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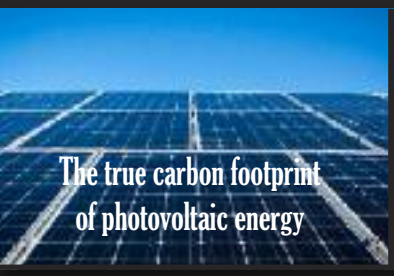
## India's Third Way



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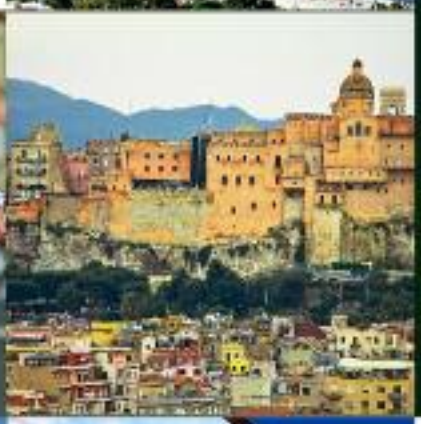


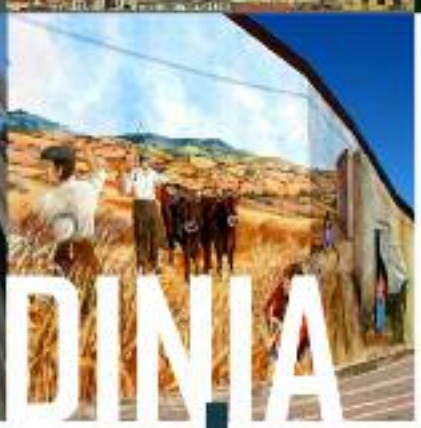


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Only Natural Energy

**Year IV - Number 3**
**JULY-SEPTEMBER 2018**

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Ensia
Undark Magazine
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**Cover Photo**:
India transition
(Photo credit: UNDP India)

**Publisher:**
Sotacarbo Ltd
CO2 Technology Centre Sulcis Grande
Miniera di Serbariu 09013 Carbonia
(Italy)

**Provider:**
Fastweb
**Reg. Nr:** 2/2014 Cagliari Ordinary Court
Only Natural Energy [ONE] is a digital magazine published every three months.
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# India's third way

**India has embarked on the ambitious challenge to sustain its rural areas development and meet the climate targets. Even transforming funereal rituals can help to reduce CO2 emissions.**

By JEZ ABBOTT
*ONE*

From death came life. Cremation, a traditional ceremony for the 8.5 million Hindus dying each year in India, is emotionally and environmentally fraught. An estimated 50 million trees are felled to build the pyres. The fires meanwhile emit about eight million tonnes of carbon dioxide into the air.

A non-governmental organisation in Delhi, however, is using a climate-friendly compromise to the centuries-old ritual of burning our dead. The solution from Mokshda is to use only 150kg to 200kg of wood for each cremation, instead of 400kg, and more efficient combustion processes.

This is a small step in fighting climate change which, says the World Health Organization, will kill an extra 250,000 people a year globally from malnutrition, malaria, diarrhoea and heat stress from 2030 onwards. And it is only a marginally more significant step for India and her 1.32 billion people. But if Mokshda's eco-cremations are transforming funereal rituals and how India views the deeply symbolic subject of the afterlife, the cremations themselves are deeply symbolic of how India is coming to view life, death and the environment in the 21st century. This change, cultural, economic and political, was formalised when India signed the historic Paris climate agreement. Along with 173 other nations, India has pledged to cut greenhouse gas emissions to combat global warming.

Environment minister Prakash Javadekar signed the agreement at a well-attended UN ceremony hosted by its secretary-general Ban Ki-moon. "This is a moment in history," Ban Ki-moon told heads of government, ministers, corporate lea-

River Ganges. A traditional cremation ceremony. The [illegible]ve eco-creamations in Mokshda are deeply symbolic of how India is coming to view life, death and the [illegible]onment in the 21st century

ders, and artists in the opulent UN assembly hall. "Today you are signing a new covenant with the future. We are in a race against time."

But if Ban Ki-moon was carried away by the historic moment, Indian prime minister Narendra Modi takes a more pragmatic, cautious view. The burden of fighting climate change, he insists, cannot be lumped on the shoulders of developing or poorer nations such as India after decades of industrial development by their wealthy counterparts. And as a newly-elected PM four years ago Modi sidestepped a question on climate change during a Q&A session with school children, insisting it was not climate that had changed but rather our ability to deal with climate. If Modi wasn't – and isn't – in the camp of the climate-change deniers led by US president Donald Trump, he was – and remains - hardly a champion of the environment.

For India, energy is the life, death and resurrection of economic growth and social development. The bedrock of energy supply is, and always has been, its substantial reserves of coal. For this reason, the black mineral remains by far the largest part of the country's energy mix – almost 60% of India's primary energy comes from coal. Demand is therefore expected to climb despite the ramping up of renewable energy capacity

implied by India signing up to the Paris agreement. Speaking to *The Hindu* newspaper, an influential former chairman of the world's largest coal-producing company Coal India, Partha Bhattacharya, said if the future of coal was dark, then the future of the country was dark. "For all this hype about renewables, 81% of power generation is out of coal. The growth in renewables does not mean generation from coal will end. It will not come down, at least in the next few decades. It will go on increasing. For existing plants, coal-based generation is the cheapest and most affordable source of power in the country."

And yet India has embarked on an ambitious journey to quadruple its renewable power capacity to 175 gigawatts by 2022 and supply electricity to every household. India seeks to add 100 gigawatts of photovoltaic capacity, 60 gigawatts of wind power, 10 gigawatts of biomass and five gigawatts of hydro projects. India insists it is completely committed to protecting the climate. But finance minister Arun Jaitley admitted recently at an industry conference "the hard reality is we have a lot of distance to cover." India, which currently produces 650 million tonnes of coal and imports 150 million tonnes, still needs more housing, power, toilets, roads and factories. Fuel requirements will therefore certainly increase, and that means more fossil fuels like coal, gas, oil. The country's coal minister Piyush Goyal agrees India's top development priority is to provide affordable electricity to all. But because the availability of coal is abundant in India, it can provide that affordable power to propel growth plans and provide the goal needed to light every household. At best, according to analysts, renewable energy sources will coexist with coal for years to come. This is especially the case given that supplying energy to all four corners of India is such a huge challenge. The country, with a monster GDP of $2.3 trillion, is home to almost 240 million people with no access whatsoever to electricity. This is bad for overall development goals including poverty alleviation, health, food security and education.

A report on the *India Climate Dialogue* website told the story of Moyna. The schoolgirl has to study by light from a kerosene lamp or candles to finish her homework. Her village, Buraburi in the district of Goalpara in Assam, has no electricity. Despite being part of a rural electrification scheme, no work has been done to provide electricity to the 20 or so households. According to reports the parents and children protested. Such a move contradicts claims by Modi that electricity has reached each village in India and is not isolated. Nearby village Tengasot has about 120 households and electricity wires, but they connect only a few households with erratic power supplies. Meanwhile only half of the Mising community – listed as a scheduled tribe in the Indian constitution – based in Majuli, also in Assam, have power. Mounting public unease at home such as this, and wider global concern abroad, have prompted the traditionally firebrand Modi and his government take a more conciliatory approach and position India as a responsible player in the global environmental movement. India's vora-

Monsoon in Chennai, India.
Photo credit: McKay Savage

cious need for energy, furthermore, comes in the shadow of several climate-change-related weather disasters. India has been wrung out by severe drought, meanwhile, an increasing number of lethal weather extremes such as thunderstorms, rain and strong winds have wiped out farms, businesses and homes in the states of Arunachal Pradesh, Assam, Manipur, Mizoram and Nagaland. Last summer more than 1,200 people died across India, Bangladesh and Nepal as monsoons blitzed 40 million people.

There is a third way. Even though coal is expected to continue to dominate India′s primary energy in the medium-term future, the country is exploring ways of using coal but reducing its greenhouse gas emissions. The government is pursuing measures to cut power-plant emissions by using cleaner, more efficient coal technologies and deploying complementary renewables, particularly solar. In recent years the Indian government has promoted plant efficiency in the country's coal fleet, closing older low- or medium-capacity stations and building or upgrading the fleet to supercritical or ultra-supercritical high-efficiency, low-emissions (HELE) technologies. Coal plants could also be re-engineered to make them more climate friendly. A recent report from *US Climate Policy Initiative* think-tank suggests plants could be reconfigured to become "flexible", so they could fill gaps in renewable energy production. After all, renewable energy's biggest drawback is its intermittency. Wind turbines for example can generate only when the wind is blowing, while most solar technology can only fully function when the sun is shining. The idea of using coal plants for grid-balancing is not new and technically it can be done. For example, two plants at Moorburg, Germany, each with 800 megawatt capacities and mentioned in the think-tank′s report, have been converted to run as flexible plants that can operate under 40% of their capacity and still stay in business.

