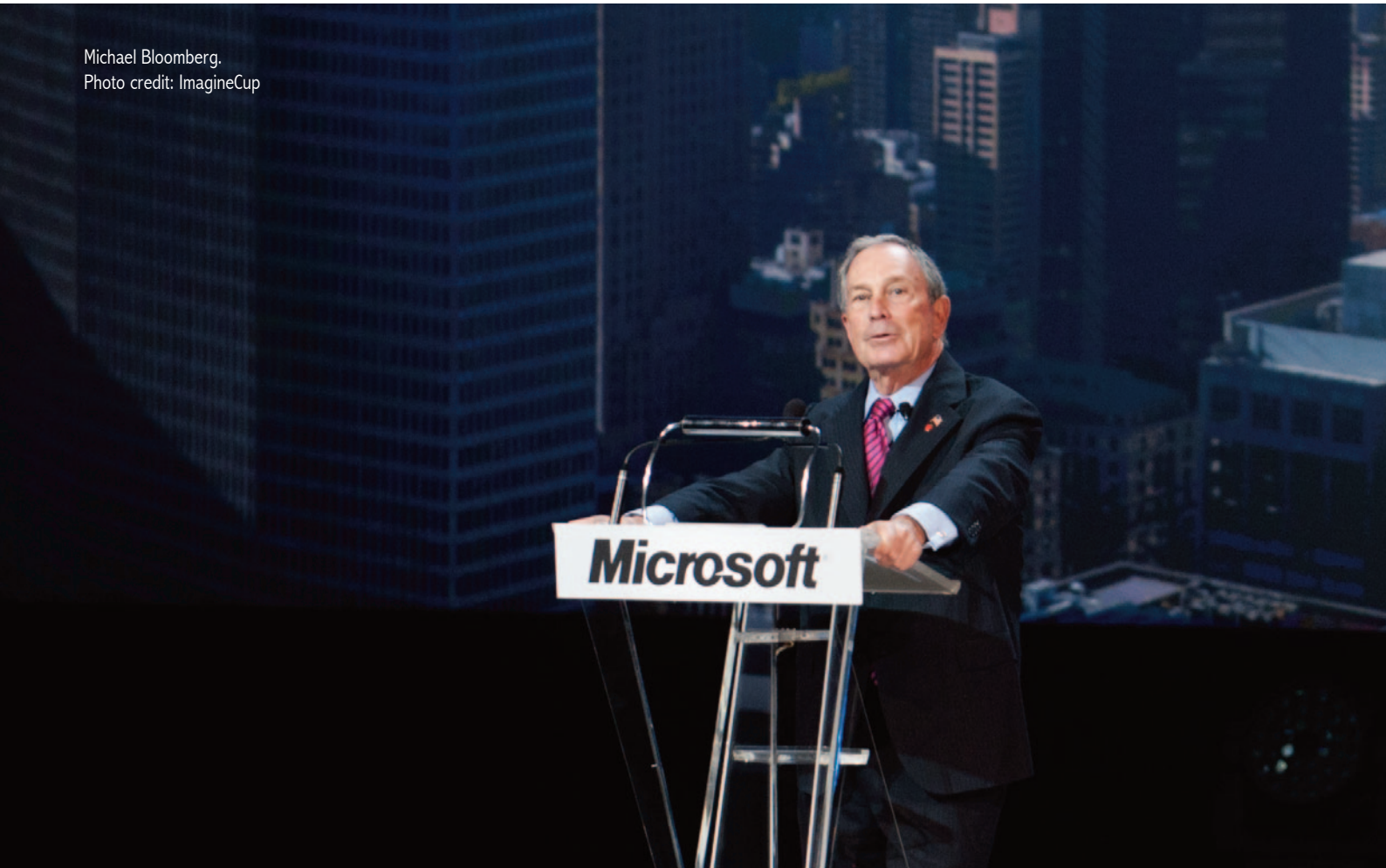
Bloomberg and Pope wrote in the preface that climate change advocates need more effective ways to motivate new people. The following rather long passage is nevertheless worth reading. *"Telling people that they might possibly save the Earth from distant and uncertain harm is not a great way to convince them to support a particular policy. But what happens when you tell people that they can definitely, right now, reduce the number of asthma attacks suffered by children, save their own families and friends from respiratory disease, extend their own life expectancy, cut their own energy bills, make it easier for them to get around town, improve their quality of life, increase the number of jobs in their community, and strengthen our national energy security—all while increasing the long-term stability of the global climate?"*

Bloomberg also discussed the positive lifestyle factors in cities that account for the lower carbon footprints of city residents than suburban and rural residents. He stated, "Because most urban residents live in apartments that are smaller than the average American home and require far less energy to heat in winter and cool in summer. City residents also tend to drive less because they can walk, bike, or take mass transit to get to work and get around. As a result, the average per capita carbon footprint in New York City is two-thirds smaller than the national average."

Thus, living in cities produces fewer greenhouse gases per person that cause global warming. This is important because rising temperatures damage the health of people.

Gates did not seem interested in climate change's global public health consequences. His health programs focus on privatized individual solutions to specific diseases. Thus, Gates concentrates on producing vaccines instead of broad-based public health measures to improve health in general.

In contrast, Bloomberg recognizes that public health issues are increased because of climate change and acknowledges that governments must be involved instead of relying solely on individual philanthropy. Bloomberg wrote: "One of the biggest changes in urban governance in this century has been mayors' recognition that promoting private investment requires protecting public health—and protecting public health requires fighting climate change. Why? Because the largest sources of air pollution that threaten public health are also the biggest sources of greenhouse gases that are warming our planet. The former president of the World Medical Association, Dana Hanson, called



Michael Bloomberg.
Photo credit: ImagineCup

climate change a 'massive threat to global health that will likely eclipse the major known pandemics as the leading cause of death and disease in the twenty-first century.'"

Bloomberg was particularly critical of the health damages from burning coal. For example, he reported that statistics from 2011 showed that the annual cost of health was over $100 billion. He also noted that the EPA estimated that more than 23,000 miles of rivers and streams had been polluted from liquefied coal ash, and half the toxic chemicals polluting American streams and rivers originated in coal ash pools.
Just as using coal has detrimental effects on health and increases pollution, biomass cooking fuels in the third world also damage health and increase pollution.

According to Bloomberg's co-author, "The soot produced by biomass cooking is estimated to kill 4 million people every year—more than malaria or tuberculosis. […] Preparing food—is estimated by the World Health Organization to be the fourth largest risk factor for disease in the developing world. […] Primitive cooking generates about 25 percent of the world's black carbon, so it's about 4 percent of the total climate problem. Women without access to modern fuels spend one to five hours a day gathering fuel."

Unfortunately, neither Bloomberg nor Gates advocated for solar ovens, which are relatively cheap, easy to produce, and do not burn fossil fuels. Another major worldwide public health problem caused by climate change is the increased number of heatwaves. Bloomberg provided alarming information about this when he stated that: "Heat waves are the deadliest kind of natural disaster in the United States, killing more people each year on average than hurricanes, lightning, tornadoes, earthquakes, and floods combined."

Thus, both Bloomberg and Gates were very aware of the problem of climate change. However, there were problems regarding both authors' solutions. For example, Gates wrote about putting several hundred million dollars into starting a company to design a next-generation nuclear power plant.

Even though he acknowledged problems with reactor accidents and that nuclear waste is dangerous and hard to store, he still supports nuclear power. Bloomberg stated that he did not want to ban fracking or stop the Keystone pipeline and that he supports nuclear power. Most environmentalists do not support fracking, pipelines, and nuclear power. Thus, some of Bill Gates and Michael Bloomberg's solutions are better than others.

Nevertheless, both men have contributed to the ongoing dialogue on climate change. However, Gates relied on high-tech solutions, which use a lot of energy. Bloomberg presented an effective way of reaching potential proponents as well as showing that people need to work together to solve the problems caused by climate change. ONE

Direct Heating and Cooling using windmills

Industrial areas and retail complexes should find them attractive since the capital investment is soon justified by less volatile and reduced energy costs. Rural areas are also likely to see them proliferate due to the diversity of what they can provide

THEO HART
ONE

Everyone is familiar with huge wind turbines producing electricity for the electricity grid. Windmills much more modest in size can also contribute to direct heating or cooling of buildings, thereby replacing burnt fuels for heating and electricity consumed for air conditioning.

The main difficulty with wind is its erratic nature. This should be obvious to everyone, yet how many think only of the installed capacity of wind turbines and not their likely contribution to the grid over many months? Their maximum output is not often sustained for long, while the actual average contribution will be less than a quarter as much and uncertain in timing. A becalmed turbine may have nearly no output at all for several days at a time.

For a smaller windmill, this necessitates having some means of storing heat or cold, or energy in some form, to have a reliable supply of heat or cooling even when the wind barely blows. Each installation will be somewhat different and requires a specific design as to size and placement of components. This is not like buying a consumer product such as a window air conditioner.

Smaller here may mean the windmill has blades of three metres or less in length. Being less obtrusive, siting one is unlikely to raise much controversy, provided the machinery chosen runs quietly.

