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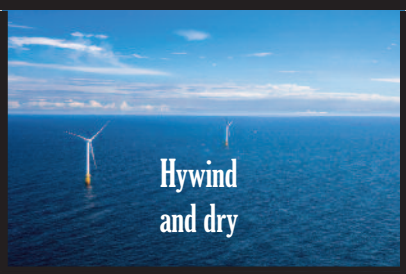
Corridor of Power

The Odd Triangle

Radon smoke it's rising



Hywind and dry

The web of life and climate change dualism

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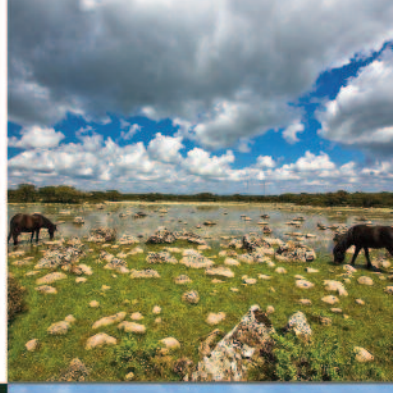



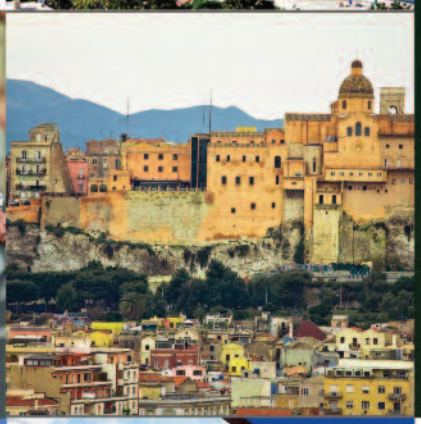


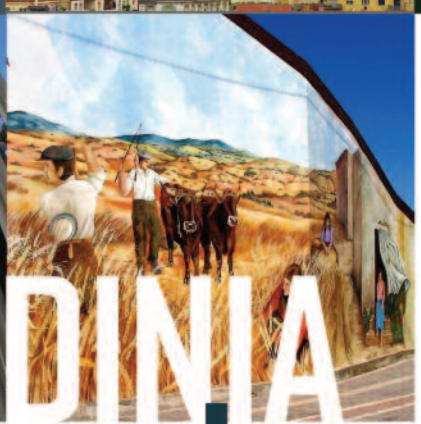


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Editor:
Gianni Serra

Editorial team:
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Toby Lockwood
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Alice Masili
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Contributors:
Sabrina Shankman
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www.onlynaturalenergy.com
info@onlynaturalenergy.com

The odd triangle

Between Cuba, Venezuela and Russia ties run deep, but one thing that divides them is money. Russia has it; the other two need it.

By JEZ ABBOTT

ONE

Venezuela's former leader Hugo Chavez statue in Sabaneta.
Photo credit: Venezuela President Press Office

It used to be missiles; now it's oil, but Cuba is still in crisis. Back in '62 the so-called Cuban Missile Crisis triggered a 13-day stand-off between the United States and the Soviet Union when the latter decided to ship ballistic missiles to Cuba. Fast forward 56 years to 2018 and the threat of a nuclear war may have receded, but war of another kind has rekindled crisis in the Caribbean.

Oil, more specifically Russian oil, is threatening not just a regional trade war, but one with global economic as well as political ramifications. It started just before Christmas in 2017 with a low-key, but nevertheless deliberately publicised meeting between Cuban ruler Raúl Castro and the head of Russia's state-owned Rosneft oil company Igor Sechin.

Few details of the meeting in mid December have been released, but speculation was and remains rife. It is now reported by industry experts that Rosneft will take, or has already taken, a hefty stake in a major refinery in the central south-coastal Cuban town of Cienfuegos. The stake was previously owned by Venezuela, whose former leader Hugo Chávez was a close ally of Cuba's Fidel Castro.

Cuba's President Raul Castro and Russia's President Vladimir Putin in Havana.
Photo credit: Alejandro Ernesto/Pool/Reuters

Unlike the crisis, Hugo Chávez and Fidel Castro are dead. The drama however is being played out by their successors: president Nicolás Maduro and Fidel's brother Raúl Castro. All three nations are tied not just by oil but an ideology rooted in revolutionary socialism. Maduro said in a speech celebrating last year's 100-year anniversary of the Russian revolution: “This is your people, Lenin.”

Russia's response was no less theatrically staunch or politically emotive: Rosneft commissioned a six-metre-high granite statue of the former Venezuelan president, installed in Chavez’s hometown Sabaneta. Addressing the crowd in Spanish Igor Sechin said at the unveiling of the Russian granite figure: “Russia and Venezuela, together forever!”

These ties run deep, but one thing that divides Russia from Cuba and Venezuela is money. Russia has it; the other two need it. The superpower has lent Venezuela billions to keep afloat a like-minded socialist regime mired in poverty. Much of this lending is through loans to the south American nation's state-run oil company PDVSA. Instead of repaying in cash, it pays in oil.

Venezuela's political and economic crisis, combined with Cuba's desperate need for foreign investment, has given Russia a stronger foothold in Latin America creating tensions

This is then resold by the Russians to the tune of an estimated 225,000 barrels a day. Venezuela's political and economic crisis, combined with Cuba's desperate need for foreign investment, has given Russia a stronger foothold in Latin America creating tensions - tensions with unsettling echoes of the missile stand-off of '62. America and its ultra-conservative president are not happy.

“There’s no doubt in my mind,” Arizona's die-hard Republican Trent Franks told the American press, “that Russia has brazenly used the geopolitics of oil, directly propping up of regimes that are antithetical to the United States. They have literally used oil as a strategic weapon.” Oklahoma Republican Tom Cole agrees, saying Russian policy is largely defined be antagonising the USA.

It could go horribly wrong for almost everyone. Russia, like Venezuela, is struggling with international sanctions. Meanwhile the refinery in Cienfuegos, about 250km from Cuba's capital Havana, is producing nowhere near its capacity of 65,000 barrels of crude daily, according to local press reports. Venezuela’s troubles have forced Caracas to cut oil shipments to Cuba that in the heyday and lifetime of Hugo Chávez amounted to 100,000.

The refinery is now processing only about 24,000 barrels per day, with the Russian state company Rosneft picking up the slack. Yet investing in an economy tottering on the edge of collapse is a high-risk strategy and counter to virtually all economic tenets. All of this is happening in the backyard of the USA, something president Donald Trump is watching with mounting alarm.

It's an alarm made worse by Trump himself. The president has become increasingly hostile to Cuba and bent on undoing much of the bridge building undertaken by his arch-enemy and predecessor Barack Obama. New regulations announced last November, for example, ban Americans from any direct financial transactions with 180 entities tied to the Cuban security services.

Yet while the tensions grow between the US under Donald Trump and Cuba, countries like Russia are all too willing to fill the diplomatic, economic and energy gaps along with others such as China and Iran. Oil has emerged as perhaps the most “powerful counterweight to US political and economic statecraft, with the effect of undercutting US objectives in a way that’s alarming policymakers and members of congress”, according to US current affairs channel Vice News.

Responding to the Cuba-Russia oil deal US senator Patrick Leahy admitted Trump's bid to clamp an iron grip on Cuba with sanctions was leaving “a gaping vacuum” for more hostile nations to fill. “The Kremlin has again become the island’s saviour amid a Cuban energy crisis caused by chaos in Venezuela,” Leahy wrote in an editorial. “This alone should set off alarm bells in the White House.”

So as Cuba takes steps to diversify the number of countries it buys oil from and sells its medical and other professional services, the changing nature of the Cuban-Venezuelan-Russian venture at the Cienfuegos refinery continues to capture press headlines and political attention.

Any energy agreement between Russia and Cuba is the result of a “financial triangulation” that also binds in Venezuela, reckons Jorge Piñón, director of the Center for International Energy and Environmental Policy at University of Texas at Austin.

The unfolding crisis of this triangulation is as fresh as the 13-day Cuban Missile Crisis is distant. But the dynamics and the dramatics are startlingly similar - days of international tension, petulant diplomatic posturing and icy political stand-off. Only the outcome of one - eventual resolution - could be wildly different from the other. ONE

Corridor of Power

How China is pouring investment into Pakistan's energy sector

By TOBY LOCKWOOD

ONE

For over a decade Pakistan's growing economy has been held back by a chronic shortage of electricity; supply has often fallen short by over 20% as roll-out of new power plants persistently lagged behind a rapid growth in demand. This situation has now begun to change fast, with several new power plants coming online in the past year and many more under construction or planned.