However, integration of large amounts of renewable energy into the grid calls for the creation of a source of power that can be switched on and off in quick time to fill in gaps in clean power generation. The CPI report calculates the technology required for this would cost more than the investments required to retrofit existing coal plants to make them flexible.

**India's voracious need for energy comes in the shadow of several climate-change-related weather disasters. Last summer more than 1,200 people died across India, Bangladesh and Nepal as monsoons blitzed 40 million people.**

Though India is the biggest recent signatory to the Paris agreement, it is merely part of a bigger picture. And all its efforts could be offset by the unstoppable economic momentum that sees businesses outsource work to the cheapest bidder. More industries in India are moving operations to less-developed Asian countries. This can only undermine not just India′s efforts to reduce climate-changing emissions, but the world′s.

Energy-intensive sectors, including manufacturing and raw materials processing, are relocating to cheaper countries like Indonesia, Vietnam and Thailand, a recent study by Britain's University of East Anglia (UEA) showed. Shifts in production and trade will make it harder to meet the Paris agreement goal of cutting emissions enough to keep the rise in global average temperatures to "well below" two degrees Celsius above pre-industrial times. So says UEA professor of climate change economics and a co-author of the report Dabo Guan.

India, along with China, should help ensure power-efficient technologies and methods are adopted by industries that move off-shore to less-developed countries, he adds. For their part, shoppers in Europe and the USA must be educated to become more sustainable consumers, says Guan. Buying big on fashion or purchasing more than one car are consumer practices that must change. "We only have one planet, unless we move to Mars," he told the *Thomson Reuters Foundation*. "If all the seven billion people in the world consumed like Americans, we would need seven or eight planets."

According to *Down to Earth*, the magazine dedicated to the politics of the environment, development and health: "The Modi government's performance when it comes to addressing climate change and the wider issues of environmental governance has been far from convincing. For optimists and supporters of the government, it could be called a mixed bag. For others, the words and actions of the government border on wily deception. Business is still the priority and all that has really changed during Modi′s four years are the words spoken in public. Where the PM used to deny climate change, he now invokes the Vedas (ancient religious texts originating in India) to find solutions - never mind that the scriptures are thousands of years old and share nearly nothing with modern realities."

# The Allam Cycle fires up

## Pioneering clean fossil power plant begins testing in Texas.

By TOBY LOCKWOOD
*ONE*

Last April the town of Laporte, Texas, was the setting for what could prove to be a turning point in the losing battle against carbon emissions. In this otherwise nondescript Houston suburb, tech start-up Net Power successfully fired up a much-anticipated test facility for a new type of gas-fired power plant which promises to capture its CO2 emissions at no extra cost.

Despite forecasts from international bodies such as the International Energy Agency and IPCC repeatedly highlighting the need for widespread use of carbon capture and storage (CCS) technology, which can purify and store CO2 emissions deep underground, existing technologies come at a cost which few governments are prepared to subsidise. Only two power plants worldwide (both coal-fired) have fitted CCS to date, and there are currently no concrete plans for more. If NET Power's facility manages to deliver on its remarkable claims, this could quickly change.

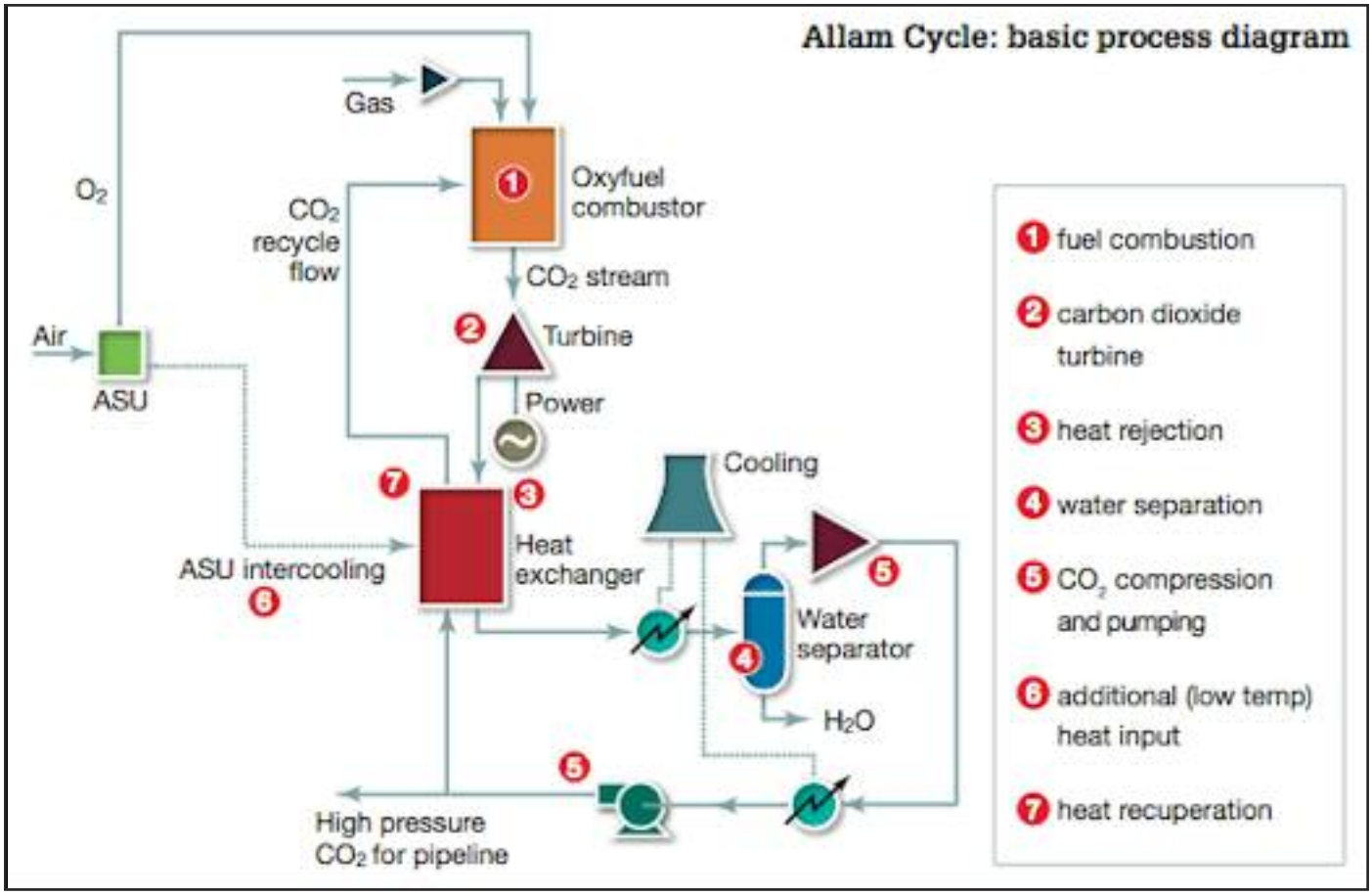
The plant is based on an entirely new power generation concept known as the Allam Cycle, after its inventor, British chemical engineer Rodney Allam. Ordinary gas power plants work in the same way as aeroplane jet engines – natural gas is burnt in compressed air, and the hot exhaust is used to drive a turbine. The most efficient plants then use any heat left in the air to turn water into steam which powers an additional steam turbine. In the place of air or water to drive its turbine, the Allam Cycle uses CO2 at temperatures and pressures at which it behaves neither as a gas nor a liquid. This form of CO2, known as 'supercritical', has long been recognised as ideally suited to the task of turning heat energy into electricity. It remains much denser than steam or air while releasing its energy, so can be used in many times smaller turbines, while its thermal properties allow it to run at high efficiencies.

In the Allam Cycle, natural gas is burnt in a high-pressure mixture of pure oxygen and CO2 – in itself a challenge as CO2 is usually used to put out fires. The combustion produces heat, steam, and more CO2 which drive the compact turbine before the gases are cooled to condense out the steam as water and leave a pure stream of CO2. The majority of this CO2 is pressurised and returned to the combustion chamber to flow through the turbine again, but some must be removed to balance the extra CO2 from the burning gas. Ideally, this would then be injected deep underground into the porous rock where it can remain for millions of years like the natural gas from which it came. A subtle, but unique feature of the Allam Cycle is that the hot exhaust gases are used to heat up the cooled gases returning to the turbine, and some extra heat is needed to make this work. Conveniently, this heat can be taken from the air separation machines required to produce the pure oxygen, neatly tying the design together.

Professor Allam came up with his eponymous power cycle following a meeting with Bill Brown – a disillusioned Wall Street banker in search of a technology which could change the world. Along with fellow MIT graduate Miles Palmer, Bill Brown is the co-founder of 8 Rivers Capital, a North Carolina-based company which co-owns the NET Power venture together with energy company Exelon and construction firm CB&I.

The entrepreneurs quickly formed a vital relationship with Japanese technology firm Toshiba, who have designed and built the new combustor and turbine needed for the technology. In early 2016, construction began at the LaPorte facility, which is big enough to produce 25 MW of electricity – about ten times smaller than a full-size power plant.

