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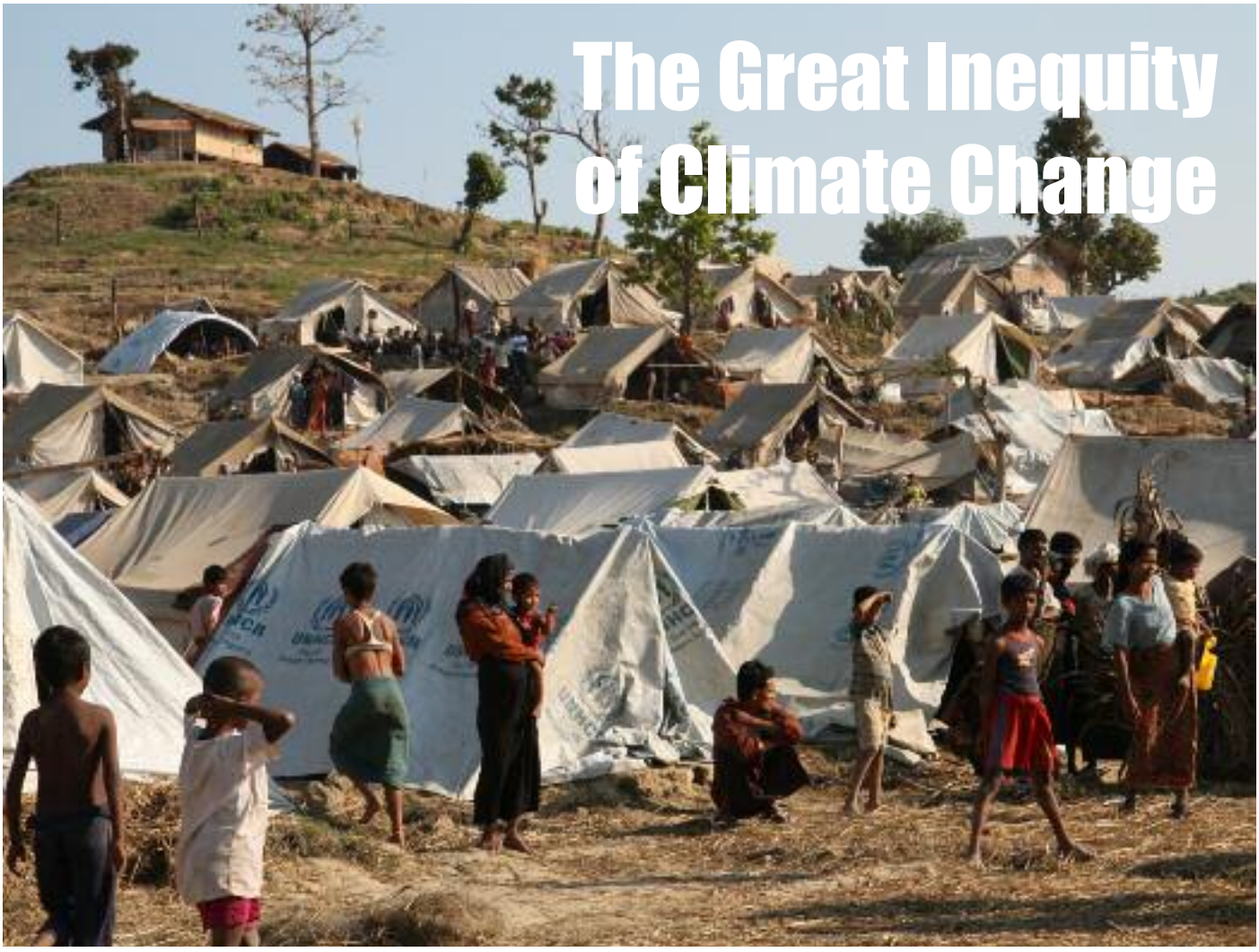

The Great Inequity of Climate Change

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Grass Lawns are an Ecological Catastrophe

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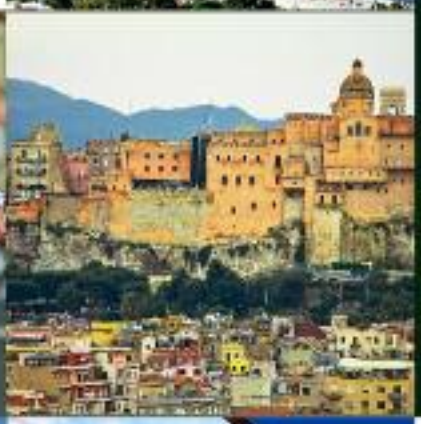


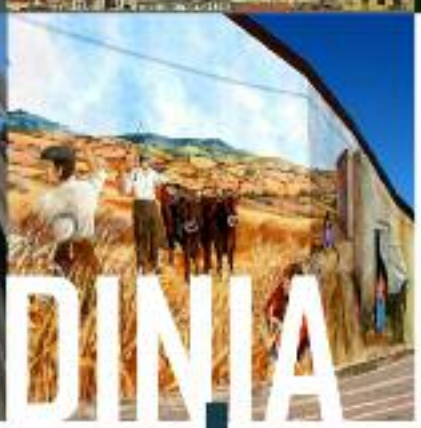


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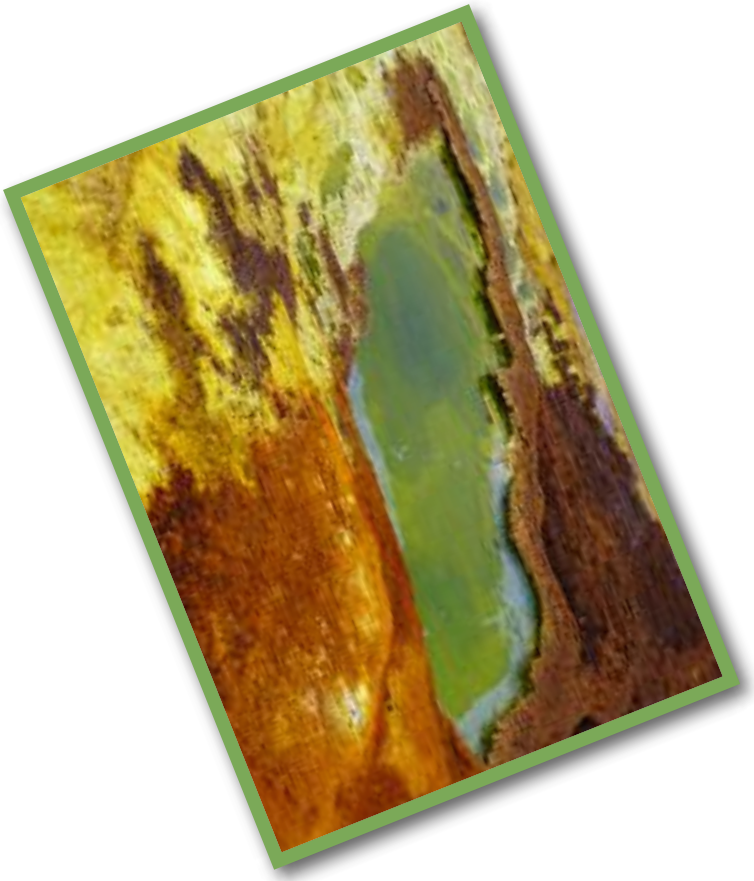

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Oceania: the politicians fiddle, the Pacific burns

By JEZ ABBOTT

ONE

It was a black moment, standing before the Australian parliament clasping a lump of coal in a pose of denunciation. Scott Morrison made headlines with his gesture last February, accusing those who doubted the environmental impacts of coal of being driven by ideology or pathological fear.

Late this August Morrison was back in parliament striking a different pose of denunciation. His party had just ousted prime minister Malcolm Turnbull to make the premiership his. Both men are in a fix, as are the remaining 24.8 million people in that vast, parched and fast-overheating country. Then there are millions upon millions of inhabitants of other nations in the wider Pacific region whose lives are affected by policymakers like Morrison and Turnbull.

One of the most dramatic weeks in Australia′s political history was triggered by energy, emissions and climate policy. Turnbull failed to pass a major energy reform - the National Energy Guarantee (NEG) - in part because ministers criticised the reform for its low emissions targets for the power sector. Bowing out, Turnbull admitted he was unable to implement a climate change policy.

Australia′s governing party cannot come to agreement, leaving Morrison as the seventh premier in just over a decade to try to cobble together consensus on climate. More failure could spell more disaster further afield. The Pacific region is a vast realm defined by the world′s largest ocean, about 30,000 islands and several million square kilometres that encompass almost an entire hemisphere.

And while politicians fiddle, the Pacific burns. Large sections of Australia are currently in severe drought and dozens of mid-winter bushfires are scorching landscapes. Fiji has experienced ongoing storm-induced drought with farmers losing crops and water supplies drying out. Rising sea levels in the south

Climate change is strongly felt in the Pacific Islands.
Photo credit: Quentin Hanich.

Pacific are forcing some of Solomon Islands' 560,000 population to leave their homes.

Quibbling in Australia and other national parliaments is matched by confusion at ground level. John Kaia, chief of the Aenabaolo tribe, can only watch as the changing climate plays havoc on his isle of Tauba in the Solomon Islands: "Before, we used to know the seasons, but now the wind, the rain, the cyclones can come at any time," he told Germany's DW website. "We don't know when."

And while the tide rises in the Pacific, the tide of data grows evermore alarming in its forecasting. According to a report published by the UK government this May, all emerging evidence points to vast differences in impacts in a 1.5 °C world, compared to the 3 °C world to which our current policies and climate change pledges are leading us.

"For Pacific islands and marine and coastal ecosystems in the region, these differences cannot be overstated," the report explains. "Even a 0.5 °C difference may mean critical tipping points are crossed." Some of the most critical impacts for ma-

"Before, we used to know the seasons, but now the wind, the rain, the cyclones can come at any time. We don't know when."

John Kaia, chief of the Aenabaolo tribe


Former Australian Prime Minister Malcolm Turnbull (left) and the current PM Scott Morrison. Photo: Reuters

rine and coastal ecosystems and communities in the region include this one: at 2˚C global sea levels could rise by about 50cm by 2100.

Also at 2˚C virtually all coral reefs in the region may be lost (98% loss) with severe implications for biodiversity and island communities, economies and cultures. Reef degradation at 1.5˚C is still catastrophic (90%), while ocean acidification will impact upon reefs, fisheries and biodiversity with knock-on impacts for communities and economies.

This puts frustrated policies such as the NEG into painful focus. Its failure to factor in climate change will cost Pacific neighbours dearly, insists Oxfam Australia chief executive Dr Helen Szoke. And right on cue – as ONE went to press - typhoon Jebi was causing chaos thousands of miles away in Japan, battering towns, killing people, tossing oil tankers and forcing the of grounding flights.

"As political leaders from across Australia meet to determine the fate of the nation's embattled energy policy, they must be under no illusion how its backwardness on climate change is perceived by our Pacific island neighbours," Dr Szoke told ABC news channel. "No region is at greater risk to the dangers of climate change than the Pacific."

She insists debate on climate and energy policy in Australia has become divorced from the escalating impacts of climate change worldwide. If Australia is to maintain its position as a trusted partner of Pacific island nations amid growing competition in the region, it must demonstrate it is serious about the "number-one threat" to the the Pacific peoples: climate change.

A good place to get serious was the Pacific Islands Forum in September. The intergovernmental group is held every year between 18 countries from across the Pacific – the smallest member country is Niue with a population of 1,600, and the largest is climate-quibbling Australia. The forum launched in 1971 to enhance the economic and social wellbeing in people across the region.

