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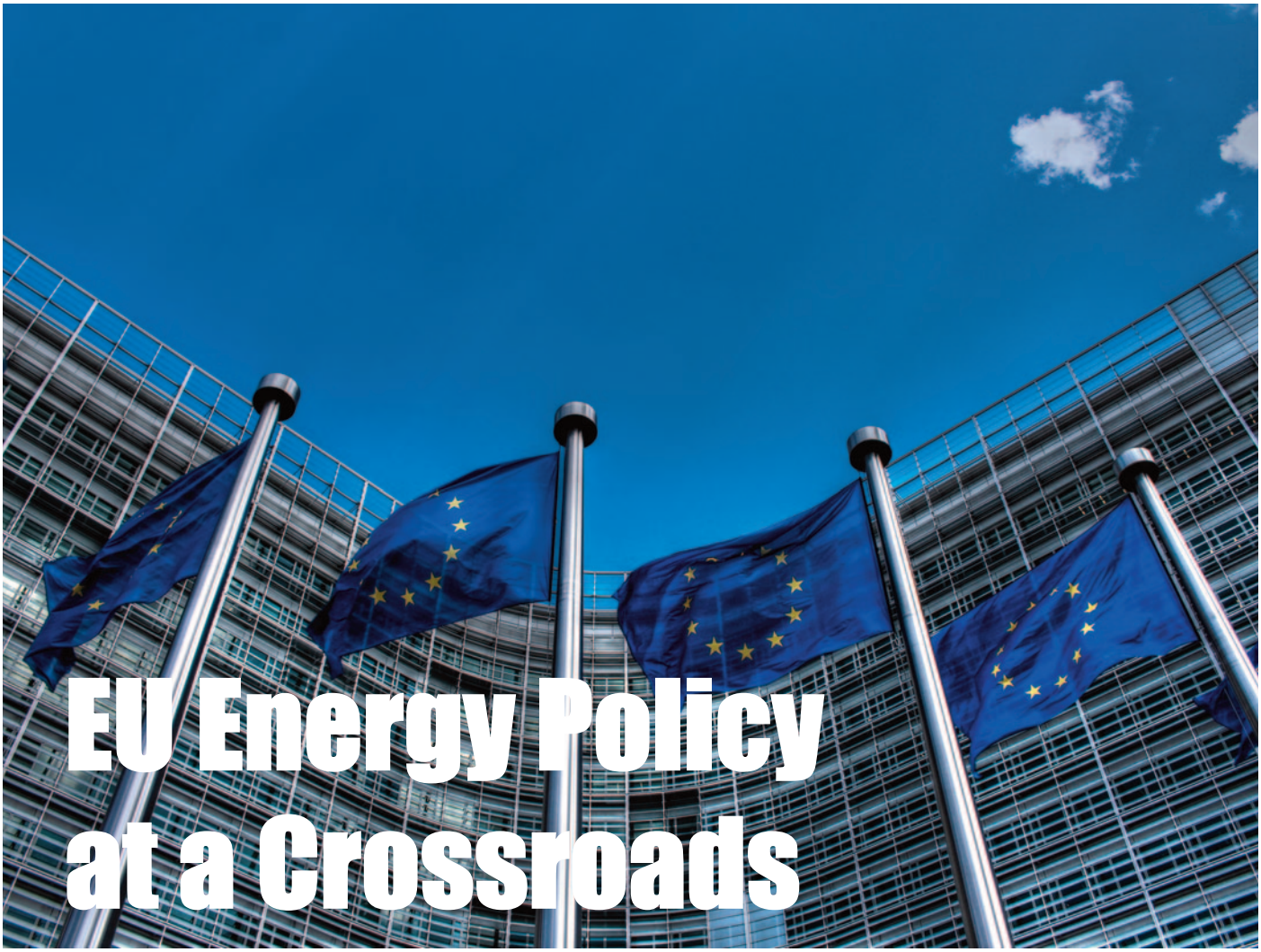
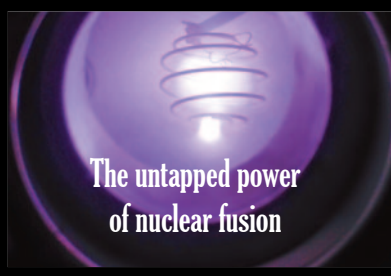


EU Energy Policy at a Crossroads

Raw War

Zhangjiakou's next gold medal

The Original Sin of American wilderness



The untapped power of nuclear fusion

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Raw War

GIANNI SERRA
ONE

Let's forget propaganda for a minute. Russia invaded Ukraine on 24 February. Fact. On the same day, Putin's army seized control of the ghost Chernobyl nuclear power plant. Not a symbolic choice - energy and resources are not irrelevant or secondary targets. Opinion.

Based on a few more facts. Ukraine is a country with massive mineral and raw material potential. According to the "National Atlas of Ukraine", it can provide for about 5% of world demand in mineral raw materials and derivative products despite covering 0.4% of the planet's surface. Ukraine ranks in the world's top four for the total value of natural resources and iron, titanium, turbines for nuclear power plants and clay exports.

Ukraine is the first country in Europe regarding cultivable land, ammonia production, and recoverable uranium reserves. And also in the top three countries for titanium, manganese, mercury ore, and shale gas reserves. If you are looking for solid motives to explain the latest events, look there. Underground. Where denazification and Nato are nowhere to be seen or heard. ONE

EU Energy Policy at a Crossroads

STEPHANIE METZGER
ONE

The Russian invasion of Ukraine has jeopardized the European Union's plan for clean and secure energy. The EU's Fit for 55 package aims to reduce emissions across the bloc by at least 55% by 2030, and most member countries have ambitious targets to phase out coal and expand renewable power.

The EU has pushed ahead with its plans despite the Covid-19 pandemic and associated economic troubles, citing the opportunity for investment in a green recovery aided by Covid-19 financial stimulus packages. However, the conflict between Russia and Ukraine has revealed the geopolitical and energy security concerns inherent in the EU's plans.

Reliance on natural gas as a transition fuel has left European countries dependent on Russia for a significant portion of their energy needs, clashing with the West's desire to economically stifle Russia amidst the conflict. This situation has shown that it may be time to reimagine EU energy policy.

Russian invasion comes as European energy markets are already under pressure

Russian President Vladimir Putin's invasion of Ukraine comes at a tough time for European energy markets, which already faced rising energy costs over the winter of 2021-2022. Skyrocketing gas prices have arrived against a backdrop of prescheduled nuclear and coal phaseouts across the continent.

Germany shut three of its six remaining nuclear plants at the end of 2021, and the others are scheduled to shut at the end of 2022. France, which relies on nuclear for around 70% of its power, is currently performing scheduled maintenance on nearly one third of its

EU Commission president Ursula von der Leyen.
Photo credit: European Commission

nuclear reactors. As a result, the country has been forced to import electricity from its neighbours at a time when resources are already strained.

Many countries are also in the process of phasing out coal power. According to national energy and climate plans, the majority of EU countries will have closed their remaining coal plants by 2030. Only Poland, Czechia, and Bulgaria intend to have any significant level of coal power past this date.

Rising gas prices have hit extra hard in this context. As of the week of March 14, gas prices hit a record high of €335 per megawatt hour. Consumers' bills are rising, sparking unrest in the general population and unease across the governments of Europe.

Coal use has also made a comeback as the economics of gas become more unfavourable, even in light of high carbon prices. Italian Prime Minister Mario Draghi has floated the idea of reopening some of the country's coal plants in order to reduce its dependence on Russian gas, which currently supplies 45% of Italy's gas demand.

Germany is considering extending the operational lifetime of its nuclear plants to bridge any shortages, and other countries such as Poland and Romania are moving forward on plans to build new nuclear. All of these changes are being made in an effort to break Europe's reliance on Russian oil and gas, which currently account for around 40% of gas and one third of oil imports.

European reliance on Russian oil and gas undermines leverage in the Ukraine conflict

The importance of European energy independence from Russian oil and gas has only been heightened in light of the Russian invasion. Putin has used his country's oil and gas supplies for diplomatic leverage in the past, and the most recent round of European sanctions against Russia have been blunted by the exclusion of vital energy products.

And while the US has banned Russian oil and gas in response to the conflict, European leaders have been hesitant to take such a step without first securing a new supply of gas from alternate sources. For example, UK Prime Minister Boris Johnson has been negotiating to increase supplies from Saudi Arabia, while the Italian Foreign Minister has said that they have increased imports from Algeria.

Germany has emerged as perhaps the most conflicted state in this regard. Under Chancellor Angela Merkel, Germany generally maintained good relations with Putin, and the personal relationship between the two leaders was seen as an important diplomatic channel for the West.

However, the new governing coalition, led by Chancellor Olaf Scholz, lacks a clear policy toward Russia. Initially, the government took a softer stance on the Russian invasion than many of its neighbours, resisting calls to send military assistance to Ukraine and implement strong sanctions against Putin's allies.

Former Chancellor Gerhard Schröder has also made overtures to Putin as a potential negotiator, despite a lack of authorisation from the official German government to do so.

Hanging in the balance was the Nord Stream 2 pipeline, which would provide a new infusion of Russian gas to a country that increasingly relies on the fuel to replace nuclear and coal plants. Ultimately, though,

Rohre für Nord Stream 2 in Mukran. Photo credit: Gerd Fahrenhorst

Scholz announced that the government would halt the certification of the pipeline, denying Putin some of the leverage he previously held over the continent.

More generally, the conflict has emphasised the importance of energy security and independence. EU efforts to decarbonise the power system have often come about by increasing the reliance on energy imports. The pre-existing crisis of high energy costs, now compounded by the situation in Ukraine, have highlighted the pitfalls of this approach – for both cost of living and effective diplomacy.

A chance for systemic change

As difficult as the current situation is for both governments and consumers, the conflict offers a stark choice for the future of the European energy system.

Plans to use gas as a 'bridge' fuel towards decarbonisation may not be as sustainable an option as previously thought. Nuclear may now see a revival, and momentum for the use of carbon capture and storage (CCS) may increase as well. Energy storage and power grid modernisation have also taken centre stage as countries grapple with unstable energy supplies. Although the recent state of affairs seems dire, it also offers Europe a chance to take bold steps toward a more sustainable and independent energy system.

Such changes are not without precedent. In response to the energy crisis of the 1970s, France remade its energy system. Faced with rising costs and a reliance on imports for 75% of national energy demand, France transformed its coal-based energy system by building out a large fleet of nuclear power plants.

The share of nuclear rose from 2% in the 1970s to 30% in the 1990s and now accounts for 70% of electricity generation. As a result, the country now relies on nuclear and renewables for 90% of its power needs and is a net exporter of electricity.

The rest of Europe should pursue a similar policy to divest itself from Russian oil and gas. Countries need to focus on using domestically available sources of energy. Renewable power, such as solar, wind, and geothermal energy, should receive increased investment. EU policy already includes a focus on renewables, but it is crucial to move on such plans without delay.

European Commission President Ursula von der Leyen has made this message clear in recent speeches, stating that 'We need to act now to mitigate the impact of rising energy prices, diversify our gas supply for next winter and accelerate the clean energy transition.' Europe also has significant coal, biomass, and waste resources, which could be revitalised with the use of CCS.

A few CCS hubs are already under development in the UK, Norway, and the Netherlands, and the current crisis should underscore the importance of these projects to potential investors and partners. They may provide a method of using domestic energy resources while still maintaining adherence to the EU's climate goals.

There should also be a stronger focus on modernising the power grid. Already in response to the crisis, the Ukrainian and Moldovan power grids have been synchronised with the Continental European Grid.

This action removed the two nations from the legacy Soviet grid which also includes Russia and Belarus. While plans to link Ukraine and Moldova to the European power grid already existed, the invasion caused grid operators to rush to complete the work over a year early.

Grid interconnectors are seen as a vital way to support Ukraine during the crisis: if domestic power sources are damaged, other European countries could export power to help keep essential services running.

Further than this immediate need, European countries should continue to strengthen the interconnections between their national grids.

Doing so would help to maintain a stable electricity supply as the use of variable renewable energy increases. It can also help to balance the effects of domestic shortages, whether from unplanned outages or disruption due to routine maintenance. In general, grid modernisation and flexibility will be key for enabling the transition to a sustainable energy system.