However, the turbine is already full-sized and only being run at




a fraction of its capacity, while Toshiba is working on a larger combustor, so scaling up the facility could be relatively quick and easy. 8 Rivers are already designing a 300 MW version of the plant, which – if all goes to plan at the test site – they ambitiously hope to start building in 2021.

Although the US recently passed a rule which will provide a significant tax credit to companies capturing CO2, the business case for CCS for the sake of the climate alone is still limited. Fortunately, the US also has a thriving market for using CO2 to push more oil out of depleted oil wells. NET Power calculates that, while its first few plants will cost slightly more than a conventional gas plant (without CO2 capture), a combination of sales of CO2 to oil companies and sales of pure nitrogen and argon gases from its air separation plants will still make them competitive without needing any climate-based incentives. Once several plants have been built, the design and supply chain will have been optimised enough to reduce its costs to below that of a conventional gas power plant, but with the crucial bonus of pure CO2. 8 Rivers is highly cautious of relying on climate policy to make its business work and has envisioned other potential markets for CO2, such as using it to remove the unwanted sulphur compounds found in many natural gas reservoirs. While the company is partly banking on forecasts that demand for new, clean fossil power plants will grow worldwide – driven by the coming electrification of transport and heat – it has recently put forward a solution for cleaning up existing power plants as well.

This idea would use a form of the Allam Cycle to turn natural gas to hydrogen, which can then be used as a clean fuel in many existing gas turbines. Natural gas may be a rising star in power generation, but coal, its dirtier fossil cousin, remains the largest source of power worldwide. 8 Rivers have not ignored this business opportunity either, having worked for several years to develop a form of the process which can run on 'gasified' coal, again at a lower cost than a conventional coal plant. Carbon capture and storage faces other challenges, not least the likely need for government involvement in helping explore possible CO2 storage sites, develop infrastructure, and underwrite some of the risks involved. If these political barriers could be overcome, existing CO2 capture technologies would perhaps already be making an impact.

However, quite apart from its attractive economics, the Allam Cycle may possess an essential psychological asset in that no extra fossil fuel is consumed in separating out its CO2 emissions. The current model of extracting and burning more fossil fuel to clean up fossil fuels finds few instant fans among the public or policymakers. If the next few months of testing prove that Allam Cycle really lives up to its hype, the stage is set for winning hearts and minds over to a CCS revolution. ONE

# The true carbon footprint of photovoltaic energy

## If panels are assessed for their entire lifecycle, they are not so clean and not so environmentally friendly.

By ALICE MASILI
*ONE*

The sun is an inexhaustible energy resource to generate electricity apparently without toxic pollutants or effects on global warming. Certainly, solar energy systems (photovoltaics, solar thermal, solar power) offer significant benefits in comparison to the conventional energy sources, but that does not mean they are advantageous in all aspects. Is the photovoltaic energy a clean form of electricity generation with no effect on the environment at all?

As pointed out by the American National Renewable Energy Laboratory (NREL), in addition to direct emissions, we must consider renewable technologies from the point of view of the entire lifecycle. In this sense, solar power has significant and multidimensional environmental impacts in the construction, installation and the decommissioning phases.

The production of photovoltaic panels still has an important carbon footprint and creates a series of waste, liquid and gaseous by-products that are harmful to the environment. Firstly, the extraction of quartz, the crystalline form of silicon, and of the other materials necessary for the construction of the panels. Moreover, for the production of metallurgical silicon, huge furnaces, and

The production of photovoltaic panels still has an important carbon footprint and creates a series of waste, liquid and gaseous by-products that are harmful to the environment.

very high temperatures, with the production of large quantities of carbon dioxide and sulphide, are needed.

Furthermore, the chemical process necessary for obtaining the polycrystalline silicon occurs through a reaction with hydrochloric acid and hydrogen, which leads to the formation of a very high by-product, silicon tetrachloride. It is a by-product but, proportionately, for each part of high-purity silicon produced by the reaction, silicon tetrachloride is from three to four times as much. The most advanced technological processes have reduced the production of toxic substances, for example subsequently reprocessing them for the extraction of other high purity silicon at lower costs, decreasing energy required for the extraction of new raw material.

Although western countries are developing technologies that can reduce the environmental impact of this type of production, most of the panels, assembled today in the West, are produced with more antiquate technologies in areas of the planet known to be less attentive in respecting the environment.

In fact, half of the world production of photovoltaic panels takes place in China. In general, it has been estimated that around six months are needed for a solar panel to produce the energy required to clear the carbon dioxide emitted to produce it. However, this aspect depends mostly on the place of production. In China, for example, much of the energy is generated from fossil fuels, mainly coal, so, the carbon footprint of its electricity production is twice that of the United States. Consequently, also taking into account other factors, such as transport and logistics necessary for export, and the fact that China is its largest global producer, when a panel is installed on a European roof it takes about a year to cancel the carbon footprint necessary to produce it. As a result, when the panel produces clean energy in China the production of greenhouse gases increases. This is why solar energy is clean, but not so much. Also recycling faulty panels, or those at the end of their life, leads to environmental problems.

A solar panel lasts 30 years. At the end of its life cycle, it has to be treated as a special waste. Numerous elements compose a PV panel, including toxic substances such as copper, lead, gallium, selenium, indium, cadmium and tellurium. The separation and recovery of these metals is not an easy process. These substances, potentially hazardous to health, are in small percentage compared to the most non-hazardous, such as glass, polymers, and aluminum.

Since photovoltaics is a relatively new product, today we have to face the first phase of development of the photovoltaic recycling industry, which could convert this waste into a resource. It is not difficult to understand that proper recycling is a precious resource for the production of materials in production chains, photovoltaic panels and more. To do this, it is necessary to disassemble the panel and correctly separate the elements that compose it. In addition, the development of a used panel market could also be interesting, especially in developing countries where purchasing power is limited.

Another adverse effect of solar power is associated with land use. To build a utility-scale solar power facility, a large area of land is required. This can interfere with the existing land uses. The use of many acres of land can result in clearing and grading of land, which can cause soil compaction, erosion, and alteration of drainage channels. Furthermore, solar energy systems can affect the area in the process of materials extraction, exploration, manufacturing, and disposal.

The rising demand for energy and the push towards low-carbon energy sources leads to rapid growth of ground-based photovoltaic parks all over the world. This constitutes an important change in land use on a global scale and requires critical studies for a detailed understanding of the impact of solar parks on the ground below them.

A study of researchers from the Centre for Ecology and Hydrology of the University of Lancaster, in Great Britain, published in the journal Environmental Research Letters, describes what happens to the soil and vegetation below the solar panels. After monitoring the plants in the large Swindon solar park for about a year, the scientists noticed that, below the panels, the temperature was on average 5 degrees lower than the rest of the surface. This shading effect causes a change in the climate that can damage the growth of some plants. Solar panels undoubtedly affect the earth, shielding the ground from the sun's rays. However, according to Dr. Alona Armstrong of Lancaster University, the shade under the panels can allow crops that cannot survive in full sun to be cultivated. In addition, water losses can be reduced and water could be collected from large solar panel surfaces and used for crop irrigation.

Although there are no global warming emissions associated with the generation of electricity from solar energy, there is no doubt that there are emissions associated with other phases of the life cycle of a photovoltaic system, including production, transport of materials, installation, maintenance and dismantling, and disposal. As demonstrated by the scientific literature collected by the NREL of the US Department of Energy, the energy invested to produce a photovoltaic system, including components and installation, ranges from 3 to 13% of what the system will produce in 30 years.

If we compare the energy payback ratio, the relation between energy invested and energy produced, with that of other sources, we see that the photovoltaic has a slightly higher performance than, for example, a coal-fired power plant. With the big difference that, in the case of PV, from 87% to 97% of the energy produced by the plant does not involve any emission or pollution.

Any human activity has what is called anthropogenic impacts. Many of which are extremely positive and some are damageable drawbacks. No human activity is environment-neutral. As always, humans have to develop technologies to fix the environmental issues caused by our inventions. Often our latest "solutions" create or add more damage, even if we initially welcome them as the ultimate answer. It keeps us busy, having to solve a continuing series of (mainly) self-inflicted problems. Unless a complete assessment of all costs (including environmental effects) and benefits is performed, better not to trust anyone glorifying a technology that has not fully analysed this balance.

# Pleistocene Park: protecting the future by returning to the past

By LENORE M. HITCHLER

*ONE*

It is a well-known fact that burning fossil fuels causes the build-dup of greenhouse gases which leads to global warming. This results in melting permafrost producing even more greenhouse gases which further accelerates climate change. *Permafrost* is defined as ground that remains at or below zero degrees Celsius for at least two consecutive years. Can we slow down this damaging process which leads to disasters throughout the planet?

One way to do so would be to slow down the melting of the permafrost. The father and son scientific duo of Sergey and Nikita Zimov maintain that this can be done by reinstating the type of flora and fauna that thrived in Siberia during the Ice Age. The Zimovs have already begun the process in Pleistocene Park in Siberia, Russia. Preliminary results indicate that it is possible to reduce melting of the permafrost and therefore slow down climate change.