According to reports before the event, hosted this year by the tiny island of Nauru, Pacific countries were looking at setting up a huge climate change fund by pooling resources to amass a $1.5 billion cash pot. Nations could dip into the money to build infrastructure to brace themselves for disaster instead of waiting for it to happen and then asking for help.

Such a fund could be used to build pre-emptive defences to protect against the kind of climate disasters that sent a high tide across the isle of Ejit in the Marshall Islands three and a half years ago to cause devastating floods in the capital of Majuro. Pacific Islands Forum secretary general dame Meg Taylor said the forum would look for donors to back the fund. Dame Taylor could tap up China. According to Sydney-based think

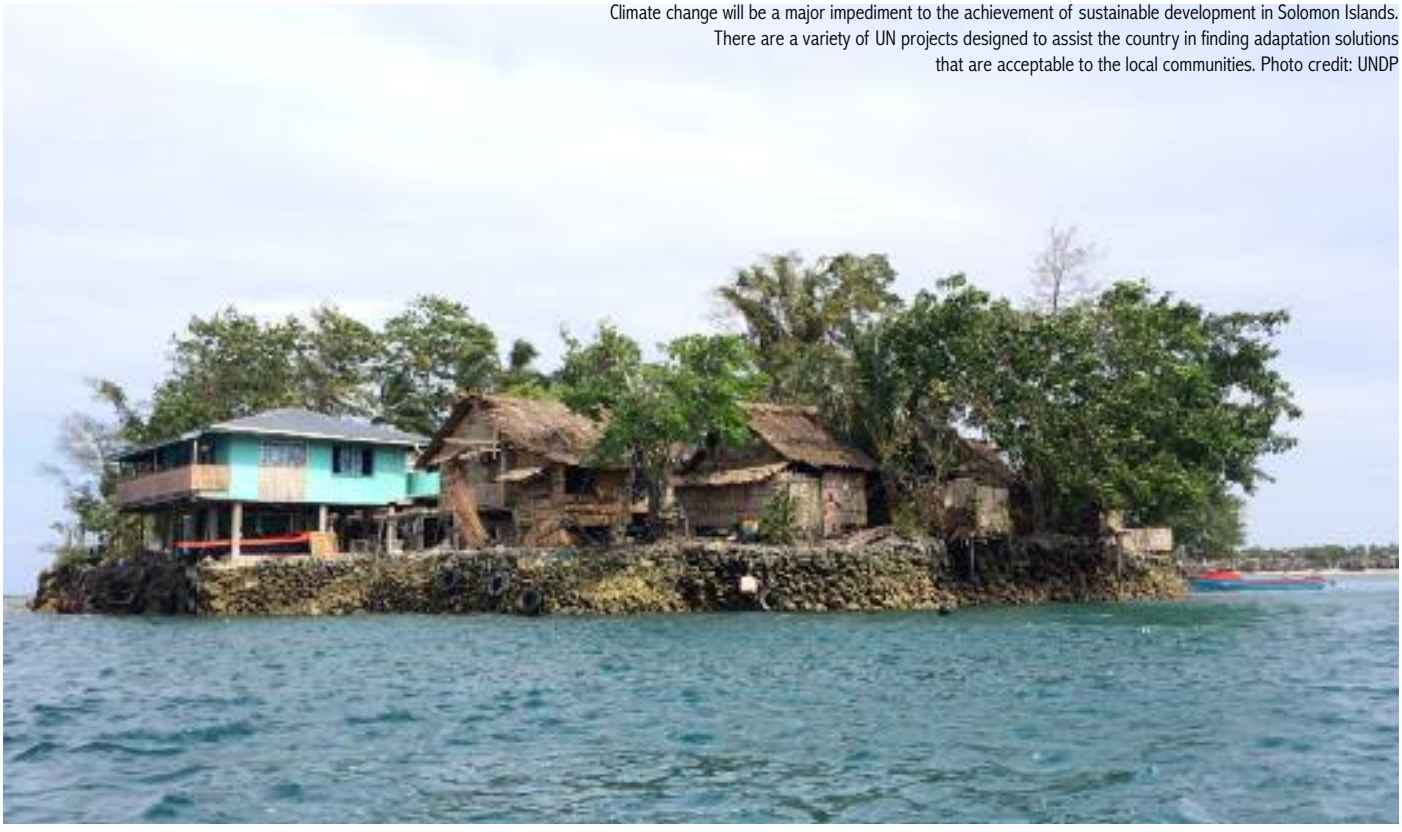
tank the Lowy Institute, China's climate aid pool – called the South-South Cooperation Climate Change Fund – totals $3 billion. President Xi Jinping has committed to providing 10 low-carbon industrial parks, 100 mitigation and adaptation programmes, and 1,000 climate change training initiatives to developing countries. Lucie Greenwood, a social enterprise researcher at the institute, draws on suggestions in a recent a UN Development Programme (UNDP) report that suggests Australia and New Zealand could potentially collaborate with China on the latter's development aid in the Pacific. The report identified climate change as a fruitful area for "trilateral cooperation" on aid projects and donors. China, she says, has vast wealth and technical know-how in renewable energy production, as well as climate change mitigation and adaptation. New Zealand and Australia meanwhile have expertise in climate change adaptation and resilience, but less experience with mitigation. Together they could blend international best practices for aid delivery, project oversight and building standards.

"Chinese development aid officials are open to learning from experience with best practice, which would likely improve robustness and sustainability of Chinese aid projects. This is in the interests not only of Pacific island countries, but China, which wants to be seen as globally responsible: an important ingredient in its efforts to minimise the rhetoric of 'threat' associated with its rise."

Greenwood concludes: "Protecting Australian and New Zealand 'values' does not require militarisation. If we want to live in a more peaceful world, where disputes are settled peacefully, the key is to put our energies into activities that align with this vision. Collaborating with China to tackle climate change is a good first step, as all parties agree this requires urgent action."

Dispute in the south Pacific echoes that in the Australian parliament. In an article titled 'The lump of coal PM', Independent Australia called Morrison a chameleon, an opportunist and "a leader this nation can ill afford", suggesting his coal pose last year might have been just that – a pose. Morrison, it went on, stood beside a prime minister "who proposed a pathetic National Energy Guarantee that would kill renewables and do nothing to stop climate change".

Meanwhile opposition to action on climate change within his own party was an "article of faith", according to Morrison's predecessor Turnbull. Issues on climate policy and emissions were "a bit like same-sex marriage used to be, almost an insoluble problem", added Turnbull with a parting shot: "As for what the future holds on energy policy, you'll have to talk to Scott about that." ONE



Climate change will be a major impediment to the achievement of sustainable development in Solomon Islands. There are a variety of UN projects designed to assist the country in finding adaptation solutions that are acceptable to the local communities. Photo credit: UNDP

Ice melting is too silent to disturb policy makers' sleep

Ice physics is not an easy subject. This is why there is no consensus among scientists on how ice will evolve in the future. Preventing ice melting in the short term is difficult, whereas something can be done in the medium and long-term.

By ALICE MASILI

ONE

In the Paris Climate Agreement, where member states agreed to limit the increase in average global temperature to values significantly lower than 2 degrees Celsius and, if possible, even lower than 1.5 degrees Celsius, there was the goal of meaningfully reducing the relapses related to climate change. But this does not seem to apply to the glaciers. Researchers argue that if the average temperature were to rise by 2 degrees Celsius or only 1.5 degrees Celsius the impact on melting glaciers would be almost identical and the loss of ice mass would be similar for the next 100 years.

Recently, a vast iceberg parked near the Greenland coast, detached from a glacier and driven by northern winds to the mainland, made fear the worst for the fate of Inaarsuit's inhabitants. If the mountain of ice melted or shattered, the remote village could be hit by a violent tsunami. About 170 people were forced to leave their homes, fearing the fury of the water could overwhelm them. A much-welcomed twist of winds pushed the iceberg further north, removing the danger of much more severe consequences.

Can such striking events be traced back to climate change? The recent ice calving case reopens the debate among scientists. The ice caps of Greenland contain some of the world's fastest-melting glaciers. A study published in Geophysical Research Letters, last April, linked human-made climate warming to the region's rapid ice loss. In this particular iceberg, there is not enough evidence to claim the detachment is imputable to climate change. It seems inevitable, however, that the number of icebergs in Greenland should increase in the coming years.

That was the most significant and dangerous detachment episode after the famous Larsen C breakup in western Antarctica on July 2017 - the most massive iceberg ever disjointed by an ice platform. Many scientists associated both episodes, as well as all those related to the icy calving phenomena, to global warming. Some experts, however, do not agree with the direct connection of the ice detachment to the greenhouse effect. The increasing of the average temperature of our planet is undeniable, and it seems trivial to deny that in an ever-hotter environment the ice tends to melt and detach. In spite of what seems logical and immediate, the bond between global warming and glacier detachment is not always so direct.

Shortly after the detachment of Larsen C, in an interview published in The Conversation, Adrian Luckman, glaciologist of the University of Swansea, confirmed that this process could not be classified exclusively as a consequence of climate change: "These are absolutely natural phenomena that occur over the decades and cannot be closely linked to global warming. The disjunction of the iceberg from the Antarctic would happen anyway" explained Luckman, who also showed satellite images to support his studies. The theory of the British glaciologist is confirmed by Carlo Barbante, glaciologist and director of the Institute for the dynamics of the environmental processes of the National Research Council (Idpa-Cnr): "We are dealing with phenomena that have taken place even in ancient times, for which there are no data that prove the human actions' influence."

View not shared by several climate scientists who claim that ice calving and terrestrial heating are in close correlation. NASA published an article where Dan McGrath, glaciologist, and climate change expert at Colorado State University, asserted that even if it is impossible to quantify the global warming impact on the iceberg calving phenomena, the Antarctic Peninsula in recent years has heated at ever faster rates. The temperature rise has caused profound environmental changes, including the collapse and detachment of several glaciers with consequence on the oceans and the mainland.

Paul Johnston, Head of the Science Unit of Greenpeace International, supports that theory: "The melting ice of Antarctica has always been recognised as a 'canary in the coal-mine' warning the world of the dangers of climate change. The collapse of this ice-shelf, the third collapse in this region in recent years, is possibly yet another signal of the global impact of climate change — and the imperative of implementing the Paris climate agreement, shifting to 100% renewable energy sources and leaving fossil fuels in the ground."

The Larsen Ice Shelf in Antarctica. Photo: NASA

Johnson urges governments to act: "No one knows for sure if climate change played a definitive role in the break of the Larsen C ice shelf, but given the relatively recent breakup of other shelves, and the contribution thought to have been made to erosion of the ice by warmer waters around the Antarctic Peninsula in those cases, it seems likely that human activities are a factor. We are still in the safe zone to avoid catastrophic climate change. But we must act fast. Decisions taken now by governments and industry will decide whether billions of people have safe, prosperous lives in the future".

The changes are even more evident in the Arctic Circle - the dramatic reduction of sea ice, the Greenland ice cap melting, the glaciers retreat and the permafrost thawing. In 2018, Greenland has already recorded 61 hours above zero, three times more than in any previous year. Its ice is melting rapidly, but part of the water produced by the process does not end up in the sea and remains on the island. Water remains trapped in the thickest ice, which has a low density and high porosity, characteristics that allow it to retain it. The dissolved water is vertically channeled into structures called "moulins", and instead of ending up in the sea remains imprisoned in the porous ice, where it can refreeze. The phenomenon was thought to be of little significance, but further analysis revealed that the original estimates on water dispersed at sea could be wrong by a massive 21-58% margin. According to Michael Mann, a climate scholar at Pennsylvania State University, Arctic ice is disappearing 50 years earlier than expected by scientists.