The time for change is now

While the choices to be made about the energy system are complex, that is not an excuse to delay. The conflict in Ukraine has underscored the need for immediate action from national and EU leaders. And the EU has been remarkably united in the weeks following the Russian invasion, in contrast to its often-chaotic process. Leaders should harness this spirit of action and cooperation to make bold changes to the EU's energy transition pathway. Doing so will not only show Russia that the rest of Europe is a united front that will not be complicit in enabling Russian expansionism - it will also help the EU achieve its decarbonisation goals. ONE

Are Microbes the Future of Recycling? It's Complicated

An enzyme-based recycling technology is poised to go commercial, but questions about cost and scalability linger.

ULA CHROBAK
Undark

Since the first factories began manufacturing polyester from petroleum in the 1950s, humans have produced an estimated 9.1 billion tons of plastic. Of the waste generated from that plastic, less than a tenth of that has been recycled, researchers estimate. About 12 percent has been incinerated, releasing dioxins and other carcinogens into the air. Most of the rest, a mass equivalent to about 35 million blue whales, has accumulated in landfills and in the natural environment.

Plastic inhabits the oceans, building up in the guts of seagulls and great white sharks. It rains down, in tiny flecks, on cities and national parks. According to some research, from production to disposal, it is responsible for more greenhouse gas emissions than the aviation industry.

This pollution problem is made worse, experts say, by the fact that even the small share of plastic that does get recycled is destined to end up, sooner or later, in the trash heap.

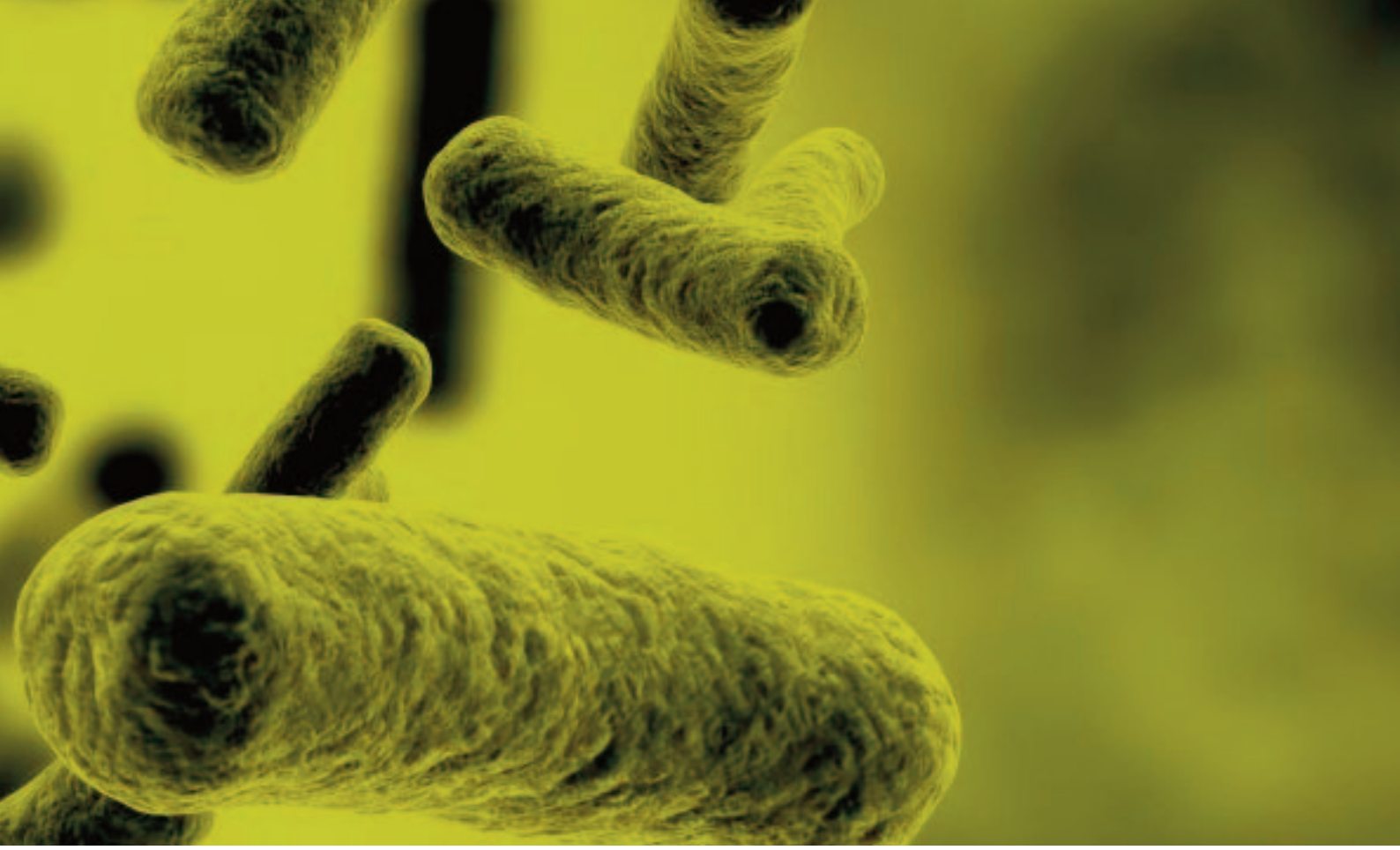
Conventional, thermomechanical recycling — in which old containers are ground into flakes, washed, melted down, and then reformed into new products — inevitably yields products that are more brittle, and less durable, than the starting material. At best, material from a plastic bottle might be recycled this way about three times before it becomes unusable. More likely, it will be "downcycled" into lower value materials like clothing and carpeting—materials that will eventually be disposed of in landfills.

"Thermomechanical recycling is not recycling," said Alain Marty, chief science officer at Carbios, a French company that is developing alternatives to conventional recycling.

"At the end," he added, "you have exactly the same quantity of plastic waste."

Carbios is among a contingent of startups that are attempting to commercialize a type of chemical recycling known as depolymerization, which breaks down polymers — the chain-like molecules that make up a plastic — into their fundamental molecular building blocks, called monomers. Those monomers can then be reassembled into polymers that are, in terms of their physical properties, as good as new. In theory, proponents say, a single plastic bottle could be recycled this way until the end of time.

But some experts caution that depolymerization and other forms of chemical recycling may face many of the same issues that already plague the recycling industry, including competition from cheap virgin plastics made from petroleum feedstocks. They say that to curb the tide of plastic flooding landfills and the oceans, what's most needed is not new recycling technologies but stronger regulations on plastic producers



— and stronger incentives to make use of the recycling technologies that already exist.

Buoyed by potentially lucrative corporate partnerships and tightening European restrictions on plastic producers, however, Carbios is pressing forward with its vision of a circular plastic economy — one that does not require the extraction of petroleum to make new plastics. Underlying the company's approach is a technology that remains unconventional in the realm of recycling: genetically modified enzymes.

Enzymes catalyze chemical reactions inside organisms. In the human body, for example, enzymes can convert starches into sugars and proteins into amino acids. For the past several years, Carbios has been refining a method that uses an enzyme found in a microorganism to convert polyethylene terephthalate (PET), a common ingredient in textiles and plastic bottles, into its constituent monomers, terephthalic acid, and mono ethylene glycol.

Although scientists have known about the existence of plastic-eating enzymes for years — and Marty says Carbios has been working on enzymatic recycling technology since its founding in 2011 — a discovery made six years ago outside a bottle-recycling factory in Sakai, Japan helped to energize the field. There, a group led by researchers at the Kyoto Institute of Technology and Keio University found a single bacterial species, Ideonella sakaiensis, that could both break down PET and use it for food. The microbe harbored a pair of enzymes that, together, could cleave the molecular bonds that hold together PET. In the wake of the discovery, other research groups identified other enzymes capable of performing the same feat.

Enzymatic recycling's promise isn't limited to PET; the approach can potentially be applied to other plastics, including polyurethane, used in in foam, insulation, and paint. But PET offers perhaps the most expansive commercial opportunity: It is one of the largest categories of plastics produced, widely used in food packaging and fabrics. PET-based beverage bottles are among the easiest plastics to collect and recycle into a marketable product.

Traditional depolymerization technologies rely on inorganic catalysts rather than enzymes. But some chemical recycling companies have struggled in efforts to turn PET recycling into a viable business model — with some even facing legal scrutiny.

In the Carbios demonstration plant, PET flakes and the patented cutinase enzymes mix in the large reactor tank on the right. Within 10 hours, 95 percent of the plastic is converted into monomers. Photo credit: Carbios

Despite this, Marty says that Carbios' enzyme-based approach offers advantages over traditional depolymerization methods: The enzymes are more chemically selective than synthetic catalysts — they can more precisely target specific sites on specific molecules — and could therefore yield purer product. Plus they work at relatively low reactor temperatures and do not require expensive, hazardous solvents.

Traditionally, however, the problem with enzymes has been that they work slowly and can destabilize under heat. In early experiments, it sometimes took weeks to process just a fraction of a batch of PET.

In 2020, Marty and colleagues at Carbios, along with researchers in France, announced that they had engineered an enzyme — a so-called cutinase, naturally found in microbes that decompose leaves — that could withstand warmer temperatures and convert nearly an entire batch of PET into monomers in a matter of hours. The discovery dramatically boosted enzymatic recycling's commercial prospects; In the 10 months that followed, Carbios' stock price on the Euronext Paris exchange grew about eightfold.

Last September, Carbios began testing its technology at a demonstration facility near its headquarters in Clermont-Ferrand, France, about a two-hour drive west of Lyon. Used PET arrives here as thin, pre-processed flakes about one-fifth of an inch across. In a 16-foot-tall reactor, the flakes are mixed with the patented cutinase enzymes —produced by Denmark-based biotechnology company Novozymes — and warmed to a little above 140 degrees Fahrenheit.

Within 10 hours, Marty says, 95 percent of the plastic fed to the reactor, the equivalent of 100,000 plastic bottles, can be converted into monomers, which are then filtered, purified, and prepared for use in plastic manufacturing. (The remaining 5 percent, made up of unreacted plastic and impurities, is incinerated.) As Marty describes it, the end product is physically indistinguishable from the petrochemical-based substances used to manufacture virgin PET.

Carbios' recycling technology has grabbed the attention of some of the world's largest consumer goods companies. L'Oréal, Nestlé, and PepsiCo have collaborated with the startup to produce proof-of-concept bottles, and all seem intent on eventually putting enzyme-recycled plastic on shelves.

But Kate Bailey, the policy and research director at Eco-Cycle, a nonprofit recycler based in Colorado, says that over her 20 years in the recycling industry, she has grown skeptical of biotechnology fixes like the one being touted by Carbios. While she acknowledges that new solutions are needed, given the urgency of the plastic problem, she says "we don't have more years to figure this out and wait for new technology."

Bailey points to lingering questions about how enzymatic recycling will be scaled up to handle commercial volumes, including questions about its energy footprint and its handling of toxic chemical additives found in many consumer plastics.

Marty concedes that Carbios' process is, indeed, more energy-intensive than conventional recycling — he de-

clined to specify by how much — but added that it's not fair to compare enzymatic recycling with thermo-mechanical processes, which don't produce as high quality of a recycled product and eventually result in the same quantity of waste. Still, he said, it requires less energy, and releases less greenhouse gas, than producing virgin PET from petroleum — claims that are supported by an independent analysis published last year by the U.S. National Renewable Energy Laboratory. As for additives, he says they are filtered out during post-reaction processing and incinerated.
But the most stubborn hurdle for Carbios and other enzymatic recycling hopefuls may be an economic one. "It's super cheap to make virgin plastic, especially with the low price of oil," said Bailey.

"You have to be able to sell your recycled PET against to some company that also has the option of buying virgin PET," she added, "and when virgin is just cheaper, then that's what companies buy."

In its analysis, the National Renewable Energy Laboratory estimated that PET monomers produced through enzymatic recycling would carry a price of at least $1.93 per kilogram; virgin, petroleum-based monomers have ranged between $0.90 and $1.50 per kilogram since 2010. And now that many fossil fuel companies are pivoting their business models toward plastic production, the market competition for plastic recyclers could grow even stiffer.

Marty, however, is optimistic about his company's prospects. He points out that the price of oil is rising and that tightening regulations on the use of fossil fuels in Europe is making recycled plastic more competitive there. Several consumer goods giants have publicly committed to sourcing more of their products from recycled materials: Coca-Cola pledged to use recycled material for half of its packaging by 2030, and Unilever aims to cut its reliance on virgin plastic in half by 2025.

"At the beginning, sure, it will be a little more costly," Marty said. "But we will reduce, with experience, the cost of this recycled PET."