Sergey Zimov has the education, knowledge, expertise, and credentials to justify his assertions. He obtained his academic training in geophysics at the Far East State University in Vladivostok, Russia where he trained as a quantum physicist. He did fieldwork in northern Siberia for the Pacific Institute for Geography, which is part of the Far East Branch of the Russian Academy of Sciences. He has also worked as a researcher at the University of California-Berkeley. He is a member of the Russian Academy of Sciences and is also listed in the Arctic Observatory Network, International Study of Carbon, Water and Energy Balances in the Terrestrial Arctic.

In an article published in the *Russian Academy of Sciences*, Dr. Igor Petrovich Semiletov, head of the Laboratory of Geochemistry in the Polar Regions at the Pacific Oceanological Institute in Vladivostok, stated that Sergey is the most cited Russian earth scientist. He has either written or co-authored articles published in various peer-reviewed scientific journals, including BioScience, Geophysical Research Letters, PLOS ONE, Quaternary Science Reviews, Science, and Science in Russia. Thus, Sergey is an accepted international expert in arctic ecosystems and global warming. Nikita Zimov, Sergey's son, is a mathematician trained at Akademgorodok, which is a major scientific center in Siberia and has the reputation of being the location of Russia's brain trust for the physical sciences. Nikita has been trained by his father for virtually his whole life. Moreover, he is a published author in peer-reviewed scientific journals, is a respected scientist in his own right, and has earned international recognition. The fact that both Sergey and Nikita have obtained their education at respected universities is important because this shows that they have the credentials to back up their assertions. Likewise, the fact that they have been published in many leading scientific journals demonstrates that their peers both respect and value their work.

In 1980 Sergey organized the Northeast Science Station located near the town of Chersky where he has served as its director. Chersky, located in the northeast section of Sakha, is a remote republic of Russia located in eastern Siberia. Sakha includes over three million square kilometers of land, which is approximately 1,158,306 square miles.

In 1989 Sergey established Pleistocene Park, which is an offshoot of the Northeast Science Station located 25 kilometers (approximately 15.5 miles) from the station. Pleistocene Park is an enclosed area of sixteen square kilometers (approximately 6.18 square miles) of forests, meadows, shrubland and lakes. Both the science station and Pleistocene Park have a good reputation among scientists in the field. Many researchers have worked at Pleistocene Park.

According to the official Pleistocene Park website, over fifteen scientific projects were conducted in 2014, with annual visits from 50-70 scientists. One scientist told an interviewer that the center ranks second among Arctic outposts as a place to do research. This is impressive since other research stations are much less isolated and more accessible. The park has received various American research grants, with one supporting the

"Heading for the River," a large-scale painting by Randall Compton. Photo credit: Theresa Bakker

center as a teaching lab and the other financially supporting remote sensing.

The goal of Pleistocene Park is to simulate the Pleistocene ecosystem in areas that were once known as the Mammoth Steppe, a grassland ecosystem which has been estimated to occupy one million square kilometers (approximately 386,102 square miles.) In other parts of the world, steppe types of ecosystems are called prairies, plains, or savanna. The Pleistocene epoch, commonly known as the *Ice Age*, began about 2.6 million years ago and ended around 11,700 years ago, at the start of the Holocene Epoch. During the Pleistocene mile-thick glaciers covered much of the northern hemisphere. However, the Mammoth Steppe was an exception as it was cold and dry. The Mammoth Steppe extended from France to Scandinavia, across all of Europe to Eurasia and then on to the Pacific land bridge and Canada.

The Mammoth steppe is considered to have been the world's most extensive ecosystem with Pleistocene grassland ecosystems having occupied about half of the world's landmass. The area was covered with grassland precisely because the cold air was too dry to produce enough snowfall to form glaciers. Fortunately, arctic grasses can photosynthesize and thrive at low temperatures. Many large mammals, including woolly mammoths, woolly rhinoceroses, horses, moose, saiga antelopes, reindeer, elk, bison, musk oxen, yaks, cave lions and wolves inhabited the region.

Before Sergey Zimov's research, scientists theorized that during the Holocene Epoch climate change caused the area to evolve from a steppe grassland to a tundra/forest/swamp ecosystem. However, the Zimovs maintain that human hunting and eradication of large animals caused the ecosystem to change from a vast mammal grassland to a landscape with mosses, shrubs, and trees. The Zimovs substantiate their claims in an article published by *Quaternary Science Reviews*, which states: "*Analysis of fossil carbon-14 dates and reconstruction of mammoth steppe climatic envelope indicated that changing climate wasn't a reason for extinction of this ecosystem. We calculate, based on animal skeleton density in frozen soils of northern Siberia, that mammoth-steppe animal biomass and plant productivity, even in these coldest and driest of the planet's grasslands were close to those of an African savanna. Numerous herbivores maintained ecosystem productivity.*"

Other scientists support this hypothesis. For example, Yadvinder Malhi, professor of ecosystem science at Oxford and one of the organizers of the "Megafauna and Ecosystem Function" conference also points out that the animals that lived in the Mammoth Steppe had previously survived millions of years of climate change.

Instead of climate change transforming the ecosystem, Sergey posits that over-hunting of herbivores changed the environment. Sergey Zimov is one of the authors of "Steppe-Tundra Transition: A Herbivore Driven Biome Shift at the End of the Pleistocene" in *The American Naturalist* published by the University of Chicago Press. The authors explain how grassland in the Mammoth Steppe is created and maintained: "*Trampling and grazing by mammalian grazers in tundra cause a shift in dominance from mosses to grasses. . . . moss-dominated tundra is favored when grazing is reduced below levels that are in equilibrium with climate and vegetation. Together these results indicate that mammalian grazers have a sufficiently large effect on vegetation and soil moisture that their extinction could have contributed substantially to the shift from the predominance of steppe to tundra at the Pleistocene-Holocene boundary.*"

Therefore, Sergey and Nikita are bringing back the types of animals that formerly lived in the area. According to the Plei-

stocene Park website, the Zimovs have already introduced bison, musk ox, moose, reindeer and horses to the park. The online site of Pleistocene Park states: "*He [Sergey] hopes that by putting a lot of large grazing animals on to the modern tundra, they will chew up the mosses that currently keep the soil moist. The drier earth will then be suitable for grassland, which is what the animals prefer."*

Thus, the introduced herbivores will cause the current wet, boggy tundra to revert to the dry grasslands that once covered the area. The high plant productivity found in grasslands reduces soil moisture and will result in less methane being produced. Methane is more than 25 times more potent as carbon dioxide (CO2) at trapping heat in the atmosphere.

Carbon dioxide, methane and other greenhouse gases are causing the Arctic to quickly warm up and this has already caused some melting of the permafrost. Microbes are digesting organic material that was previously sequestered in the permafrost producing either carbon CO2 or methane depending on whether or not the digestion occurs with or without oxygen. For instance, when lake bottoms are filled with melted permafrost, microbes in their digestion process produce bubbles of methane which rise to the surface. Already more than one million of these lakes dot the Arctic, and NASA finds new ones in their satellite images every year.

Unfortunately, an immense amount of carbon is stored in permafrost and this carbon is released into the atmosphere when permafrost melts. And it has been estimated that the permafrost is one mile thick in places. The Zimovs are not the only scientists who are extremely concerned about the dangers of melting permafrost.

For example, Julian Merton, member of the International Permafrost Association, states that "The methane and carbon dioxide levels will increase as a result of permafrost degradation." There are many different estimates of the total amount of carbon in the permafrost. For instance, Sergey states that "permafrost areas hold 500 billion Tongans of carbon." It has been estimated that the melting of the world's permafrost is equivalent to burning all of the world's forests 2 ½ times.

On a hot day, the permafrost can melt by as much as 20 centimeters, approximately 7.87 inches. In summer, the permafrost recedes by 3 meters, approximately 3.28 yards. As a result of permafrost melting in Chersky, a small town near Pleistocene Park, apartment blocks have cracks running through their walls because of subsiding (sunken) land and some have been demolished as unsafe. Whole houses have already sunk into the mud. This is an illustration of why Sergey stated that "This is the most dangerous territory in the world in terms of climate change."

Preliminary results from Pleistocene Park find that where the herbivores trample the snow to get at the grass underneath the soil temperatures are lower. The temperature difference is enough to protect the permafrost from melting. In winter when the air temperature has been recorded as minus 40 degrees Celsius, (about minus 40 degrees Fahrenheit) the temperature of snow-covered ground was minus 5 degrees Celsius, (about 23 degrees Fahrenheit.) However, in places where the animals trampled down the snow, the ground temperature was minus 30 degrees Celsius (about minus 22 degrees Fahrenheit.)