According to NASA glaciers in the world would decrease by 13.2% every ten years. The question mark is what happens afterwards. The ice, being white, like a shield, reflects most of the solar radiation towards the sky, therefore also the heat. Because of the rise in temperature ice melts and increase the darker surface, which absorbs more heat, helping to raise further the temperature that melts the ice even more. A vicious circle that is difficult to escape without rapid and effective intervention on greenhouse gas emissions. *The Sleeping giant* is how climatologists call the permafrost, the layer of icy terrain typical of Siberia, composed of vegetable biomass, remains of ancient forests. It contains enormous quantities of greenhouse gases such as methane and carbon dioxide. Frozen, as in a time capsule, it is now opening due to the temperature rise. A study conducted by the CNR and the University of Stockholm, published in Nature Communication, estimates that at the end of 2100, the release of greenhouse gases by permafrost could reach a quarter of all emissions related to the use of fossil fuels. The ice physics is not an easy subject. This is why there is no consensus among scientists on how ice will evolve in the future. For sure preventing ice melting in the short term is very difficult, whereas something can be done in the medium and long-term.

A new study of researchers at the Bremen (Germany) and Innsbruck (Austria) universities concludes that even if our greenhouse gas emissions fall to zero the melting of the Earth's vast glaciers will not stop in this century. It is mainly due to the inertia of the phenomena and the slow reaction of the glaciers to climate changes, which only in recent years have begun to heavily suffer from the increase in the temperature of the last decades. Nevertheless, one day you have to start doing something if you want to stop the trend. If the governments keep their promises to counter global warming, the pattern could change. Despite diverging views, experts agree that it is necessary to act quickly, as indicated in the Paris Climate Agreement, and drastically reduce CO2 and other greenhouse gases released into the atmosphere. So why not pursue a less polluting energy and transport policy and have a sustainable impact on the environment? The transition from fossil fuels towards renewable and clean energy sources is taking ages, but it could be much faster. If only policymakers would adopt more ambitious and braver measures on a global scale, like supporting and implementing the rational and efficient use of energy and materials, catastrophic scenarios could be avoided. Unfortunately we are doing too little and too slowly, whereas the climate changes rapidly. ONE

Mapped: The US nuclear power plants 'at risk' of shutting down

By ZEKE HAUSFATHER
Carbon Brief

Nuclear power plants generate more than half of the US's low-carbon electricity. However, record low gas prices associated with the US fracking boom have made many existing nuclear plants uncompetitive in the current market.

About 90 terawatt hours (TWh) of nuclear generation is scheduled to retire in the next decade, more than all of the US's current solar generation. Studies suggest that another 135TWh is probably not cost competitive with gas plants and, therefore, at risk of retirement.

This means the source of about 15% of US low-carbon electricity could shut down and largely be replaced by gas, making it harder for the US to meet its emission reduction targets. Research suggests that many existing nuclear plants would avoid being shut down if they were rewarded for their minimal CO2 emissions. Additionally, keeping existing nuclear plants open may be one of the lowest-cost forms of carbon mitigation, cheaper than building new wind or solar plants to replace them. If the US is going to retain most of its existing nuclear plants, "additional programmes to subsidise their life extension and continued operation will have to be implemented in just the next few years", according to a recent study in the Proceedings of the National Academy of Sciences (PNAS).


The now closed San Onofre Nuclear Generating Station in San Diego, California. Photo: Luke Jones

Losing low-carbon generation

Nuclear power accounts for 20% of US electricity generation and more than half of the low-carbon electricity. In total, there are 60 nuclear plants currently operating in the US. While some carbon emissions are associated with nuclear plant construction and operation, on a per-TWh basis, nuclear generation has emissions equal to or below that of renewable energy technologies.

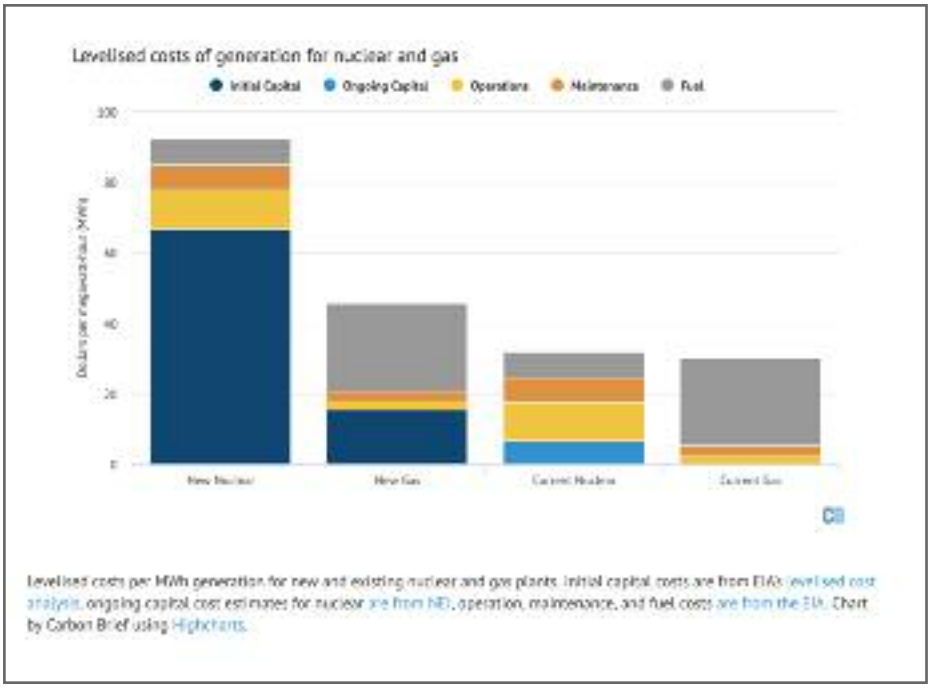
Nuclear plants are expensive to build, but historically have been seen as having lower operating costs than most other sources of power once built. This is no longer the case in the US where a combination of an aging nuclear fleet, unprecedentedly low gas prices and increased low-cost renewables have put many existing nuclear plants at risk of premature retirement. Five US nuclear plants have already retired over the past five years, despite regulatory approval to continue operation. Prior to their retirement these plants produced 38TWh of low-carbon electricity, or roughly half of current combined utility and small-scale US solar generation (77TWh in 2017).

Nine US nuclear plants have announced that they plan to shut down over the next five years, representing an additional 90TWh. An additional 16 plants representing 135TWh are "at risk" of losing money compared to gas generation in the current market, according to a 2017 paper in the journal Energy by Michael Roth and Prof Paulina Jaramillo of Carnegie Mellon University. Overall, 263TWh of nuclear power has either been retired, has a planned retirement date, or is at risk of retirement due to market forces. This represents around 15% of all current low-carbon generation in the US.

An additional six nuclear plants generating 67TWh of electricity were scheduled to be closed, but have been kept open by state-level policies in New York, Illinois and Connecticut.

Existing nuclear increasingly uneconomic

To examine why existing nuclear plants are becoming uncompetitive in the current market, Carbon Brief has compared estimates of their running costs with those for new nuclear plants and new or existing gas-fired generation. The figure below shows the estimated levelised cost of generating a megawatt-hour (MWh) of electricity from both new and existing nuclear and combined cycle gas plants in the US.



Levelised costs per MWh generation for new and existing nuclear and gas plants. Initial capital costs are from EIA's levelised cost analysis, ongoing capital cost estimates for nuclear are from NEI, operation, maintenance, and fuel costs are from the EIA. Chart by Carbon Brief using Highcharts.

These numbers are based on fuel, operation and maintenance costs estimates for US nuclear plants from the US Department of Energy's Energy Information Agency (EIA) and the industry-run Nuclear Energy Institute (NEI).

The initial capital costs, taken from the EIA, assume that construction projects will be completed on-time without cost overruns, something that has generally not been the case for recently built reactors. Ongoing capital costs associated with the replacement and major renovation of old components have averaged around $7 per MWh in recent years for the aging US nuclear fleet, the NEI figures suggest, while similar ongoing capital costs for the much newer combined cycle gas plants have been negligible. Costs for current US nuclear reactors are split between fuel, maintenance, ongoing capital costs and operations, with operations being the largest single expense at $11 per MWh. These costs include payments to the government for nuclear waste storage and disposal.

By contrast, fuel represents more than 80% of the costs for existing combined cycle gas plants – at $25 per MWh with current gas prices of $2.50 per MMBTU – with relatively small operations and maintenance costs of $3 per MWh each.

Carbon Brief also analysed 30 financial reports from individual nuclear plants submitted to the Federal Energy Regulatory Commission (FERC) obtained through the Public Utility Data Liberation Project. These plants generally reported average operating expenses (excluding ongoing capital improvements) of between $19 and $61 per MWh between 2010 and 2016, with a median cost of $26 per MWh – the same as the average number found in the EIA data.

One surprising finding is just how big a role employee salaries play in making nuclear less competitive than gas. A typical nuclear reactor with a capacity of 1,000megawatts (MW) will employ around 700 people, or 0.7 people per MW. Assuming a cost of around $100,000 per employee per year – including wages, taxes and benefits – Carbon Brief estimates that salaries add about $9 per MWh generated, higher than the cost of nuclear fuel. Other studies have suggested that salaries may comprise up to two-thirds of total operations and maintenance expenses, which would amount to $12 per MWh.

A combined cycle gas plant with a capacity of 1,000MW would have only 30 employees, or 0.03 people per MW. This is 25 times fewer staff than is required by a nuclear plant, reflecting the relative simplicity and high level of automation found in new gas combined cycle plants. Lower labour and maintenance expenses represent one of the major cost advantages of gas over nuclear today and make up for the difference in fuel costs.

Generating electricity from an existing nuclear plant is, typically, cheaper than building a new gas plant to replace it, the figures suggest. However, there are many existing gas plants that are not operating at full capacity, which could increase output to replace power from existing nuclear plants if they closed. Nuclear reactors in the US currently run about 90% of the time, while combined cycle gas plants only operate about 50% of the time.

There is also a large amount of new gas capacity currently being installed in the US. There are around 400 new gas plants planned by 2020, representing 71GW of capacity. Roth and Jaramillo suggest that "the availability of such capacity would likely result in such plants making up for lost generation from retired nuclear power plants".

The recent PNAS paper by Prof M Granger Morgan and collea-

gues agrees, suggesting that "economic pressure from low gas prices", rather than the expansion of renewable energy, is the primary driver of US nuclear retirements and will be the primary replacement for lost nuclear generation.

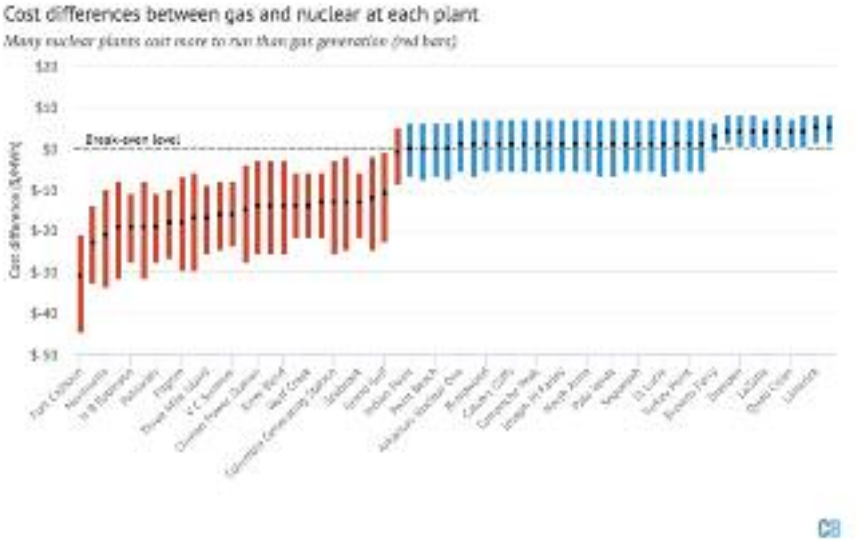
The costs of nuclear shown here exclude one-time expenses associated with the decommissioning of reactors, which is estimated to be between 9-15% of the initial capital cost of a nuclear power plant. These decommissioning costs are already covered by a US Nuclear Regulatory Commission (NRC) fund that reactors have paid into over their lifetime and are reflected in reactor operating costs, so decommissioning retired reactors does not necessarily add any additional costs for utilities.