Industrial areas and retail complexes should find them attractive since the capital investment is soon justified by less volatile and reduced energy costs. Rural areas are also likely to see them proliferate due to the diversity of what they can provide, the reliability of having their own supply, cost savings, and less worry about what ensues when the grid goes down. In some locations, getting connected to the electricity grid may even be difficult or expensive.

Cooling

Wherever summers are hot and winters not overly cold, cooling is more important than heating, so air

Photo credit: Semtive Energy / Flickr

conditioning is common and a large user of electricity. This is because the air conditioners are usually vapour compressor types powered by an electric motor running for most of each hot day. Air conditioning, at least heavy use of it, is very seasonal.

In Mediterranean lands, summer is when peak electricity use occurs. For example, July is the month of most significant electricity consumption in Italy, and powering all those compressors in the air conditioners is a major reason. Naturally, the electricity grid must be able to meet that peak demand with production that is not needed at any other time. Lowering the summer demand for electricity would be a development welcomed by the grid operator. Wide use of windmill cooling could do it.

The operating sequence of a typical air conditioner is as follows: a refrigerant with a low boiling point enters the cooling coils through an expansion valve and becomes a vapour.

This takes a lot of energy in the form of heat extracted from the air blown over these coils by a fan, hence cool 'conditioned' air. Next, the refrigerant vapour within the coils gets sucked into the mechanical compressor, which compacts it back into a hot liquid. Typically, it is cooled by going through coils that give heat to the outside air. The cooled liquid refrigerant is ready to repeat the cycle by passing through the expansion valve mentioned earlier.

While the above sequence may be efficient and convenient in keeping the components relatively compact, having a liquid phase is not necessary. Even having a gas compressed, cooled, expanded and ejected provides cooling. Rather conveniently for windmill cooling, air may be that gas. The wind is rarely smooth

A small Giromill Darrieus vertical-axis wind turbine (VAWT) in rural Rollinsville, Colorado.
Photo credit: Tony Webster

and steady for very long, but stronger or less strong, a bit gusty or turbulent, and the shaft to which a windmill's blades (vanes) are attached conveys such variation in its rate and force of rotation. With an air compressor attached, what is produced is a variable amount of heated air of a set pressure, governed by a valve. This is no problem for its use in cooling, and hot air has many other benefits besides — be sure the compressor runs quietly.

The compressor is atop the windmill and would deliver a variable though a usually high volume of air at not much pressure (maybe 100 kPa), taking away most of the heat generated by the machine. This would go down the tower in a large diameter pipe, losing heat as it goes, then likely run some distance laterally, perhaps underground, to arrive where it will be expanded, creating cooling.

Usually, this will be within a storage reservoir. A well-insulated cistern of very salty water could be such. It would be a store of coolness for use in air conditioning even when the windmill is not providing much. The saltiness prevents unwanted biological activity. The air from the top of the windmill exits back into the atmosphere. Likely it will be cleaner than what it now mingles with.

Within a building, cooling comes from blowing air over cold pipes or coils in which a transfer fluid (or perhaps the salty water of the cistern itself) flows and returns to the cistern. The speed of the fan regulates the amount of cooling. The reservoir may be nearer the windmill than the building to be cooled, in which case an insulated pipe will carry the cold fluid to it.

The cold fluid could also be used in a heat exchanger to provide cooled drinking water, say in a restaurant or for a drinking fountain. As golf courses are likely places for windmill air conditioning of their clubhouses and caddy shacks, they would also want a cool water fountain at the first tee where players could fill thermoses with cooled water to carry with them.

Windmill cooling is but one way to cool the reservoir, for there is another of ancient pedigree. Evaporative cooling is its label, and a simple example shows how it works. Take a jar of water wrapped in a damp cloth and place it anywhere out of direct sunlight, preferably on a window sill. As the cloth dries, the heat absorbed in evaporating the water is drawn from the jar and its contents, so the water in the jar becomes cooled. Re-wetting the cloth continues the process, so the water in the jar can become quite cold. Naturally, this works best when the humidity of the air is not high. The ancient Egyptians were likely not the only desert people to have figured this out.

One way of effecting this for the reservoir is to have a small exit fan suck humid air from above the water and blow it outside. Fresh outside air then enters passively to replace it. Having that air immediately in contact with the water's surface helps have its humidity increase. Some means of preventing the growth of moulds or smelly bacteria would be helpful.

Heating and hot air

Having a windmill run an air compressor may also be a means of heating. Instead of all the hot compressed air being cooled by giving off heat to the atmosphere, much of it could be carried down the tower in a well-insulated pipe and then give its heat to some means of storing it, such as a long run through an enclosed amount of gravel, pebbles, bricks, or the like.

This, combined with what comes directly from the windmill, is a reliable source of hot air. Hot air can also come from a solar panel where the sun beats down on a metal tube, which gets blown through the mentioned materials. Solar and wind together would be an even more reliable source of such heat.

Heating a building is seasonal, though hot air used for mainly drying is not — think of a launderette as an instance. However, some drying is indeed seasonal. Certain crops that farmers grow are routinely dried upon harvest, typically using fossil fuels to provide the hot air. Here, hot air from the windmill would prove very useful. Also, where the growing season is often rainy, farmers must dry their hay.

An air compressor is not, of course, the only means of creating heat from a windmill. Frictional heating also arises from swirling a blade, spoon, or similar object in a liquid. The more rapid and more prolonged and turbulent the action, the greater and quicker heating will occur. The temperature of the liquid rises accordingly. Frictional heating also arises by churning some working fluid within a casing until it reaches the temperature at which a release valve opens to allow some hot liquid out while drawing cool fluid in. This would be driven from the windmill's shaft and likely located at the base of the windmill tower.

A surge tank, well-insulated, accumulates these intermittent releases to reach a volume of heated fluid sufficient for its uses. This is the most straightforward application, mainly where the need for heat is relatively large for many months. Somewhere with wet, windy winters is an excellent example. Should a ground-source heat pump already appear an attractive investment there, due to security of supply and freedom from price swings in purchased fuel, adding heating from a windmill would offer even greater security. It would also change the composition of the fixed investment, with less looping needed underground, though, of course, the windmill is another expense. But it is a long-term investment that avoids using purchased fuel, thus reducing future costs.

Moreover, it can also provide hot water in addition to room heating by adjusting the trip point of the release valve upward and having it sent through tubing in a tank of water, thereby heating it. So for any place where much hot water is being used, this could substitute for most, perhaps all, of the current expense in providing the same.

When the heating of buildings is not needed, this hot fluid may be run through the ground loops to give up heat to the ground, which becomes a reservoir of it. Warmer soil helps the following winter by making ground loop heating more effective. This presumes that only the churning heater is connected to the windmill's shaft.

There are many options to consider when it comes to windmill heating and cooling, particularly the placement of the main components. Nonetheless, some standardised designs sizing the major components in an appropriate relationship are sure to arise because this simplifies matters for the buyer. Which is a good thing, as the more of these that get built, the less electricity will be used for cooling and the less fuel burnt for heating, and the less dependent these people will be on overly centralised systems. ONE

I Helped Pen the UN Climate Report. Here's Why It Gives Me Hope

SARAH BURGH*
Undark

On April 4, the United Nations Intergovernmental Panel on Climate Change released the final installment of its Sixth Assessment Report, an epic synthesis of science exploring the causes and consequences of climate change. This latest document focused on the causes — chiefly, the rampant emission of greenhouse gases — and how to reduce them, fast.

As one of the lead authors of the new report, I and more than 230 scientists from around the world collectively reviewed over 18,000 scientific articles and responded to around 60,000 reviewer comments over the course of more than three years. Our goal was to compile the most accurate and nuanced picture of current climate science and social science, and to use this to inform international climate change treaty-making and policy design. The result was a nearly 3,000 page document that details a stark, urgent threat — but that also gives us reason for optimism.

First, the grim news: Average annual greenhouse gas emissions were the highest during the past decade than they have been in human history. This, despite escalating social movements, high profile declarations, and splashy vows from political and business leaders to integrate climate into investment and business decisions.

Without immediate, deep, and accelerating emissions reductions in all sectors and in all regions of the world, the goal of limiting warming to no more than 1.5 degrees Celsius — the threshold for avoiding the worst, but not all, impacts of climate change — will be out of reach. The human and environmental toll of such a scenario is unfathomable.

But glimmers of hope also emerge from this report. For the first time, we're seeing evidence of real, sustained decreases in greenhouse gas emissions from some countries. These reductions aren't blips that can be attributed to the economic recession of 2008 and 2009 or to the hardships inflicted by the Covid-19 pandemic. Rather, they are the result of effective and, in some cases, targeted efforts to scale up renewable energy, electrify transport, enhance building efficiency, foster compact, sustainable communities, and otherwise reduce society's carbon footprint. In some countries, these reductions are deep and comprehensive enough to be consistent with limiting global warming to 2 degrees Celsius, the overarching target set in the Paris Agreement of 2015. These signs of progress also point to a path forward.

The solutions to climate change now exist; we just have to adopt them.

In the energy supply sector, which is responsible for around a third of global greenhouse gas emissions, a particularly major transition is required. Limiting warming to 2 degrees Celsius will require us to prematurely shut down oil and gas infrastructure by mid-century. In other words, we will have to leave fossil fuels in the ground, and the new infrastructure that continues to be announced in countries like Canada may end up as stranded assets by 2050. Coal, of course, will have to go. Absent effective carbon capture and storage, neither of which is currently used widely or well enough to measurably impact our cli-

Vilamendhoo, an island at south-east edge of the South Ari Atoll.
Photo credit: Neville Wootton via Flickr

mate goals, coal use will need to decline by up to 92 percent by 2030.