Wolfgang Streit, a microbiologist at the University of Hamburg, says that even if companies achieve commercial success with PET, some polymers may never be amenable to the enzymatic recycling. Polymers like polyvinylchloride, used in PVC pipes, and polystyrene, used in Styrofoam, are held together by powerful carbon-carbon bonds, which might be too sturdy for enzymes to overcome, he explains.

That's one reason Bailey believes new policies need to be considered alongside new technologies in addressing the global plastic waste problem. She advocates for measures that limit the production of hard-to-recycle plastics and improve collection rates for materials like PET, which can be recycled, albeit imperfectly, with existing technologies. Bailey notes that currently only about three in 10 PET bottles gets collected for recycling. She describes that as low-hanging fruit "that we could solve today with proven technology and policies."

Now that many fossil fuel companies are pivoting their business models toward plastic production, the market competition for plastic recyclers could grow even stiffer.

Most PET produced globally is used not for bottles but for textile fibers, which, because they often contain blended materials, are rarely recycled at all. Mats Linder, the head of the consulting arm of Stena Recycling in Sweden, said he'd like to see chemical recycling technologies focus on these and other parts of the recycling industry where conventional recycling is coming up short.

As it happens, Carbios is working to do just that, Marty says. The French company Michelin has validated the company's technology, which could allow it to recycle used textiles and bottles into tire fibers. It aims to launch a textile recycling operation in 2023, and Marty says the company is on track to launch a 44,000-ton-capacity industrial scale facility in 2025.

Gregg Beckham, a senior research fellow at the National Renewable Energy Laboratory, believes the global plastic problem will call for a diverse mix of technological and policy solutions, but he says enzymatic recycling and other chemical recycling technologies are advancing rapidly, and he's optimistic that they will have a role to play. "I think chemical recycling is useful in the contexts where other solutions don't work," he said. "And there are many places where other solutions don't work."

Originally published by Undark.org February 23, 2022

Mining companies seek to expand into Brazil's indigenous territories

LIVIA MACHADO COSTA
Dialogo Chino

The search for new mining areas is expanding into Brazil's indigenous territories, amid rising mineral revenues and exports, as well as incentives from Jair Bolsonaro's government, a new report has revealed.

In total, 570 mining companies and associations currently have 2,478 active applications filed for mineral research within 261 indigenous lands. They aim to exploit a total area of 10.1 million hectares, almost the size of England. The data, found in November 2021 in the National Mining Agency's (ANM) own system, are contained in a new report, released on 22 February by the Articulation of Indigenous Peoples of Brazil (APIB) – the country's largest network of indigenous organisations – and Amazon Watch, an international NGO.

"These applications represent a destruction, a genocide of indigenous peoples," says Dinaman Tuxá, executive coordinator of APIB. "They represent the socio-environmental conflict that is now established."

Exploitation in these areas is currently prohibited, but priority can still be guaranteed to companies in the eventuality of laws being approved that allow the advance of activity in indigenous lands. For example, the bill 191/2020, currently with Brazil's congress, regulates mining and other activities in indigenous territories; and the bill 490/2007, now with the Supreme Federal Court, can change the established demarcation of indigenous lands. The bills have support from Bolsonaro's base and are seen by the mining sector as a way to free up exploration of inactive lands to help develop the country. Recently, the president also signed a decree to encourage small-scale mining in the Amazon, with the aim of generating income, according to the text, for "hundreds of thousands of people".

"Mining is elevated to the status of an essential activity for the Brazilian economy, and this allows it to receive investments very easily," says Rosana Miranda, a campaign advisor for Amazon Watch in Brazil. For indigenous groups like APIB, however, they represent a failure by the Brazilian government to comply with the protection of native peoples, and with the International Labour Organization's Convention 169, which provides for the free, prior and informed consultation of indigenous communities affected by large enterprises.

"There is no concern to build, along with indigenous people, mechanisms that are less harmful to the extraction of these raw materials," said Tuxá.

A spokesperson for ANM told Diálogo Chino that mining on indigenous lands depends on a decision by congress and that the agency only follows the laws and regulations in force. The agency also stated that "no application for the execution of mineral activity succeeds in areas with legal blockage", such as indigenous lands.

Contradictions of mining

Despite being responsible, according to a study from McKinsey Sustainability, for up to 28% of global indirect CO2 emissions, mining is treated tangentially in the global environmental agenda. Though fossil fuels make up a significant portion of global mining operations – with coal alone accounting for around 50% of the market and a large share of these emissions – mining still holds a relevant place in discussions of the global energy transition, since minerals such as lithium are essential to renewable energy technologies.

But despite new resources and technical improvements, mining has long been associated with accusations of human rights violations in Brazil, since the gold rush of the 17th century, and later at Serra Pelada, in the state of Pará, during the 1980s.

According to the report, the main targets of the application requests are the Xikrin indigenous lands of Cateté, whose ethnic group has already been almost decimated by the Serra Pelada mine's operations, and the Waimiri Atroari territory, in Amazonas state. In addition to land invasion, mining activities have destroyed places considered sacred in these regions, affecting cosmologies and rites, the indigenous groups say.

Last year, the Taboca mining company, owned by the Peruvian group Minsur, dumped mining waste into rivers in the Waimiri Atroari territory. The Pitinga mine near the indigenous land produces tin – a mineral that is sent from Brazil to countries including the United States, Germany and the Netherlands. Although China is the largest consumer of the mineral, it is not on the list of importers of the Brazilian product, according to foreign trade data seen by Diálogo Chino.

Indigenous protests in Brasilia against bills that open protected areas to exploitation. Photo credit: Tuane Fernandes (Greenpeace)

Financiers of the mining giants

The report, which is now on its fourth edition, also analysed the financing of nine mining companies with significant operations in Brazil: AngloAmerican (UK), Belo Sun and Potássio do Brasil (Canada); Taboca and Mamoré, both owned by Minsur (Peru); Glencore (UK-Switzerland); AngloGold Ashanti (South Africa); Rio Tinto (UK-Australia); and Vale (Brazil).

Besides the operations already permitted in the country, these companies have 225 active mining applications in indigenous territories. Although Vale and AngloAmerican announced the cancellation of their applications last year, the report shows that new applications were made in October 2021.

These corporations have received inflows of US$54.1 billion (R$275 billion) over the past five years, taking into account the value of loans, underwritings, equity and bond investments. The main lenders are from the United States – Capital Group, BlackRock and Vanguard have invested a total of US$14.8 billion – and from Brazil itself, with pension fund Previ and Banco Bradesco investing US$11.8 billion over that period.

Large contributions also came from private groups from France, Germany, Japan, Canada and South Africa. Despite Chinese demand for iron ore being touted as one of the factors driving mining in 2021, no Chinese institution appears among the sector's biggest lenders – even though Potássio do Brasil has signed a controversial contract with China's CITIC bank to finance the "soy belt" in the Amazon.

Territories a target for illegal gold

In addition to interest in minerals for industrial use, indigenous lands are the target of predatory gold mining. In 2020, Brazil exported 110,000 tonnes of gold to countries such as Canada, Switzerland, Poland and the United Kingdom, with almost 20% of this gold being illegal, according to a study by the Instituto Escolhas.

Canadian companies have the largest stake in mining projects in the Amazon. For Rosana Miranda of Amazon Watch, the performance of Canadian companies in Brazil is a mirror for the financialisation of mining, in which the sector no longer meets real demands, but the financial market.

"These are companies that speculate on the possibility of exploring gold in the global south," Miranda explains. "This is quite characteristic in Canada, where mining on indigenous land is allowed, and seen as an example for Brazil – despite having millions of problems."

If realised, the current moves by Canadian company Belo Sun in the state of Pará will kick off the largest gold mining project in Latin America. Indigenous groups in the region where the mine is to be built, close to the Belo Monte hydroelectric power plant, are concerned about deforestation and the contamination of soils and waters by toxic substances.

Deforestation linked to mining in the Amazon, the report says, increased by 62% in 2021 compared to 2018, before Bolsonaro became president. Of the 225 mining applications made by the nine companies studied in the report, 143 are in territories in Pará – the leading state for deforestation in the biome, according to Imazon. This number has doubled in just six months: there were 67 active requests in July 2021.

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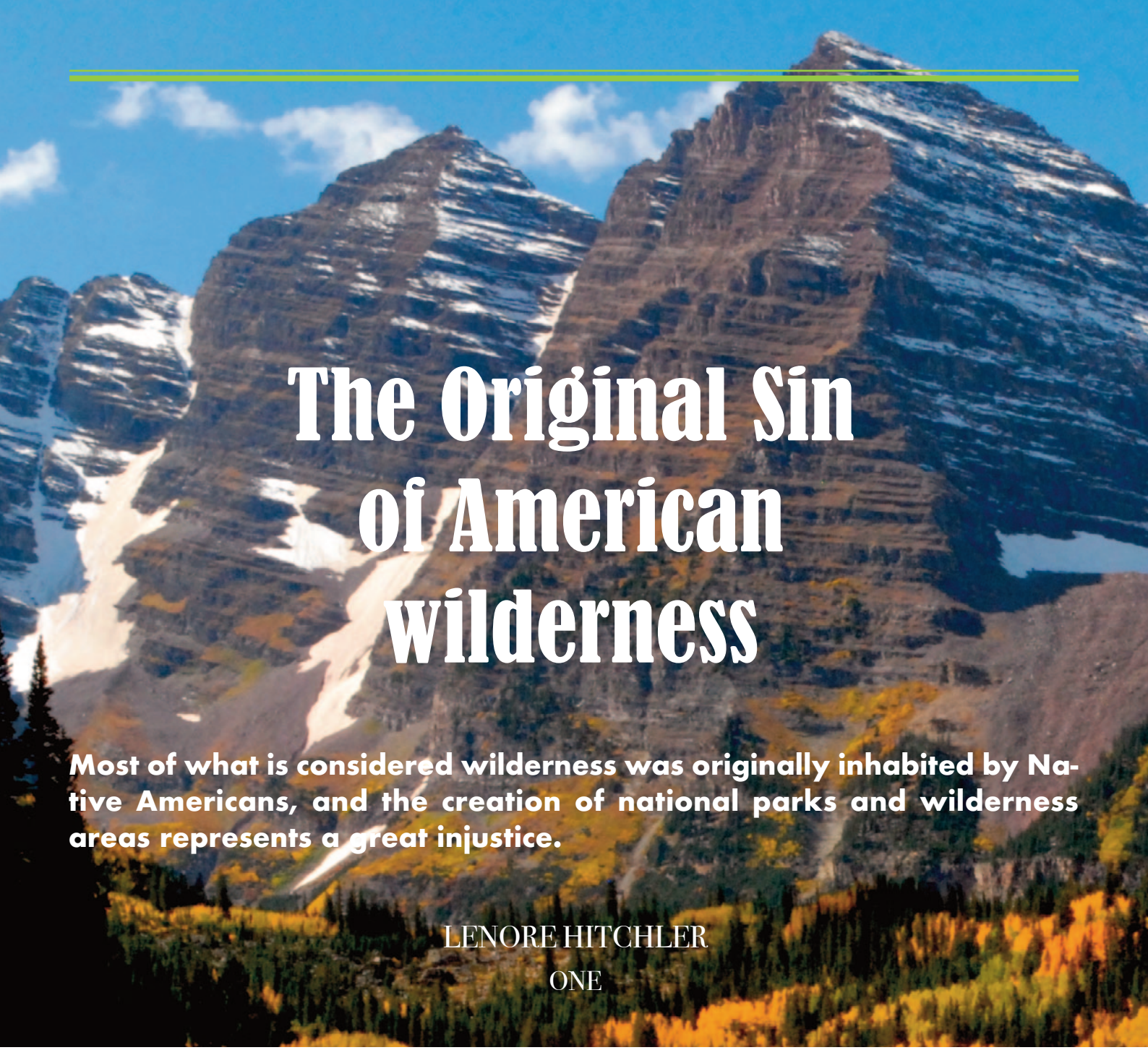

The Original Sin of American wilderness

Most of what is considered wilderness was originally inhabited by Native Americans, and the creation of national parks and wilderness areas represents a great injustice.

LENORE HITCHLER
ONE

The Good… The Bad... And the Ugly. A good analysis of American wilderness includes all three of these categories. Wilderness is defined in the Merriam-Webster Dictionary as "an area essentially undisturbed by human activity together with its naturally developed life community." To preserve wildlands, the American government has set aside 803 specific locations as wilderness areas. The *Merriam-Webster Dictionary* defines wildland as "land that is uncultivated." To be fair and honest, much of the research in this article is recent and is not yet part of the scientific canon.