Similarly, waste disposal costs were paid to the government by reactors as part operating costs, though are currently suspended until a permanent storage option becomes available. The NRC has determined that waste can be stored on-site for 60 years after a reactor shuts down.

Many nuclear plants at risk

In their 2017 paper, Roth and Jaramillo built a model to estimate the cost of electricity generation at each US nuclear plant. They compared these to the cost of generation from gas to identify reactors at risk of being shut down due to market forces.

The figure below, adapted from their paper, shows these cost comparisons for each nuclear plant in the US – along with estimated uncertainties. Positive values in blue indicate that the plant is expected to be cheaper than gas between 2015 and 2040, while negative values in red show plants expected to cost more to operate than combined cycle gas turbines.



Relative cost of electricity from each US nuclear plant between 2015 and 2040, compared to a combined cycle gas-fired generation plant. Based on "missing money payment" calculations in Roth and Jaramillo 2017. Note that the x-axis shows every other label name; hover over the bars to see each plant name. Chart by Carbon Brief using Highcharts.

Roth and Jaramillo find a sharp divide in the economics of nuclear plants based on the number of reactors on site. Plants with a single reactor have a higher estimated cost of generation. However, all cost more than comparable gas generation.

With the exception of the Cook plant, all multi-reactor nuclear plants are expected to remain cost-competitive with gas in the years up to 2040, at least in the EIA's reference gas price scenario. Roth and Jaramillo's findings are similar to an analysis done by the US Environmental Protection Agency (EPA), which determined that "some nuclear plants may be running at a deficit of $6 per MWh" compared to gas. These levelised costs present a somewhat incomplete picture of the economics of individual nuclear plants. Some of the multi-reactor plants that Roth and Jaramillo find are economically viable are, none the less, scheduled to be retired. This is because average electricity sales are not the full picture of plant revenue. Plants also make some revenue from capacity markets, where they are compensated for ensuring that sufficient generation capacity is available in the future.

Capacity markets are volatile and generally do not comprise a large percentage of plant revenues. However, in a number of recent cases nuclear plants were not chosen in the capacity auction, with the bulk of the required capacity being provided by gas. Gas is also proving more viable in areas where lots of variable renewables have been installed. In parts of the Midwest US, large amounts of wind generation coupled with low demand often leads to near-zero or negative electricity prices overnight. Because fuel represents upwards of 80% of the cost of generation for gas, these plants can easily cut back production in times when prices are low and there is a surplus of renewable generation on the grid, as well as quickly ramping up production when prices increase.

Nuclear, on the other hand, has low fuel costs and much higher fixed costs, such as salaries and maintenance. These mostly have to be paid, regardless of how much electricity is generated by the plant. While it is technically possible for nuclear plants to curtail generation, it is not particularly economic in most cases.

Future of US nuclear

The prospect for new nuclear reactors in the US in the near-term seems bleak. Morgan and colleagues write in PNAS:

"There is no reason to believe that any utility in the US will build a new large reactor in the foreseeable future. These reactors have proven unaffordable and economically uncompetitive. In the few markets with the will to build them, they have proven to be unconstructible. The combination of political instruments and market developments that would render them attractive, such as investment and production credits, robust carbon pricing, and high gas costs, is unlikely to materialise soon."

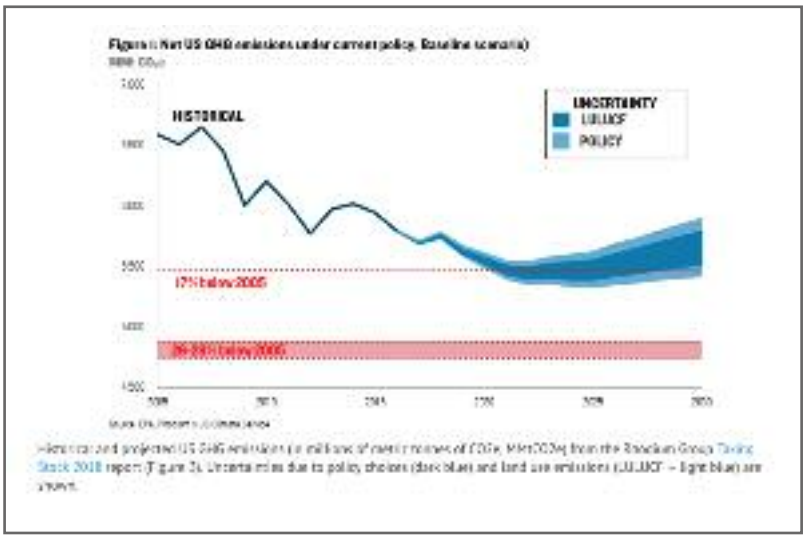
The two most recent nuclear projects in the US illustrate this point. The construction of two AP1000 reactors at the Virgil plant in South Carolina was abandoned last year after massive cost overruns and $9bn in expenditures, contributing to the bankruptcy of Toshiba subsidiary Westinghouse – with knock-on impacts for nuclear projects around the world. The construction of another two AP1000 reactors at the Vogtle plant in Georgia is still ongoing, but the company expects the project to cost at least $25bn, more than $10bn over budget. Duke Energy recently cancelled plans to build new nuclear plants in South Carolina and Florida. New conventional nuclear plants are currently a very expensive means of producing low-carbon electricity, according to the EIA – even if they can be built on-budget. However, keeping existing nuclear plants operating – and not being replaced by gas – is a very different story.

Roth and Jaramillo estimate that keeping the most uneconomic existing nuclear plant open would cost $69 per tonne of "CO2 saved" compared to gas. The typical at-risk plant would cost just $31 per tonne CO2 to keep open. They suggest that subsidising existing nuclear plants would be a cheaper way to cut CO2 emissions than building new wind, solar or nuclear plants. They argue that even wind generation, which has the lowest cost of avoided CO2 emissions, is more expensive than preserving the least financially viable nuclear plant currently in operation.

That said, there may be individual plants where replacement with other low-carbon alternatives might prove more cost-competitive. For example, Pacific Gas and Electric – a large California utility – has argued that the replacement of the Diablo Canyon nuclear plant by renewables and storage would "have a lower overall cost than relicensing [Diablo] and operating it through 2044". Others contest these claims, however, as they depend in large part on how quickly future renewable energy and storage costs decline.

Roth and Jaramillo also suggest that the retirement of existing nuclear power plants will result in large amounts of low-carbon electricity being replaced primarily with generation from gas power plants, limiting the US's ability to meet its emission reduction goals. They suggest that states could follow the lead of New York, Illinois and New Jersey by providing incentives to compensate nuclear plants for the value of their low-carbon generation similar to existing renewable energy credits, as this would provide a relatively cost-effective mitigation option.

A recent report by the Rhodium Group projected that US emissions will continue to decrease up to 2020. Emissions may begin increasing again after 2025, with nuclear retirements playing an important role in driving the increase. The report's projection – along with uncertainties – is shown below. The report suggests that the US nuclear fleet may shrink by between 13% and 26% by 2025, helping reverse a trend of declining US emissions driven by the retirement of coal plants, among other factors. There are many reasons why experts are sceptical about the future of nuclear power, particularly the economics of new nuclear power plants. However, the potential loss of around 15% of all low-carbon generation is problematic, when very rapid emission reductions are needed to meet US Paris Agreement targets.



As Morgan and colleagues point out in PNAS: "It should be a source of profound concern for all who care about climate change that, for entirely predictable and resolvable reasons, without immediate and profound changes, we appear to be set to lose one of the most promising candidates for providing a wedge of reliable, low-carbon energy over the next few decades and, perhaps, even the rest of the century."

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Ozone pollution in US national parks is nearly the same as in large cities

Most Americans associate U.S. national parks with pristine environments that represent the very best of nature. Not anymore.

By DAVIDE KELSER, GABRIEL LADE, IVAN RUDIK
The Conversation

"Another glorious day, the air as delicious to the lungs as nectar to the tongue" – John Muir, My First Summer in the Sierra (1911)

Most Americans associate U.S. national parks with pristine environments that represent the very best of nature. In the 1916 law that established the National Park Service, Congress directed the new agency to "conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

But over the past century it has become increasingly hard to protect the parks from impacts of human activities outside their boundaries. In 2015 the National Parks Conservation Association, a national advocacy group, released a blistering report giving many popular parks poor grades for unhealthy air, haze and impacts from climate change. In a study just published in Science Advances, we analyzed levels of ozone, the most widely monitored pollutant in parks, and their impact on visits to 33 national parks from 1990 to 2014. The sites we studied included popular parks such as Acadia, the Grand Canyon, Great Smoky Mountains, Joshua Tree, Sequoia and Kings Canyon and Yosemite. We found that while cities once had more "bad air days" with unhealthy ozone levels than national parks, today parks and metro areas have virtually the same number of unhealthy ozone

The Joshua Tree National Park in south-eastern California in the United States.
Photo: Sydney and Russell Poore

days per year on average. We also found that park visits fall on high ozone days – especially during summer and fall, when peak ozone levels typically occur.

Looking west from Shenandoah National Park's Shaver Hollow on clear (left) and hazy (right) days. Photo: NPS

The impact of bad air days

Regulatory efforts to protect the national parks have a long history. The Clean Air Act Amendments of 1977 and 1990 designated parks as Federal Class I Areas, granting them special air quality and visibility protections. The U.S. Environmental Protection Agency's 1999 Regional Haze Rule increased these protections by requiring states to develop and implement plans to improve visibility and air quality in parks and wilderness areas. However, these regulatory actions have spurred contentious debate and litigation. Environmental groups argue that these measures are not stringent enough, while some states and industries call them too costly. Major sources of park air pollution include power plants, automobiles and industrial facilities. Unlike other pollutants emitted directly from these sources, like sulfur dioxide or lead, ozone is a secondary pollutant. It forms in the atmosphere through chemical reactions between nitrogen oxides, volatile organic compounds and sunlight. Nitrogen oxides originate from the usual urban pollution sources, but biogenic sources like trees are actually the largest source of volatile organic compounds, above industrial sources and cars. Ozone pollution is a serious threat to human health and the environment. It has been linked to increased respiratory symptoms, hospitalization rates and mortality. It also is correlated with poor visibility in parks, and can damage sensitive plant species.

Ozone trends over time

To our surprise, for most of our study period we found that average annual ozone concentrations in national parks were nearly identical to those in metropolitan areas. However, summertime levels and the incidence of unhealthy days told a different story. Since ozone forms in sunlight, levels typically are highest on hot, sunny days. When ozone levels exceed the national standard, which is currently 70 parts per billion, local and regional governments may issue alerts or urge people to avoid outdoor activities. In 1990 cities had far more days bad ozone days on average than national parks. But through the decade, summertime ozone and unhealthy ozone days worsened in national parks. By the year 2000, ozone levels in national parks were, on average, very similar to those in metropolitan areas. Explaining this increase was beyond the scope of our study. According to the National Park Service, pollution in national parks can come from many sources, including power plants, industrial sources, vehicle emissions and wildfires. Since the early 2000s, ozone levels in both national parks and metropolitan areas have improved. But bad air days still occur. On average, among the locations we studied, metro areas currently have 18 unhealthy ozone days per year, while parks have 16.