It has been estimated that permafrost covers approximately 25% of the Northern Hemisphere landmass. Thus, melting


**Grassland ecosystems keeping the permafrost itself from melting and releasing CO2, they are considered the most effective carbon sink on Earth.**

Pleistocene Park is a nature reserve located on the Kolyma River in the Sakha Republic, also known as Yakutia. A project is currently running to recreate the environmental conditions at the time of the last ice age, including the grasslands. Courtesy of Siberian Times.
Photo credit: Chris Linder, Nikita Zimov

permafrost could rapidly and profoundly increase global warming. Fortunately, the largest concentrations of carbon are found in northeast Siberia, central Alaska, and the Yukon Territory of Canada. This means that if the Zimovs are proven correct, then only these specific areas will need new herbivores introduced to keep the permafrost from melting.

Besides grassland ecosystems keeping the permafrost itself from melting and releasing CO2, they are considered the most effective carbon sink on Earth. In the summer the growing grass consumes CO2 and the plant stores carbon in its tissues as well as building up carbon storage in the soil. Since grass insulates the permafrost from warming temperature, melting permafrost would slow down.

Forests and shrublands are dark year round and absorb considerable amounts of the sun's radiation. Thus, they contribute to the greenhouse effect. Whereas grasslands are lighter and are white in the winter when covered in snow, and they reflect more of the sun's heat and help slow down global warming.

Therefore, creating more grasslands by reintroducing herbivores will help slow down global warming several ways. Herbivores trample down the snow thus enabling colder winds and temperatures to keep the permafrost cooler. Additionally, the white snow covering the grassland, as opposed to the darker shrublands and tree cover, will reflect more sunlight thus slowing down the greenhouse effect. Also, the new grasslands will store CO2 in the grass and in the soil which will also help stop global warming. Thus, by bringing back the types of flora and fauna found during the Pleistocene era, climate change can be slowed down.

Otherwise melting permafrost will add to the greenhouse effect and cause rapid global warming that will jeopardize the future of society. Some of these threats to humanity are rising sea levels, toxic amounts of CO2 in the oceans, floods, droughts, the loss of glaciers which provide one-sixth of the world's population who depend upon glacier-fed rivers for drinking and irrigation, and the loss of species that humans depend upon. Pleistocene Park includes many species of herbivores, including reindeer.

Perhaps someday instead of singing these lines from Rudolph the Red Nose Reindeer:

*Then how the reindeer loved him*
*As they shouted out with glee*
*Rudolph the Red-Nosed reindeer*
*You'll go down in history*
we will sing:
*Then how humanity loved grasslands*
*As they shouted out with glee*
*Pleistocene Park*
*You'll go down in history*

# From Australia to El Salvador to Vietnam, the environment is finally getting its day in court

**Specialized environmental courts are now operating on every continent except Antarctica. What's behind the boom?**

By ANNA-CATHERINE BRIGIDA
*Ensia*

When the improper disposal of wastewater from the construction site of a joint shopping center and apartment complex threatened to contaminate hundreds of residents' water in Sonsonate, El Salvador, activists and community leaders filed a lawsuit through the country's specialized environmental justice system. In response, Lina Pohl, El Salvador's minister of environment and natural resources, went to inspect the water. When she found signs of contamination, she ordered the suspension of construction.

Using legal tools to report an alleged violation of the law might not seem groundbreaking. But in El Salvador, justice in environmental disputes has long swung in favor of rich developers with political connections rather than activists and citizens. So, in 2014 the Central American nation established three regional environmental tribunals to even the playing field in environmental disputes.

"Historically, institutions in El Salvador have operated with lots of corruption. This is a system that breaks with that tradition of corruption," says Salvador Recinos, specialist in ecological policy for the Salvadoran Ecological Unit (UNES), a non-governmental organization based in San Salvador. "With this court system, there is clearly a better chance of people in El Salvador having access to justice in these types of environmental cases."

Justice systems around the world face obstacles to settling environmental cases quickly and fairly, whether from corruption, drawn-out trials or judges who lack understanding of environmental issues.

Specialized environmental courts have emerged as an important defense against human-caused destruction of the environment. In 2009 there were only 350 of these specialized court systems in the world. Today there are at least 1,200 in 44 countries.

## Evolving Understanding

The boom in environmental courts is driven by an evolving understanding of human rights and environmental law, increased awareness of the threats of climate change, and dissatisfaction with general court systems, according to George (Rock) Pring, co-author of "Environmental Courts & Tribunals," a United Nations Environment Programme (UNEP) guide for policy-makers.

Litter problem on the coast of Guyan. Photo credit: Nils Ally

"Human rights and environmental rights are now seen as overlapping and complementing each other, not surprisingly," he says. "Climate change has also been a big pressure on creating environmental courts, as have concepts such as sustainable development." International agreements like the Paris Climate Change Accords have made important strides in recognizing the severity of the problems posed by climate change, but their non-binding nature means that it is up to national court systems to ensure these promises are carried out.

Specialized environmental justice systems are now operating on every continent except Antarctica with a range of responsibilities and capabilities. The goal of these specialized justice systems is always the same: to decide cases quickly, fairly, and more cheaply than would be the case through the conventional court system.

Specialization, the logic goes, is the way to do that. Take India, for example. The country suffers from intense air and water contamination, problems that have dire consequences for the environment as well as public health. Solving these problems is urgent, but the country of 1.3 billion people has a court system that is notoriously slow, with some cases dragging on for more than 10 years In 2011, a specialized court system called the National Green Tribunal (NGT) began operating in India. The tribunal, with multiple branches across country, is made up of specialized environmental judges and scientific experts. The court can settle cases in multiple ways. In some cases, instead of just handing down judgments, the court practices a stakeholder consultation process, working with the activists, companies and government institutions to come up with solutions, such as phasing out older cars to reduce air pollution.

"Problem solving is very central to this tribunal, and to solve the problems the court is looking beyond the traditional remedies that are available because they want to solve the issue rather than linger on for years to come," says Gitanjali Gill, a National Green Tribunal expert and professor of environmental law at the Northumbria Law School in the U.K. To ensure swift judgments, the tribunal is required to solve cases in six months. Gill reports that this rule is not strictly followed, with some cases lasting longer than six months, but they are still resolved much faster than in India's general justice system.

## Key to Success

In Australia, the Land and Environment Court of New

South Wales has operated successfully since 1980, solving problems of sustainable development, fighting against the effects of climate change, and protecting the coastline and national parks.

Its longevity has given it the time to evolve and test difference approaches, making it one of the most innovative environmental court systems to date. One of these innovations is the concept of the "multi-door courthouse," which offers different types of conflict resolution so all parties involved can reach an agreement that is not necessarily handed down from a judge. Strong leadership, steady funding, and political support have been the key pillars to the court's success, according to the UNEP report.


The UNEP report attributes the success of the court to "judicial leadership, sufficient budget, comprehensive jurisdiction, political support and stakeholder overview. In El Salvador, trust in the justice system is low and risk of environmental damage by climate change is high, making the country a prime candidate for a specialized environmental court system. Before the system launched in 2014, some Salvadoran citizens and activists didn't see the point in reporting environmental violations. Without pressure from civil society, government institutions didn't keep on top of environmental violations. But that's changing.

"Nowcitizens know that there are environmental tribunals. Companies also know. So there is a new push within the country towards recognizing the importance of environmental laws given that there is a new institutionalized system that handles these cases," says Samuel Lizama, presiding judge at the Environmental Tribunal of San Salvador, one of the three regional courts in the country's specialized environmental court system.

## Far From Perfect

These specialized systems are far from perfect. Some experts oppose them in principle, arguing that they lead to biased judgments, that the benefits do not outweigh the costs, and that they are a Band-Aid for a larger problem of a weak justice system, as Pring explains. In India, judgments are not always carried out, and the tribunal does not have the capability or resources to follow up on all the cases. In El Salvador, environmental judges balance other caseloads, taking their time and energy away from environmental cases. In at least seven cases, including Bahamas, Netherlands and South Africa, environmental court systems have been discontinued because of lack of funding, change in political leadership or pressure from special interest groups. In addition, it's hard to objectively judge the value of environmental court system decisions in a world in which environmental law evolves and climate change creates new challenges.

"The problem is, how do you tell if something is a good environmental judgment?" says Pring. "Ten years ago, courts were not focusing on sustainable development or climate change and rulings that looked good at the time are not good now. It's hard to tell today what today's good-looking environmental decision will look like 10 years from now."

Environmental courts don't provide a one-size-fits-all approach to solving problems of governance when it comes to environmental issues, but they have proved effective for many countries, from El Salvador to India to Australia. They will likely continue as an important line of defense against environmental deterioration as the threats from climate change intensify in the coming years.