Driving the change is a massive influx of Chinese investment and engineering expertise known as the China-Pakistan Economic Corridor (CPEC) – a grand vision to connect Western China to the Arabian sea by modernising Pakistan's energy and transport infrastructure.

Closely related to China's 'Belt and Road initiative' which is investing in infrastructure and trade links throughout Eurasia, the main focus of CPEC is to provide China with a fast connection to Pakistan's deep water port at Gwadar, but the $62 billion worth of projects also encompasses over 16 GW of new generation capacity in the energy sector. Still more Chinese investment, through export credit agencies and development banks, is flowing into Pakistan's energy sector outside of the official umbrella of CPEC, carrying similar obligations to use mostly Chinese equipment and engineering.

Pakistan's historic power generation problems have been exacerbated by an unusual reliance on burning the petroleum product 'fuel oil' in many of its power stations, making up around a third of its electricity supply in 2015. More expensive than gas and as dirty as coal, this liquid fuel has widely fallen from favour as a way to generate electricity outside of oil-rich states and small islands. As a relatively small-time oil producer, Pakistan has relied on imports to feed its power plants, and began to feel the pinch when oil prices soared in the 2000s.

Hydroelectric plants in the country's mountainous north provide another significant contribution, as well as some gas and nuclear plants, but coal – the cheap fuel of many a developing nation – is conspicuously absent from the mix. Pakistan discovered vast coal reserves in the Thar desert in the early 90s, but has been slow to exploit the resource, while sometimes using it as a barganing chip in climate negotiations. Thar coal is the watery, low-energy variety known as lignite, which is not worth transporting any distance, but is mined worldwide in huge opencast pits and fed directly to nearby power stations.

Coal will be the biggest winner from China's investment, as over 10 GW of Chinese-built coal power plants are deployed over the next few years, and nearly all of them feature on CPEC's list of priority projects poetically known as the 'early harvest'. The Thar coal field has been divvied up between a handful of new companies formed by Pakistani and Chinese investors, and one power plant is already under construction.

However, even further ahead are coal plants elsewhere in the country which do not exploit Pakistan's resource at all, instead relying on shipments of coal from Indonesia and South Africa. Two of these, one in the port of Karachi and one in Punjab are already operating, and another in the western province of Balochistan is set to be completed next year. While these projects can move faster without having to rely on construction of the new mines, there is some political dissent over the country taking the proverbial coal to Newcastle rather than drawing on its own natural wealth. Provincial tensions have also come into play, with regions such as Punjab keen to secure their own power plants rather than relying on electricity transmitted from the new coal fields.

Exploitation of the Thar coal fields is mired in controversy over its potential environmental and social impact. Local villagers have taken the Sindh Engro Coal Mining Company to court in protest against an enormous (600 hectare) reservoir needed to contain effluent from the mine, which they fear may contaminate their land and water. The company maintain that the area will be fully rehabilitated following the mining, and have sought to appease residents with an elaborate corporate responsibility campaign, including new homes, schools, a hospital, and pledges to hire locally. On an international level, the high CO2 emis-

Pakistan Prime Minister Shahid Khaqan Abbasi in Boao, China.
Photo credit: CPEC

sions inextricably associated with the use of such low-grade coal has also sparked the concern of climate activists, and it is suspected that climate concerns were a significant factor in the withdrawal of the World Bank from the project in 2009. While the bank gave more prosaic financial reasons for its exit, it has since hugely reduced coal project financing, joining other major development banks such as the European Investment Bank; such environmental scruples do not tend to pose a problem for the Chinese lenders.

Nevertheless, China leads the world in deployment of renewables as well as coal, and these cleaner energy sources have not been ignored by CPEC. The 1000 MW Quaid-e-Azam Solar Park will become one of the world's largest solar power plant when it is completed later this year, 250 MW of wind farms have already sprung up, and three large hydroelectric projects are scheduled to start generating in the early 2020s. Although mostly outside of the sphere of CPEC, Chinese investment is also seeking to play a role in the ongoing expansion of Pakistan's infrastructure for importing liquefied natural gas (LNG), but faces much fiercer global competition in a sector fraught with geopolitical complications.

Plans to construct an Iran-Pakistan gas pipeline have long been on hold due to international sanctions on Iran, while US pressure has favoured LNG ship terminals for imports from Qatar. China had backed a pipeline to the port of Gwadar (which lies close to the Iranian border), with the option of eventually connecting to the Iranian pipeline, only for Pakistan to abandon the plan last year in response to US and Saudi pressure. Undeterred, China has sought to become involved in Russian-led plans to build another pipeline north from new LNG terminals in Karachi. This pipeline would help fuel three state-of-the-art gas power plants in Punjab, recently completed by Chinese engineering contractors using GE equipment.

This rapid growth in Pakistan's power generation capability may turn the energy shortage into a surplus by the end of 2018, but it has not been without criticism. Many commentators in Pakistan have urged for a slowdown and rethink of the country's energy priorities, either to reduce dependence on imported gas and coal, or to shun Thar coal in favour of cleaner, renewable energy. However, with Pakistan's per capita energy consumption still a fraction of the global average, and the International Energy Agency forecasting a doubling in demand by 2025, it seems likely that the Chinese power projects will fulfil a real need. CPEC and the far-reaching Belt and Road Initiative have come under suspicion as a means of expanding China's political influence among its neighbours and beyond.

On a more practical level, international infrastructure projects are providing an outlet for China's vast engineering and construction capacity, as the frantic modernisation of China itself subsides. Whatever the primary motivation, it is clear that CPEC represents just one story in a key trend for energy financing in the developing world: the influence of multilateral development banks is receding, to be replaced in part by Chinese institutions with much less-demanding criteria for environmental protection or market reform. ONE

We can pull CO2 from air, but it's no silver bullet for climate change, scientists warn

Europe's science academies say policymakers are being 'seriously over-optimistic' about carbon capture technologies, but that doesn't mean giving up.

By SABRINA SHANKMAN
Inside Climate News

While technologies are being developed that can remove carbon dioxide from the air, they aren't yet feasible on the scale needed to slow global warming, Europe's national science academies warn in a new report.

A wide array of technologies—from land management to ocean fertilization to capturing carbon dioxide from the air and storing it—are in various stages of testing and use, but according to the European Academies' Science Advisory Council, climate scientists and policymakers are being "seriously over-optimistic" about how much these approaches can help deal with the global warming crisis.

In recent years, climate experts have suggested that it's not enough to just decrease the amount of greenhouse gases emitted. To avoid more than 2 degrees Celsius of global warming this century, they say, net emissions will have to fall to zero within a few decades, and it's worth considering "negative emissions"—steps that subtract pollution from the atmosphere to offset what is being added.

But despite the appeal of that notion, which in theory allows the world to overshoot its emissions budget for a while and make up the difference later, the new report warns against banking on it.

"These technologies offer only limited realistic potential to remove carbon from the atmosphere, and not at the scale envisaged in some climate scenarios," wrote the report's authors, a group of experts representing the national science academies of the European Union member states, Norway and Switzerland.

The global efforts to slow warming typically rely on two methods: enacting policies to drastically reduce greenhouse gas emissions and developing technologies that can remove CO2 from the atmosphere.

While the policy side of mitigating the crisis made great strides with the Paris climate agreement of 2015, on the negative emissions side, there are still more questions than answers.

That's troubling, because most of the pathways laid out by the UN's Intergovernmental Panel on Climate Change (IPCC) rely on deploying negative emissions approaches by the middle of this century.

The inclination to think that technological breakthroughs will eventually save the day may be dangerous, warns Thierry Courvoisier, president of the European Academies' Science Advisory Council.

"It is no exaggeration to see responding to the real threats of climate change as a race against time: the longer action is delayed, the more acute and intractable the problem becomes," he wrote in the report's foreword. "If such technologies are seen as a potential fail-safe or backup measure, they could influence priorities on shorter-term mitigation strategies."

But others say it's also a mistake to rely wholly on emissions cuts, which are unlikely to come fast enough to avoid a crisis.