Bad air days drive away park visitors

To see whether visitors responded to changing ozone levels in the parks, we matched monthly visitation data from the National Park Service with various measures of monthly average ozone levels. We found that a one percent increase in ozone concentrations was associated with approximately a one percent decrease in park visitation on average. This response was most pronounced during summer and fall, when both visitation and average ozone levels are highest.
Why do visits decrease when ozone is high? We see two possibilities. First, visitors may worry about adverse impacts on their health. Second, visibility is typically poor when ozone levels are high because ozone participates in chemical reactions in the air that can form haze. We found stronger evidence that health concerns keep visitors away. Park visitation has a robust negative correlation with the incidence of unhealthy ozone days, perhaps because of air quality warnings that accompany these high levels.

The value of further ozone reductions

Across the United States, ozone levels declined by 31 percent between 1980 and 2016. But city residents and tourists in national parks still experience unhealthy ozone levels for two to three weeks per year. Exposure to high ozone levels may be particularly harmful in national parks, since health effects from ozone are greater during exercise, such as hiking, backpacking or rock climbing. Although we found that some people decrease their visits during unhealthy days, we still observed that since 1990, nearly 80 million visitor days have occurred during high ozone periods. This suggests that improving air quality in U.S. national parks could produce significant human health benefits. We hope that state and federal policy makers will weigh these benefits of improved air quality along with their costs as discussions move forward on air pollution regulations.

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Australia is Running Out of Fuel

By MIKE HOSEY
Think Sustainability

Last week, it emerged that Australia was just 43 days away from completely running out of fuel. That would mean people aren't able to fill up cars, planes won't be able to fly and many of the emergency services would be unable to do their jobs. There have been many warnings about an impending crisis as Australia's dependence on fuel imports has grown, yet very little has been done to manage it.

Australia's Fuel Shortfall

The International Energy Agency (IEA), of which Australia is a part of, requires countries to have a minimum of a 90-day reserve of fuel for cases like this. Given that Australia had only 43 days last week, they're obviously well below that requirement and now in danger of not having enough despite having pledged to meet the 90-day reserve target in 2015.

There have been a number of warnings in recent years, yet the Australian Government has continued with 'business as normal. 'They operate on a 'just in time' approach that means, whilst they receive the required fuel to keep the country going, they rarely have enough in reserve should there be a breakdown in supply.

Supply Breakdown

The consumption of fuel is fast outpacing the production of oil within Australia and so importing fuels from outside is the only way for the demand for fuel to be met. In 2016-17, Australia imported 54,853.4ML of fuel into the country and used 57,780.7ML. Australia still produced 27,353.4ML of fuel in the same period, but over the last 6 years that has dropped by more than 33% (Department of the Environment and Energy 2018).

Just last year, Australia's fuel security was called into question by a number of defence experts. Tensions in the South China Sea, a route that much of Australian fuel imports take, were putting a risk on the supply Australia needed. Whilst no real crisis has yet arisen from that, conflict in Syria and the Middle East is putting an even greater strain on fuel supply, creating the crisis that is now occurring. Like many places around the world that are heavily reliant on oil from the Middle East, the recent conflicts in the region have strained the supply of oil to many import-dependent countries. 91% of Australia's oil comes from the Middle East region before being shipped off to a number of countries in Asia and to Australia to be refined into fuels that are most commonly used for transport. This reliance on imports in unsustainable for Australia and could lead to economic and social disaster unless it is addressed and a more sustainable source can be used.

"The fundmental assumption they've made is because we haven't had a problem in 30 years, we're not going to have a problem." – John Blackburn, retired Air Vice Marshall.

Australian Alternatives?

The demand for fuel is set to increase over the next few decades as the population of Australia continues to grow. As the population increases, so will the number of cars on the roads of Australia's cities. If Australia is to sustain the projected population growth then it must find additional sources of fuel within its own country and/or develop alternatives and encourage the Australian population to purchase these cars.

Australia's dependence on imported fuel should be much more of a worry to the Australian Government than it appears to be. This crisis is not a new one, it's just worse than previous problems the country has faced in sourcing fuel. First, Australia must secure fuel supplies to stop the impending crisis that could bring Australia to a standstill before the end of May. Secondly, Australia must secure the reserves required by the IEA to ensure that a crisis like this doesn't happen again. Finally, Australia should look to alternative fuels to keep the country moving. Fossil fuels aren't a long-term solution to what will become a growing problem in Australia but alternative fuels are. In most cases, they are cleaner to produce and use and will reduce Australia's fuel dependence. Let's just hope they can find a way out of this crisis first.

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The Great Inequity of Climate Change

Some nations are likely to experience more adverse effects than others, whereas other nations may even benefit from climate changes.

By EUSEBIO LORIA

ONE

Climate change is a multifaceted phenomenon but is also iniquitous. It affects the most disadvantaged countries harder. In a papal encyclical letter called "Laudato Si" ("Praised Be") Pope Francis declared that the Catholic Church views climate change as a moral issue that must be addressed to protect the whole planet and everyone on it.

The Vatican' stance is not isolated. There's a growing, global movement to make human communities and ecosystems more resilient to climate extreme impacts and inequality. The winning strategy is the adaptation, but global commitment is needed.

A damaged village surrounded by flooded fields, nearly three weeks after the 1991 Bangladesh cyclone hit the country. Photo: Defense Visual Information Center

Climate change results in rising sea levels, changing precipitation patterns, and an increased risk of extreme weather events. Science tells us that climate change is already underway; according to an analysis by the World Meteorological Organization 2016 was the hottest year ever recorded, with the global average temperature 1.1°C above the pre-industrial period. The Intergovernmental Panel on Climate Change (IPCC) has already predicted that risks associated with extreme events continue to increase as the global mean temperature rises. There's a link between climate change and extreme weather events. And not a subtle one.

Years of drought and extreme heat had fuelled the worst fire disaster in Chile's history. The fire began in November 2016, and in January 2017 the country reached its all-time temperature record. Fires affected an area of 547,190 hectares (1.35 million acres). Multiple studies have linked the underlying "mega-drought" in Chile to climate change, attributing increased greenhouse gas emissions to recent declines in precipitation. Regarding the extreme heat in Chile, one of the most robust findings of is that global warming is dramatically amplifying the intensity, duration, and frequency of extreme heat events.

The summer of 2017 in Western Europe and the Euro-Mediterranean region featured a series of significant heat waves. Early August saw a particularly intense heat wave — called "Lucifer" — in south-eastern countries. The three-day heat event broke numerous records, including several all-time highs. An analysis conducted by the World Weather Attribution group in September 2017 found that climate change has made extreme three-day heat events like Lucifer four time as likely since 1900. The increasing frequency and intensity of heat waves are among the most apparent and documented effects of climate change, according to the National Academy of Sciences. Four out of five record-hot days globally are now attributed to climate change.

In 2017, Bangladesh was judged to be the sixth hardest hit

Eastern Samar Province, Republic of the Philippines (2013) A Guiuan woman stands outside of her makeshift shack in the aftermath of Super Typhoon Haiyan.
Photo: U.S. Navy photo by Mass Communication Specialist Seaman Liam Kennedy

country out of 180 nations, during the 1996–2015 period. The high level of poverty and increasing population density, as well as limited adaptive capacity and weak local governance, turned the region into one of the most affected by climate change on the entire planet. Sea level in Bangladesh is rising while the country is sinking. Two-thirds of Bangladesh has an elevation of five meters or less, which leaves the country vulnerable to devastating natural disasters. Bangladesh is consistently cited as one of the most disaster-affected countries in the world, exposed to a variety of natural disasters including cyclones, floods, earthquakes, and landslides, and ranks first regarding vulnerability. The national population is increasing by two million people a year and is generally poorly funded to respond to natural disasters as the government is unable to help.

In 2007, after a series of floods and Cyclone Sidr, food security was severely threatened, and crop yields worsened. The loss of rice production was estimated at around two million metric tons (MT), potentially feeding 10 million people, effectively increasing the 2008 rice price and leading to about 15 million people without much food. Bangladesh is an example of how a rise in sea level and global temperature could lead to displace millions of people. Improving the country's biodiversity is essential to prevent the depopulation and to sustain the development; resilience and adaptation are mandatory to avoid and fight next and future climate calamities.

Environmental risks are becoming more prominent than economic and geopolitical risks. Four of the top five global threats in the next ten years are related to climate change. Failure to respond to climate change has a massive impact on global risk.

The Global Risks Report 2018 (World Economic Forum, 2018) looks at five categories of environmental risks: extreme weather events and temperatures; accelerating biodiversity loss; pollution of air, soil and water; failures of climate change mitigation and adaptation; and risks linked to the transition to low carbon. The Paris Agreement, a legally binding international in-

strument designed to limit global warming to well below 2°C above pre-industrial levels, entered into force in 2016.

Climate scientists have warned that to avoid a catastrophic degree of climate change, the concentration of carbon dioxide in the atmosphere should remain below 450 parts per million. In 2016, the 400 parts per million limit was crossed for the first time, highlighting the urgent need for accelerated climate action among all global stakeholders, including governments, businesses, and civil society.

Acting on climate change means limiting risks around the world, for the benefit of future generations

Unfortunately, until now too little has been done globally to mitigate climate change. The likelihood of missing the Paris Agreements target of limiting global warming to 2ºC or below is greater than the possibility of achieving it.

However, these global temperature targets mask much regional variation that occurs as the Earth warms. For example, land warms up faster than oceans, high-latitude areas more quickly than the tropics and inland areas faster than coastal regions.

Furthermore, the warming felt by people is typically higher than the average global warming. Even in a world where global warming is limited to "well below" 2°C, there is still 14% of the world population experiencing temperatures + 2°C. In the worst-case scenario of continued growth in emissions, in 2100 about 44% of the population will experience 5°C warming – and 7% over 6°C (Source: Carbon brief, 2018).

Warming is not globally uniform. But who suffers the most from extreme weather events?

The most affected countries in 2016 were Haiti, Zimbabwe as well as Fiji. For the period from 1997 to 2016 Honduras, Haiti and Myanmar rank highest. Altogether, more than 524, 000 people died as a direct result of more than 11,000 extreme weather events; and losses between 1997 and 2016 amounted

The Climate Justice march. Photo: Shadia Fayne Wood

to around US$ 3.16 trillion. Storms and their immediate implications – precipitation, floods, and landslides – were one major cause of damage in 2016. According to the most recent scientific research, rising sea surface temperatures seem to play a crucial role in intensifying storms. Of the ten most affected countries (1997–2016), nine were developing countries in the low income or lower-middle income group, whereas only one was classified as an upper-middle income country (USA). Over 75% of the 31 million people displaced during 2016 left their homes as a result of weather-related events.

Fiji - hosting nation of the UNFCCC-COP23 and representative of Small Island Developing States (SIDS) - was severely affected by extreme weather in 2016. Cyclone Winston hit Fiji in February as a category five storm – making it the strongest cyclone on record for the archipelago. It resulted in significant destruction, especially on the island of Viti Levu, leaving over 44 dead and causing around US$1.4 billion in damages. Over 34,000 people became homeless, and infrastructure was severely damaged. Just six weeks after Winston wreaked havoc, Fiji was devastated by Hurricane Zena in April with top speeds of 105 Mph, forcing the evacuation of 3,500 people and the suspension of aid distribution.

Climate change is global for sure, but some nations are likely to experience more adverse effects than others, whereas other nations may even benefit from climate changes. People living in the least developed countries (LIC: Low-income countries) have ten times a more significant chance of being affected by a climate disaster than those in wealthy countries (HIC: High-income countries).