The Good

One good aspect of having wilderness areas is that they preserve and protect vegetation that fights climate change. Trees and other flora absorb carbon dioxide (CO2), a major greenhouse gas, during photosynthesis and store it during their lifetimes, thereby slowing down climate change. Additionally, fossil fuel extraction and residential, agricultural, and industrial developments are banned in these areas.

Another good benefit is that wildlife is protected in wilderness areas, and this might also help fight climate change. Recent research finds that increasing wildlife populations aid in climate mitigation.

According to the *Global Rewilding Alliance*, "animals can enhance the carbon density of plant communities, prevent massive CO2 releasing wildfires, protect against permafrost thawing [melting permafrost releases methane which is a very potent greenhouse gas], and enhance soil and sediment carbon reten-

White River National Forest in Colorado.
Photo credit: U.S. Department of Agriculture

tion through influence on microbial processes and chemical reactions."

Retaining grasslands is another good because they are highly efficient at storing carbon. According to Dr. Cynthia Cambardella, a soil scientist with the Department of Agriculture, prairies store much more carbon below ground than a forest does above ground.

Still another good advantage of wilderness is its positive influence on people's attitudes towards preserving the environment. Whether visiting or watching on television, viewers see how magnificent, beautiful, and truly awesome they are. People are fascinated and enthralled by wilderness scenery and wildlife, and then become interested in protecting it. A desire to preserve and improve the environment frequently leads to fighting climate change.

The Bad

However, the idea of a pristine wilderness is a myth, and it is bad. It was originally used to justify English colonialism. This is shown in an article in *Natural History*, which stated that: "when the lawyer John Winthrop took control of an English company in the Atlantic colonies in 1630, he declared that most land in America was vacuum

domicilium—i.e., legally "waste"—because the Indians had not "subdued" it by methods recognized in English law and therefore had no "natural" right to it."

Besides distributing land to settlers, the creation of both national parks and wilderness areas was ugly because the original inhabitants were forcibly removed. For example, to create Yellowstone National Park, 27 tribes lost their homelands, for Yosemite it was 7 tribes and 4 for Glacier National Park. The human rights of Native Americans were violated. They frequently were removed to remote locations, and they were not reimbursed as others are when their property is expropriated by the government.

Removing indigenous peoples to preserve wilderness is ironic as natives have a good record at maintaining biodiversity as shown by journalist Julia Rosen. She reported: "Studies show that, in many places, Indigenous lands host equal or higher levels of biodiversity than wilderness protection. … these landscapes exist at least in part because of human actions—not simply in spite of them. … A recent UN report found that Indigenous-held lands also experience less deforestation and store more carbon than surrounding areas. … Removing humans, on the other hand, can actually degrade ecosystems."

Also, to specifically fight climate change, third-world countries are encouraged to set aside areas to offset the burning of fossil fuels by industrialized nations. This is ironic as, in the name of preservation, the very people who cause very little climate change lose their livelihoods, homes, communities, and homelands so that the people who have the largest carbon footprints can still produce more than their share of greenhouse gas.

Just as there are critics of the way that national parks and nature preserves are created, there are critics of the way that they are maintained. For example, some maintain that natural resources found in wilderness areas, such as minerals and fossil fuels, should be made available for use. One convincing argument is that the poor should not be deprived of the benefits of using these resources.

However, the other side of this is that those who own the extracting corporations are the ones who profit from those resources. In addition, the processes of extracting, refining, transporting, and disposing of wastes increase climate change.

The original preservationists did not recognize that what they perceived as wildlands had actually been created by Native Americans. These indigenous peoples had manipulated nature for their own purposes and created the very places that the environmentalists perceived as pristine. Yellowstone National Park itself is not an official wilderness area although part of it is managed as a wilderness.

Aston Chase was specific about Yellowstone, but his statement is true for all wilderness areas. He stated: "Created for the benefit and enjoyment of the people, Yellowstone destroyed a people. Dedicated to preservation, it evicted those who had preserved it. Touted as pristine, the policy required that we forget those whose absence diminished it. Denied its Indian past, it deprived us of the knowledge to keep it pristine."

To make things worse, specific geographic areas were sometimes named after the very people who led massacres on natives. Within the park itself, a major Yellowstone summit was named after General Philip Sheridan. As part of the military campaign against Native Americans, Sheridan ordered an attack on a Blackfoot camp. This was despite the fact that the army had recently pledged protection for this group of women, children, and the elderly. Approximately two hundred Blackfeet were killed. Mount Doane in Yellowstone park was named after Gustavus Doane who was a US Army officer who took part in the massacre.

When indigenous peoples are removed from their homelands, their past does not usually become part of the common history of the nation. For example, it is not well-known that before Europeans came to North America, Native Americans had engaged in agriculture throughout the continent. The following information regarding pre-colonial Native Americans is lengthy and extensive. However, it is necessary to include this information because it is not familiar to people and has not been included in the history of North America. Also, it finally disproves the concept that indigenous peoples were nomadic hunters and gatherers who did not inhabit and tend the lands that the settlers wanted for themselves.

The following long quotation by history professor Allan Greer, Ph.D. is an excellent summary of indigenous agriculture. He wrote: *"There was, of course, agriculture in the pre-Columbian New World—indeed, the majority of the hemisphere's population subsisted primarily through cultivating the soil … but it was purely crop-based: maize, beans, squash, and other cultivations were grown without a significant component of animal husbandry. Because crops did not share space with domestic animals, fences and hedges were largely unnecessary, and in that literal sense, the land was not enclosed. …*

Grand Canyon of the Yellowstone River (Yellowstone, Wyoming, USA).
Photo credit: James St. John

North of Mexico lay a vast continent occupied by peoples who subsisted on various combinations of hunting, fishing, foraging, and agriculture. … Most land was held as a kind of commons. Maize cultivators of the northeast, including Iroquoians as well as the various Algonquian nations such as the Delaware and Narragansett, typically planted fields surrounding a village, relocating and clearing new lands every ten or twenty years. … Agricultural work and the distribution of the fruits of the harvest also had a strongly collectivist character (inner commons). Outside these small islands of cultivation, however lay terrain that provided vital supplies of game, fish, fruit, and other useful resources to those who knew how to harvest them (outer commons). … [the seventeenth-century missionary Gabriel Sagard wrote about the Huron Native Americans] 'for all the forests, meadows and uncleared land are common property, and anyone is allowed to clear and sow as much as he will and can, and according to his needs; and this cleared land remains in his possession for as many years as he continues to cultivate and make use of it. After it is altogether abandoned by its owner, then anyone who wishes uses it, but not otherwise.'"

Further evidence of Native American agriculture is found in "Humanized Landscapes of the Americas Before 1492." The authors stated: "By 1492 almost all American landscapes were marked by the human presence. … "domesticated plants such as maize (corn), beans, squash, tobacco—plants that cannot

propagate without human intervention [were grown throughout North America] … [Native Americans] also manipulated the growth of many plants nearly everywhere, and, hence, transformed much of the American landscape by plant husbandry. … [Some indigenous agriculture was quite sophisticated and reflected a high degree of scientific knowledge.] Northern America, particularly in the upper Midwest, [contained] raised or 'ridged' fields. … Some of these have been found through experimentation to have been built to promote 'cold-air drainage.' That is, cold air is heavier than warm air and flows off of raised fields into adjacent ditches. Temperatures on the field surfaces are, therefore, warmer than surfaces and less prone to both early and late frosts."

Even further evidence of Native American agriculture was provided by geography professor William E. Doolittle, Ph.D. He stated: "household garbage and other materials were often included in the mounds [of corn, beans, and squash throughout North America] as fertilizer. … [Early Europeans reported seeing fields that were both numerous and large] … Permanent or fixed fields, inter-cropping, and perhaps in some cases multi-cropping on an annual basis characterized nearly all of the east coast of North America from north of Cape Cod south to the Okefenokee Swamp; the bottom lands of the Mississippi, Missouri, Ohio, Tennessee, and St. Lawrence river valleys; areas north and south of Lake Ontario; some of the larger valley bottoms in the southern Appalachian Mountains; and patches along rivers flowing through the Great Plains. … "Fixed fields in the American Southwest, although small … were common in 1000 CE."

Still even more evidence of Native American agriculture in areas that were considered wilderness is provided by Geography professor William Denevan, Ph.D. He wrote that throughout "North America, burning not only maintained open forest and small meadows but also encouraged fire-tolerant and sun-loving species. Fire created conditions favorable to strawberries, blackberries, raspberries, and other gatherable foods. … [burning by Native Americans burning] created ideal habitats for a host of wildlife species … exactly those species whose abundance so impressed English colonists: elk, deer, beaver, hare, porcupine, turkey, quail, ruffed grouse, and so on."

Recent scholars have stated that grasslands were created by Native Americans. The anthropologist Omer Stewart stated: "The fact that Indians throughout America set fire to vegetation is firmly established.

The rich prairie soils were the result of the grass cover and the fact that the cover had been regularly burned off. … Grassy plains and prairies were present when the Europeans arrived in Illinois, Nebraska, Kansas, and Texas. … [the tall grass prairies stretched] from central Saskatchewan to the Texas Gulf Coast, almost 2000 miles, and from Indiana to central Nebraska." He also stated that in 1952, mesquite covered an area of 75 million acres in the Southwest, and this whole area had formerly been set on fire by Indians. Thus, the preceding long passages about Native American agriculture debunk the wilderness myth.

Therefore, most of what is considered wilderness was originally inhabited by Native Americans, and the creation of national parks and wilderness areas represents a great injustice. However, to be fair and honest, it must be pointed out that many European Americans are not aware of this past, and a good defense of this lack of knowledge can be made. Even the very definition of wilderness seems to verify the idea that these lands were pristine. Wilderness areas look like they have never been inhabited. These areas are filled only with vegetation and magnificent animals. The lack of any permanent architecture certainly reinforces this idea. Additionally, after early colonialism, evidence of native inhabitation would have been extremely difficult to find until recently when new tools of archeology, such as aerial photography, were developed. Also, most people follow the mindset of their culture and believe what they are told by experts.

Many environmentalists believe that Native Americans left no traces and did not negatively affect the environment and therefore left us with pristine wilderness to cherish and protect even though Native Americans certainly had modified their environment. Instead of ignoring indigenous agricultural ways we could learn about their ways which are much more sustainable than industrial agriculture.

First-world countries would benefit by learning appropriate agricultural techniques from indigenous peoples, such as planting various species together. Perennial crops such as acorns and native wild berries, tubers, and plants that European Americans perceive as weeds could also be adapted for contemporary use. Relevant mindsets from indigenous peoples could be adapted to use in protecting the environment and combating climate change. ONE