Klaus Lackner, the director of Center for Negative Carbon Emissions at Arizona State University, explains it with an analogy: The global emissions trajectory is like being in a car that's careening toward a curve. Just taking your foot off the gas (slowing emissions) isn't enough, Lackner says—you need to step on the brake, too, and remove some of what has already been emitted.

"I know that with that curve coming in front of us, we are going to hit the guardrail," Lackner said. "My way of looking at it is not 'can we avoid hitting it,' but 'can we avoid a rollover'."

What's Challenging These Technologies?

The EU scientists' conclusion that negative emissions technologies represent more of a wish than a promise followed an exhaustive review of academic studies on each technology. The report examined seven technologies and weighed how likely

each was to make a difference on global climate:

Afforestation and reforestation: Simply put, more trees means less carbon in the atmosphere. But offsetting emissions from fossil fuels would require huge forests, competing with food production and posing other problems.

Land management to increase carbon in soil: Changing agricultural practices to increase the carbon stored in soil could make a significant contribution, but these practices can be easily reversed if farming returns to more intensive methods.

Bioenergy with carbon capture and storage: Burning trees or other crops instead of fossil fuels in power plants, then capturing the CO2 from the smokestacks and storing it underground, would require huge tracts of land and risky changes to ecosystems.

Ocean Fertilization: A variety of corals form, part of the Great Barrier Reef near Cairns, Queensland, Australia.
Photo credit: Toby Hudson

Enhanced weathering: By adding minerals to oceans and soils, enhanced weathering is expected to be able to remove carbon, though on a smaller scale than the other technologies being explored. As of now, however, there are no projects to test the feasibility.

Direct air capture and storage: When air flows past a direct capture system, the carbon dioxide is selectively removed. It's then released as a concentrated stream for disposal or use. This technology is currently in operation on a small scale, but the size and cost of the equipment could get in the way of scaling it up.

Ocean fertilization: Tiny plants in the ocean take up CO2, then die and sink to the ocean floor. Enhancing this process, such as by adding iron to stimulate phytoplankton growth, could have a substantial impact on atmospheric CO2 concentrations over several decades to centuries. But there are drawbacks, including risks from algal blooms and other ecological damage.
Carbon capture and storage: This basically is a way to continue burning fossil fuels by capturing their greenhouse gases and storing them, keeping them out of the atmosphere. Technology and policy experts have been hoping to make it work for years. But so far, CCS has not proven affordable, and governments have been unwilling to pay for it on a large scale. A few projects are up and running, but many others have been cancelled.

That Doesn't Mean Abandon the Work

The report's authors aren't suggesting that the technology should be abandoned—just that its limitations have to be fully understood. "In the event of mitigation failing to deliver a safe future operating space for humanity, failure of such technologies to deliver would then condemn humanity to a dangerously warming world," the authors wrote.

Lackner said the high-stakes nature of the climate change battle are precisely why both mitigation and technology need to be pursued simultaneously.

"We have a demonstrated record of having not succeeded with mitigation alone," he said. "We, at this point, have reached a point where even heroic efforts won't get you there."

He believes the most likely candidate is direct capture of carbon dioxide from air. "The reason the cost is high is because it's new," he said. "If you look at PV (photovoltaic solar energy), it's 100 times cheaper now than in 1960."

Peter Kelemen, a professor of earth and environmental science at Columbia University, said he favors an "all of the above" approach. "It is a mistake to wait for complete implementation of other mitigation approaches, since meanwhile huge damages will accrue, and we will be left focusing on the consequences, rather than attempting to avoid the damages in advance," he said.

Kelemen sees the most potential in technologies that aim to emulate natural processes.

"We should be ready to implement negative emissions at scale if, in 10 years, progress in the energy transition and/or greenhouse gas capture has not been sufficiently fast to avert huge damages due to climate change," he said. "The rest is guesswork. And politics."

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The web of life and climate change dualism

By LENORE M. HITCHLER

ONE

Imagine an intricate and infinite web. This web represents the interrelationship among all life forms both with each other as well as the rest of the planet. More than two centuries ago, the scientist Alexander von Humboldt originated the concept of both the web of life and climate change. Unfortunately, climate change unequivocally has become rampant and will continue to alter the web of life.

To fully comprehend the extent of climate change it is necessary to understand the web of life and that removing one strand of the web will disrupt the whole. Many species will become more prolific while numerous species will eventually become extinct. Humboldt's research and original analysis about both the web of life and climate change influenced many naturalists, scientists and philosophers who came after him, including Darwin, John Muir, Thoreau, and others who are less well known. In turn, these followers of Humboldt added to the discussion about the web of life and climate change.

Andrea Wulf is the author of *The Invention of Nature—Alexander von Humboldt's New World*. Wulf points out that besides influencing some of the most important scientists of his time, Humboldt influenced many others. Wulf provides many examples of this. United States president Thomas Jefferson called Humboldt "one of the greatest ornaments of the age."

Humboldt also inspired philosophers and poets. Ralph Waldo Emerson said that Humboldt was "one of those wonders of the world," and "no one knew more about nature than Humboldt." Emerson also said that only Napoleon was more famous than Humboldt. Edgar Allan Poe's poem *Eureka* was dedicated to Humboldt and was a response to Humboldt's book Cosmos. Walt Whitman was also inspired by Humboldt. Many geographical sites and phenomena were named after Humboldt, including the Humboldt current, glaciers, mountains, rivers, lakes, towns, and parks. Several minerals and around 300 plants and 100 animals were named in his honor.

Researchers in different branches of science study climate change, including naturalists. Naturalists are defined as scientists who study natural history, comprised of botany, zoology, and mineralogy. The words naturalist and scientist are used interchangeably throughout this article.

The concept of the web of life is similar to the contemporary concept of ecosystems. The online site of the University of Illinois Extension—Natural Resources, the Environment and Ecosystems provides a good explanation of how ecosystems work:

> *An ecosystem is made up of all the living animals and plants and the non-living matter in a particular place, like a forest or lake. All the living things in an ecosystem depend on all the other things – living and non-living for continued survival – for food supplies and other needs.*

In some ways the actions and reaction that take place within an ecosystem are like a spider web – when one strand is broken, the web starts to unravel. What affects one part of an ecosystem, affects the whole in some way. The idea of the web of life is shown by the interdependence within an ecosystem. Animals and plants depend on a complex system of food for survival. Since the word "ecosystem" was not in use during Humboldt's lifetime, the term "web of life" is used throughout this article.

In *The Invention Of Nature* Wulf presents an excellent summary of Humboldt's life and work. He was in the vanguard of scientists to understand both the web of life and climate change. This shows the brilliant foresight of Humboldt as he was born in 1769 in Prussia. Wulf's book contains biographical information and provides a summary of Humboldt's achievements, as well providing accounts of how he influenced the naturalists and scientists who came after him. Humboldt was extremely knowledgeable about many subjects, and he had an insatiable curiosity about how the planet functions.

According to Wulf, he was the most famous scientist of his age. He authored many books and he inspired many naturalists who came after him. Humboldt devoted much of his life to original research and reporting his findings.

Wulf writes eloquently and her book is both enlightening and captivating. Interspersed throughout the book are references to both the web of life and climate change. Many scientists are extremely poetic and eloquent when they write about the concept of the web of life. Therefore, it is necessary and appropriate to quote extensively from their work. Wulf writes about Humboldt and the web of life:

> *In this great chain of causes and effect, Humboldt said, 'no single fact can be considered in isolation.' With this insight, he invented the web of life, the concept of nature as we know it today. When nature is perceived as a web, its vulnerability also becomes obvious. Everything hangs together. If one thread is pulled, the whole tapestry may unravel. … Everything that he had ever observed fell into place. Nature, Humboldt realized, was a web of life and a global force. He was, a colleague later said, the first to understand that everything was interwoven as with 'a thousand threads.' This new idea of nature was to change the way people understood the world.*

Henri Lehmann portait of Baron Alexander von Humboldt (1769-1859)

Thus, Humboldt was aware that to know how the planet functions as a whole, the relationships between the various facets must be understood. If one aspect is removed, the entire structure can unravel.