There are promising indications, however, that a transition in the energy sector is already underway. As we watch the volatility of gas prices, we've also seen the price of renewable energy fall. The costs of photovoltaics used to harvest solar energy plummeted by around 85 percent over the last 10 years, surpassing even the most optimistic projections. Likewise, the price of wind has come down around 55 percent over the same time span, and the price of lithium-ion batteries — crucial for when the sun doesn't shine and the wind doesn't blow — has come down by 85 percent as well. Fuels like hydrogen and biofuels will fill in the gaps to support a transition in aviation and heavy shipping.

Our report also suggests vast potential to shift our cities toward low-carbon, resilient development. Cities are responsible for more than two thirds of global greenhouse gas emissions. This is where the transport, building, and infrastructure sectors collide to shape individual decisions.

Demand for transport can be reduced by locating homes near workplaces, recreation, and services. The remaining emissions can be dramatically reduced by encouraging a shift toward electric vehicles powered by clean energy sources and toward active transport, like walking and biking. Efficient buildings that use zero net energy or produce zero net carbon emissions will also be critical, and we find evidence that these buildings are springing up in every climate.

But it's also important not to pin responsibility for mitigating climate change on the individual. We can only choose low carbon transport if the infrastructure is available and affordable; we can more easily make our homes energy efficient if incentives and building codes support these changes. The link between collective decision making, at all levels of governance, and individual behavior is a powerful one.

Ultimately, the new IPCC report lays bare the state of our efforts to mitigate the worst harms emerging from the rampant burning of fossil fuels. It shows that we cannot reach our broader sustainable development goals of a vibrant natural environment, clean water, peace, zero poverty, and healthy communities without addressing climate change. It just won't work. Our report shows that addressing climate change is a matter of justice, and that a stable climate is the foundation upon which our societies thrive. We now have the solutions, and the path ahead is difficult, but clear:the energy to power our homes and businesses.

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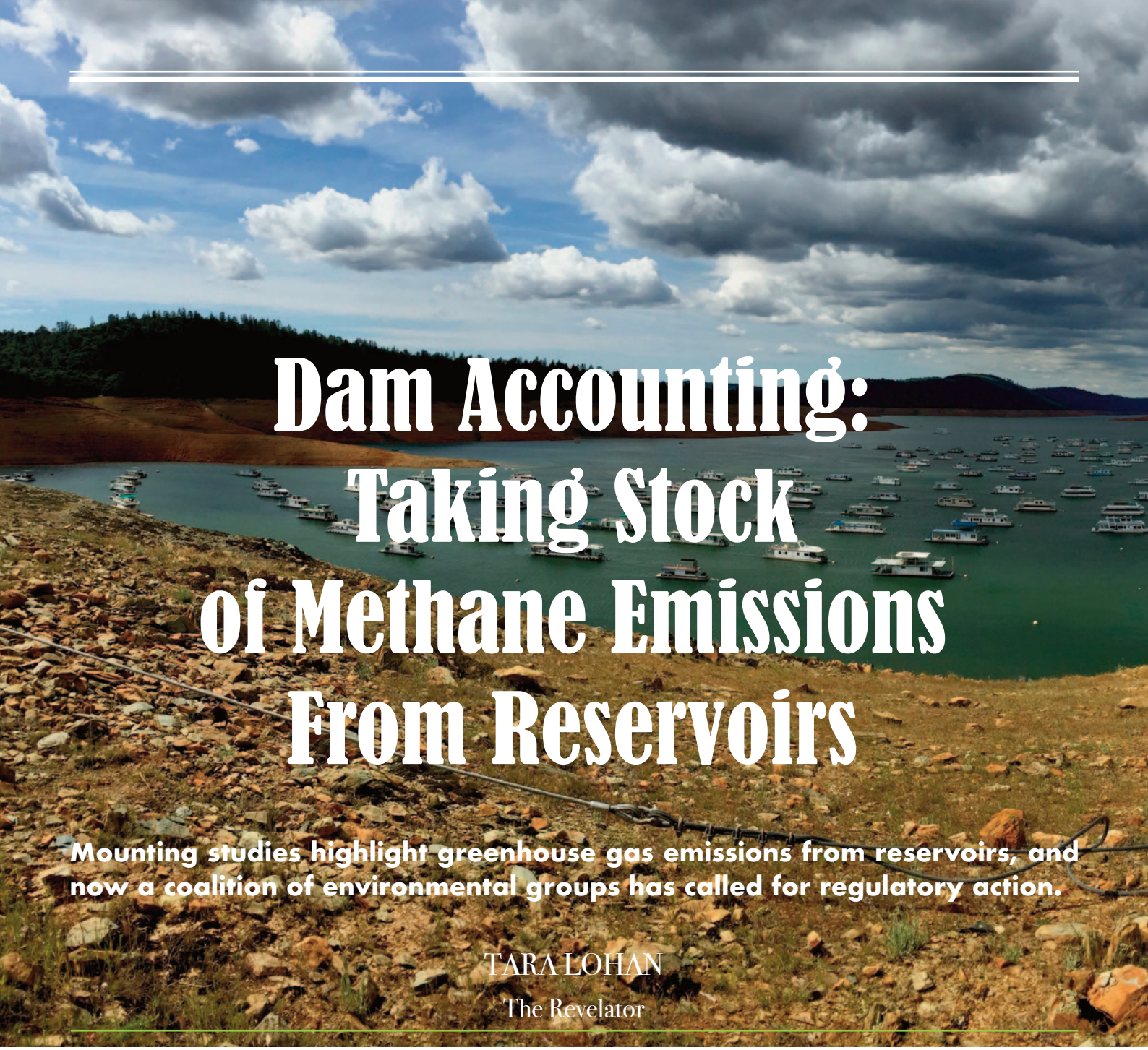
* Dr. Sarah Burch is a Canada Research Chair and executive director of the University of Waterloo's Interdisciplinary Center on Climate Change. She is a lead author of the IPCC's 6th Assessment Report.



Dam Accounting: Taking Stock of Methane Emissions From Reservoirs

Mounting studies highlight greenhouse gas emissions from reservoirs, and now a coalition of environmental groups has called for regulatory action.

TARA LOHAN
The Revelator

This month regulators greenlighted a transmission line that would bring power generated from Canadian hydroelectric dams to New York City. New York's plan to achieve a zero-emissions grid by 2040 depends on hydropower, and it's not alone.

Globally hydropower is the largest source of renewable energy. In the United States it makes up 7% of electricity generation, and 37 states allow some form of hydropower in their renewable portfolio standards, which establishes requirements for the amount renewable energy that must be used for electricity generation.

As U.S. states and countries across the world work to reduce fossil fuels and boost renewables, hydropower is poised to play an even bigger role.

There's just one problem: A growing body of research published over the past two decades has found that most reservoirs, including those used for hydropower, aren't emissions-free.

"Hydroelectric reservoirs are a source of biogenic greenhouse gasses and in individual cases can reach the same emission rates as thermal power plants," Swiss researchers found in a 2016 study published in the journal PLoS ONE.

Hidden Emissions

Despite the green reputation of hydropower among policymakers, some reservoirs emit significant amounts of methane, along with much smaller amounts of nitrous oxide and carbon dioxide.

Drought conditions in California at Lake Oroville.
Photo credit: Ray Explores

That's bad news because we already have a methane problem. This short-lived but potent gas packs 85 times the global warming punch of carbon dioxide over 20 years. If we hope to stave off catastrophic warming, scientists say we need to quickly cut methane. But new data show that despite this warning it's still increasing at record levels — even with a global pledge signed by 100 countries to slash methane emissions 30% by 2030.

Methane can rise from wetlands and other natural sources, but most emissions come from human-caused sources like oil and gas, landfills and livestock.

We've known about the threat from those sources for years, but emissions from reservoirs have largely been either uncounted or undercounted.

In part that's because tracking emissions from reservoirs is complicated and highly variable. Emissions can change at different times of the year or even day. They're influenced by how the dam is managed, including fluctuations in the water level, as well as a host of environmental factors like water quality, depth, sediment, surface wind speed and temperature.

But recent scientific research provides a better framework to undertake this critical accounting. And environmental groups say it's time for regulators to get busy putting it to work.

A Paucity of Policy

In the United States "there are no policy requirements and no regulatory requirements that reservoir emissions be assessed and reported," says Kelly Catlett, director of hydropower reform at American Rivers. And that's concerning, says Daniel Estrin, general counsel and advocacy director at Waterkeeper Alliance. "We think hydropower is a totally false solution to the climate problem and would really dramatically exacerbate problems for our rivers' biodiversity."

Dams disrupt free-flowing rivers and cause a well-documented list of harms to fish, freshwater mussels and other animals.

Gary Wockner, executive director of the river advocacy group Save the Colorado, likens the current push for more hydropower to fracking, which was once thought of as a low-emissions "bridge fuel" to ease transition between fossil fuels and renewables.