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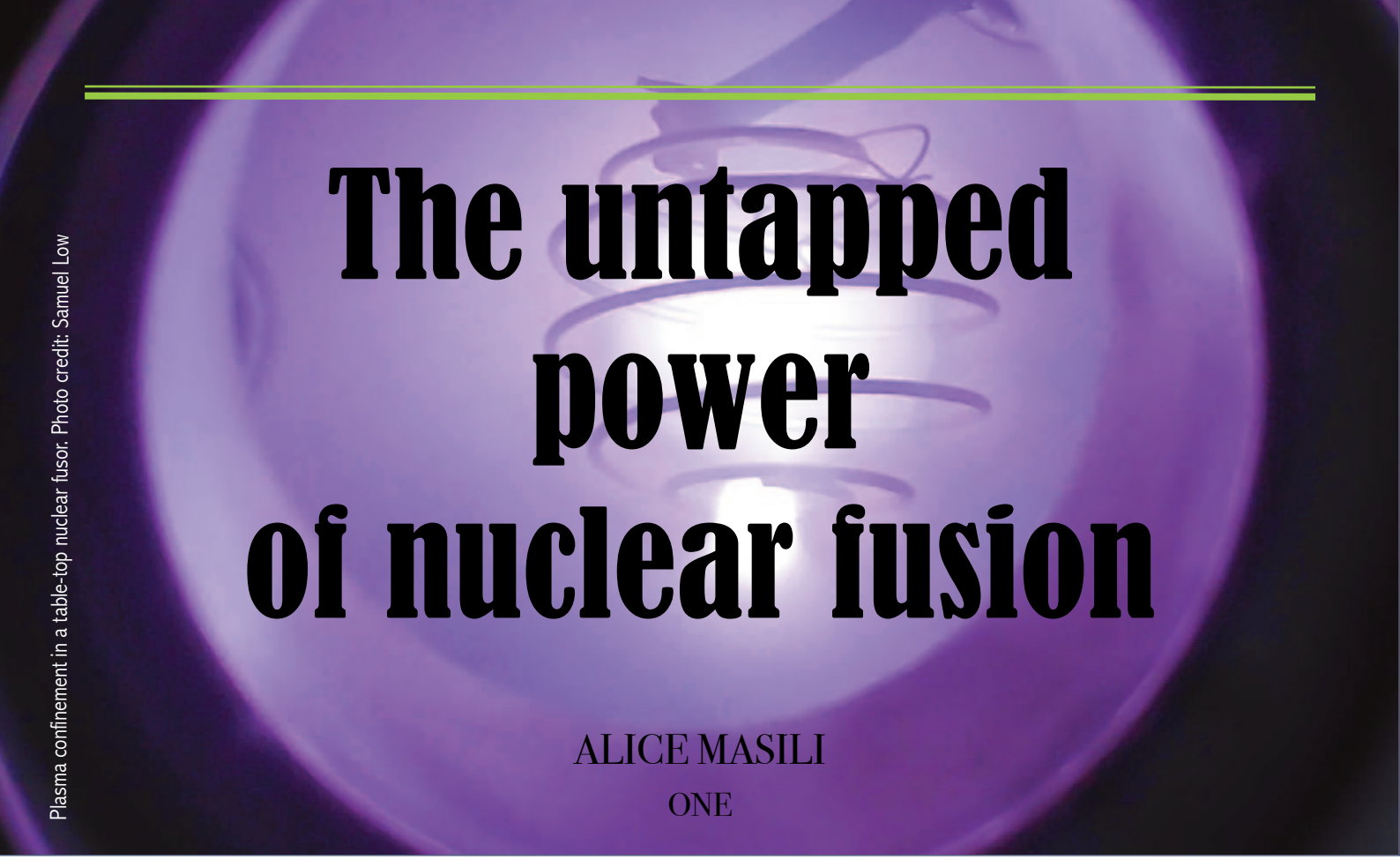


Plasma confinement in a table-top nuclear fusor. Photo credit: Samuel Low

The untapped power of nuclear fusion

ALICE MASILI
ONE

Two nuclear power stations in Ukraine were among the first Russian targets. Putin's troops attacked and seized control of the Chernobyl and Zaporizhzhia plants. This situation puts the energy community again in a dilemma: nuclear provides a stable energy supply with fewer emissions, but it always poses different risks. Being an easy military target is probably the most evident.

However, a steady and affordable energy source is crucial for sustainable development, poverty reduction, and climate protection, especially today.
Is there any chance of having clean and inexhaustible energy without wastes or pollutants? Or is it just a dream? Nuclear fusion could be the answer.

What is nuclear fusion? We associate nuclear power with Fukushima with radioactivity, something hazardous and harmful. But that is atomic fission. Nuclear fusion is the process that powers the stars, and the sun. Two light nuclei, such as Deuterium and Tritium, both isotopes of hydrogen, the most abundant element in the universe, collide and merge into another harmless element: Helium. The process produces a large amount of energy.

Deuterium and Tritium fuse or react to lower energies than other light elements such as hydrogen or Helium. They were chosen as the fuel for the first fusion reactor.

Deuterium is an isotope of hydrogen commonly found in seawater. In about 30 litres of water, one gram of Deuterium is dissolved. It is a common and easy to find material.

Tritium, a weakly radiative element, which decays in about 12 years, does not exist in nature but can be obtained directly inside the reactor through Lithium, an element abundant in rocks. Fusion energy's availability is practically unlimited.

Despite many decades of discussions on fusion's pros and cons, why are we still reluctant?

To start the fusion reaction is not a straightforward process. To fuse two deuterium and tritium atoms, we need enormous energy to defeat the atomic repulsion force of two positive nuclei. Only very high temperatures, over a hundred million degrees Celsius, could activate it. Two problems ensue. First, a material resistant to such temperatures does not exist. Most scientists' efforts are focused on building a reactor that can isolate these very high temperatures.

It is possible through a complex system capable of generating a magnetic field and trapping and confining plasma in its coils, keeping it from the containment walls. We are talking about the tokamak, the heart of the nuclear fusion reactor. It has a toroidal shape inside which the hot gas fluctuates and gives life to the fusion.

Secondly, a large amount of energy is needed to heat

the plasma to the required temperature. "The gain factor is the ratio between the energy produced and the energy required to trigger the process and keep it alive. This ratio must be greater than the one for the fusion to be economically viable. The former must be greater than the latter, an objective not yet achieved.

There is no nuclear fusion reactor yet, but several experimental projects are ongoing. One of the most prominent fusion reactors is Jet, the acronym Joint European Torus, which recently produced 59 megajoules for 5 seconds, and already reached a record gain factor of 0.67 in 1997.

This international project has its hub in Europe. It involves the collaboration of the EU, the United States, Japan, South Korea, China, India and Russia -yes, Russia is still in. The ITER (International thermonuclear experimental reactor) project is already in the pipeline. It will involve the construction of a double-sized reactor at the French site of Cadarache, aiming to raise the gain factor to 10, generating from 400 to 500 MW of power for a time of 400-600 seconds.

The fundamental element that will help make nuclear fusion an industrial process will be constructing a device capable of treating the exhausted plasma. The ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) research centre in Frascati is working on this in the Divertor tokamak test or DTT project.

Suppose these key objectives are achieved by 2030; the next step will be the Demo project, a demonstration reactor capable of producing energy and feeding it into the grid.

The European consortium EFDA (European Fusion Development Agreement) says that to generate electricity from fusion by 2050, the construction of the Demo needs to start during the early 2030s. In fact, in 2040, an operational phase should begin that will last another decade. In 2050, the large-scale commercial nuclear fusion reactors will only see the light.
The product of the fusion reaction is Helium, a light and inert gas. Therefore, compared to conventional power plants, a fusion reactor does not produce CO2 or toxic fumes.

This form of energy production is clean. Sure? Or will fusion reactors also produce wastes?
This technology has two potential sources of radioactive waste products: neutron activation and tritium retention. The current research focuses on Deuterium and tritium, which release neutrons in the fusion process. Many elements, bombarded by neutrons, can turn into radioactive isotopes. An example is Vanadium, an element often presented in steel, which can be transformed by neutron activation from the more common and stable V51 into radioactive V52. As a result, the materials exposed to the neutron flux need to be appropriately selected to minimize the effects of neutron activation.

However, there is research on aneutronic nuclear fusion reactions, i.e. they do not lead to the formation of neutrons. According to the physicist of the INFN (National institute of nuclear physics), Federico Ronchetti, among the few possible aneutronic fusion processes, the most interesting in terms of application are the reactions between Deuterium and helium 3 (3He helium isotope) and between two 3He nuclei (3He + 3He). Instead of neutrons, the (3He + 3He) process emits high-energy protons, which can be easily confined with magnetic/electric fields.

Another problem is the retention of tritium. Tritium behaves chemically like hydrogen. Carbon would be an excellent element to build some reactor parts, given its excellent thermal conductivity. Nevertheless, it quickly reacts with hydrogen and with tritium. The risk is to obtain excessively tritium-rich materials, resulting in the need for decontamination - a long and expensive process. This materials research aims to avoid high and medium activity waste reactor production.

Jet, Iter and Dtt are not the only existing experimental projects. ENI (the Italian multinational oil and gas company), for example, is involved in a significant international research project in partnership with Commonwealth Fusion Systems (Cfs) and the Massachusetts Institute of Technology (MIT). In Boston, scientists are working on constructing a pilot nuclear reactor called Sparc, with a small tokamak that produces magnetic fields four times higher than Iter.

Still, scientists from the National Ignition Facility at Lawrence Livermore National Laboratory in California are experimenting with "inertial confinement" with laser-powered nuclear fusion.

Nuclear fusion is a fascinating technique. If exploited, it will make a massive contribution to clean energy production. However, in all likelihood, it will arrive in many years. Although times may be very long, evaluating its contribution to the energy transition is not premature. Especially on the threshold of the expected changes in the energy system, in the medium and long term. In the meantime, to pursue climate neutrality, we need to exploit more and better available technologies and renewable energy sources. ONE

What the latest science says about Antarctica and sea-level rise

The southern polar ice cap is a wild card.

KRISTEN POPE
Yale Climate Connections

As the Earth's climate warms, sea levels are rising, threatening to swallow coastlines and flood low-lying cities. Scientists are working to understand how much and how quickly seas could rise in coming decades – and Antarctica is one wild card.

Here are some of scientists' most important findings from 2021 about the changes occurring in and around the world's coldest continent.

What happens if Antarctica melts?

More than 97% of Antarctica is covered in ice. With a depth of up to three miles, the continent's 6 million cubic miles of ice contain 70% of Earth's fresh water. If all of that ice melted, the world's oceans would rise by 200 feet (61 meters), enough to inundate Tokyo, New York City, Shanghai, and other cities.

How much the Earth's average temperature rises is one of the main factors that will determine how Antarctic melting plays out. The climate has already warmed by roughly 1 degree Celsius (1.8 degrees Fahrenheit) since the late 1800s.

A 2021 study published in the journal Nature found that ice loss would likely continue at a pace similar to current patterns as long as the world does not rise more than 2 degrees Celsius (3.6 F) above pre-industrial levels. However, if the temperature rises 3 degrees Celsius (5.4 F) or more, the paper's authors found the rate of loss would rise to "an order of magnitude faster than today."

Scientists use models to estimate how much the sea would rise under different scenarios. In 2021, researchers published a paper in Science Advances noting that previous estimates of impacts may be far too low. Earlier studies of the vast West Antarctic Ice Sheet had estimated that its collapse would cause global sea levels to rise by about 3.2 meters (10.5 feet). But in the new study, researchers said the collapse could actually cause the ocean to rise by an additional meter.

One-third of Antarctic ice shelves could collapse

The fate of Antarctica's massive ice shelves will also play a role in determining future sea-level rise. These shelves of ice jut out from Antarctica's coastline, floating into the ocean. Importantly, they hold back the enormous glaciers that flow from the continent's massive interior ice sheets toward the ocean.

If the Earth's temperature were to rise to 4 degrees Celsius (7.2 F) above pre-industrial levels, a third of Antarctica's ice

The calving front of Thwaites Ice Shelf.
Photo credit: NASA ICE / James Yungel

shelves could become destabilized and would be at risk of collapse, according to an April 2021 paper in Geophysical Research Letters. About 193,000 square miles (500,000 square kilometers) of these ice shelves – an area slightly smaller than California and South Carolina combined – could fail. The effect of ice shelf collapse, the researchers said, would be akin to pulling a cork out of a large bottle, speeding the movement of ice into the ocean.

Some ice shelves are already melting rapidly. The George VI Ice Shelf is the second-largest ice shelf on the Antarctic Peninsula, the northernmost region of mainland Antarctica. Scientists reported that 2019-2020 was a record-breaking melt year, with "the most widespread melt" they'd seen there, though they did note they had seen longer melting seasons for the peninsula as a whole before.