Aaron Sachs adds more information to our knowledge of Humboldt and the web of life. Sachs, PhD, is a history professor at Cornell University and the author of The Humboldt Current: Nineteenth-Century Exploration and the Roots of American Environmentalism. He quotes Humboldt as stating that: *"In considering the study of physical phenomena … we find its noblest and most important result to be a knowledge of the chain of connection, by which all natural forces are linked together, and made mutually dependent on each other." Just as Humboldt writes artistically, Sachs also waxes poetic in The Humboldt Current stating: "Tug on one strand in the web of life, and the whole structure quivers."*

Humboldt was not the only author of his time period who wrote about the web of life. **Johann Wolfgang Goethe** was his friend and colleague, and the two men influenced each other. Goethe was also a German scientist and author. He writes eloquently and poetically about how everything is connected. His poetry summarizes the workings of the web of life. *In Faust*, he writes "How it all lives and moves and weaves into a whole! Each part gives and receives." Goethe's writings about the web of life reinforce those of Humboldt.

Ernst Haeckel, who lived from 1834 to 1919, was a German zoologist and another follower of Humboldt. According to Wulf, Haeckel "took Humboldt's idea of nature as a unified whole made up of complex interrelationships and gave it a name. Haeckel said *ecology* was the 'science of the relationships of an organism with its environment.'"

Charles Darwin wrote about both the development of new species and the extinction of old species which certainly impacts the web of life. Darwin is one of the pioneers of evolution. According to Wulf, he paid deep homage to Humboldt. In fact, Darwin wrote "Nothing ever stimulated my zeal so much

as reading Humboldt's Personal Narrative." Darwin said that he would not have undertaken his voyage on the Beagle or even conceived of the *Origin of Species* without Humboldt's influence. The article entitled "Alexander von Humboldt Pioneered the Science Now Used to Study Climate Change" was published in *The Economist*. According to the anonymous author of the article, Darwin stated that "I have always admired him, now I worship him." Darwin's work reinforces the concept of both the web of life and climate change. Extinctions and the development of new species certainly alter the web. In the past, climate change has led to mass extinctions and new life forms emerged. It is reasonable to assert that the predicted continued change in climate will likewise lead to mass extinctions and thus alter the web of life.

Aaron Sachs reinforces our knowledge of Darwin's enthusiasm toward Humboldt. Sachs is the author of "Humboldt Legacy and the Restoration of Science" published in *World Watch*. This article corroborates Wulf's work on Humboldt. According to Sachs, Darwin wrote "my whole career is due to having read and reread" Humboldt's personal *Narrative to the Equinoctial Regions of America*. Sachs also wrote that the only books Darwin brought with him on his voyage on the Beagle were the Bible, Milton, and Humboldt's Personal Narrative. Sachs states that Darwin often sent his manuscripts to Humboldt to read and make comments. According to Sachs: "Darwin was fascinated with the idea of nature as a 'web' – 'we may all be netted together,' he mused in the late 1830s – and strong ecological currents run through many of his early writings."

Henry David Thoreau also held Humboldt in high esteem. Like Humboldt, he was an extremely eloquent author. For example, Thoreau said: "The true harvest of my daily life is somewhat as intangible and indescribable as the tints of morning or evening. It is a little star-dust caught, a segment of the rainbow which I have clutched." Wulf states:

> *Thoreau read Humboldt's most popular books: Cosmos, Views of Nature and Personal Narrative. Books on nature, Thoreau said, were 'a sort of elixir.' As he read, he was always noting and scribbling. 'His reading was done with a pen in his hand,' one friend remarked. During these years, Humboldt's name appeared regularly in Thoreau's journals and notebooks as well as in his published work. Thoreau noted "'Humboldt says' or 'Humboldt has written.' '*

According to Wulf, Thoreau was so influenced by Cosmos that he rewrote his classic *Walden*. Thoreau was not only influenced by Humboldt's concept of the web of life but also his botanical concepts. Professor Sachs in the Humboldt Current states that when classifying New England's climate zones, Thoreau used Humboldt's model of plant ecology.

Richard B. Primack, PhD, is the author of *Walden Warming –Climate Change Comes to Thoreau's Woods*. He teaches biology at Boston University and is also the author of several textbooks on conservation biology and one of the editors of the international journal, Biological Conservation. In private correspondence Primack describes Humboldt's influence on his career, Primack writing:

> *I have been strongly influenced by Humboldt in three ways: I now realized that the style of careful and often quantitative observations made by Thoreau, and which contributed to my own research, were in fact developed by Humboldt. I have now read the writings of Humboldt and I have learned new ways of observations in his style. And third, I received a Humboldt Research Award from the German government which facilitated my climate change research.*

In his book, Primack also describes the web of life. He states that "nature is a web of relationships, in which every change in one plant or animal species has consequences for many other plants or animal species."

Wulf includes another example of Humoldt's eloquence about the web of life in "What Thoreau Saw" published in *The Atlantic* magazine. In this article she quotes Humboldt as saying: "A vast array of observations revealed 'unity in diversity – each fact and detail of nature threading together into an interconnected whole."

The naturalist **John Muir** was another admirer of Humboldt. Muir read Humboldt and was influenced by his work. Wulf stated that when Muir was young said "How intensely I want to be a Humboldt." Wulf writes about Muir and the web of life:

> *'When we try to pick out anything by itself, we find it hitched to everything else in the universe,' he later wrote in his book My First Summer in the Sierra. Again and again, Muir returned to this idea. As he wrote of 'a thousand invisible cords' and 'innumerable unbreakable cords,' and of those 'that cannot be broken,' he mulled over a concept of nature where everything was connected. Every tree, flower, insect, bird, stream or lake seemed to invite him "to learn something of its history and relationship and the greatest achievements of his first summer in Yosemite, he said, were 'lessons of unity and inter-relation.' … Muir marked in his copy of Views of Nature and Cosmos the sections where Humboldt had written about the 'harmonious co-operation of forces' and the 'unity of all the vital forces of nature,' as well as Humboldt's famous remark that 'nature is indeed a reflex of the whole.'*

Contemporary scientists also follow in Humboldt's footsteps when they discuss the web of life. For example, Wulf states that Silent Spring by Rachel Carson is based on Humboldt's concept of interconnectedness. She also writes that James Lovelock's Gaia theory says the earth is a living organism and is similar to Humboldt's web of life. In fact, Humboldt originally thought of calling his last book Gaia. However, he finally titled it Cosmos. Carl Sagan in his own Cosmos, writes Humboldt's Cosmos is a "broad-gauge popularization of all of science." Interestingly enough, Sagan's Cosmos is also a popular book about the entire field of science. Since Sagan was obviously familiar with

Lake Valencia, Venezuela. Photo credit: NASA

Humboldt's Cosmos it is reasonable to speculate that Sagan was influenced by Humboldt. In his own Cosmos, Sagan writes poetically about interconnections. Sagan states: "There are a million threads from the past intertwined to make the ropes and cables of the modern world."

Just as Humboldt explored the planet, it is necessary to explore his influence on the climate change movement. From 1799-1804 Humboldt traveled around North and South America. As a result of Humboldt's explorations, he became concerned about climate change. According to Wulf, Humboldt was the first person to describe human-induced climate change. One of the places he visited in 1800 was Lake Valencia, Venezuela. Humboldt's research on the area around the lake led him to formulate his ideas on climate change. According to Wulf:

> *Now at Lake Valencia, Humboldt began to understand deforestation in a wider context and projected his local analysis forward to warn that the agricultural techniques of his day could have devastating consequences. The action of humankind across the globe, he warned, could affect future generations. What he saw at Lake Valencia he would see again and again from Lombardy in Italy to southern Peru, and many decades later in Russia. As Humboldt described how humankind was changing the climate, he unwittingly became the father of the environmental movement.*

Thus, Humboldt can be considered the father of both the climate change and the environmental movements. Humboldt devoted many years writing about what he had learned on this expedition. He pursued his goal to explore India but was stymied in his objective, and unfortunately was never able to do so. However, in 1829, Humboldt was able to explore Russia. He visited St. Petersburg, Moscow, and traveled through parts of Siberia. He wrote two books about this expedition, and he listed three ways that humans were changing the environment. These were deforestation, irrigation, and the 'great masses of steam and gas' produced in industrialist centers. In Saint Petersburg he presented a speech about climate change. Humboldt stated he would like to have data collected showing the effects of deforestation on the climate and that this endeavor would be the first large-scale study to research the impact humanity had on the climate. According to Wulf, "he even prophetically warned about deleterious gas emissions at industrial centers." Humboldt wrote "the great masses of steam and gas produced by industry" are the causes of climate change." Andreas Moser adds in "Humboldt Discovered Man-made Climate Change," that Humboldt "predicted that man-made interventions would lead to irreversible climate change."