*Originally published by Ensia April 24, 2018*

@realscientists

# CLIMATE CHANGE MONTH

## 05-11 JULY

@KA_Nicholas
Kimberly Nicholas, Lund University
*Sustainable food, ecosystem services*

## 12-18 JULY

@ClimateOfGavin
Gavin Schmidt, NASA GISS
*Climate modeling*

## 19-25 JULY

@conservbytes
Corey Bradshaw,
University of Adelaide
*Impacts, mitigation, sustainability*

## 26 JULY-1 AUG

@msanclem
Michael SanClements, NEON
*Forests, water, carbon cycling*

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# Environmentalism 4.0

**We are riding the Fourth Wave of environmentalism where Innovation, People and Action drive environmental progress giving new ways to solve invisible problems, making them visible and actionable.**

By EUSEBIO LORIA

*ONE*

Global leaders at the latest World Economic Forum 2018 Meeting in Davos were talking about "the Fourth Industrial Revolution", the drastic changes that technology, Artificial Intelligence (AI), Internet of Things (IoT) are having across the global economy. When we talk about The Fourth Wave of Environmentalism in the US, we're thinking about a subset—how innovations are influencing our choices about environmental progress.

The Fourth Wave comes after three huge ones. The first was the land conservation movement, led by President Teddy Roosevelt; the second, the anti-pollution laws of the 1960s and 1970s (the Clean Air Act); and finally, the rise of powerful market-based solutions and corporate partnerships with EDF (Environmental Defense Fund) in the 1990s, widely known as the *Third Wave* (related to acid rainfalls).

The Fourth Wave will fundamentally transform how we solve environmental problems through solutions driven by innovation – scientific and technological discoveries, new public policy ideas, and new ways to collaborate and communicate – that gives people the power to take action and to participate. Innovation means new ideas, new policy approaches and new technologies that are helping us measure and reduce pollution, protect public health and preserve habitats. People means everyone—from business leaders and investors to politicians, and from farmers and fishermen to consumers and citizens.

EDF have put sensors on Google Street View cars and have mapped methane leaks in Boston, Chicago, Dallas and other cities. Photo credit: Steve Jurvetson

The Fourth Wave also gives us new ways to communicate and work together in partnerships like never before. Last but not least there's Action. Fourth Wave environmentalism translates data and insight into concrete action and measurable results. EDF commissioned a first-of-its-kind survey exploring the intersection of technology, business and sustainability. The business leaders revealed how emerging technologies are changing the way of thinking and investing in sustainability. 86% of the executives surveyed say their business objectives and environmental goals are more aligned than they were five years ago, primarily due to technology innovations. Sustainability is not just some "nice-to-have" by-product of change. It is an integral part of strategic decision-making that reduces costs and makes performance efficient as it contracts a company's environmental footprint.

Market-based approaches and business partnerships are standard practices today. Yet too many environmentalists still consider businesses as enemies, and viceversa. This could finally change, because the Fourth emerging wave is making these partnerships more productive and their results more precisely measurable. Top executives say environmental innovation is good for business.

But what is the role of business in the Fourth Wave? Many of the environmental challenges - especially climate change - are linked to the global economy. Industry must, therefore, play an integral role in solving them and finding common ground between business drivers, like profit and growth, and environmental drivers, like carbon emissions and clean air.

Here are some recent examples of the Fourth wave: Smithfield Foods, the world's largest pork producer, is using precision agriculture tools to reduce fertilizer waste on the

(Honghe Hani Rice Terraces) in Yunnan Province, China. Photo credit: Jialiang Gao

network of farms that supplies the company with corn. It's part of Smithfield's goal of 25 percent cutting supply-chain greenhouse gas emissions by 2025. The company is the first in its industry to set such a target, and its progress is enabled by corn growers increasing investment in tools that help determine the most efficient ways to apply fertilizer. Levi Strauss & Co. just announced a new digital manufacturing capacity that automates part of the jeans production process, allowing the company to tailor supply to meet demand, reducing textile waste and eliminating thousands of chemicals previously needed for finishing.

EDF have put sensors on Google Street View cars and have mapped methane leaks in Boston, Chicago, Dallas and other cities. Google Earth Outreach has also mapped the air pollution threats to West Oakland, block by block, providing local citizens with high-resolution data that strengthens the emission cut policy according to the new state air quality law. Oil and gas facilities owned by Statoil, PG&E, and Shell have installed methane detection units after warning entrepreneurs to find cost-effective and new solutions to help operators identify leaks on distribution lines. EDF is just one of many groups doing this kind of work. Walmart, Unilever, and Nestle are also working with IBM to explore "blockchain" applications for food supply chains.

The advantage for the environment is less food waste. For business, this approach increases supply chain efficiencies and ensures food safety. World Resources Institute is using satellites to track Amazon deforestation and uploading data on a website that can alert local authorities to fires; companies are implementing "blockchain" processes to improve traceability and accountability across supply chains from verifying the sustainability of Indonesian tuna supply chains to managing energy trading across solar-powered microgrids. There is a great promise on the oceans where fishing boats can be coordinated and monitored remotely. Some fisheries are testing technology that will count and classify a boat's catch with cameras tied to machine learning. All these actions can prevent overfishing and illegal fishing while at the same time protecting critical food sources.

In April, EDF announced plans to develop and launch a new satellite that will be built to locate and measure methane emissions from sources worldwide, starting with the oil and gas industry. Free and open data from this satellite will give countries and companies data to recognize problem areas, identify savings opportunities, and measure their progress in reducing methane emissions over time.

Sensors, machine learning, IT, data analytics are used to shape smart policy. They are the prerogative of business and the environment. The result will be a positive change that helps people and nature to stand up straight on the crest of the Fourth Wave. ONE

Dagverðará Snæfellsnes. Photo credit: Jon Gretarsson

# Amid High-Tech alternatives, a reckoning for Iceland's glacier keepers

**Citizen scientists have served as glacier trackers in Iceland — and witnesses to the ravages of climate change — for generations. Will they continue?**

By GLORIA DICKIE

*Undark Magazine*

A 30-meter, Komelon-branded measuring tape, a pencil, and a yellow paper form are all Hallsteinn Haraldsson carries with him when he travels to the Snaefellsnes Peninsula in western Iceland. But unfurling the measuring tape before me at his home in Mosfellsbaer, a town just outside of Reykjavik, he says it is a significant upgrade from the piece of marked rope he used to take with him.

"They are almost like ambassadors of climate change, infiltrating information into different branches of society."

With 11 percent of the landmass covered in ice, rapidly ebbing glaciers are threatening to reshape Iceland's landscape, and Haraldsson, 74, is part of a contingent of volunteer glacier monitors who are at the frontlines of tracking the retreat. Every autumn, Haraldsson, often accompanied by his wife and son, sets off on foot to measure the changes in his assigned glacier. Their rudimentary tools are a far cry from the satellites and time-lapse photography deployed around the world in recent decades to track ice loss, and lately there's been talk of disbanding this nearly century-old, low-tech network of monitors. But this sort of ground-truthing work has more than one purpose: With Iceland's glaciers at their melting point, these men and women — farmers, schoolchildren, a plastic surgeon, even a Supreme Court judge — serve not only as the glaciers' guardians, but also their messengers.

Today, some 35 volunteers monitor 64 measurement sites around the country. The numbers they collect are published in the Icelandic scientific journal Jokull, and submitted to the World Glacier Monitoring Service database. Vacancies for glacier monitors are rare and highly sought-after, and many glaciers have been in the same family for generations, passed down to sons and daughters, like Haraldsson, when the journey becomes too arduous for their aging watchmen.

It's very likely one of the longest-running examples of citizen climate science in the world. But in an age when precision glacier tracking can be conducted from afar, it remains unclear whether, or for how long, this sort of heirloom monitoring will continue into the future. It's a question even some of the network's own members have been asking.

As Haraldsson tells it, his father was raised in a modest yellow farmhouse on the Snaefellsnes Peninsula. As an adult, he spent his days tending his fields and teaching at the local school, and in his free time, he studied the geology of the region, walking miles through the lava beds that lay in the shadow of the crown gem of the region: Snaefellsjokull, a 700,000-year-old glacier-capped volcano. It was a quiet life, unremarkable to those who passed through, until the arrival in 1932 of Jon Eythorsson — a young man who had recently returned to Iceland after studying meteorology, first in Oslo, and then in Bergen, Norway.

Jon Eythorsson established the first program to monitor the growth and retreat of Iceland's glaciers, enlisting the help of locals in the effort.

Haraldsson began accompanying his father to the glacier around 1962. When his father died 14 years later, Haraldsson took over the task full time.

Eythorsson was now working for the Meteorological Office in Reykjavik, and in his spare time he had established the first program to monitor the growth and retreat of Iceland's glaciers – but getting around the country to check up on them was troublesome and time-consuming. For the scientific record, every glacier needed to be measured in the same month, and travel was slow, often complicated by fierce, unpredictable storms. If his project was going to succeed, he needed new recruits, ideally farmers who need not travel far.

That, says Haraldsson, is how his family came to inherit Snaefellsjokull. At the time, there was no sense of scientific urgency to glacier monitoring; glaciers had always expanded and deflated naturally in modest increments. But that was decades ago. The world's glaciers now serve as harbingers of human-caused climate change, providing powerful visual evidence of how people have changed the planet.

Inside Haraldsson's home, portraits of Snaefellsjokull adorn the white walls in a way often reserved for close family members. Some are rendered in pastels and watercolor, while others are more abstract, etched in black and white. To Haraldsson, his wife Jenny (who painted many of them), and their son, Haraldur, it's the family glacier.