Thwaites: the 'Doomsday Glacier'

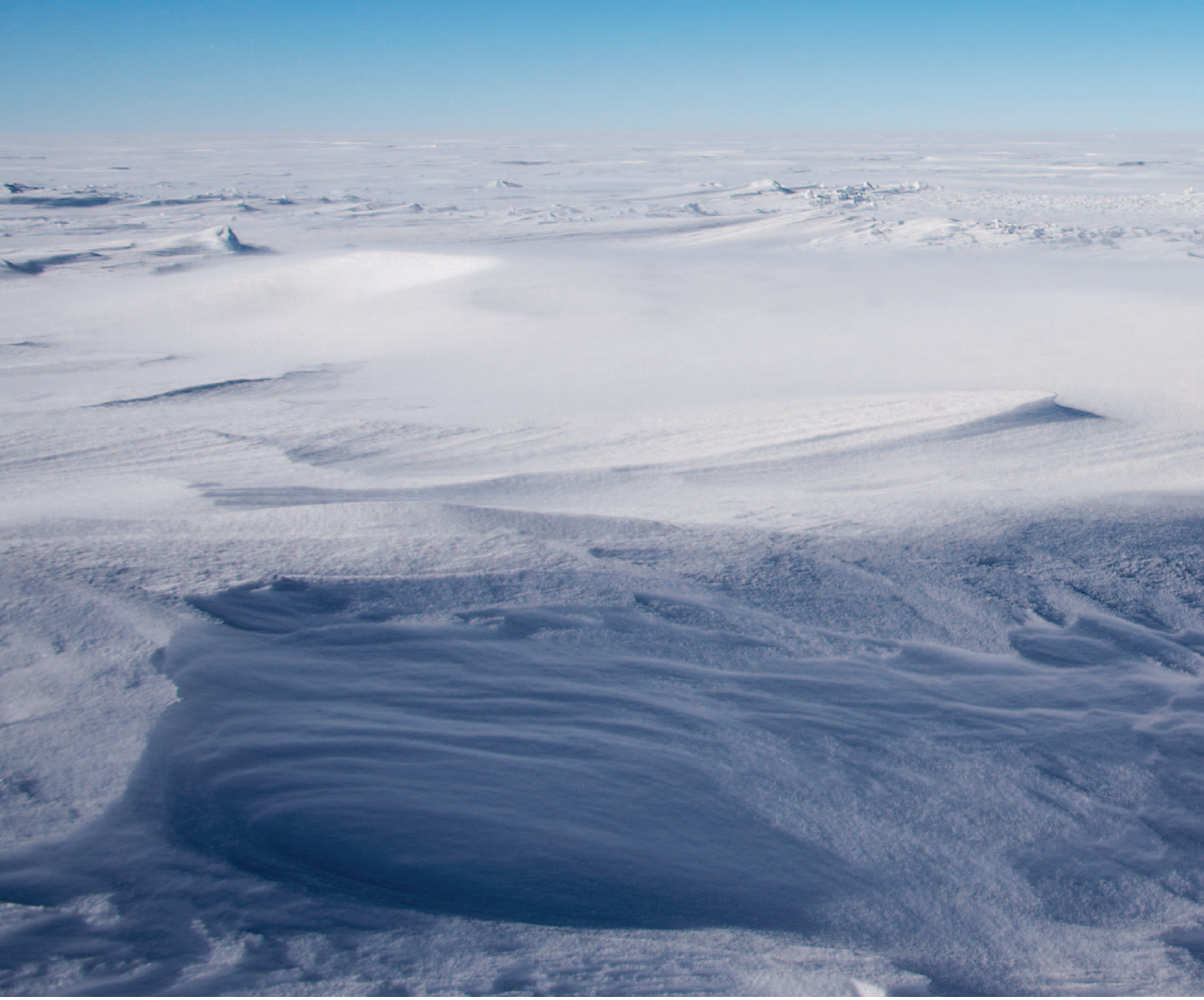
Perhaps the most talked-about Antarctic ice story of 2021 was the potential fate of Thwaites Glacier, popularly dubbed the "Doomsday Glacier." This massive body of ice, larger than the state of Florida, is located on the West Antarctic Ice Sheet.

In December 2021, scientists announced that cracks in the Thwaites Eastern Ice Shelf signaled that this ice shelf – which is holding back large parts of the Thwaites Glacier – could fail in as soon as five years. Without the ice shelf to stabilize it, the glacier could speed up its flow into the ocean. If the entire glacier melted, sea levels around the world would eventually rise about 25 inches (63.5 centimeters).

Pine Island Glacier thins, Getz region loses ice

Pine Island Glacier, which contains 180 trillion tons of ice, has been thinning for decades. And between the 1990s to 2009, the glacier's flow toward the ocean accelerated from around 1.5 miles (2.4 kilometers) per year to approximately 2.5 miles (4 km) per year, staying toward the higher end of that range for around a decade. And its movement continues to speed up: Researchers published a 2021 paper in Science Advances showing that from 2017 to 2020, the rate of flow increased by around 12%.

The Getz region in West Antarctica is also showing signs of speeding up. One study published in Nature Communications found that most glaciers in the region were accelerating. Between 1994 and 2018, the glaciers in this region lost about 315 metric gigatons of ice.



Parker Ice Tongue collapsed in 2020

Ice tongues are distinctive features that protrude from a glacier and can stick out far into the ocean. Normally, sea ice that is attached to land helps stabilize them and protect them from the ocean's waves and currents. However, when sea ice disappears, the ice tongues are more vulnerable to collapse.

In March 2020, the nearly 16-square-mile (41-square-kilometer) Parker Ice Tongue fully collapsed into the western Ross Sea. In December 2021, scientists published a paper in Geophysical Research Letters detailing their findings about the event.

While the authors believe that calving likely occurred on and off for many centuries in the region, this loss was massive – and unusual. The authors wrote, "A complete ice tongue collapse for these otherwise stable glaciological landmarks along the Victoria Land Coast is previously unrecorded."

It could rain more often in Antarctica

Antarctica isn't known for rainy days. The continent's high plateau very (very!) rarely gets rain. The northwestern Antarctica peninsula is the continent's rainiest region, with around 50 days of rain each year.

But a 2021 study in Geophysical Research Letters found the continent's rainfall could increase 240% by the turn of the century. The researchers also forecast more intense storms.

Liquid precipitation could cause big problems and lead to faster ice melt, especially as the insulating snow on top of the ice melts, making the ice more vulnerable.

South Pole.
Photo credit: Christopher Michel

Rain also is a threat to wildlife like penguins. Young penguin chicks are coated with downy feathers that are not rainproof. Wet chicks can freeze, especially in stormy and windy weather.

And rain is already causing problems for penguin colonies. During the 2013-2014 season, one Adélie penguin colony with about 20,000 breeding pairs failed to produce a single surviving chick. Scientists believe rain was one of the factors involved.

Melting ice in Antarctica could cause ecosystem-wide effects

Melting ice also changes the composition of the ocean itself. To study how the water is changing, scientists affixed data loggers to 14 seals near Pine Island Glacier, using the seals – and other methods – to gather data, including water temperature and salinity. Their results, published in Communications: Earth and Environment, suggest that when warmer meltwater rises to the top of the ocean, it can make it harder for sea ice to form, causing areas of open water. Warmer water on the surface can also lead to other ecosystem impacts.

As scientists continue to study Antarctic ice, we will learn more about how this "wild card" may affect life, not only on the Seventh Continent, but all around the world.

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Zhangjiakou's next gold medal

The Zhangjiakou Renewable Energy Demonstration Zone: a showcase of the pathway for integrating renewable energy into China's coal-dominated power system.

XING ZHANG and LAURI MYLLYVIRTA*

ONE

Zhangjiakou is a medium-sized city located in northwest Hebei Province, 164km away from Beijing. The region's biomass power generation capacity is small, around 65 MW at the end of 2021. But it has abundant wind and solar resources. Zhangjiakou receives annual radiation of 1400-1750 kWh/m2 with an average of 3000-3200 hours of sunshine per year and a yearly wind power density greater than 150W/m2.

With the closing of the Beijing Winter Olympics Games on 20 February, China fulfilled its promise to deliver the first 'green' Olympics in history and made Zhangjiakou a well-known city not only for its beautiful snow trails but also for its wind turbines. China powered all 26 sporting venues of the Games entirely with renewable energy from Zhangjiakou Renewable Energy Demonstration Zone.

In July 2015, China's National Development and Reform Commission (NDRC) issued the 'Hebei Zhangjiakou renewable energy demonstration zone development plan'. This is the first national pilot project with the aims of testing applications of advanced and innovative renewable energy technologies, as well as for power sector reform in favour of accelerating the nationwide scale-up of renewable electricity generation and use.

In 2015, wind and solar power combined installations in Zhangjiakou were 7970 MW. The plan to develop Zhangjiakou Renewable Energy Demonstration Zone and the determination to host a green Beijing Winter Olympics Games accelerated wind and solar installations. By the end of 2017, the total wind and solar installation reached 9646 MW, then hit 23.47 GW, split between 16.4GW wind and 7.0GW solar, before the Beijing Winter Olympic Games.

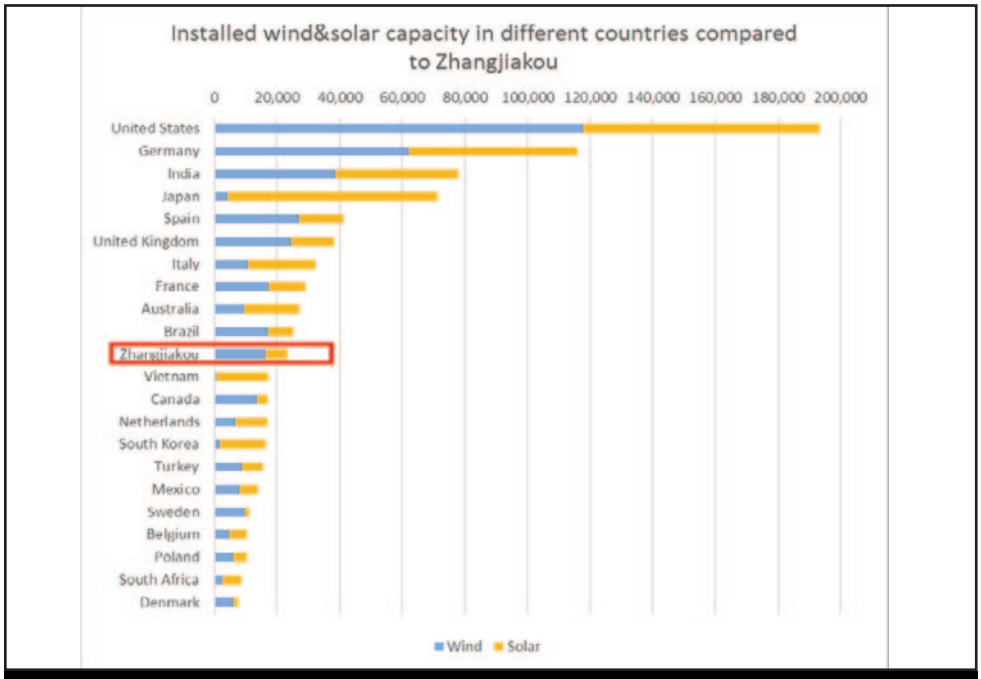

Figure 1: Wind and solar capacity (GW) of Zhangjiakou city in China (highlighted) compared to the countries with the largest combined capacity in the world in 2021. Photo credit: Myllyvirta and Zhang (2022)

If the city was a country, its combined wind and solar capacity would have been the twelfth largest in the world in 2021, behind Brazil but ahead of Vietnam (*see Figure 1*).

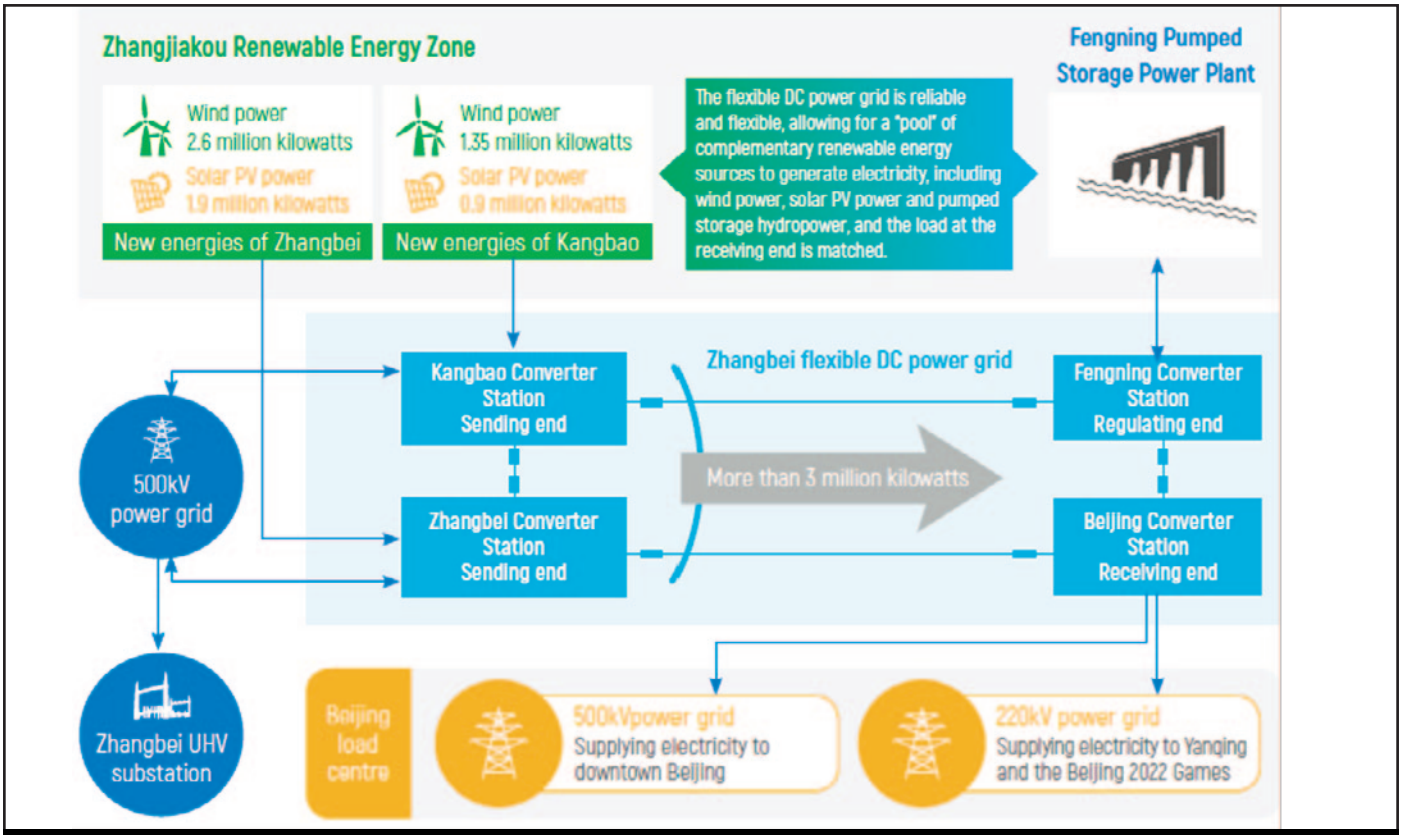

Figure 2: Zhangbei renewable energy flexible DC grid.
Photo credit: Beijing Organising Committee for the 2022 Olympic and Paralympic Games.