"But as the science evolved, we now know that's not true," he says. "In some cases, with all the leaks of methane, fracking can be worse than coal. And so here we are again in essentially a similar situation with hydropower as the science continues to evolve."

That's why this March his organization, along with outdoor retailer Patagonia and the nonprofit Earthjustice, started pushing regulators for more accountability. The groups, along with more than 100 other signers (including *The Revelator*'s parent organization, the Center for Biological Diversity), have petitioned the Environmental Protection Agency to begin a rulemaking that would add dams and reservoirs under the Greenhouse Gas Reporting Program.

The program currently requires 8,000 facilities to report their greenhouse gas emissions — but none are hydropower plants or other reservoirs. The United States currently has 90,000 dams, 2,500 of which provide hydropower.

"Just like we require coal-fired power plants and natural gas power plants to report their emissions, I think we should require hydropower systems to report theirs," says Mark Easter, a senior research associate at Colorado State University studying greenhouse gas emissions and a backer of the petition effort.

East Dam, High Island Reservoir, Sai Kung District, Hong Kong.
Photo credit: Underwaterbuffalo

Mounting Evidence and Better Methods

It's hard now to sidestep the issue of reservoir emissions if you're serious about cutting greenhouse gases.

The first studies digging into the topic took place in Canada and Brazil in the 1990s. Research continued in the years following, with a 2000 study being the first to take a more global look at the issue. In 2013 another study found that 10% of reservoirs have emissions factors larger than equivalent carbon dioxide emissions from gas-powered plants.

The issue got a big bump in the public's consciousness in 2016, when major media outlets picked up a study of global reservoir emissions published in Bioscience that found that previous research had underestimated methane emissions, which we now know to be the second biggest contributor to climate change.

The researchers urged policymakers across the world to take note and concluded that global reservoirs account for just under a gigaton of annual carbon dioxide equivalents — about 1.3% of all global emissions.

They also cautioned that their numbers still likely underestimate reservoir emissions. Most studies analyze emissions over a 100-year time frame, but methane has a much larger impact in the short term. There are also multiple pathways for methane to reach the atmosphere from reservoirs, some of which weren't captured in their research but could be major contributors in certain places.

When areas are flooded to create a reservoir, microbes decompose the submerged organic material, a process that can lead to methane, carbon dioxide and nitrous oxide emissions depending on the water chemistry and other factors. A lack of oxygen triggers methane production.

Early studies tracked the release of methane as it diffused from the surface of reservoirs. But recent research has found that it can also bubble to the surface sporadically — a process that's enhanced when reservoir levels are lowered. New acoustic tools have made it easier to capture these variable fluxes. Additional emissions can occur downstream after water

A 2006 report from the IPCC on climate change included an appendix that gave some crude method to estimate greenhouse gases from reservoirs. But because it was in an appendix, it was never formerly adopted as a method and countries didn't have to report their greenhouse gas emissions from reservoirs.

passes through dam turbines, which usually draw water from the deepest, most methane-rich parts of a reservoir.

"Much more methane either bubbles out of reservoirs or is emitted just downstream from reservoirs than was previously known," found the researchers of a 2021 study that focused on developing a new framework for calculating reservoir emissions, called the G-res tool. When taking these factors into consideration, they found global reservoirs emit around 29% more greenhouse gas emissions per area than previously calculated.

Methane emissions are a bigger concern in tropical climates where there's more biomass and warmer temperatures, the study found. But additional research has revealed that more temperate climates like the United States aren't immune from the problem, either. A 2014 study of an Ohio reservoir led by EPA scientist Jake J. Beaulieu found that mid-latitude reservoirs can have comparable methane emissions to those in the tropics. "We estimate that CH4 [methane] emissions from agricultural reservoirs could be a significant component of anthropogenic CH4 emissions in the U.S.," the researchers wrote.

Six years later Beaulieu and other researchers found that methane emissions from reservoirs in Ohio were the state's fourth largest source of human-caused methane. That's because nutrients continually wash into reservoirs from the upstream watershed. For reservoirs near developments and agriculture, the nutrient runoff can cause algae blooms that lead to more methane production.

"Reservoirs draining watersheds that are subject to high levels of nutrient loading, such as fertilizer application to croplands, tend to have higher methane emission rates than reservoirs draining undeveloped watersheds," Beaulieu explained in an email to *The Revelator.* That finding also means we can expect methane emissions from reservoirs to increase with climate change. Warmer waters produce more algae, and increased storms and runoff will send more nutrients into rivers and the impoundments created by dams. That creates a vicious cycle: more algae, more methane emissions and more warming.

A Global Concern

The work scientists have done to advance the methods used to calculate these greenhouse gas emissions from reservoirs is helping to push real-world action. And it's coming at a critical time.

Governments and utilities have planned thousands of new dams throughout the world. And many of these would be built in tropical and subtropical areas likely to have the largest emissions.

"What you could be worried about is the fact that there are hydropower building booms going on in South America, Southeast Asia, Eastern Europe and Africa," says Tonya DelSontro, an assistant professor at the University of Waterloo and a co-author of the 2016 Bioscience study. "If you build these large water surfaces for reservoirs, then we'd be increasing emissions."

One thing that could help is action from the Intergovernmental Panel on Climate Change. A 2006 report from the IPCC on climate change included an appendix "that gave some crude method to estimate greenhouse gases from reservoirs," says Yves Prairie, an aquatic ecologist and the UNESCO chair in global environmental change at the University of Quebec at Montreal.

"But because it was in an appendix, it was never formerly adopted as a method and countries didn't have to report their greenhouse gas emissions from reservoirs."

However, the large body of scientific research done since then — including the G-res tool developed by Prairie and colleagues — led the IPCC to adopt a new methodology in 2019 that draws on these advances. It's expected that soon countries will be required to report their reservoir emissions in their annual greenhouse gas inventories, he says.

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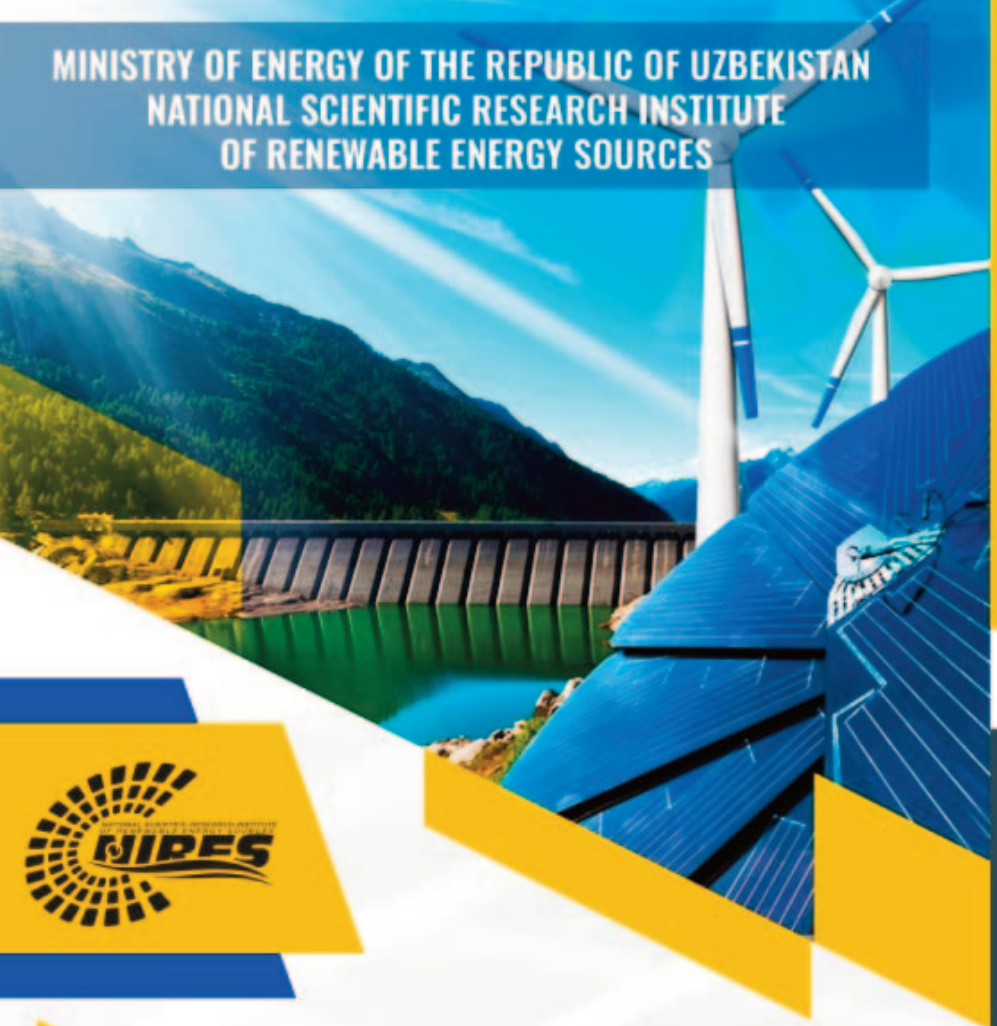
MINISTRY OF ENERGY OF THE REPUBLIC OF UZBEKISTAN
NATIONAL SCIENTIFIC RESEARCH INSTITUTE
OF RENEWABLE ENERGY SOURCES



23-24 SEPTEMBER 2022 YEAR

International scientific-technical conference on the theme

"New Horizons of Low-Carbon Development in the World and Uzbekistan"

On September 23-24, 2022, National Scientific Research Institute of Renewable Energy Sources under the Ministry of Energy of the Republic of Uzbekistan will host an International scientific-technical conference on the theme **"New Horizons of Low-Carbon Development in the World and Uzbekistan"**. This conference is held in accordance with the Resolution of the Cabinet of Ministers of the Republic of Uzbekistan 101-F from March 07, 2022.