Haraldsson began accompanying his father on his hikes to the glacier around 1962. Back then, the journey to the terminus was 10 to 15 kilometers by foot through steep, rocky terrain. The glacier itself spanned some 11 square kilometers – tiny as glaciers go. When they arrived, they would pull a long piece of thin rope with meter marks taut to measure the distance between the last icy bit and a metal rod, jotting down the observations they would send to the Society. When his father passed away 14 years later, Haraldsson took over the task full time. From 1975 to 1995, the glacier actually advanced 270 meters, according to Haraldsson's records. Such findings weren't uncommon during that period: In the 1930s, many of the country's glaciers had retreated significantly due to an unusually warm climate, but beginning in 1970, they advanced once more until human-caused climate change beat them back again.

Eventually his wife, and then his son, joined him in his annual glacial pilgrimage. By then a road had been built, passing within one meter of the glacier. From 1995 to 2017, their records suggest that Snaefellsjokull retreated 354 meters – a net loss of 84 meters from its position in 1975.

Most local people are upset to see the glacier disappearing, Haraldsson says. Everyone on the peninsula uses the glacier as their key landmark; in casual conversation, distance is defined by how far away something is from Snaefellsjokull. Others describe feeling a supernatural pull towards it. Perhaps Jules Verne felt the same: Snaefellsjokull served as the setting for his book "Journey to the Center of the Earth."

When the glacier began its retreat in the 1990s, the family thought of it as a natural fluctuation. But since then, almost all of Iceland's monitored glaciers have entered a state of decline. Now, they understand, their glacier is disappearing because of global warming. In 2016, scientists announced they expected Snaefellsjokull to vanish entirely by the end of the century.

Two years ago, scientists announced they expected the Snaefellsjokull Glacier, on Iceland's Snaefellsnes Peninsula, to vanish entirely by the end of the century. This and a larger inland glacier, Langjokull, are among dozens that citizen scientists monitor year after year – sometimes with just a measuring tape and a notebook.

Most data contained within the World Glacier Monitoring Service database, which includes more than 100,000 glaciers worldwide, has been created via aerial photograph comparisons. Each glacier inventory includes the location of the glacier, length, orientation, and elevation. "Entries are based on a single observation in time," reads the WGMS website – a snapshot of a glacier in a particular moment. About half of all glaciers in the authoritative database are measured via a comparison of aerial photographs from year to year and maps.

In 2005, the WGMS and the National Snow and Ice Data Center launched the Global Land Ice Measurements from Space program. Rather than rely solely on photographs and in-person observations, glacier inventories can now be collected via a remote sensing instrument on NASA's Terra satellite. The benefits of such increasingly sophisticated remote monitoring are substantial in terms efficiency. But if even aerial photogra-

phy is going the way of the dinosaurs, what's to become of Iceland's glacier monitors?

It's something that even Jon Eythorsson's granddaughter, Kristjana Eythorsdottir, thinks about. She was only 10 years old when the elder Eythorsson, who formally established the Iceland Glaciological Society in 1950, passed away, but she followed his vocation and today works at the Iceland Meteorological Office. Her grey hair is shorn into a spiky pixie cut, and her hiking pants and running shoes suggest she's ready to set out into the field at a moment's notice.

"The [Glaciological] Society has a lot of written songs and texts," she says, recalling the impact her grandfather's volunteer network had on her life. "One saying goes that my grandfather loved the glaciers so much they were shrinking."
"One saying goes that my grandfather loved the glaciers so much they were shrinking."

When traveling together to examine the glaciers, the society's members and scientists would sing songs written by Sigurdur Thorarinsson, an Icelandic geologist, volcanologist, glaciologist – and lyricist. They would write new ones, too; sometime before 1970, the Society published a book of glacier songs. Since 2000, Eythorsdottir has been monitoring a terminus at Langjokull, a large glacier in the south of Iceland 100 times the size of Snaefellsjokull. (She didn't inherit her glacier, but rather applied when one became available.) Each September, she sets out on the roughly five-hour round-trip hike to the glacier with her husband. "There is a river that goes here," she says, tracing its path carefully on a map. "It's kind of a bad smelling, geothermal river – the white-tempered river. We have to take our clothes off, or put on waders," to get across.

Sometimes they'll look for different routes, passing through grazing sheep and their herders. The landscape is ever-changing. Already, the glacier has retreated more than 500 meters. Unlike Haraldsson, Eythorsdottir is using more modern technology. "We used to use measuring tape, but now we are tracking with GPS," she says. "There are more possibilities to represent the data...but I think we will always go there anyway until it's gone."
Whenever he runs into friends, Hallsteinn Haraldsson, the keeper of Snaefellsjokull, says they first they ask how he and his family is doing. And then, he says, they ask, "How is the glacier?"

It's a question that was intimately familiar to all of Iceland's volunteer glacier monitors as they gathered in 2016 at the natural sciences building at the University of Iceland in Reykjavik. Most had never met each other before, and they were there to discuss how the glaciers were changing and what tools would

Jökulsárlón, glacier. Photo credit: CGP Grey

be best to measure the glacier fronts moving forward – mainly whether or not volunteers should increase their use of handheld GPS devices over reference points and measuring tapes. Iceland's Svinafellsjokull Glacier, as seen through the eyes of a drone. If such technology is available, should Iceland's human glacier keepers keep at it?

"There's been [internal] discussion as to whether we should keep doing this or not since it can now be done with remote sensing," says Bergur Einarsson, a glacial hydrologist who recently took over management of the network from geologist Oddur Sigurdsson. Though some might see the crude nature of pen and paper measurements as a hindrance, Einarsson argues it's actually an asset. "One of the strengths is that these measurements have not evolved. They're done more or less in the same way they were done in the 1930s."

"There's been [internal] discussion as to whether we should keep doing this or not since it can now be done with remote sensing."

That means that while scientists can now use remote sensing to gather precise images and coordinates, that record is much shorter and often lacks the same specificity as ground-level measurements. Moreover, complex technological projects require significant funding that often comes with a sunset clause: Time-lapse photography and remote sensors aren't nearly as cheap – or as dependable – as a few dozen volunteers armed with measuring tapes.

*(The strength of Iceland's program was underscored last year when scientists from around the globe met at the American Geophysical Union in Washington, D.C., to discuss the fate of NASA's Terra satellite. After 18 years in orbit, the satellite was beginning to run low on fuel – jeopardizing the scientific record.)*

But for Einarsson, there's an even bigger reason to keep it going – one that the Haraldssons and Eythorsdottir and some 33 other volunteer glacier monitors would likely share. "People are going out there, going to the glacier front, [where] they see the changes," he says. "Then they are going back into society and they are almost like ambassadors of climate change, infiltrating information into different branches of society." "It is very important to engage with people in some way," his predecessor Sigurdsson says, "and keep them interested in their surroundings."

*Originally published by Undark Magazine April 6, 2018*

# Antarctica has lost 3 trillion tonnes of ice in 25 years

## Time is running out for the frozen continent

By STEVE RINTOUL and STEVEN CHOUN
*The Conversation*

Antarctica lost 3 trillion tonnes of ice between 1992 and 2017, according to a new analysis of satellite observations. In vulnerable West Antarctica, the annual rate of ice loss has tripled during that period, reaching 159 billion tonnes a year. Overall, enough ice has been lost from Antarctica over the past quarter-century to raise global seas by 8 millimetres.

What will Antarctica look like in the year 2070, and how will changes in Antarctica impact the rest of the globe? The answer to these questions depends on choices we make in the next decade, as outlined in our accompanying paper, also published today in Nature.

Our research contrasts two potential narratives for Antarctica over the coming half-century – a story that will play out within the lifetimes of today's children and young adults.

While the two scenarios are necessarily speculative, two things are certain. The first is that once significant changes occur in Antarctica, we are committed to centuries of further, irreversible change on global scales. The second is that we don't have much time – the narrative that eventually plays out will depend on choices made in the coming decade.

### Change in Antarctica has global impacts

Despite being the most remote region on Earth, changes in Antarctica and the Southern Ocean will have global consequences for the planet and humanity.

For example, the rate of sea-level rise depends on the response of the Antarctic ice sheet to warming of the atmosphere and ocean, while the speed of climate change depends on how much heat and carbon dioxide is taken up by the Southern Ocean. What's more, marine ecosystems all over the world are sustained by the nutrients exported from the Southern Ocean to lower latitudes.

From a political perspective, Antarctica and the Southern Ocean are among the largest shared spaces on Earth, regulated by a unique governance regime known as the Antarctic Treaty System. So far this regime has been successful at managing the environment and avoiding discord.

However, just as the physical and biological systems of Antarctica face challenges from rapid environmental change driven by human activities, so too does the management of the continent.

### Antarctica in 2070

We considered two narratives of the next 50 years for Antarctica, each describing a plausible future based on the latest science.

In the first scenario, global greenhouse gas emissions remain unchecked, the climate continues to warm, and little policy action is taken to respond to environmental factors and human activities that affect the Antarctic.