The construction of the Zhangbei renewable energy flexible direct current (DC) grid was also accelerated to improve the power transmission capacity of the demonstration zone, resulting in the launch of the $2bn project in June 2020.

As shown in *Figure 2*, two converter stations, Zhangbei and Kangbao, are used to gather local wind and solar energy. Fengning converter station is connected to a local pumped storage hydropower plant which can restrain renewable energy power fluctuation. Beijing converter station is connected to the Beijing power grid to provide stable green electricity for Beijing, used at the venues of the Winter Olympic Games.

China has deployed two types of UHV lines. Direct current (UHVDC) lines are suitable for very long-distance (over 1000 kilometres) transmission. In contrast, alternating current (UHVAC) lines work better over slightly shorter distances but permit branching links along the way. UHVDC technology is used for the Zhangbei flexible green grid.

In addition to the grid linking Zhangjiakou to Beijing, Zhangjiakou's renewable energy feed a direct long-distance transmission line built to power the new city of Xiong'an, China's "city of the future", being built outside of Beijing (see *Figure 3*).

Zhangjiakou's wind and solar energy can generate about 44 TWh per year. The city's consumption is about 19 TWh, leaving about 25 TWh for exports.

The green flexible DC grid is projected to transmit about 14 TWh of renewable energy from Zhangjiakou to Beijing every year, equivalent to approximately 10% of the electricity consumption of China's capital. Another 7 TWh per year will be transmitted to Xiong'an.

A long-standing challenge with China's long-distance transmission lines has been their inflexible operation, which has meant that much of the power dispatched through the lines has been generated from coal.

The Zhangjiakou Renewable Energy Demonstration Zone project exhibited a new institutional set-up required for the power grid to absorb high shares of intermittent generation, at least as much as new hardware. It strengthened the competitive position of far-reaching clean energy against local coal-fired power plants.

Figure 3: Project map for the Zhangjiakou green grid and the Zhangbei-Xiongan UHV line.
Photo credit: Myllyvirta and Zhang (2022)

Zhangjiakou aims to reach 50 GW combined wind and solar power generation by 2030, more than double its current capacity. On an even larger scale, China's NDRC announced the first batch of projects and plans for 100 GW capacity of "clean energy bases" in the Gobi and desert areas last December, and has recently announced the second batch, with 455 GW capacity of wind and solar to be installed by 2030.

During the 14th Five Year Plan (FYP) period, 200 GW wind and solar energy will be installed at the clean energy bases, and 150 GW will be exported.

During the 15th FYP period, 255 GW clean energy will be installed with 165 GW to be exported. The bases will be a vast regional network of wind and solar power installations designed to transmit power to the more densely populated areas.

However, fossil-fuelled power generation continued to grow. 33 GW of new coal power plants entered into construction in 2021, the most since 2016. Five coal power projects totalling 7.3 GW of capacity cleared for construction in just the first six weeks of this year.

This might appear paradoxical, as renewable energy has a clear cost advantage against new coal power, especially after the increases in tariffs paid to coal power plants late last year. In response to the coal shortage and power crisis, the government allowed tariffs paid to coal plants to rise to 20% above the province-specific benchmark prices.

The critical issue determining the pace of China's transition is the decision makers' confidence that clean electricity can keep the lights on without further additions of coal-fired capacity. Pioneering regional grids with a high share of renewable energy, especially a grid that powers the top decision makers' own offices in Beijing, Zhangjiakou Renewable Energy Demonstration Zone has broader national significance in this context. ONE

** Lead analyst at the Centre for Research on Energy and Clean Air*

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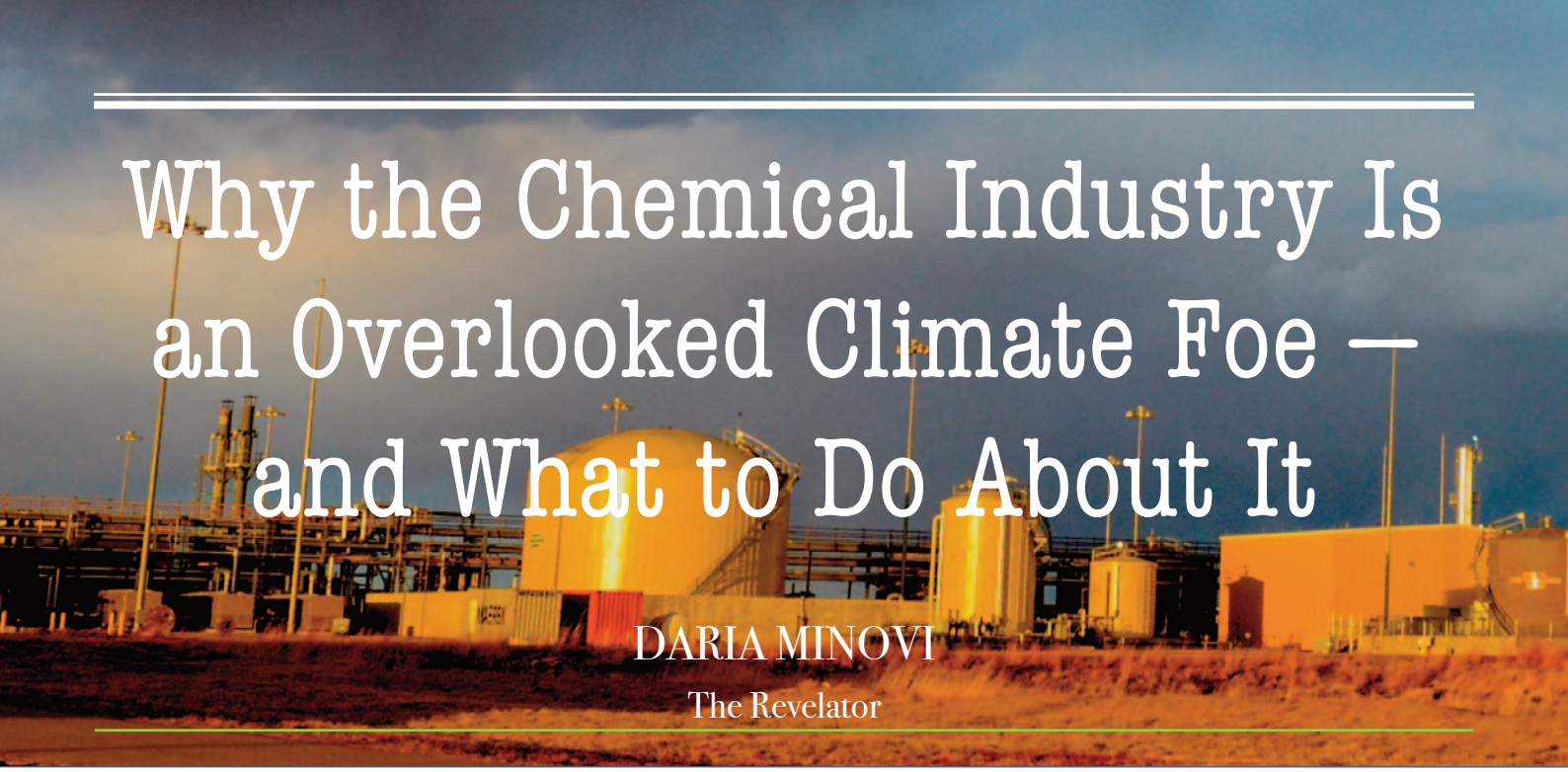

Why the Chemical Industry Is an Overlooked Climate Foe — and What to Do About It

DARIA MINOVI
The Revelator

Climate change is quickly evolving into climate catastrophe, and there's a narrow window of time to do something about it. While the world works on solutions, there's surprisingly little focus on the chemical industry, which accounts for roughly 7% of global greenhouse gas emissions — as well as other environmental harms.

Weak or nonexistent regulations of the industry have led to widespread cancer, respiratory illnesses, and even facility explosions, primarily in low-income communities and communities of color. But the industry essentially has a free pass to continue business as usual — it just keeps on keepin' on, with little accountability. The same holds true when it comes to the industry's contributions to our warming planet, which is happening in three major ways:

First, fossil fuels are the "feedstocks" for chemical manufacturing, meaning that oil, natural gas and coal are used as raw material for chemicals. Global plastic production relies heavily on fossil fuel feedstocks and is expected to grow by 40% by 2030. That will bring more environmental problems. Around 98% of single-use plastic is derived from fossil fuels, and it releases greenhouse gas emissions at every stage of its life cycle. Only a small amount of plastic products are recycled. Most end up in landfills or the environment, and nearly one-quarter is incinerated, releasing millions of metric tons of carbon dioxide and other harmful air pollutants.

Second, fossil fuels power chemical manufacturing. Some of the most commonly manufactured "primary" chemicals, like ethylene, propylene, benzene, toluene, ammonia and methanol, account for two-thirds of the energy used by the industry, according to the International Energy Agency. While the industry has implemented some energy efficiency measures and low-carbon technology, direct carbon dioxide emissions from chemical production have continued to increase.

Third, the chemical industry contributes to climate change by producing chemicals that are themselves potent greenhouse gases. For example, hydrofluorocarbons, used as refrigerants and foam-blowing agents, are 3,800 times more damaging to the climate than carbon dioxide.

Under the Kigali Amendment of the Montreal Protocol, countries have committed to cutting production and consumption of HFCs by at least 80% by 2047. And just this year, the EPA announced a goal to reduce U.S. production. But this may create new problems. For example, some proposed plans for capturing HFCs (rather than replacing them with safer chemicals that don't harm the climate) will result in emissions of other hazardous air pollutants like chloroform, hydrochloric acid, chlorine and hydrogen fluoride. All of these hazardous air pollutants contribute to the cumulative burden faced by fenceline communities.

Finally, not only does chemical production and use contribute to climate change — the intensifying weather patterns of climate change will worsen the industry's environmental

Pueblo Chemical Agent-Destruction Pilot Plant Biotreatment Area.
Photo credit: PEO ACWA

and public health impacts. Chemical and petrochemical facilities are concentrated along the Gulf Coast of Texas and Louisiana: the very same areas that are and will be hit hard by hurricanes, flooding and sea-level rise. Many of these facilities are unprepared for these effects, increasing the risk of catastrophic chemical disasters – predominantly in communities of color and low-income communities.

Ultimately, to mitigate the worst impacts of climate change, limit the risk of chemical disasters, and begin to remedy a legacy of environmental injustice, we must significantly reduce and replace the use of fossil fuels in every part of the chemical industry, which needs a systemic overhaul.