The main goal of the Conference is to bring together scientists, young professionals, engineers, politicians, entrepreneurs and economists to evaluate and test existing tools and scientific-technical groundwork for the development of low-carbon development mechanisms, also in terms of renewable and hydrogen energy.

The conference will be held off-line and there will be two types of presentations: presentation and poster presentation.
During the conference, it is planned to hold a competition in the following nominations: "The best report", "The best development" and "The best poster presentation". **The winners will be awarded with memorable gifts.**

SCOPE OF THE CONFERENCE:

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- Low-Carbon Development;
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Conference proceedings will be published in journals cited in the SCOPUS DATABASE

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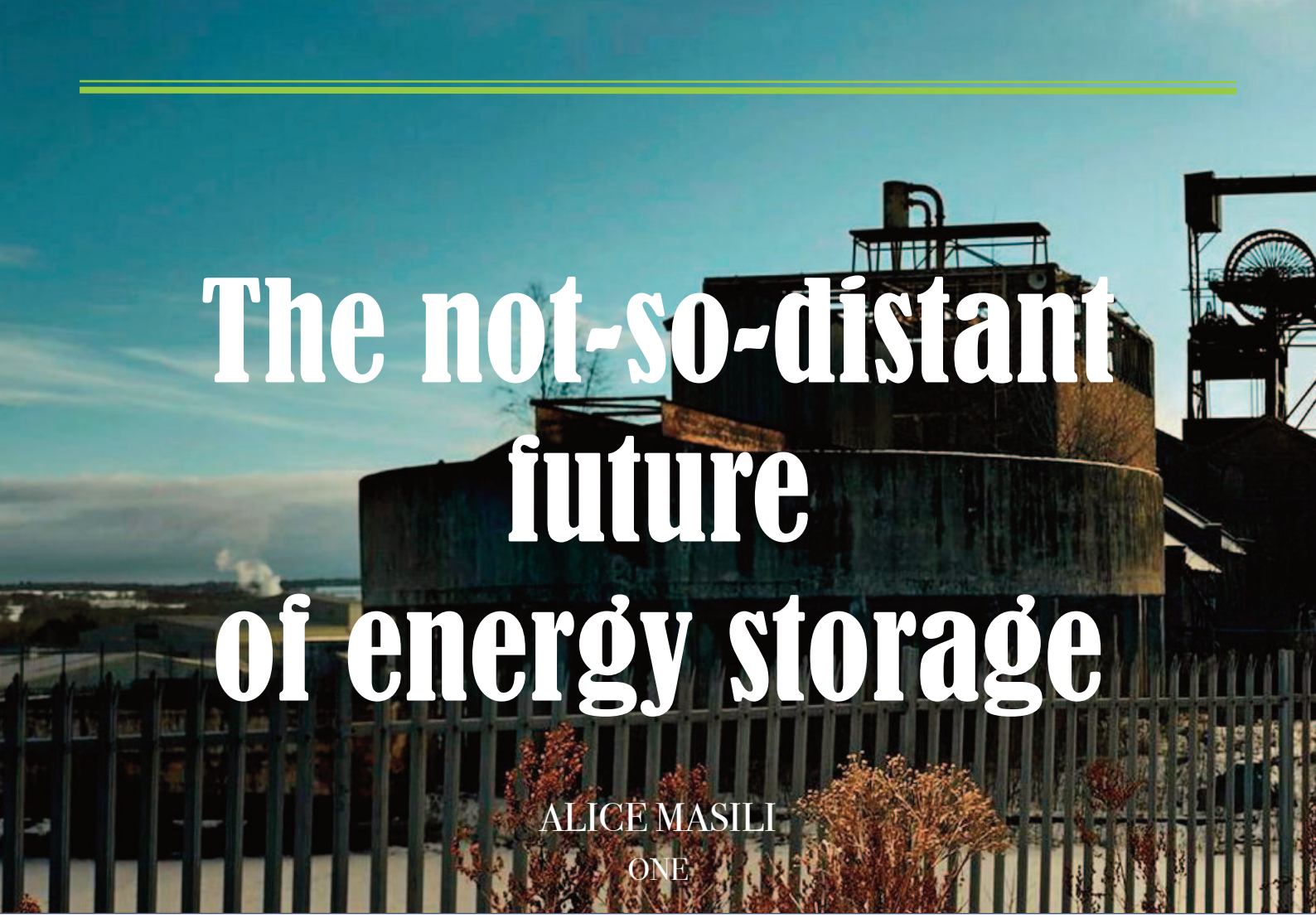

The not-so-distant future of energy storage

ALICE MASILI

ONE

The war in Ukraine put some European countries in front of a strategic problem: how to cut ties with Russia and quickly find a reliable energy alternative? The obvious choice should be to invest immediately and massively in renewable, safe, clean, mature and competitive energy.

Nevertheless, there is still a problem to be solved. When the sun shines, and the wind blows, there is plenty of green energy to generate. But what to do when the wind calms down and the sky gets dark? Increasing conventional energy production by burning more fossil fuels should no longer be an option. So energy storage is the key to overcoming the problem of renewable sources' intermittency.

The development of innovative systems of energy storage is underway. *Gravitricity* is an Edinburgh-based engineering start-up that uses a simple principle: lifting and lowering a heavy weight to store and release energy.

Last year, they successfully tested a prototype gravity battery: a 15mt steel tower suspended a 50 tons iron weight. Electricity was held in the form of potential energy by lifting weights. Then, the lowering of weights generates power to turn on a generator. Gravity can store energy in excess and release it whenever needed, from zero to full power in less than a second. Compared to traditional lithium batteries, this technology promises a design life of 50 years, with lower costs and no cycle or degradation issues. In addition, it shows great versatility as it can adapt its speed to power variations and can be easily built close to the grid.

First, Gravitricity will take advantage of the disused mining wells. The company managing director Charlie Blair argues that building towers makes no sense when you have many disused mine wells deep enough to house a full-size installation (at least 300 meters). An underground prototype is expected to be operational by 2024.

"We need to look closely at the existing civil structures – the shaft lining, the shaft's surroundings – and make sure they're sound and capable of holding up several thousand tonnes," Blair explains. "There are also potential safety issues related to methane gas and the mines being flooded." The next step will be to build special wells - costs will increase but stability too.

According to researchers from the International institute for applied systems analysis (Iiasa), the "gravitricity" principle is valid for skyscrapers too. The so-called *Lift energy storage system* (Lest) would yield

Gravitricity Managing Director Charlie Blair at Newtongrange Mining Museum, Scotland. Photo credit: Gravitricity

existing elevator systems in tall buildings. Some of these elevators are equipped with regenerative braking systems that can harvest energy during the elevator's descent, so they can already be considered pre-installed energy generators.

The Lest would also use the free spaces of the building - less expensive than the construction of a dedicated gravity battery system.
The technology of the Italian start-up Energy Dome relies on a different concept. Their CO2 battery exploits a thermodynamic process that efficiently stores energy by transforming CO2 under other conditions.

The CO2 battery works in charge mode, absorbing power from the grid, and in discharge mode, releasing energy back to the grid. In charge mode, CO2 is taken from an atmospheric gasometer, the "dome", and compressed in a compressor. The heat generated in this way is stored in two thermal energy storage systems (Tes). Then, CO2 is condensed and stored under pressure at room temperature in appropriate containers.
In discharging mode, the liquefied CO2 is evaporated and heated by recovering heat from the Tes.

CO2 flow expanded in a heated turbine returning energy to the grid and stored as a gas in the dome at ambient temperature and pressure without any dispersion into the atmosphere.

The system is capable of long-term and large-scale storage of energy. According to Claudio Spadacini, Ceo of Energy Dome, once successfully tested, the technology can be easily replicated anywhere; all you need is steel, CO_2 and water. Energy Dome estimates that it can beat lithium-ion batteries by offering up to 6 times longer life at half the price.

A first demonstration plant was recently built in Ottana, Sardinia (Italy). The Mediterranean island is blessed with wind and sun in large quantities, ideal condition to exploit renewable sources fully.
Long-life energy storage technologies are essential to support the integration of renewable energy generation. Energy storage is also a potential replacement or complement to almost every aspect of an electrical system, including generation, transmission and demand flexibility.

Once these technologies become common standards, it will signal the final passing of the baton between fossil and renewable energy. ONE

Protecting biodiversity – and making it accessible – has paid off for Costa Rica

ALEJANDRA ECHEVERRI OCHOA and JEFFREY R. SMITH
The Conversation

After two years of pandemic lockdowns and border closures, global travel appears to be rebounding in much of the world in 2022. Wilderness is a big tourist attraction – but do countries that protect their natural environments earn a payoff in tourism revenues?