It will take over 100 years for LIC to reach the resiliency of more affluent countries, while the BRICS (Brazil, Russia, India, China, and South Africa) should be there in a 50-year time (source Notre Dame Environmental Initiative).
Different regions and different impacts need different solutions, and therefore winning strategy is mitigation through adaptation to climate change. Therefore fighting to climate change aims to motivate communities to build social, physical and natural systems that save lives and improve livelihoods, protect our environment, and strengthen market and policy positions.
Mitigation addresses the primary causes, by reducing greenhouse gas emissions, while adaptation seeks to lower the risks posed by the consequences of climatic changes. Both approaches are necessary. Even if emissions decrease in the next decade, adaptation will still be needed to deal with the global changes already in motion.

Humans have been adapting to their environments throughout history by developing practices, cultures, and livelihoods suited to local conditions. To name one: Vietnamese people build homes on stilts to protect against monsoonal rains.

Adaptation measures may be planned or put in place spontaneously in response to local pressure. They go from large-scale infrastructure changes – such as building fences to protect against sea-level rise or improving the quality of road surfaces to withstand hotter temperatures – to behavioral shifts such as individuals using less water, farmers planting different crops and more households and businesses buying flood insurance. Adaptation measures always imply costs that governments must support through incentive policy or subsidies. The IPCC describes vulnerability to climate change as being determined by three factors: exposure to hazards (such as reduced rainfall), sensitivity to those hazards (such as an economy dominated by rain-fed agriculture), and the capacity to adapt to those hazards (for example, whether farmers have the money or skills to grow more drought-resistant crops).

Adaptation measures can help reduce vulnerability – for example by lowering sensitivity or building adaptive capacity – as well as allowing populations to benefit from opportunities of climatic changes, such as growing new crops in areas that were previously unsuitable.

Within the Notre Dame Environmental Change Initiative, there is a program (ND-GAIN, http://gain.nd.edu) to enhance the world's understanding of adaptation-resilience to climate change through knowledge, products, and services that inform public and private actions, and investments in vulnerable communities all over the world.

The UNDP (United Nations Development Program) works in nearly 170 countries and territories, helping to achieve the eradication of poverty and the reduction of inequalities and exclusion. It aims to help countries to develop policies, leadership skills, partnering abilities, institutional capabilities and build resilience to sustain development results. UNDP's climate change adaptation works across six signature programmes to support vulnerable communities in building resilience to climate change: supporting integrated climate change strategies; advancing cross-sectoral climate resilient livelihoods; ecosystem-based adaptation; fostering resilience for food security; climate resilient integrated water resource and coastal management; promoting climate resilient infrastructure and energy.

The future generations and the poorest ones are the most vulnerable to the climate change impact and the most likely to suffer the most, without bearing any responsibility. The wealthiest people pollute, and the weakest ones suffer and pay the price. Tide should turn. The sooner, the better. ONE

How land under solar panels can contribute to food security

Adding plants to solar farms offers all kinds of benefits to the facilities' primary aim of reducing carbon emissions and expanding renewable energy.

By FRANK JOSSI
Ensia

At a recent solar energy conference in Minneapolis, attendees unwound at happy hour tasting free pints of a local honey-based India Pale Ale called "Solarama Crush." Minnesota-based 56 Brewing makes the smooth IPA using honey from hives located on solar farms outside the Twin Cities.

Honey producers Travis and Chiara Bolton keep bees at three solar farms where developers seeded native plants underneath and around panels.

"The advantage to these sites is that they are intentionally planted for pollinators," says Travis Bolton. "At these sites they're really trying to get them back to a native prairie, and that's a benefit to us."

Native plants have replaced turfgrass and gravel as the go-to bedding for solar gardens in Minnesota, a result of a 2016 state standard that outlines how developers can create pollinator-friendly environments. More than half of the 4,000 acres (1,600 hectares) of solar farms built in 2016 and 2017 feature native plants that not only benefit pollinators but also beautify the site.

Although Minnesota may be in the vanguard of encouraging solar farm developers to grow native plants, it is far from the only place studying how solar farms can harvest more than just energy. Universities in the United States, Germany and elsewhere are testing the concept of "dual use farming," as some advocates call it, where crops grow below canopies of solar panels. They are finding they grow just fine – and, in some cases, better than crops in full sun.

All Kinds of Benefits

Adding plants to solar farms offers all kinds of benefits to the facilities' primary aim of reducing carbon emissions and expanding renewable energy. "Solar development is happening on a massive scale as lands are being converted from agricultural land or unused land into solar projects," says Jordan Macknick, energy-water-land lead analyst with the National Renewable Energy Laboratory (NREL), which funds research on the impact of native and crop plants grown in solar farms. "That represents an amazing opportunity to improve our agriculture and improve our food security while developing energy at the same time."

And native and crop vegetation can help improve the health of pollinators, which are threatened by habitat loss, pesticide poisoning, poor nutrition, disease, decreased genetic diversity and a host of other factors. As a result, managed honeybee colonies used for honey production declined from 5.7 million in the 1940s to around 2.7 million today. Pollinators have an enormous impact on the economy, too, by annually contributing US$24 billion to the nation's economy.

Adding plants to solar farms offers all kinds of benefits to the facilities' primary aim of reducing carbon emissions and expanding renewable energy.

With more land being devoted to solar energy production, the idea of making those acres pollinator friendly seems to make ecological and economic sense. "Incorporating habitat into these solar farms across the nation is a good way to promote and protect pollinator health," says Val Dolcini, president and CEO of the San Francisco–based Pollinator Partnership, a non-profit organization promoting pollinator environments.

Under-panel native plants benefit not just their immediate solar farm surroundings but nearby cropland. Lee Walston, an ecologist at Argonne National Laboratory, says pollinating insects roam beyond solar installations to other agricultural fields, where they help increase production. Native plantings offer refuge for declining species such as monarch butterflies and rusty patched bumblebees while serving the additional purpose of controlling stormwater and erosion, he adds.

Native gardens and vegetables also offer an aesthetic benefit having nothing to do with panels or agricultural production, advocates say. They offer a more colorful and pleasing visual tapestry rather than the monolithic green of turf grass or the gray of gravel, a feature not to be underestimated at a time when some communities seek to stop solar garden expansion due in part to the uniform monotony of endless rows of panels.

NREL-funded research found growing native plants could reduce land acquisition costs, reduce weed control costs, slow panel degradation and slice permitting charges.

Pilot Projects

Pilot projects in Massachusetts, Arizona, Germany, China, Croatia, Italy, Japan and France look encouraging for mixing crops with solar panels, referred to as "dual use" farms because they offer both agricultural and electrical production. "So far, the pilots have been extremely successful in showing that you can grow crops and make electricity at the same time," Macknick says.

A dual-use farm operated by the University of Massachusetts–Amherst grows a variety of plants – peppers, beans, cilantro, tomatoes, swiss chard, kale – below solar panels elevated roughly 7.5 to 9 feet (3 meters) or more above ground to allow for easier harvesting mainly by hand. Project researchers have found that 1- to 1.2-meter (3- to 4-foot) gaps between panel clusters led to crop yields almost the same as what they would have been in full sun sites.

One of the first concepts for mixing solar and agriculture, dubbed "agrophotovoltaics" (APV), was developed more than three decades ago by physicist Adolf Goetzberger. The research institute Goetzberger created – the Fraunhofer Institute for Solar Energy Systems – finally got around to building its own dual-use farm on one-third of a hectare (just over three-quarters of an acre) at an existing farm cooperative a few years ago. The institute elevated 720 solar panels high enough for farm machinery to harvest plants underneath and nearby, according to a 2017 press release.

The researchers planted wheat, potatoes, celeriac and clover grass in the open and under the panels and compared the yields. Solar shading decreased production 5.3 percent to 19 percent. Yet electricity from the panels, which capture both indirect and direct light, was used to power a crop processing plant and electric farm machinery, offsetting those costs and increasing land use efficiency by 60 percent.

While the farm made a profit, the research team seemed a bit wary of claiming the approach could work everywhere at any scale. Project manager Stephan Schindele said in the press release that "in order to provide the necessary proof-of-concept before market entry, we need to compare further techno-economical applications of APV, demonstrate the transferability to other regional areas and also realize larger systems."

Similarly, agriculture faculty members at the Josip Juraj Strossmayer University of Osijek in Croatia grow shade-happy organic vegetables beneath solar canopies on a local farm operated partly by faculty members. The energy generated goes to power the farm's irrigation system and farm machinery. In Austria, an entrepreneur created a system similar to APV but using fewer stationary poles by placing panels on a cable infrastructure in an effort to reduce costs and potential accidents involving farm machinery. APV systems are being tested in another part of Germany and in several other countries.

Greg Barron-Gafford, associate professor in the School of Geography and Development at the University of Arizona, has worked on a solar "agrivoltaic" pilot project – basically, the American version of APV – for two years. Tucson public schools with existing solar canopies are being used, as well as the university's Biosphere 2 research and public education center. Focused initially on reducing the heat island effect of solar panels, the project morphed into one testing crop yields under

panels. A first run at a salsa garden of cilantro, pepper and tomato "was awesome," Barron-Gafford says. Crops grown underneath the panels required only half the water of those growing out in the open and grew well in the microclimate beneath the panels. "The plants seem to love the modulated temperatures," he says. Panels protect the plants from frost, allowing a longer season for avocados, cilantro, peppers, tomatoes and mangos. In late spring researchers began harvesting a winter crop of carrots, kale, chard and lemongrass. "It's really been something to watch," he says.

The experiment found other advantages to the panels as well. The skin temperature of people harvesting crops underneath the panels was 25 degrees cooler than those working out in in the sun, no small matter in a state with scorching summers. And some claim the shade-grown produce tastes better than conventionally grown crops. Barron-Gafford would like to try the dual-use concept out in collaboration with a community-supported agriculture (CSA) farm that would involve at least 10 acres of cropland under solar panels, he says. The extra cost of adding a solar canopy over crops could be paid for by the 5 percent gain in power production seen in panels in Arizona, reduced maintenance and premium pricing for solar-grown produce.

Despite the promising results of pilot dual-farm projects the idea of a future where American farms will be covered by solar canopies is not likely anytime soon. Rob Davis is director for the Center for Pollinators in Energy at the nonprofit Fresh Energy in St. Paul. The huge scaffolds holding solar panels cost a great deal of money, he says, and one bad turn by a farm tractor driver hitting a post could bring down hundreds of

Solar panels installed at the Washtenaw Food Hub on Whitmore Lake Road in Ann Arbor Township, just north of the city of Ann Arbor. Photo: MLive.com

thousands of dollars of solar panels. In places where agricultural land is tight and electricity prices high, such as Europe, the economics might play out in favor of dual-use farms. In the United States, however, farmland remains relatively plentiful and acres of canopies are unlikely to be feasible unless energy and agricultural markets change, he says.

"There are a lot of different ways to design solar arrays that provide significant benefits to agriculture," Davis says. "One of those ways that is certainly the most cost effective – and continues the accelerated rate of large scale solar needed to address climate change – is creating pollinator habitat in and around solar projects."

Native plants have their own challenges, such as the perception of higher up-front planting costs partly mitigated by less required maintenance. Not all a solar farms' neighbors are in love with natives, either, due to their sometimes less-than-tidy appearance. Yet Davis argues American farmers are on board with more native habitats because without pollinators their livelihoods could be at risk.

"They understand the need to keep pollinators alive and in abundance" to seed the fruits and vegetables they grow, to maximize yields and to avoid more regulation, he adds. "This opportunity unlocks private sector dollars and deploys solar energy capital in investing in high quality pollinator habitat that is urgently needed in agriculture."

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Planet or plastic?