There is still another important way in which Humboldt contributed to climate change research. Humboldt created isotherms, which are the wavy lines on maps pointing to different areas having the same temperature at a given time. Isotherms are still used by climatologists to aid in understanding climate change.

Just as Humboldt was concerned about climate change, so was Muir. A traveling display from the Wisconsin Historical So-

ciety referred to Muir's study of glaciers in California and Alaska in the 1870s. He described how warming climates had changed glaciers over time. According to the exhibit, Muir stated: "How much longer this little glacier will live will, of course, depend upon climate and the changes slowly effected in the form and exposure of its basin."

George Perkins Marsh was an American diplomat, linguist, and author who lived between 1801 and 1882. While not as well known as the major naturalists, he influenced such people as Gifford Pinchot who was the first Chief of the US Forest Service. Pinchot is the father of the utilitarian conservationists, who believe even though we can use some natural resources, we should not use them up, and we should save some natural resources for future generations. Marsh thought highly of Humboldt. According to Wulf, Marsh maintained an entire section in his personal library of books authored by Humboldt. Marsh himself is the author of Man and Nature: Physical Geography as Modified by Human Action.

Assel and Herche: "Lake ice is a sensitive indicator of climate and climate trends".

Leo Hickman is an environmental journalist who has written about Marsh. Hickman writes that Marsh "is considered to be America's first environmentalist." Hickman wrote that when Marsh was a U. S. congressman in 1847, he gave a lecture to the Agricultural Society of Rutland County, Vermont that predicted human-induced climate change. Marsh wrote about the industrial system in a way that was extremely complex and difficult to understand in the present time. However, the following passage shows that Marsh foresaw that industrialism was going to alter the climate in an adverse way:

Man cannot at his pleasure command the rain and the sunshine, the wind and frost and snow, yet it is certain that climate itself has in many instances been gradually changed and ameliorated or deteriorated by human action. The draining of swamps and the clearing of forests perceptibly effect the evaporation from the earth, and of course the mean quantity of moisture suspended in the air. The same causes modify the electrical condition of the atmosphere and the power of the surface to reflect, absorb and radiate the rays of the sun, and consequently influence the distribution of light and heat, and the force and direction of the winds. Within narrow limits too, domestic fires and artificial structures create and diffuse increased warmth, to an extent that may effect vegetation. The mean temperature of London is a degree or two higher than that of the surrounding country, and Pallas [Peter Simon Pallas, 1741-1811, was a Prussian zoologist and botanist who explored Russia from 1767-1810] believed that the climate of even so thinly a peopled country as Russia was sensibly modified by similar causes.

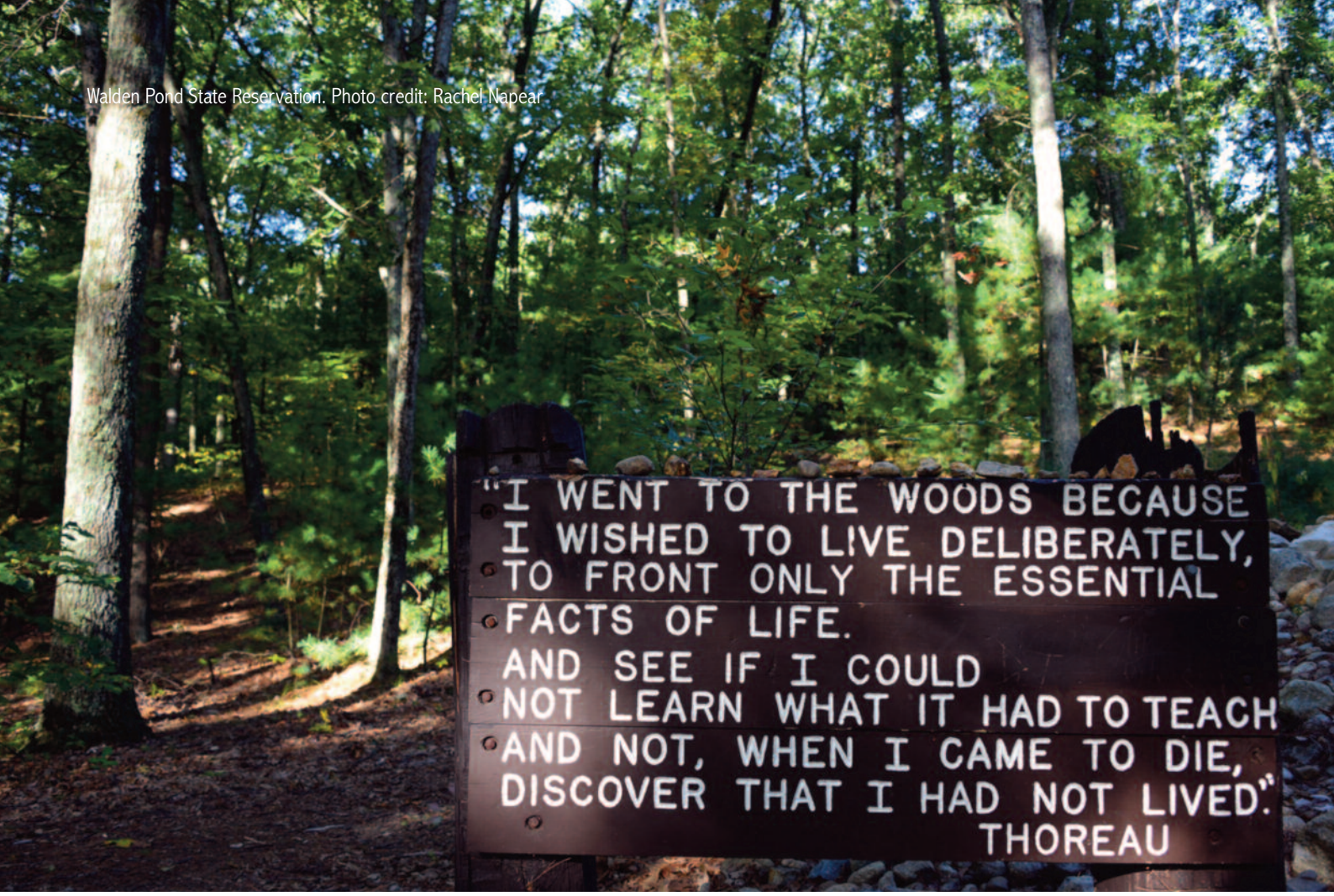
According to Hickman, "Some of the terminology he uses is clearly a little archaic to our ears today, but, broadly speaking, his hunch has subsequently proved to be correct. You can see him grappling with concepts that we now know as the urban heat island effect and greenhouse effect."

R.A. Assel and **L.R. Herche** are the authors of *"Ice-on, ice-off, and ice duration for lakes and rivers with long-term records."* This article states that "Lake ice is a sensitive indicator of climate and climate trends. Ice formation and loss are indices of integrated air temperature over late-fall-to winter, and winter-to-spring periods." According to Thoreau's records, the average date of ice-out was April 1. Between 1995 and 2009, the average date of ice-out was March 17. Primack finds that "ice-out occurs three days earlier for each single degree Fahrenheit increase in temperature during the first two months of the year."

Primack notes that the map of United States plant hardiness zones has been revised by the Department of Agriculture to reflect higher temperature ranges. Many plant hardiness zones in New England have been reclassified so that they are now are equal to the immediate zone to their south reflecting the fact they are now warmer than they had been previously.

Primack also uses phenology to show various responses to the climate change around Walden Pond. According to the online definition from the Merriam-Webster dictionary site, phenology is: "a branch of science dealing with the relations between climate and periodic biological phenomena (such as bird migration or plant flowering.)" Walden Pond is located in Concord, Massachusetts and Thoreau observed and kept records of when plants flowered throughout the area. Thoreau's records are Primack's starting point and he returns to Thoreau's records time and time again.

Primack states that his research found plants are responding to warmer weather in Massachusetts by flowering around 1.7 days earlier for each degree Fahrenheit increase in temperature. Primack is a co-author of an article entitled *"Phylogenetic*



Walden Pond State Reservation. Photo credit: Rachel Napear

Patterns of Species Loss in Thoreau's woods Are Driven by Climate Change" in PNAS [Proceedings of the National Academy of Sciences.] This article states that: "the mean annual temperature in the Concord area has risen by 2.4 degree Centigrade over the past 100 years and that this temperature change is associated with shifts in flowering time: species are now flowering an average of 7 days earlier than in Thoreau's time." In his book, Primack also refers to a study that found that wild bees in the eastern United States fly 2.0 days earlier in the spring for each degree Fahrenheit of warmer temperatures. Primack also stated that the range of honeybee's pathogens could be enlarged by a warmer wetter environment.