It's a mighty task. Only a handful of more than 40,000 chemicals on the market have ever been restricted; even asbestos hasn't been fully banned. There are still almost 3.5 billion pounds of hazardous releases to the environment every year. The United States is covered with 1,300 toxic "Superfund" sites, plus thousands more contaminated sites. But that hasn't stopped affected communities and organizations from banding together to say enough is enough. Recently a group of more than 100 health, science and environmental justice groups called for a transformation of the chemical industry with the release of the new Louisville Charter. Named after an area in Kentucky with 11 industrial facilities that release millions of pounds of toxic air emissions every year – disproportionately impacting people of color – the Charter's 10 principles outline a vision for how to overhaul chemical policies in favor of safety, health, equity and justice, and how to avoid false solutions that simply shift harms to other people and places.

These principles include calls to reduce or eliminate fossil fuel use, substitute toxic chemicals with safer alternatives, remedy environmental injustice, end subsidies for polluting companies, and give communities and workers information about chemical risks and the ability to act upon these disclosures.

We can make gains to achieve these goals if Congress passes the Environmental Justice for All Act and the Build Back Better Act, which would advance the some, but not all, of the Charter's principles. More action is needed, and the Charter can guide the way.

Whether it's to solve climate change, stop toxic chemicals from bombarding overburdened communities, or reduce hazardous substances in household products, we need to start replacing harmful chemicals with safe alternatives. No more free passes.

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Green Fuels for Several Types of Engines

THEO HART
ONE

Roads and road vehicles are everywhere, but reliable grid electricity is not. So, however appealing all-electric cars may be, they aren't for everywhere, nor for everyone. Needed now are green fuels of several types if we are to quit relying on fossil fuels in transportation worldwide.

Everyone is familiar with road vehicles using either gasoline or diesel fuel, each specific to a particular type of internal combustion (IC) engine. Green fuels for each are needed. Not so with external combustion (EC) engines, which can use a wide array of fuels, where almost anything that burns completely will do. Since such engines could be in road vehicles, it is bizarre that today they are not. Given the challenge, technologists could certainly adapt an EC design for this use.

Also different are the engines in the biggest cargo ships. Though technically diesel in type, they turn over slowly and have huge cylinders (a person can stand up in one), which allows the use of many fuels unsuitable for smaller types of diesel. This fact is of great significance for the production of green fuels.

Marine Fuel

The largest cargo ships at sea have huge diesel engines and consume tremendous amounts of fossil fuels annually. However, the dawn of green (non-fossil) fuel use in these ships is peeking over the horizon and may soon flood the world with its radiance.

The Danish shipping line Maersk, wanting to transition to non-fossil fuels, chose to retrofit one ship for methanol as fuel and is building another.

Of course, almost all methanol today is made from natural gas of fossil origin. But it can be a green fuel when made from CO_2 and electrolytic hydrogen (if the electricity is greenly produced).

However, when the hydrogen is coming from the electrolysis of water, it is reasonable to be somewhat skeptical. Because in making methanol this way, only two-thirds of the hydrogen combines with CO_2 in doing so, while the other third creates water molecules as a by-product. This seems an inefficient use of electricity, using it to produce hydrogen only to have a third of it wind up again like water. Nonetheless, this route is being touted as a wonderful thing by the likes of the Swedish company Liquid Air.

But methanol is a fuel of convenience, not the future fuel in large cargo ships. Maersk chose it for its widespread availability, not for methanol's attributes as a fuel, which frankly are not great.

Maersk is currently experimenting with using lignin as the basis for a ship's fuel. It is much more energy-dense and could be available from wood pulp mills and thus a biofuel. Likely smaller types of diesel could not use it, their fuel needs being more specific.

Photo credit: emerson.com

Interestingly, the use of green fuel in these ships may be done in stages through dual fuelling. Here, two fuels are stored separately, and then injected together into the engine in any proportions. Even existing ships may be retrofitted to use dual fueling.

Thus, the green fuel may be a small proportion at first and become the major fuel when it is more available. And one such fuel for these huge diesels may be a future green gasoline.

One Type of Green Gasoline

While methanol and ethanol have low energy densities, making either of them a poor choice as fuel, when chemically combined two to one with a ketone (acetone, say), they become an energy-dense fuel that works as gasoline.

In 1956 Dow Chemical patented a means of doing this. (US Patents 2.827.494 and .495 for the details.) But the reaction is reversible, and to get a pure product, the water also formed must be removed. Experience in dewatering the ethanol azeotrope to get pure ethanol could be instructive here.

The best use for these types of gasoline would be in the largest ships' diesels. Better gasoline for cars is shown later in discussing 2,3·butanediol as a preferred fermentation.

Isolation from Ferments

Generally speaking, the two highest costs of an industrial ferment are the material being fermented (the substrate) and the isolation of the products made, or at least the desired ones.

Distillation or extraction by some means are the most frequent choices, and recovery of some of the energy used is often a means of reducing costs overall. For isolating alcohols, diols or ketones on an industrial scale, salting out has much to recommend it. A cheap and disposable salt, such as sodium chloride (NaCl) or sea salt, is one approach. Another is to use potassium chloride fertiliser (KCl). Either way, a saturated solution of these salts will float the desired products to the surface, where they are readily decanted.

Yes, but what about the salty water left over? Well, with sea salt or sodium chloride simply run it slowly into the sea so as to quickly disperse the overly salty plume. This enriches the area with fermenter debris which marine life will soon consume. The resulting increased harvest of edible filtre feeders and fish should be a welcome development for the locals. In the case of potassium chloride, send the salty water after product removal into an outdoor evaporation pond. Dry it down, scoop out, and pellet for re-sale. It may be marketed as enhanced fertiliser, having besides potas-

sium, some nitrogen, phosphorus, and many micronutrients. As such, it will fetch a higher price – particularly, one would expect, from commercial growers of vegetable crops.

EC Engines

Internal combustion engines do not have clean emissions, whatever fuel is used in them. Smog formation may be a problem. In contrast, an external combustion engine has inherently cleaner emissions, comparable to a furnace burning liquid fuel. Properly adjusted, its smoke is white in cold air.

Such EC engines may use a much broader spectrum of fuels. For example, in 2014, the Swedish company Precer had a vehicle, a fun buggy one might associate with partying round a bonfire at some beach. But this was no ordinary vehicle.

Ford tried Stirling type engines as prototype in cars some sixty years ago but then gave up.
Photo credit: Ford

It was a hybrid with electrical storage batteries and an EC engine burning wood pellets as fuel! (I kid you not). Well, that might not have caught on. Also, the engine was a Stirling type of hot air engine, which unfortunately needs very high internal pressures to be powerful enough for a road vehicle. Ford and General Motors, among others, tried it as prototype engines in cars some sixty years ago but then gave up.

A closed-loop turbine, another EC engine, is a far better choice. The working fluid exits a boiler, spins a high-speed turbine (smaller than a dinner plate), gets condensed to a liquid and returns to the boiler. Round and round and round it goes, hence the term ″closed-loop″.

DuPont built one circa 1972 primarily to test various chemicals as the working fluid. Their dream was to supply that for thousands upon thousands of these engines in road vehicles. But no car manufacturer took sufficient interest.

The test engine was small (15 kW) and innovative. It featured a rotating boiler, with a rotating condenser on the same shaft and was cooled by air. The centrifugal force pushed the liquid fluid against the outer wall of the boiler, where heat from the open flames vapourised it. This made heat transfer very efficient, contributing to the engine reaching nearly 24% in overall heat efficiency, which is better than gasoline engines in cars.

The design is a good one except for the air cooling of the rotating condenser. It would be too lengthy for an engine large enough for a road vehicle. It should instead be short and rely on a separate cooling system with a radiator, like today′s vehicles.

This also provides layout flexibility regarding the radiator. It is particularly suitable for hybrid vehicles, whether hybrid electric or hybrid hydraulic, where the engine is either run near maximum output or is off. The heat efficiency of this type of engine drops off at partial loading.

External combustion allows a wide choice of fuels for the engine, even the wood pellets of the Swedish fun buggy.

A liquid fuel of some sort is naturally much more convenient. Since all any fuel does is must burn completely, many inexpensive fuels would soon be on offer. O welcome change!

Fuels of fossil origin should be banned from use.

This type of EC engine could replace the engines in diesel-electric locomotives. The attraction would be cheap fuel, which is a significant operating expense for railways that rely on diesel power – often, it is second only to wages.

These would be powerful engines, and there are ways of varying their output with minor loss in heat efficiency. A sizeable cooling system for the condenser would be needed, which could be on a separate railcar behind the locomotive, an articulated connexion keeping them permanently joined. Or it could be in front of the locomotive instead.

Why 2,3-Butanediol from Paenibacillus polymixa

There are at least seven good reasons.
One. Readily made into butanone, perhaps better known as MEK, methyl·ethyl·ketone, a solvent with an established market.

Two. Combines with butanone to form a cyclic compound with attachments, a five·member ring having two O atoms, a cyclic di·ether. Expect it should be relatively stable.

Three. Excellent gasoline from only one ferment, which has ethanol as a co-product. (Note that acetone could instead be the ketone, though that would involve more than one ferment.)

Four. A safe ferment, unlike any Klebsiella species that produce 2,3·butanediol which is toxic and require special precautions.

Five. One unique feature not immediately relevant, both hydroxyls are on the same side (Levo isomer); it has a low freezing point and Canadian researchers circa 1950 felt it could re-place ethylene glycol as the antifreeze in a radiator coolant for engines.

Six. It can grow on a good many substrates, starch and glucose in particular, but also pectin, mannose, galactose, cellobiose and xylose. Produces the enzymes α·amalase, xylanase, and inulase. It can therefore utilise hemicellulose directly and cellulose in-directly, perhaps also kelps. Likely it will be able to ferment immature grasses (fresh hay) to a largish degree since that cellulose is not yet as intractable as it later becomes. The enzymes which attack starch should be helpful in this.

Seven. The bacteria show a strong preference for six-carbon sugars and won't utilise xylose when glucose, starch or cello-biose is present. Thus it is possible to halt the ferment when xylose has accumulated yet not been attacked. The xylose could then be utilised to make furfural, xylitol, or otherwise made use of. [Doing so in strong brine featured in an early patent on furfural.]

Sugarcane as Fuel Crop

One possible substrate might be the tops of sugarcane lopped off and left in the fields at harvest because, being the newest growth, they contain almost no sucrose, the newest growth.

This also suggests using sugarcane as a fuel crop, repeatedly removing the top growth above a certain height – say 1.8 m – and at season's end, the bottom part would also be harvested and taken to a sugar mill.

If it is a new purpose-built mill, the focus should not be on maximal sugar production but on keeping capital costs down and operating procedures simple: low-cost.

Then the canes would undergo a ferment to rid them of resid-ual sucrose and perhaps the xylans, leaving cellulose and lignin. Removing the lignin would give cellulose fibre the purity required for various industrial uses, such as fibre in compo-sites or making speciality pulps.

Biogasoline could be a good industry for some islands in the Caribbean and tropical Pacific. Perhaps also Mediterranean lands where sugar cane was once grown before the discovery of the New World. Kenaf or sorghum could be another fuel crop in such places.

Recall that cargo ships with their colossal diesel engines can burn such biogasoline, and they consume a considerable amount of fuel annually. Also, they need to refuel periodically and require fuel depots in most parts of the globe.

Road vehicles are seemingly everywhere and need fuel where they are. So a biogasoline industry would be worldwide and welcomed almost everywhere since it is local production creating much local employment. Plus, it often enhances seafood output as well.

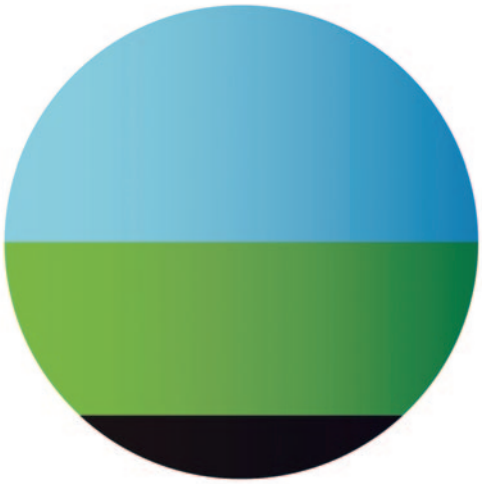
Of course, EC engines would pollute less and use a wider array of biofuels, but that is the world of tomorrow.
Today's world needs bio gasoline to stop burning fossil fuels. Worldwide. ONE

LAST STAND

Photo credit: Michal Belka

Founded on 4 February 1970 to serve the nearby Chernobyl Nuclear Power Plant; evacuated sixteen years later on the day after the Chernobyl disaster. On the first day of the 2022 Russian invasion of Ukraine, Putin's army seized what remained of Pripyat. ONE

SOTACARBO



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