By JOHANNA NORTH
Medium

Out of sight, out of mind, they say. I'm originally from Finland, a country that prides itself on having the purest air in the world, being the cleanest country in the world. I never really paid any attention to trash or pollution, excluding the occasional cigarette stump or a plastic wrapper here and there in the ground. Breathing in the fresh air always made me happy.

It would only be a few times in a year, after public holiday parties outdoors or Saturday nights in the capital city centre, when I'd see litter on the streets and smell urine and pollution. The sight always made me sad. But the trash would disappear as quickly as it had appeared. And so did the sadness I felt. Out of sight, out of mind.

However, I live in India now. The sight of trash and pollution is simply unavoidable. I ask myself frequently: What happens to all the trash?

The global hypocrisy angers me immensely. The stereotypes and prejudices are frustrating. While India as a country will be deemed trashy and polluted and the people unclean and ignorant, an average Finn or a person of another developed country will have a bigger carbon footprint and use more plastic than a typical Indian. But we Westerners get the trash out of sight very efficiently. Thus we praise ourselves for our ability to keep a clean, unpolluted environment.

But for many industrialised countries safe and proper waste disposal remains a challenge to this day. They will dump the trash to developing nations, who are unequipped to handle it, rather than deal with the cost and difficulties of proper waste management themselves.

One of these developing nations is India, where a lot of European waste including textile, metals and e-waste end up. Alang shipyards in India receive half of all the ships salvaged around the globe for recycling. About two-thirds of global textile waste is sent to India. However, the Indian facilities are unable to process all that waste efficiently. So eventually, they end up in incinerators and landfills instead.

For the first time, India was the host of World Environment Day 2018 last week. Journalists and social media activists were advocating for the environment fiercely. Clean-up events were organised all over the country. There's no denying pollution is a big issue in India. What can you expect with a population of 1,4 billion people? However, pollution is not an issue only to a country as populated as India. Even in a country seemingly as clean as the sparsely populated Finland—where people do trash but there is a smaller number of them—the threat is real.

While India will be deemed trashy and polluted an average Finn or a person of another developed country will have a bigger carbon footprint and use more plastic than a typical Indian. But we Westerners get the trash out of sight very efficiently. Thus we praise ourselves for our ability.

The amount of plastic produced in a year is approximately the same as the weight of all humanity. Packaging materials serve as the largest market for plastics today. Nearly a million plastic beverage bottles are sold every minute and a trillion plastic bags used every year worldwide. In America alone a million straws get tossed daily. This sector now accounts for more than half of plastic waste generated globally. Most of it never gets recycled or incinerated. Over 40 percent of plastic is used just once, then chucked.

Virtually every piece of plastic that was ever made still exists in one form or another. Excluding the small amount that has

been burned, consequently harming the environment nevertheless. As of 2015, more than 6,9 billion tons of plastic waste had been generated. About 9 percent of that was recycled, 12 percent incinerated, and 79 percent accumulated in landfills or environment. Globally, 73 percent of beach litter is plastic. Rough calculations for how long plastics endure vary from 450 years to forever.

In the Mediterranean, the enormous amount of plastic trash combined with improper waste management results in over 95 percent of the waste that ends up in the oceans being plastic. Bags, bottle caps, synthetic fibres from clothing, tiny rice-sized bits. Plastic breaks down, but it can't biodegrade. It breaks down into small microplastics and even nanoplastics, which then spread all over the marine ecosystem and eventually end up back to the dry land through food cycle. The microplastics, at a record high in the Mediterranean, are a particular concern to the scientists. The concentration is a whopping four times higher than that of the infamous Great Pacific Garbage Patch! Only one percent of the world's water is in the Mediterranean, but it contains as much as 7 percent of all the microplastics.

Recently, scientists at the University of Eastern Finland released a survey where they studied the microplastic concentration in Finnish lakes. It hasn't been until the past few years that the researchers have realised the issue in freshwater bodies too. Relatively, there might even be more plastic in the lakes than in the oceans.

Collected trash on Perhentian Kecil beach, Perhentian Islands, Malaysia. Photo: Coloco

Plankton, the tiny organisms that live near the ocean surface and drift along freshwater bodies, play a vital role in the stability of the marine ecosystem. Plankton are the key to the climate and food cycle. They are the basis of all existence of life on earth.

A few years ago, scientists discovered that some species of zooplankton (animal plankton) are eating plastic. Microplastics resemble their food and thus become appealing to the hungry crustaceans. The ingestion of plastics introduces toxic chemicals into the food chain already at a very preliminary level affecting the entire marine ecosystem.

Scientists also agree that there is oxygen from ocean plants in every breath we take. Most of this is from phytoplankton via photosynthesis. It's difficult to make a precise calculation of the total number, but a popular estimation is that phytoplankton contribute between 50 and 85 percent of the oxygen in earth's atmosphere, which nonetheless is most of the air we breathe.

18 billion pounds of plastic end up in the ocean each year. There are over five trillion pieces of plastic in our oceans. Ocean plastic is estimated to kill millions of marine animals every year. Nearly 700 species, including endangered ones, are affected by it—some visibly, many more probably invisibly.

Plastic trash is found in 90% of seabirds. One million seabirds and around a 100,000 marine mammals are killed annually from plastic in our oceans. And the rates keep growing as the production of plastics increases. By 2050 every seabird species on the planet will be eating plastic. Marine species of all sizes, from zooplankton to whales, now eat microplastics—as do we people.

Imagine your home. There you have a big, secret closet. You don't have the time or energy to clean your house properly or to find out about the proper methods for waste disposal. Nor have you thought about these issues beforehand in your consumer decisions. But you do not want to live in the middle of a chaotic wasteland. So what do you do?

You keep just tossing everything in the secret closet, where it will accumulate day by day, but hidden from your eyes and thoughts. Out of sight, out of mind. You can pat yourself on the back. You are a tidy, well-organised human being. At least until the closet can't take in any more waste and you'll be in the middle of a much bigger disaster than you would have originally had to deal with.

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Grass Lawns are an Ecological Catastrophe

By LENORE HITCHLER

ONE

Are American lawns beautiful visions of nature? Or ecological calamities? Unfortunately, the grass leaves in our parks leave havoc in their wake. Lawns are extremely costly in many ways, including dollars spent on them, the deadly consequences of fertilizer and pesticide use, watering, and mowing. Carbon dioxide (CO_2) and other greenhouse gases emitted during these stages of lawn care contribute climate change. There are various estimates of how much land in the United States is covered by turfgrass. Turfgrass is defined as any of various grasses grown to form turf.

Turf is defined as the grass and the surface layer of earth held together by its roots. A new study from NASA finds that there are 63,248 square miles of lawn in America. Another study published in Environmental Management found that turfgrass covers 1.9% of the US, including 700,000 athletic fields and 14,500 golf courses. Many sources state that turfgrass is our largest agricultural crop. An article in Science Line titled "Lawn Vs. Crops in the Continental U.S." states that "there may be more acres of lawn than of the [combined] eight largest irrigated crops."

According to *Lawn People: How Grasses, Weeds, and Chemicals Make Us Who We Are*, based on calculations from air photography and tax assessments, 23% of urban areas are covered in turf. According to a 2005 NASA study, lawns cover 10% of Delaware and 20% of Connecticut, Rhode Island, Massachusetts, and New Jersey.

Golf course in Madison, Wisconsin. Photo: Goodfreephotos

Standard grass lawns are very expensive. They require more equipment, labor, fuel and use more agricultural toxins than industrial farming, therefore making them the largest agricultural sector in the US. According to the Economic Research Service, Americans invest roughly $60 billion a year in the turfgrass industry, including lawn care products and engaging lawn care companies. Besides being overly expensive, lawns are incredibly time-consuming. Americans spend more than three million hours per year pushing or riding lawnmowers. It has been estimated that the average American mows their lawn 22 times per year.

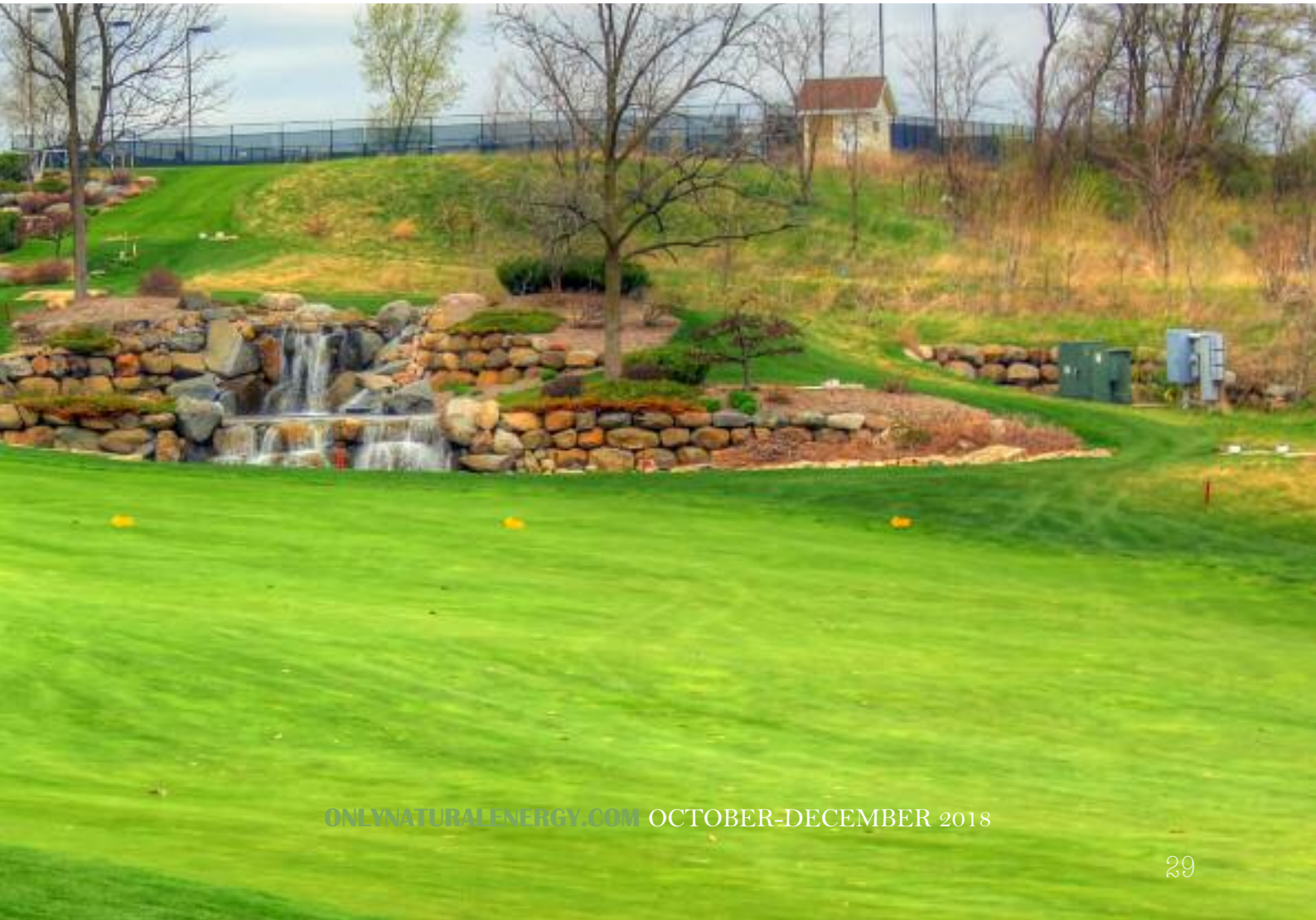
According to the online site "People Powered Machines," about 54 million Americans mow their lawns every weekend. Using lawn equipment also significantly adds to noise pollution. The World Health Organization recommends that general daytime outdoor noise levels should not go above 55 decibels. According to Lawn and Landscape Maintenance, the average leaf blower produces 70-75 decibels at 50 feet. And the time spent mowing lawns is disliked by millions of Americans. A study conducted by the Consumer Reports National Research Center in 2008 found that 58% of those polled do not enjoy mowing their lawns.