Other scientists have researched the changing patterns of vegetation caused by climate change. For example, Humboldt's research was used to investigate whether the vegetation on the volcano that Humboldt climbed and wrote about had changed.

The article "Strong Upslope Shifts in Chimborazo's Vegetation Over Two Centuries Since Humboldt" was published in PNAS. In 1802, Humboldt climbed the Chimborazo volcano located in Ecuador. Scientists restudied the vegetation of the volcano in 2012. They found that the distribution of vegetation zones moved higher up the volcano. Some species moved higher by around 500 meters, which is around 546 yards. David Bressan is the author of "Old Plant Surveys show How Modern Climate Change Is Threatening High Altitude Species" published in *Science*. Bressan adds further information about the results of climate change on the Chimborazo volcano:

> *Humboldt mapped the upper limit of any plant life at 15,091 feet, the new research found seedlings at 17,011 feet. The vegetation follows the melting glacier, 200 years ago ice was found at 15,793 feet, now the glacier retreated to 17,290 feet. Some plants from lower altitudes were found almost 1,600 feet higher than during Humboldt's time.*

The same article reported that temperatures rose in the Alps since the nineteenth century by almost 2 degrees Celsius [3.6 degrees Fahrenheit.] The tree line has moved by almost 330 feet in certain areas. Thus, South American and European findings show the movement of plants to higher ranges on mountains. In other words, climate change has affected the web of life throughout various locations on the planet.

Thus, using the concept of the web of life is a good way to analyze the ecology of the planet and is an appropriate metaphor to analyze the effects of climate change. Climate change is causing some species to increase both their range of their habitat and their population. Other species will become extinct. Humboldt was in the forefront of warning about this phenomenon two centuries ago. His many followers contributed to contemporary scientific thought on the earth's ecosystems which help us to understand both climate change and the web of life. The web of life is fraying. However, mankind unravels the web of life at its own peril.

Radon smoke: You can't see it but it's rising!

By EUSEBIO LORIA

ONE

Warning: "Radon is all around us. You are now entering a radioactive area.". It could be the sign at your front door. Would you stay - or would you turn round into the open air?

Globally Harmonized System of Classification and Labelling of Chemicals (GHS), pictogram for substances hazardous to human health

It is an invisible, odourless gas that seeps out of the ground and it is called radon.

Radon is a natural radioactive gas produced by the decay of uranium 238, which is present throughout the Earth's crust. In the open air, radon causes no problems. We all breathe it. But it can seep into buildings through cracks and holes in the foundations, where it can rise up to dangerous levels.

The most important pathway for human exposure is permeation of radon gas into buildings, but radon from water, outdoor air and construction materials can also contribute to the total exposure. What makes it dangerous is that, being odourless and colourless, it is easy to ignore. Professor Sir Richard Peto, a well-known cancer epidemiologist, once remarked: "If only it were blue and people could see it they would take it seriously, but unfortunately it isn't."

At home we are at risk from unsafe exposure to indoor radon gas, which may cause lung cancer. Smoking is the leading cause of lung cancer. Radon is the number one cause of lung cancer among non-smokers. The largest and most rigorous study of radon, published in 2004, showed that the gas is responsible for about 20,000 deaths from lung cancer in the European Union each year. The research combined the results from 13 studies and showed that smokers were at greatest risk. Worldwide, radon causes a million deaths every decade. Neil McColl, of the HPA's Centre for Radiation, Chemicals and Environmental Hazards, says: "The scientific evidence has shown that the lung cancer risk is proportional to the long-term exposure to radon. There is no safe or unsafe level. We want to keep our focus on homes above 200 becquerels (bq) but we also want to make sure that people who are reducing the level should not think that below 200 they are safe. The risk is smaller, but it is not zero – particularly if they are smokers or ex-smokers."

Previous warnings about the risks have been based on evidence from miners who were exposed to high levels of radon while working underground. Current policy in house building is to identify areas where radon levels are high, seal the foundations of new homes with gas-resistant membranes and advise existing home owners how to reduce their

Professor Sir Richard Peto: "If only Radon were blue and people could see it they would take it seriously, but unfortunately it isn't."

Regulators, as well as many scientists, didn't take much notice of contaminant intrusion until the 2000s.

exposure by building a radon sump. Home owners have to create a radon sump by digging below the foundations and installing a fan and pipe to blow the gas to the outside. But nowaday it's not safe to focus on radon high radiation. The national policy could force the installing of sealed membranes in all new homes, regardless of where they are built.

Indoor pollution, much more than tobacco smoke

Many of us might spend up to 90 % of our day indoors — at home, work, school or in the cars. The quality of the air we breathe indoors also has a direct impact on our health. What determines indoor air quality? How can we improve indoor air quality? The quality of air in our homes, work places or other public spaces varies considerably, depending on the material used to build it, to clean it, and the purpose of the room, as well as the way we use and ventilate it.

Smoking is not the only source of indoor air pollution. Erik Lebret from the National Institute for Public Health and the Environment (RIVM) in the Netherlands says "Air pollution does not stop at our doorsteps. Most outdoor pollutants penetrate into our homes, where we spend most of our time. The quality of indoor air is affected by many other factors, including cooking, wood stoves, burning candles or incense, the use of consumer products like waxes and polishes for cleaning surfaces, building materials like formaldehyde in plywood, and flame retardants in many materials. Then there is also radon coming from soils and building materials."

According to the latest report by the World Health Organization (WHO) titled "Ambient Air Pollution: a global assessment of exposure and burden of disease", air pollution (outdoor and indoor) is the main environmental risk factor for the health of the world population. "Between 1930 and 2000 the global production of man-made chemicals increased from 1 to 400 million tons a year - says Professor Alessandro Miani, President of SIMA ONLUS - and in the last 50 years man has released about 80 thousand new chemicals into the environment ".

The indoor air is basically the same as the external air, but with different quantities and types of contaminants. The health effects of exposure to indoor air pollutants are a function of several factors: time spent in a certain environment, the actual air pollutant concentration, temperature and humidity levels. Since most people spend 85–90 % of their time indoors, indoor sources actually provide most of the personal exposure to certain chemicals. Measures to improve indoor air

You can breathe radon sitting at your desk. Photo credit: pxhere.com

quality have to be part of a comprehensive management strategy, taking account of climate and outdoor air quality, building materials and technologies, knowledge of behaviour patterns of the occupants, including use of consumer products, as well as energy and sustainability policies.

Regulators, as well as many scientists, didn't take much notice of contaminant intrusion until the 2000s. At that time, awareness had grown about the hazards of radon. The average person is not likely to detect radon intrusion. You need sophisticated instrumentation to measure low concentrations that are involved. The World Health Organization concludes that radon causes lung cancer in Europe, North America and Asia. The analyses assume that the lung cancer risk increases proportionally with increasing radon exposure.

This assumption has been questioned. As many people are exposed to low and moderate radon concentrations, the majority of lung cancers related to radon are caused by these low exposure levels rather than by higher concentrations (WHO). Most of the radon-induced lung cancer cases occur among smokers due to a strong combined effect of smoking and radon. WHO proposes a reference level of 100 Bq/m3 to minimize health hazards due to indoor radon exposure (WHO). However, if this level cannot be reached under the prevailing country specific conditions, the chosen reference level should not exceed 300 Bq/m3.