Surprisingly, little research has been done on this question. Some early studies in Africa demonstrated that people from across the world travel to find "the big five" – elephants, rhinos, buffaloes, lions and leopards. But it remains unclear whether people will travel to see a wide variety of plants and animals, or just a select few iconic species.

As scholars who study conservation and ecology, we wondered whether biodiversity – specifically, the number of species in a given place – influenced where people chose to travel for tourism. We analyzed that question in a recently published study focused on Costa Rica, a country that markets itself to the world as green and biodiverse, and derives almost 10% of its gross domestic product from tourism activities.

Our study assessed whether the opportunity to see many vertebrate animal species mattered to tourists visiting Costa Rica, and if so, how important it was compared with other features like hotels and beaches. We found that an abundance of animal species alone does not drive tourism; rather, in Costa Rica, our research shows that biodiversity needs to be paired with infrastructure like hotels and roads that enable access to nature. Costa Rica has shown other countries how to do this and is reaping benefits from it.

Biodiversity, satellites and social media

For our study we used millions of sightings of animals in Costa Rica from the Global Biodiversity Information Facility, a public repository of open-access data about all types of life on Earth. The GBIF shares reports from members – including governments, conservation groups, libraries and scientific societies – about observations of plants, animals and other living species, with geographic locations. Scholars and governments draw on this data to inform scientific research and policy decisions.

We paired these wildlife observations with satellite-derived maps of climate conditions, such as temperature and rainfall, and habitat elements, such as tree cover and impervious surfaces like roads. Using this data, we created distribution maps across Costa Rica for 699 birds, mammals, amphibians and reptiles. We selected species that had more than 25 data points in the country.

We then used these maps to see how important species richness was in driving two types of tourism. First we consi-

View of the Arenal Volcano, Costa Rica.
Photo credit: Leonora (Ellie) Enking

dered general tourism, measured by where people go to take pictures and upload them to the Flickr photo sharing site. Second, we looked at checklists on eBird, a social media platform where people who identify as birders can share which species they see during nature walks.

Next we added other factors that are widely known to drive tourism, including the location of hotels, roads, national park boundaries and water features like lakes. This allowed us to consider how important biodiversity was compared with other key tourism drivers.

Our data came from NASA's Global Roads Open Access Database, a global map of roads; the GeoNames database, a global source with the coordinates of all registered hotels and lodges; and the Natural Earth database, which contains a map of the world's lakes and oceans. We used those maps to predict where tourists were going by mapping where people were taking pictures that they would then upload to Flickr, or where they were bird-watching and uploading their lists to eBird.

Nature plus small-scale infrastructure

We found that tourism is highest in zones of Costa Rica where both biodiversity and infrastructure are present and accessible to tourists. One such area is Monteverde, a lush high-elevation forest that National Geographic calls "the jewel in the crown of cloud forest reserves."

Here visitors can find the resplendent quetzal, a green bird with a red belly and long green-bluish tail that glistens in the sunlight. Considered sacred by Aztecs and Mayans, the quetzal is a major draw for bird-watchers and other tourists. Another species of high tourist interest is the red-fronted parrotlet, a small green parrot with a red forehead that is found only in Costa Rica and northern Panama.

Places like Monteverde are top tourist destinations in Costa Rica because they are replete with endemic and threatened species that visitors want to see, and that can only be found at those locations. Importantly, these areas also have enough ecolodges for people to spend the night.

Understandably, places that have high biodiversity but no infrastructure receive fewer visitors. For example, Amistad International Park, which is located in both Costa Rica and Panama, has a large tract of forest and many species. But very few people go there compared with other high-biodiversity areas. Our results indicate that this is because there

Monteverde Cloud Forest Reserve, Monteverde, Costa Rica.
Photo credit: Cephas

aren't enough roads to make the park accessible and see wild animals and birds.

Conversely, places with very high levels of infrastructure and very few species also are not desirable to tourists. Think of big-city hotels where tourists may stay for a day or two for convenience, but don't book longer stays because of the limited access to wild species.

Our findings suggest that for countries like Costa Rica to continue deriving economic benefits from tourism, they need to invest in both infrastructure and biodiversity conservation. We believe that, rather than building large resorts or multilane roads, countries would be wise to adopt Costa Rica's model of tourism infrastructure, which is mainly small ecolodges and nature hostels. Sustainability is a central theme of the nation's tourism policy, which emphasizes supporting small- and medium-sized businesses.

Just enough development

Governments around the world will convene in the fall of 2022 for a critical conference on protecting the world's wild species over the coming decade. One of the main goals for this meeting is to negotiate ways for humans to live in harmony with nature.

A key issue on the agenda is evaluating and managing trade-offs between protecting nature and promoting economic growth. Our results clearly indicate that these two things cannot be considered in isolation. In our view, the tourism sector should emphasize conserving species, because many people will pay to see wildlife and unspoiled places.

Today tourism employs some 700,000 people in Costa Rica. Our research shows that if other countries want to develop ecotourism industries modeled on Costa Rica's, they should increase access to nature-based tourism opportunities by building roads and hotels.

They also need to invest in protecting biodiversity, especially species that are endemic and threatened, which can serve as tourist draws. With careful planning and an inclusive perspective, we believe that nations can build sustainable tourism programs that benefit their economies and the environment.

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Combining Old and New: Aquaponics Opens the Door to Indigenous Food Security

Indigenous communities and partners are combining ancient knowledge with modern technology to revitalize food systems and self-determined economies in the face of ever-increasing climate pressures.

KAYLA DEVAULT

Yes Magazine

All across the United States, Indigenous peoples suffer higher rates of mortality than other ethnic groups, largely due to poorer diets and other colonial stressors that have completely altered their traditional lifeways.

One nonprofit organization in Hawai'i, Malama Waimānalo, is attempting to improve food production through aquaponics. In Hawaiian, malama means "to take care of or protect," and waimānalo, also a name of a community on O'ahu, means "potable water." The program was founded to test "culturally grounded family-based backyard aquaponics intervention," according to the organization's website. Now, the program is working to expand its operations to other communities and islands, bringing malama to more Hawaiians.

Aquaponics: Renewing the Old

Aquaponics is the combination of cultivating fish (aquaculture) and plants in water (hydroponics). Essentially, it is a method of growing animal protein in a confined space with practically no waste materials. Bacteria in the tank convert ammonia from fish waste into nitrates. Nitrates then serve as a nutrient to plants.

The only inputs include fish, fish food, seeds, pest control (which can be done with insects), and the electricity required to run pumps and water wheels. Murky fish tank water is recirculated to plants, which purify it in the process of gleaning its nutrients, and then the oxygenated water is pumped back into the fish tanks. Aside from some evaporation, these systems can produce for years with very little water replacement.

Aquaponics as practiced by Malama is a powerful system utilizing ancient Indigenous knowledge, improved with contemporary materials and methods. Much criticism can be made of the food systems that exist in contemporary society that are harmful to human and environmental health, including mass monoculture cultivation, soil degradation, chemical use, and food waste, which is an enormous sector of global carbon emissions today. The result is not only the destruction of biodiversity, but also of ideas.

In Hawai'i, Malama's founder, Ilima Ho-Lastimosa, was "doing a lot of food sovereignty work, traditional gardening, and connecting it to kids," says Jane Chung-Do, the organization's public health researcher and an assi-

A lettuce plant growing in a nutrient film technique hydroponic tube he built in Durham, North Carolina.
Photo credit: Ildar Sagdejev

stant professor of public health at the University of Hawai'i at Hilo. Ho-Lastimosa's vision was to preserve Native Hawaiian culture, founding a nonprofit in 2005 called God's Country Waimanalo. The vision would grow into one that focused on ecological practices and the health benefits of returning to traditional diets.

Malama Waimānalo, as the organization was renamed, incorporated that cultural legacy into a program focused on backyard aquaponics. Ho-Lastimosa "just really saw the need for Hawaiian families to get interested in family-based, multigenerational, culture-based activities," Chung-Do says.

A Legacy of Exploitation

While Hawai'i has fantastic conditions for scientific research—including the first observations of increasing atmospheric carbon dioxide levels on Mauna Loa that led to early warnings of global warming—the state has always been at the intersection of exploration and exploitation.

Hawaiians were first "discovered" by Captain James Cook in 1778, and the islands became the site of sugar cane plantations owned by haole (White) sugar barons, a situation that persists to the present day. Though widely recognized as a sovereign nation since at least the 1840s, Hawai'i suffered the cruel overthrowing of its queen and an abolishment of its language for nearly a century. The subsequent adoption into the United States in 1898 as a territory and in 1959 as a state has yet to provide sovereign rights to Native Hawaiians, as the U.S. does to people who are Indigenous to the contiguous United States and Alaska.

Today, the islands face high food costs and environmental destruction from the tourist industry. Couple these colonial stressors in Hawai'i with a rapidly changing climate, and the topic of food sovereignty reigns superior. Climate change, as evidenced by the rising carbon dioxide recordings in Mauna Loa (which have gone from 315 parts per million in 1958 to nearly 420 parts per million today) has caused the oceans around the Hawaiian Islands to warm, rise, and acidify. These changes have damaged coral reefs with algal blooms, harming other native food species that rely on reefs for calcium carbonate—the literal backbone of so many of these species. Consequently, land-based ecosystems are also suffering, as increased drought harms traditional foods like breadfruit and taro, which have fed Indigenous peoples on these islands since time immemorial.