Moreover, lawn fertilizers are used much too extravagantly. It is estimated that Americans use ten times more fertilizer on lawns per acre than they do on food crops. According to the Environmental Protection Agency (EPA), in 2004 Americans used 70 million pounds of fertilizers on their lawns. According to an article in the June 24, 2011 issue of The Week, Americans use 90 million pounds of fertilizer on their lawns every year.

The manufacturing of synthetic fertilizers leaves a large carbon footprint leading to climate change. Carbon dioxide (CO_2), nitrous oxide and methane are produced during the fabrication of fertilizers. In an article titled "Energy Consumption and Greenhouse Gas Emissions in Fertilizer Production" published by the International Fertilizer Association it is estimated that fertilizer production consumes approximately 1.2% of the world's energy and is responsible for 1.2% of total greenhouse gas emissions. For every ton of fertilizers manufactured, two tons of carbon dioxide are produced.

Most conventional fertilizers are produced using ammonia, which is extracted from natural gas, and two-thirds of natural gas is obtained by fracking. Therefore, lawns also contribute to all of the environmental damages, including water pollution, caused by fracking.

Besides the manufacturing of fertilizer leading to climate change, the actual use of fertilizer also contributes to climate change. Research from Michigan State University, in a study published in the Proceedings of the National Academy of Sciences, finds that any nitrogen not used by plants is converted by soil microbes into nitrous oxide, a greenhouse gas estimated to be approximately 300 times more potent than CO_2. The University of Florida's Institute of Food and Agri-



Synthetic nitrogen fertilizers were causing the loss of soil carbon and organic nitrogen leading to erosion and runoff.
This runoff contributes to water pollution and less sequestration of CO2 in the soil leading to more climate change. Photo: Reuters/Carlos Garcia Rawlins

cultural Sciences estimated that a 9.88-acre plot in Miami-Dade, in which 85% of the area is covered by lawns, emits over 11 tons of CO2 per year.

Additional evidence of fertilizer use causing climate change is found in research from Dr. Chuanhui Gu, a professor in the geology department at the Appalachian State University. Dr. Gu and his co-authors, in a paper published online January 9, 2015, by the Journal of Environmental Management, found that a 2.47-acre plot of lawn in Nashville, Tennessee, produces greenhouse gases equivalent to up to 2,443 kg of CO2 per year.

This is equivalent to the amount produced by a flight more than halfway around the world. Dr. Gu also states that standard lawns emit about 5 or 6 times more CO2 than what is absorbed during photosynthesis. Nitrous oxide emissions from fertilizers lead to an estimated total equivalent of about 25 million tons of CO2 each year in the US. Gu adds that if clippings were left to decompose on lawns, the US could store up to 16.7 teragrams [16,700,000 tons] of carbon each year in the soil.

Moreover, synthetic nitrogen fertilizers also damage the soil as shown in an article titled "Synthetic Nitrogen Fertilizers Deplete Soil Nitrogen: A Global Dilemma for Sustainable Cereal Production" in the Journal of Environmental Quality. These researchers found that synthetic nitrogen fertilizers were causing the loss of soil carbon and organic nitrogen leading to erosion and runoff. This runoff contributes to water pollution and less sequestration of CO2 in the soil leading to more climate change.

Some runoff from synthetic fertilizers reach wells and contaminate water. Wells with high concentrations of nitrates may cause congenital disabilities, blue baby syndrome, nervous system impairments and cancer. Other runoff contaminated by fertilizers eventually reaches streams, lakes, and estuaries and then finally our oceans. Nitrogen and phosphorus from fertilizers result in excessive growth of water plants, and they initially flourish.

However, these plants die and sink to the bottom where they decompose resulting in less oxygen in the water. Since fish and other aquatic animals require oxygen, the lowered oxygen levels from eutrophication cause dead zones, defined as an area of water in which the concentration of oxygen is so depleted that most life cannot be sustained. In 2008 it was estimated that there were more than 400 dead zones in the world's oceans. The dead zone in 2016 from nitrogen runoff in the Gulf of Mexico was the size of Connecticut.

Along with fertilizers, pesticides contribute to climate change because they are manufactured using petroleum products, and energy is also used during the manufacturing process and for transportation. Around 78 million US households use pesticides on their yards each year, according to Beyond Pesticides. According to an article in the June 11, 2011 issue of The Week, an estimated 78 million pounds of pesticides are used yearly on our lawns. Weed killers are the most used chemical with 90 million pounds of herbicides being used on lawns every year according to the Pesticide Action Network.

One danger of lawn chemicals is that they are tracked into our homes, thus placing our pets and small children in danger. Small children are at particular risk since their developing bodies are far more vulnerable to toxins. The National Cancer Institute states that children in households that have lawns treated with pesticides have a 6.5 times greater risk of developing leukemia.

Watering our lawns is another way that lawn practices increase climate change. A large amount of energy is used in purifying, transporting, and irrigating with water which is provided by local governments. Thus, our lawns are subsidized by the government. Much of that water is wasted as studies have found that twice as much water as lawns need is used on lawns.

A 2005 NASA study found that in terms of surface area residential and commercial lawns are the single largest irrigated crop in America. Christina Milesi, one of the study's researchers, told NASA's Earth Observatory that she estimated that there are three times more acres of irrigated lawn in the US than irrigated corn. She put the practice of watering our lawns in perspective by stating that farmlands consume 88.5 million acre-feet of water per year in contrast to lawns which use two-thirds as much and that most municipalities use 30 to 60% of their water on lawns. The EPA's figures agree with these percentages of water used on lawns.

The total estimation of greenhouse gas emission from lawn care, which includes fertilizer and pesticide production, watering, mowing, leaf blowing and other lawn management practices, was found by a University of California-Irvine study to be four times greater than the amount of carbon stored by grass. In other words, our lawns produce more CO2 than they absorb.

Even the lawn mowers that we use are responsible for greenhouse gases. It is complicated to ascertain how many lawn mowers exist in the US. One article found on the online site NBCNews.com provided an estimate by the owner of the American Lawn Mower Co. that 350,000 manual mowers are sold in the US each year. The article also stated that 6 million gas-powered walk-behind mowers were on the market in 2006. According to the online site HBS DEALER, the 2009 lawn mower sales were about 3.2 billion dollars. CO2 is also produced in the manufacturing, transportation, and disposal of these lawn mowers.

The process of mowing lawns produces a large amount of CO2. Scientists use different criteria from each other and therefore their statistics vary from each other. Thus, there is quite a significant difference in the estimates of how much gas lawnmowers use. According to the EPA, the figure is 580 million gallons of gas per year whereas the Department of Energy's value is 1.2 billion gallons per year. Estimates vary from 16 billion to 41 billion pounds of CO2 being emitted from lawn mowers every year.

Another estimate is that every gallon of gasoline burned by lawnmowers emits 20 pounds of CO2. According to the EPA, one gas lawn mower emits 89 pounds of CO2 and 34 pounds of other pollutants per year. According to a Swedish study, using a mower for one hour has the same carbon footprint as a 100-mile car trip. The EPA found that gasoline-powered lawn mowers emit eight times more nitrogen oxides, 3,300 times more hydrocarbons, 5,000 times more carbon monoxide and more than twice the CO2 per hour of operation than electric lawn mowers.

Lawn mowers are not the only cause of greenhouse gases produced in lawn care. According to statistics based on US Census data and the Simmons National CO2 Consumer Survey, 115.5 million Americans own leaf blowers. It has been estimated that thirty minutes of their use produces the same amount of hydrocarbon emissions as driving a car seventy-seven hundred miles at a speed of thirty miles per hour.

Besides producing greenhouse gases, mowing our lawns produces other types of pollution. The EPA estimates that hour-for-hour, gasoline powered lawn mowers produce 11 times as much pollution as a new car. According to the EPA, each gas-powered lawn mower produces as much air pollution as 43 new automobiles driven 12,000 per year - lawn care produces 13 billion pounds of toxic pollutants per year.

Even refilling lawnmowers damages the environment. It is estimated that 17 million gallons of gas are spilled annually while refilling lawn mowers. In contrast, the Exxon Valdez spill was just under 11 million gallons. A lot of energy was used to extract these wasted fossil fuels and to transport them, resulting in greenhouse gases and climate change in addition to even more pollution of our soils and water supply.

A large number of lawn clippings are sent to landfills. Yard waste is estimated to make up 20 to 50% of US landfills. In 2011, Americans sent 14.4 million tons of yard trimmings to landfills.

Besides wasting valuable nutrients, transportation of grass clippings produces CO2 and other forms of air pollution. Frequently, grass decomposes in landfills anaerobically and produce methane, another greenhouse gas. According to the EPA, methane is 21 times more potent than CO2. Additionally, empty containers of lawn chemicals are transported to landfills, thus contributing even more CO2 to the environment.

Thus, even though many people like to look at an undivided expanse of green grass, there is a terrible cost that we pay for this view. Too much money, chemicals, and time are spent maintaining it. Ironically, there is a vast array of options to replace standard American lawns. These options do not involve fertilizers, pesticides, watering, and mowing. Additionally, replacements for lawns can be a thing of beauty.

Next issue will contain alternatives that will be more environmentally suitable in addition to being even more attractive than our current gardens. ONE

Photo credit: Ji-Elle

DALLOL

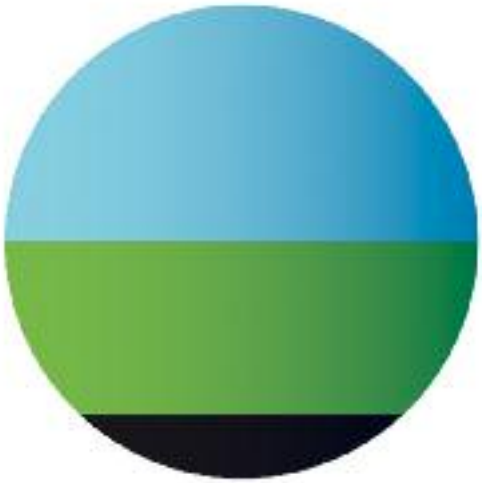
Dallol is a village located in the Danakil Desert, northern Ethiopia. Known as the hottest place year-round on Earth, Dallol holds the official record for record high average temperature for an inhabited location (35°C).

Extreme weather conditions coupled with complete isolation make of Dallol one of the most remote places on the planet. The area is rich of a key component of fertilizer: Potash.

Potash is not rare, but Dallol conditions are unique for mining as salt deposits allow drilling with low-tech requirements. The discovery was made by the Italian brothers Adriano and Tullio Pastori, who managed in 1912 to get a 35-year mining lease from the Ethiopian Negus. Five years later the permission was sold to the Compagnia mineraria coloniale (Cmc), which dared to operate in such a prohibitive site. Production stopped after World War I due to larger-scale supplies from Germany. Between 1920 and 1941 several attempts to reopen production failed. The mining infrastructure was deliberately damaged after World War II, preventing the chance to restore its activity.

Today the Dallol mining site looks an abandoned place, where only the ruins of salt-block walls remain, surrounded by few rusted trucks and boilers. In spite of all the hurdles, Delles is still capable of attracting interest: the Ethiopian government is looking for a new partner to develop the potash mine abandoned in 2016 by Israel Chemicals, which accused the government of failing to support the project and sought a $198 million compensation at the Court of Arbitration in The Hague. To develop potash market, Ethiopia remains one of the primary goals of the Ethiopian government to stay Africa's fastest-growing economy over the past decade. ONE

SOTACARBO



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