Country	Argentina	Australia	Canada	China	India	Japan	South Korea	USA
Mean Bq/m3	35	11	34	44	57	16	53	46
Max value Bq/m3value	211	420	1720	596	210	310	1350	-

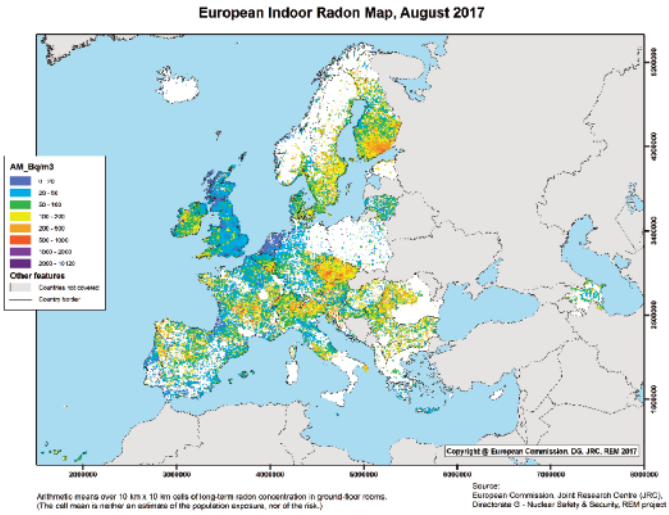


Photo source EU-JRC – Nuclear Safety & Security, Radioactivity Environmental Monitoring (REM)

Indoor radon pollution mapping in dwellings

In 2006, the Joint Research Centre of the European Commission launched a project to map radon at the European level, as part of a planned European Atlas of Natural Radiation starting with a map of European indoor radon concentrations. Although a few uninhabited areas remain, the reason for which is that radon surveys are still ongoing, or national surveys have concentrated on high-radon areas.

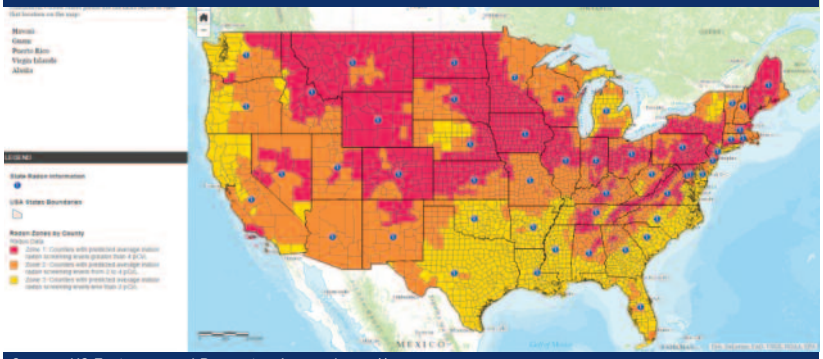
Almost all European countries have monitoring programmes for radon. Clearly, radon monitoring and reduction strategies are best developed in countries with an established radon problem. Radon mitigation in these countries includes national information systems, guidance documents for buildings and local and national radon maps.

The majority of European countries do not have different policies for the various population groups — only a few countries make distinctions between children and the rest of the population by establishing lower reference levels for radon in schools and kindergartens or offering additional financial support for remediation to reduce children's exposure.

The European Commission issued a Recommendation (EC, 1990) on the protection of the public against indoor radon exposure (90/143/Euratom) in order to harmonize Member States's provisions for the application of the basic safety standards for health protection against the dangers arising from ionizing radiation. This Recommendation gives guidelines for public information, an indoor radon reference level, an annual average concentration of 400 Bq/m3 applicable for existing dwellings; and design levels of an annual concentration of 200 for future construction, above which remedial actions and preventive measures should be considered.

In addition to reference levels for indoor radon concentration in workplaces (1000 Bq/m3) and dwellings and buildings with public access (300 Bq/m3 for existing, 200 Bq/m3 for new ones), the Euratom Basic Safety Standards foresees obligating EU Members to establish a radon action plan, aimed at managing long-term risks of radon exposures in dwellings, buildings with public access and workplaces for any source of radon ingress, whether from soil, building materials or water. JRC has prepared a map on indoor radon concentration and is currently trying to produce a European geogenic radon map.

EPA RADON ZONES



Source: US Environmental Protection Agency https://www.epa.gov

A geogenic map has been produced and a first trial version was presented at the 11th International Workshop on the Geological Aspects of Radon Risk Mapping held in Prague in 2012. After that the JRC has created a more comprehensive geogenic radon database asking the participating countries to supply radiometric data related to radon. Nowadays, the range and distribution of indoor radon levels in other countries, such as the US, have been quantified and scientifically measured by national surveys.

Don't worry. You can still rent a house for your holidays even abroad. The risk from radon is on the basis of a lifetime spent in the same house. Some experts argue that small doses of radiation may even be good for us, stimulating our immune defences. But if they invite you to try, politely decline: "I am trying to give up smoking. Radon, at least". ONE

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Bright Lights, Green City

How a handful of community organizers got the biggest city in America to take on the one of the most powerful industries on Earth.

By JEREMY DEATON
Nexus Media News

Some people start the new year by pledging to give up carbs or hit the gym. New York Mayor Bill de Blasio kicked off 2018 by declaring war on the oil industry.

In what author and activist Bill McKibben called one of the "most important moments" in the decades-long fight against climate change, the city has pledged to sell off around $5 billion in fossil fuel shares. It will also sue BP, Exxon Mobil, Chevron, ConocoPhillips and Shell for damages—namely, the gradually rising seas laying siege to New York—noting these companies deliberately misled the public about climate change.

But this isn't a story about farsighted politicians drawing up battle plans in the basement of city hall. The call to arms didn't come from the mayor's office or from chambers of the City Council. It came from the streets, from the outer boroughs and from a modest network of community organizers spurred to action by one of the deadliest storms in New York history.

This is a story about people who had never had a voice sending a message that could be heard around the world.

It begins in 2012, when Hurricane Sandy delivered a harrowing sneak preview of New York's future in a hotter, wetter, more turbulent world. A ferocious tide swept across the low-lying parts of the city, stealing lives and livelihoods. Michael Johnson watched the ocean crash into his Coney Island home. "I lost everything when Sandy's floodwaters rose in my apartment," he said.

Further inland, howling winds uprooted trees, while torrential rain hammered aging apartment buildings. Rachel Rivera watched the ceiling of her daughter's bedroom collapse under the weight of hours of punishing rainfall. She rescued her child just moments before the roof gave in. "She cries to me every time it rains hard, asking me, 'Mommy, is it going to happen again? Are we going to live? Are we going to die?'" Rivera said.

For many New Yorkers, Sandy was a turning point. The historic storm, made measurably worse by climate change, turned private citizens into public advocates. Johnson and Rivera both joined environmental justice group New York Communities for Change (NYCC). Together, along with other survivors, they made a forceful case for divestment. Their testimony was a powerful indictment of an industry that had long resisted change. The divestment campaign began in earnest in the wake of Sandy. Initially, organizers took a gentle approach to political pressure—reasoning with people in power while rallying public support. It didn't work. So last year, the gloves came off.

"We set a strategy of moving from mostly lobbying and intellectual arguments in support of divestment to a focused campaign urging the comptroller of the city, Scott Stringer, to lead action on divestment," said Pete Sikora, senior advisor with NYCC. By refusing to divest, they argued, Stringer was turning his back on New Yorkers like Johnson and Rivera who had been victims of climate change. "The truth is you have to put a face on a problem. You can't just say the city has to divest. There has to be some elected official who feels the heat on this issue," Sikora said. "In this case, it ended up being Comptroller Stringer, because he's the most important elected official on this decision, and he was resisting divestment."

NYCC was hardly alone in the effort. They worked with national advocacy groups like 350.org, Divest/Invest and the People's Climate Movement, in addition to other New York-based environmental justice groups.

"Our membership is overwhelmingly from black and Latino communities, low- and moderate-income communities of color," Sikora said. "We partnered with environmentalists who are overwhelmingly white progressives. That combination of organizations and political forces really helped shape this debate."

Throughout 2017, organizers repeatedly targeted Stringer. "We did everything from large rallies and marches to small direct actions to catching Scott Stringer at events and protesting him," Sikora said.

The campaign kicked off with a rally outside the mayor's office, where Rivera called out Stringer by name. Next came a teach-in inside Trump Tower, where protestors excoriated Stringer for his complacency on divestment in the face of President Trump's full-scale assault on federal climate protections.

In May, advocates invited Stringer to a town hall where he fielded a series of pointed questions about divestment. "That was very impactful," Sikora said, recalling the evening. "How could the city be investing in the likes of Exxon Mobil, whose business model is destroying the city's collective future? On its face, it's insane. How can you finance your own destruction?"

In June, after Trump pulled out of the Paris Agreement, advocates held a rally decrying the decision while urging the city to divest. New York Public Advocate Letitia James, the city's second-highest ranking elected official, spoke to those assembled. She publicly declared her support for divestment, turning up the pressure on Stringer.