Mount Jackson, Antarctica. Photo credit: Euphro

Under this scenario, Antarctica and the Southern Ocean undergo widespread and rapid change, with global consequences. Warming of the ocean and atmosphere result in dramatic loss of major ice shelves. This causes increased loss of ice from the Antarctic ice sheet and acceleration of sea-level rise to rates not seen since the end of the last glacial period more than 10,000 years ago. Warming, sea-ice retreat and ocean acidification significantly change marine ecosystems. And unrestricted growth in human use of Antarctica degrades the environment and results in the establishment of invasive species.

In the second scenario, ambitious action is taken to limit greenhouse gas emissions and to establish policies that reduce human pressure on Antarctica's environment. Under this scenario, Antarctica in 2070 looks much like it does today. The ice shelves remain largely intact, reducing loss of ice from the Antarctic ice sheet and therefore limiting sea-level rise.

An increasingly collaborative and effective governance regime helps to alleviate human pressures on Antarctica and the Southern Ocean. Marine ecosystems remain largely intact as warming and acidification are held in check. On land, biological invasions remain rare. Antarctica's unique invertebrates and microbes continue to flourish.

## The choice is ours

We can choose which of these trajectories we follow over the coming half-century. But the window of opportunity is closing fast. Global warming is determined by global greenhouse emissions, which continue to grow. This will commit us to further unavoidable climate impacts, some of which will take decades or centuries to play out. Greenhouse gas emissions must peak and start falling within the coming decade if our second narrative is to stand a chance of coming true.

If our more optimistic scenario for Antarctica plays out, there is a good chance that the continent's buttressing ice shelves will survive and that Antarctica's contribution to sea-level rise will remain below 1 metre. A rise of 1m or more would displace millions of people and cause substantial economic hardship.

Under the more damaging of our potential scenarios, many Antarctic ice shelves will likely be lost and the Antarctic ice sheet will contribute as much as 3m of sea level rise by 2300, with an irreversible commitment of 5-15m in the coming millennia.

While challenging, we can take action now to prevent Antarctica and the world from suffering out-of-control climate consequences. Success will demonstrate the power of peaceful international collaboration and show that, when it comes to the crunch, we can use scientific evidence to take decisions that are in our long-term best interest.

*Originally published by The Conversation June 13, 2018*

# These are the world's most innovative cities, and here's why

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Innovation is seen as a key ingredient for successful cities in the 21st century economy, as new technologies constantly emerge to disrupt the status quo. The idea of an "innovative city" can cover a broad range of different styles, sectors and outcomes. It can refer to a city where commercial breakthroughs by world-famous multinational companies occur, or where groundbreaking research is carried out by universities and the public sector, or the places where new ideas are created by startups and entrepreneurs.

To help understand the global system of cities, JLL's Cities Research Centre has identified 10 city "types". Cities within the same category possess a shared DNA with other cities in the group, having similar characteristics, opportunities and challenges.

The "Big Seven" global cities – including New York, Tokyo and London – are the core of this system, and possess strong all-round offers in the modern economy. These are the cities traditionally associated with innovation, home to multinational corporations, a wealth of talent and clusters of world-class universities. However, mid-sized cities and cities in emerging markets are also establishing themselves as sites of innovation, carving out niches for themselves in the modern economy. These two groups have been nicknamed the "Innovators" and the "Enterprisers".

## 1) The Innovators

In recent years, a group of mid-sized cities, mainly in Europe and the US, have become specialists in the knowledge and high-tech sectors, gaining important positions in global networks of innovation. Fittingly, we call these the Innovators. These relatively small cities are gaining a distinct edge over many of their peers as the economy shifts towards technology and research-oriented industries.

Often, these cities attract interest from internationally mobile talent and businesses, due to the perception that they lack many of the negative externalities (for example, lack of affordable housing, environmental problems) of many larger rivals.

However, while these cities share characteristics, that's not to say that they have all taken the same pathway to innovation. Universities, corporations, the public sectors and entrepreneurs all drive innovation in different cities, but each example shares a critical mass of knowledge and expertise.

Some examples of Innovators:

• **Austin** provides a mix of cost, culture, talent and business environment benefits that has led to the small city becoming one of the US's key technology hubs. The major presences of the University of Texas and Texas State University underpin the city's strong talent pipeline which, along with business-friendly policies, have attracted the likes of Dell, IBM, Amazon and Facebook. It has gained the nickname "Silicon Hills" due to the high concentration of technology firms, as well as its position as the leading US metropolitan area for start-up activity in 2016.

• **Berlin** has become a magnet for cosmopolitan, international talent, based initially on its low housing costs and cultural scene. The city is developing its own startups, with Rocket Internet spawning a network of successful companies, including online fashion site Zalando, food delivery service Delivery Hero and HelloFresh, a food box provider. In 2015, Berlin attracted more venture capital funding than either Paris or London, demonstrating Berlin's ability to compete with larger cities. Boston's strengths come from its position as one of the world's leading higher education hubs, home to two of the world's top three universities (MIT and Harvard). This exceptional talent pipeline and research strength means that Boston has emerged as a leader in a number of scientific fields, notably biotechnology and the life sciences.

• **Stockholm** has become known as Europe's "unicorn factory", thanks to its track record of producing $1 billion-plus companies. Only Silicon Valley can outperform the Swedish capital in terms of unicorns per capita. Music streaming service Spotify and Candy Crush Saga developer King Games are two of the city's successful start-ups. This is underpinned by Stockholm's exceptional digital, transport and public service infrastructure.

Investors have recognised the long-term ingredients of success that many of the Innovators possess. Of the 10 city types, they have the second highest level of investment intensity (ie real estate investment as a proportion of economic size), behind only the Big Seven, which includes the world's most popular real estate destinations.

## 2) The Enterprisers

Innovation isn't just about established cities in developed economies. Increasingly, cities in emerging economies are becoming key hubs in global networks of innovation – referred to as Enterprisers. These are highly dynamic cities that have created their own start-up ecosystems and globally competitive companies, becoming magnets for domestic talent as a result.

• **Shenzhen** has built on its reputation for hardware manufacturing to develop its own internationally competitive innovation ecosystem. Internet giant Tencent is based in the city, as are the global hardware firms of Huawei and ZTE. As a result, the city sees the third highest number of patent applications of any city in the world. As China's capabilities grow, Shenzhen is likely to be at the centre of this.

• **Bangalore** established itself as a popular destination for IT-related outsourcing, with successful home-grown companies such as Wipro and Infosys emerging from this context. Now, multinational companies are flocking to Bangalore to take advantage of the city's research and development capabilities, including Google's first R&D centre outside the US. New start-ups, such as e-commerce platform Flipkart and InMobi, India's first unicorn, have emerged from the city's entrepreneurial talent pool.

The Innovators and Enterprisers both reflect the importance of innovation and technology-related strengths in 2018. The Innovators have been able to punch well above their weight by positioning themselves as specialist hubs and key nodes in important value chains. The Enterprisers have developed momentum by using the assets gained as centres of production and outsourcing, and harnessing them to create their own indigenous ecosystems of innovation.

While we cannot be sure how well these cities will respond to new, disruptive technologies in the future, they have the essential ingredients and are well placed to continue their pathways to success.

*Originally published by Weforum.org - Janaury 16, 2018*

Austin, Texas.
Photo credit: Ed Schipul

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# COCKATOO ISLAND

Located in Sydney Harbour, Australia, Cockatoo Island, between 1839 and 1869, operated as a convict penal establishment, for convicts who had re-offended in the colonies. But Cockatoo Island was also the site of one of Australia's biggest shipyards, operating between 1857 and 1991. Convicts built the first of its two dry docks. Although some large workshops, slipways, wharves, residences and other buildings remain, and some significant buildings were demolished after Cockatoo Island closed as a dockyard in 1991, the island is still important for its demonstration of the characteristics of a long-running shipyard and shipbuilding complex, including evidence of crucial functions, structures and operational layout. The site has been managed by the Sydney Harbour Federation Trust since 2001.

In July 2010, UNESCO proclaimed Cockatoo Island as a World Heritage Site, as "the best surviving example of large-scale convict transportation and the colonial expansion of European powers through the presence and labour of convicts". ONE

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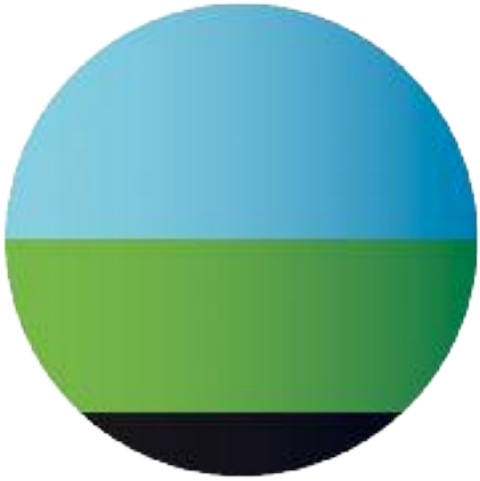

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