In Waimānalo, on the eastern tip of O'ahu, Malama's backyard aquaponics research project is restoring sustainable and fresh foodways by rejuvenating harmonious techniques similar to the ancient ahupua'a method, which utilizes the water flowing from the mountains to the sea to grow plants and fish, Chung-Do says.

This traditional system divides land vertically along rivers so that each ahupua'a has a region of mountain, valley, and sea, creating a wedge of land with all a community's needs along its slopes: salt, fish, taro, sweet potatoes, koa trees, and so forth. Although the classes the organization offers and the food-growing systems it implements are at a much smaller scale and use contemporary materials, Chung-Do says the team views these methods as "mini ahupua'a" capable of continuing traditional knowledge, foodways, and the healthy communities that come with it.

Chung-Do described the toll colonization, militarization, and mass agriculture took on Indigenous farming systems. Malama Waimānalo works to counter those effects by providing equipment and training to build backyard aquaponics systems and grow traditional plants, such as taro. She says the Waimānalo community has responded well to the concept and how it incorporates Indigenous 'āina ("love of the land") farming practices and stewardship.

The strength of aquaponics in this context comes from the symbiotic relationship of all the elements, Chung-Do says. All organisms involved (plants and fish and humans) benefit from each other, reflecting the relationship Indigenous peoples around the world have with the land. Malama, through its work, demonstrates that it's possible to restore ancient methods and revitalize the systems threatened by modern environmentally damaging practices that do not contain the same symbiotic relationships, she says.

Restoring Traditional Foods in Untraditional Lands

While Hawai'i faces its unique challenges as a collection of destination islands without a treaty that guarantees the rights of Native Hawaiians, other tribal

Ebb and flow trays fed aquaponics water.
Photo credit: Aleon

communities within the geopolitical boundaries of the United States navigate their own troubled waters.

They face many historically similar challenges, threats of cultural erasure, and legacies of oppression. While many tribes are combating the high prevalence of obesity, diabetes, and other diseases in their communities by restoring traditional foodways and place-based spirituality, tribes removed from their ancestral lands must find unique ways to cope.

The Seminole Nation of Oklahoma teamed up with Symbiotic Aquaponic, a Native-run company, to build customized aquaponics farming systems for individuals, schools, businesses, communities, and tribes. Kaben and Shelby Smallwood, two brothers from the neighboring Choctaw Nation of Oklahoma, founded the business in 2012. Symbiotic Aquaponic partnered with, trained, and provided equipment to the Seminole Nation through a grant, and now that system grows and distributes foods to the tribe. These sy-

stems allow organic foods to be grown with 1% of the water used in industrial agriculture, empowering Oklahoma tribes who, like the Seminole and Choctaw, were forcibly relocated here.

Seminole Aquaponics, a division of the Seminole Nation Division of Commerce in Oklahoma, is managed by rancher and self-described former-nurse-gone-ag Rebecca Votaw. Votaw, who is not Native, combines her passion for holistic healing with the Seminole traditions of her husband and children's Indigenous ancestors to restore food sovereignty for the tribal nation and help improve its members' health.

Votaw grows traditional foods in the system, such as the Three Sisters (corn, pole beans, and squash), and also prioritizes finding the best varieties for nutrition, seed saving, and succession planting. She also grows Job's Tears, a variety of millet related to maize and other important crops, and analyzes seed catalogs to pick tomato varieties that can be canned if a surplus is produced.

"The whole idea for creating [an aquaponics system] was finding ways to expand on [Seminole] food sovereignty, but also create a business that could potentially turn around and affect the community," Votaw explains. "If used properly, and the way it was intended for, it will do just that. But it's a growth process."

One of the initial barriers to that growth process was a financial one. Votaw says that startup costs are high, but the return on investment can be surprising. For example, Seminole Aquaponics started with 12 pounds of bluegill in one tank. In less than a year, that had increased to 29 pounds, and the tribe is now expanding its system to include catfish and bass.

All the project's income goes back into expanding the system. Votaw says that, in early spring, they are "starting seeds, putting in pots, and getting ready for plant sales to make available to the [Seminole] Nation and outside sources." Seeds are started on-site near the aquaponics system and then transferred to pots to make the best use of limited space.

Besides distributing produce, these pots are also given to tribal members to grow their own food, create their own seed banks, and continue the positive feedback loop. Because potting soil is expensive, Votaw is now introducing red wiggler worms and their castings. She calls it "doing our own worms" to reduce costs and exponentially increase the system's zero-waste quality.

One of the challenges for the Seminole Nation of Oklahoma, however, is that not all traditional foods thrive in the hot Oklahoma summers like they did in the tribe's ancestral lands in the American Southeast, before the tribes were forcefully relocated in the 19th century.

Examples include the medicinal tea leaf yaupon, the incense sweetgrass, and blueberries. Votaw says tribal members have tried different techniques to grow these species, such as companion planting, and continue to explore a variety of options for maximum nutrition and the benefits of an aquaponics system that is sheltered from the weather.

But she says the best part of their aquaponics endeavor is the flavor.

When visitors bite into ancient yellow and purple carrots, Votaw says, they are surprised by the taste. "People in general, that shocks them, because store-bought food is picked too early and is not the same flavor."

Seminole Aquaponics also provides tribal youth with wholesome samples as part of its partnership with various diabetes and wellness programs. The food Votaw and her two-person team grows packs a punch of nutrients and taste to get tribal members tucking in.

Restoring Indigenous foodways is not just about restoring sovereignty and traditional practices. It's also about celebrating the ancestors and taking care of a community of relatives. "Food is the center of so many Indigenous cultures. Food is central to everyone's health," Malama Waimānalo's Chung-Do says.

She says the participatory community endeavor is being validated by the impact aquaponics are having in Native Hawaiian households. Not only are families eating healthier, but children are learning where their food comes from, and entire communities are reconnecting to the land.

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Meet Zacua, Mexico's first electric car brand

ALEJANDRA CUELLAR

Dialogo Chino

Zacua, Mexico's first electric car brand, started in 2017, over twenty years since the idea first struck its founder, Jorge Martínez. As director of one of the country's biggest car parking businesses, Martínez knew first-hand just how many petrol vehicles were on the country's roads, and understood that the world of motoring had to change.

Martínez envisioned the first Mexican-built electric car, teaming up with electrical and mechanical engineers and naming the company Zacua, after the favourite bird of sixteenth-century emperor Moctezuma II. In 2018, it opened its first production plant, in the state of Puebla.

Zacua's first test vehicles were delivered that same year, and its team have since been perfecting the models. But the project has not been free of obstacles: in an ever more crowded market, competing against established international brands with longer histories – and deeper pockets – Zacua has had to make a name for itself from scratch. In Mexico, however, the company has built a community of users that has supported the project at every step, testing and helping to improve its vehicles.

Zacua currently has two models on the production line – the MX2 and MX3 – both starting at 599,000 Mexican pesos (US$30,500), with the company also offering subsidies of around US$2,500 to cover part of the cost for its users. Its compact cars are pitched as urban vehicles, with a range of 160 km and batteries claimed to be capable of 3,000 full-charge cycles, translating into an estimated eight-year life. In recent years, Latin America has seen moderate growth in its electric vehicle market, with over 10,700 EVs estimated to be on the roads in 2020. Many countries in the region have introduced incentives for electric vehicles, such as exemptions or discounts on sales, environmental and import taxes. And beyond Mexico, manufacturers in Bolivia, Brazil and Argentina have also begun to develop their own domestically built electric vehicles.
However, the high price of electric cars is still a barrier for the majority of Latin American consumers – and for their local producers, many of whom have so far seen more losses than profit.

Nevertheless, Zacua has found a positive reception. Earlier this year, the country's Secretary of Foreign Affairs, Marcelo Ebrard, arrived in a Zacua for the launch of a Mexico-United States Electric Vehicle Working Group in California, in a clear show of support for the Mexican brand. As interest in the company's work builds, Diálogo Chino spoke with Nazareth Black, Zacua's CEO, to hear more about its origins and projections.

Photo credit: Zacua

Diálogo Chino: What is Zacua for you?

Nazareth Black: More than a brand, Zacua is a state of mind: all of us need to travel, but when you get into a Zacua, you get into a very positive state of mind, saying "I am travelling and I am no longer polluting". The aim is to reduce the impact on the earth and leave a better world for those who come. But we as a species are killing ourselves with the cars we choose to use: we are choosing the weapon that is killing us.

All these actions that we can take, we are taking to increase our chances of survival and of those to come, to be able to survive in an environment of the highest possible quality. Zacua is also the name of a bird – it was the favourite of Emperor Moctezuma, who is important to Mexico's history. As a Mexican project, we seek to promote our country to the world, and this gives us the opportunity to start conversations about our history.

What was the process of developing the technology like?

The car's electronics were developed in-house, at the plant with our engineers. So we have technological independence – that is, we own that technology. And that strikes me as an extraordinary achievement. It is our first attempt, being a small and emerging company.

Within the community, within an international industry experiencing [a shift to] Industry 4.0, we are a star, and many countries have come to learn about the project. We have that recognition. They ask us: "How did they do it?" Obviously we know that we have to improve on so many things, but our whole life is [dedicated to] constantly improving. In the internal team we have mechanics, electrical engineers, mechanical engineers. Even me, we all ended up teaming up to pull this off.

How was were the first cars to hit the streets received?

At the beginning, we had the support of family and friends. Because at the beginning, who is going to buy you? Your cousin, your best friend, your husband who says "I'm going with you" – because we are not a brand that has a history. There is no background, where they say, for example, "a Toyota works like this". We are very aware that we do not have that. The first ones knew that they were coming to "work with us", rather than simply buying a car. We had gotten it out of the dream stage, so then it's onto "go and try it, and tell me if it moves and works as we think". Others came along, saying "I want one", but we had to tell them, the first round is just family and friends. Then several other people said they wanted to become a test pilot. And like this, we reached 50 [testers].

What problems have you encountered and what has been changing?

At first, little things appeared, but no mechanical issues. What mattered most to me was that the car didn't get left behind. In that regard, it has been very good, and we have been improving things. Now it is more like an experimentation workshop. Someone had the idea of developing a screen from which to manage the whole car, it's totally touch screen-based. That is new.

When we started, we brought in the transmission systems from outside. Now, we make them at the plant. We want all the parts to be Mexican. That is what we have been doing over the years: working on supply issues. And working with those who have our cars on the move. It has been three and a half years since they began to be delivered, and so far we have not had a crash, or even a flat tyre. We are also in the process of building a database of information, working out the things we have and things we don't.

And how about the economics?

No one who is selling electric cars makes any money. Currently it is not profitable. It will probably be at some point, but all of us here at Zacua, firstly, do not live from this and, secondly, we are not expecting it to be a quick business – nor are we expecting to make money. We are not the exception.

It is a family business, belonging to a group of companies. At the moment, we are raising capital – that's how all businesses are, for new businesses you have to invest. Everything is more expensive for us than a global brand. If I buy 50 steering wheels, for example, Ford buys 5 million. Who will get it cheaper? For us, currently, everything is more expensive. That is why we are practically profitless.

What's next for Zacua?

We are currently working on other prototypes: utility vehicles for home deliveries, and goods vehicles. Also, many foreign companies are coming to work in Mexico as it is cheap to assemble here. So there is a wave of suppliers and car brands realising it is convenient to assemble here and then enter North American markets. So why don't we make a platform to serve them? Either we see them as competition or we collaborate and capitalise on this. We already have a structure in place: we have an assembly service, we provide assembly for other cars. We can offer more certainty, and confidence for those who need our services.

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Fossil Fuels Drive Increase in Atmospheric Helium

JENNIFER SCHMIDT

EOS

The release of carbon dioxide (CO_2) during the extraction and burning of fossil fuels has contributed to major changes in Earth's atmosphere in the centuries since humans realized their value as an energy source. Often accompanying CO_2 are benign gases such as helium (He) that can be used to trace such emissions. Scientists have long speculated that the amount of ^4He—an isotope of helium—in the atmosphere is increasing because it is found in the same reservoirs as natural gas and other hydrocarbons. But measurements have so far been conflicting and imprecise. Now, researchers have developed a new way to measure the noble gas, shedding light on the decades-old conundrum.

"With our measurements, for the first time, we're able to demonstrate that [the theory is] actually true, that helium concentrations in the atmosphere are increasing," said Benjamin Birner, an atmospheric chemist and postdoctoral researcher at Scripps Institution of Oceanography. The new discovery could lead scientists to better identify sources of CO_2 in the atmosphere, which could guide policies to curb emissions. The increase in ^4He also raises questions about its isotopic companion, ^3He, and a potential undiscovered reservoir of the gas—a critical resource in some research and commercial industries.

Helium Pairs with Fossil Fuels

Some minerals naturally contain uranium and thorium. These radioactive elements decay to stable ones over millions of years, releasing ^4He in the process. Because ^4He is a noble gas, it does not readily bond with other elements and slowly leaks out of its host crystal over time. Rogue helium in Earth's crust percolates toward the surface before escaping to the atmosphere. In some cases, the rising gas gets trapped beneath an impermeable cap rock. Natural gas, escaping from buried source rocks, also rises through the subsurface and becomes trapped along with helium. "If you have a geological setting that's suitable to contain [natural] gas, it's probably also suitable to trap the helium," Birner said.

When humans come along and extract the gas from these reservoirs, ^4He is also liberated. With the growth of fossil fuel use since the beginning of the industrial era, ^4He should be flooding the atmosphere. And scientists have been looking for it. Unfortunately, conflicting data have so far muddled any evidence of a long-term rise in atmospheric helium—some studies measured an increase, whereas others showed little to no change.

A Precise 4He Measurement

Birner and colleagues developed a new way to calculate ^4He that boasts a precision higher than that achieved by any previous studies. First, they obtained samples. Because of helium's leaky nature, air samples are difficult to store, and scientists have had to mine creative sources of old air. One past study extracted air from inside carburetors and sealed metal pétanque game balls. "[Helium] doesn't diffuse through metals. So you had to find some good metal boxes," said Bernard Marty, a geochemist at the University of Lorraine who was not involved with the study. Birner and colleagues used gas stored in metal tanks sporadically collected by scientists for other experiments since the 1970s. Then the group measured the change in the ratio of ^4He and nitrogen (N_2) through time. Nitrogen levels in the at-

mosphere remain relatively constant over the years; therefore, any change in the ratio between samples indicates a change in the amount of $_4$He. The researchers discovered a significant increase in $_4$He in air samples dating back to 1974—two orders of magnitude more than what is expected from Earth's natural processes, according to the study. The increase is also larger than the small amount released by commercial and research applications.

Because $_4$He can now be precisely measured and is demonstrably increasing, scientists can trace the origins of associated greenhouse gases such as carbon dioxide. $_4$He concentrations are highest in natural gas compared to other fossil fuels such as coal and petroleum. By measuring the amount of both $_4$He and carbon in an air sample, scientists hope to determine how much of the total emissions comes from natural gas burning as opposed to automobiles or a coal power plant, Birner said. Surprisingly, scientists also still have a lot to learn about Earth's natural carbon emissions. Having a precise way to trace carbon with helium could help them determine how much is being pumped into the atmosphere by nature, said Marty. "I think we'll learn a lot more about how the world works from helium," Birner said.

A $_3$He Mystery

The new data settle the long-standing debate about $_4$He in the atmosphere. "They are great measurements," said Marty. But, he added, they pose an interesting problem.

Earlier studies, including some by Marty and colleagues, investigated the ratio of $_3$He to $_4$He in air samples to get at the $_4$He concentration in the atmosphere. $_3$He is a naturally occurring, stable isotope of helium. The most precise $_3$He/$_4$He measurements available have shown that ratio is unchanging in the atmosphere over time. The fact that the researchers in this study independently observed an increase in $_4$He means that $_3$He must also be increasing.

$_3$He is rare on Earth; it is released primarily from a mantle reservoir remnant from the formation of our planet. It is also produced from cosmic ray bombardment, solar wind, and interstellar gases and in the manufacture of nuclear weapons. But none of these sources can account for the amount entering the atmosphere. "The signal is about 10 times the geological fluxes, and we don't know how to explain the source of this additional $_3$He," Birner said.

$_3$He is used in applications such as cryogenics, nuclear fuel, and medical imaging. In recent decades, as demand on the world's supply has increased, it has become a scarce resource. The prospect of an undiscovered source of $_3$He is therefore intriguing. "People have thought about flying to the Moon to mine $_3$He there. That's how important that resource is," Birner said. "It will become even more important in the future because nuclear fusion reactors are theorized to run on $_3$He," he added.

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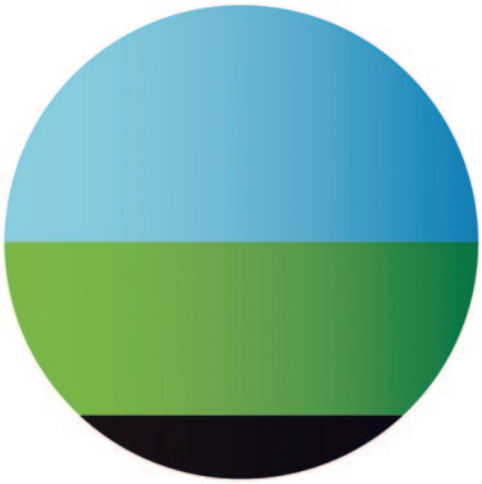
Photo credit: Paul Searing

SHOREHAM

The plant that never was. But no one envisaged that in 1965 when Long Island Lighting Company (LILCO) President John J. Tuohy announced plans for the first commercial nuclear power plant on Long Island. Initially, that proposal faced no or little opposition, as Brookhaven already had multiple research nuclear reactors a few miles south of Shoreham. Everything changed after the 1979 Three Mile Island accident when 15,000 protesters gathered in front of the plant.

The nuclear plant was completed in 1984 and received the federal go-ahead for some tests one year later. But then the Chornobyl disaster happened. It was the beginning of the end for the Shoreham plant, as the local communities did not sign on to the evacuation plan, which meant the plant could not open. Ten years after its completion, Shoreham became the first commercial nuclear power plant ever dismantled in the US. ONE

SOTACARBO



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