2014 People's Climate Change March in New York City

As organizers applied political pressure, singling out Stringer in meetings and town halls, allies made the financial case for divestment. "On a campaign like this, it really does take a diversity of factors pushing for climate action," said Denise Patel, coordinator at Divest/Invest. "The fossil-fuel sector is the worst-performing sector of the [Standard & Poor's 500 index]. It's completely lagging," she said, arguing that continued investment in fossil fuels poses a risk to retired teachers, police officers, firefighters and other public-sector workers.

The campaign came to a head on the fifth anniversary of Hurricane Sandy, when thousands of New Yorkers marched across the Brooklyn Bridge, calling for divestment. Rivera spoke at the march.

"I'm here as a mother, fighting for this cause. I lost everything from photos to everything else an apartment has—memories. I almost lost my child," Rivera said. "And I'm here being displaced to this day. Living a nightmare with my daughter to this day. And it's hard, even five years later. We're still struggling."

Finally, at a public hearing in November, where Johnson spoke about losing his Coney Island home, the public advocate formally declared her support for divestment. The mayor and comptroller came around shortly thereafter. While New York City had pledged to divest from coal in 2015, it wasn't until this year that it decided to sell off its oil and gas stocks as well.

It's unclear precisely what combination of rallies, marches, teach-ins, leaflets and lobbying pushed Stringer to get behind divestment, but when the decision came, he credited organizers for their efforts. "Thank you to the advocates and activists who called me a few times in the last couple of years," Stringer said, with a touch of sarcasm, at the press conference announcing divestment. "That's how this works. Pushing government makes us better."

De Blasio also gave a nod to activists. "There has been an incredible movement in New York City," he said in an conversation with Vermont Sen. Bernie Sanders. "I want to give them a lot of credit, because I have to tell you, when I first raised it to experts in my administration, they raised all sorts of problems, road blocks, challenges, but that movement kept pushing us and saying divestment would make a huge difference."

Sikora credits Johnson, Rivera and other Sandy survivors for being "the moral force that we rallied around to make clear that the city had to act." He said, "The activist story and how things happen behind the scenes is often not told. I think it's really important, because people don't realize how people power drives these decisions."

Environmental justice groups are now on their way to scoring big victories outside the five boroughs. In December, New York Gov. Andrew Cuomo announced his support for divesting the state's pension funds from fossil fuels. Sikora is elated.

"Generally, when you're an activist, a lot of the stuff feels really good," Sikora said. "But it can be a grind—event after event after event, getting people to sign petitions. All of those kinds of things take a lot of work, and oftentimes it's thankless work. But people should not get discouraged. Keep their eyes on the prize and make the argument loud and clear over and over again, and escalate it."

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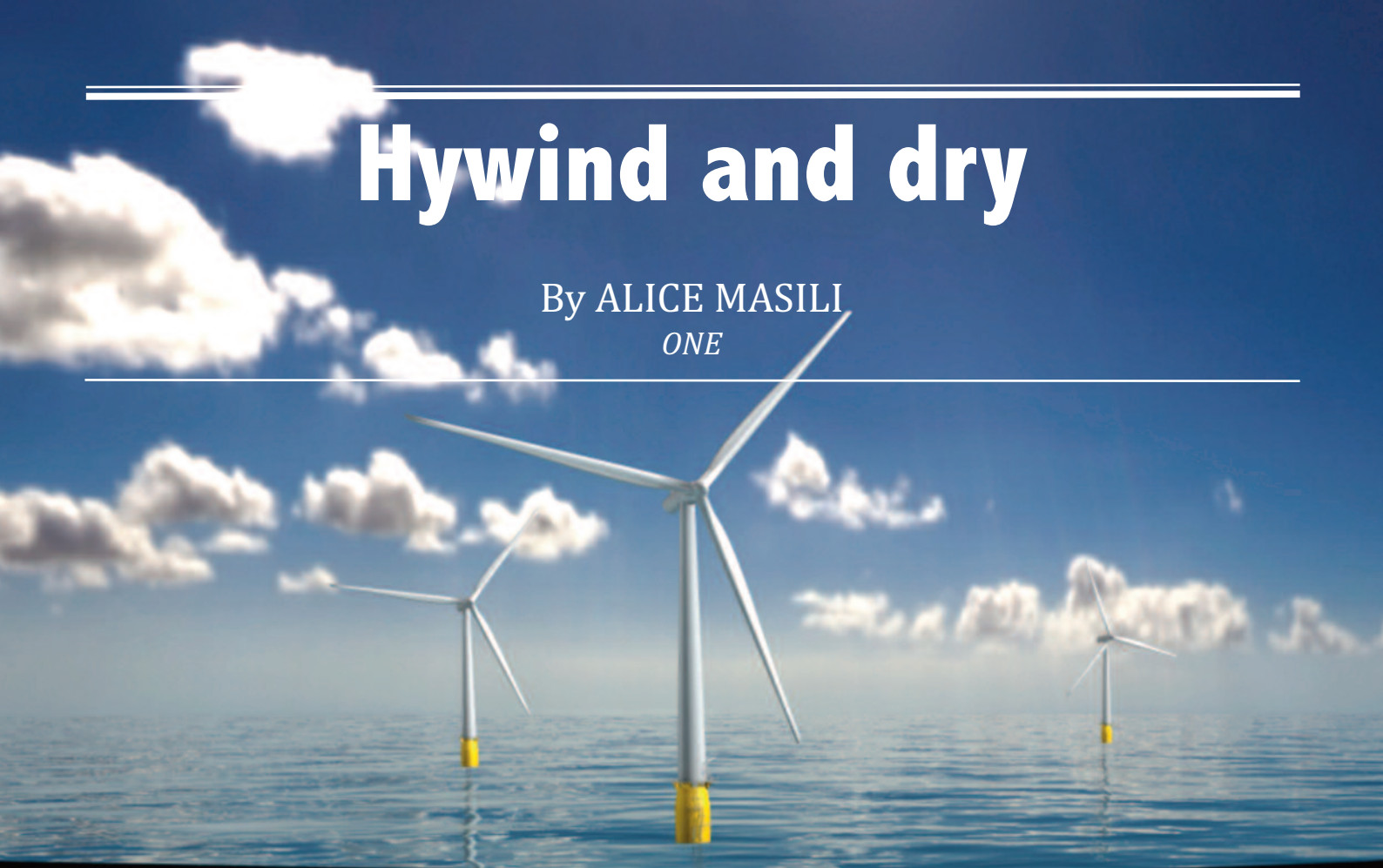
Hywind and dry

By ALICE MASILI

ONE



We are in Buchan Deep, where Scotland has given the green light to Hywind, a project that brought about the construction of the largest floating wind farm in the world off the coast of Peterhead.

The Norwegian giant Statoil and the Arab company Masdar took 8 years of experimentation to complete the work, as well as 200 million pounds of investment and a long sea voyage from Norway to Scotland, to transport turbines. The marine license granted to the Statoil has allowed installing at a distance of 25 km from the Scottish coast, five turbines of floating wind that produce 6MW of energy each with a total installed capacity of 30 MW and covers the annual requirement of about 20 thousand families.

These structures have a total height of 254 meters, with 176 meters of the structure floating above the water and the remaining 78 meters submerged underwater. Today the site occupies four square kilometers of surface in water depths varying between 95—129 meters. They do not have foundations, but they are mounted on a single floating cylindrical spar buoy moored by cables or chains to the sea bed. Its substructure is ballasted so that the entire construction floats upright. In detail, the Hywind turbine used for the Scottish project has a steel float filled with a ballast, which extends for 100 meters below the surface and is fixed to the sea floor by three anchor cables. A special control software on board relentlessly monitors the wind turbine and alters the pitch of the blades to maximise production. Cables bring electricity to shore.

Project	**Hywind Scotland**
Location	Buchan Deep, UK
Dimension	6.0 MW
Mass	11200 tons
Height	254 mt
Draught	78 mt
Hub height	98 mt
Water depth	105 mt
Substructure diameter	14,4 mt
Rotor diameter	154 mt
Anchor	Suction anchor
Mooring	Chain

Born from the collaboration between Siemens and Statoil-Hydro, the unit has been specifically designed to be installed in waters with a depth of 100 to 800 meters, values difficult to reach by rational offshore wind farms that already at depths greater than 20-50 meters are very expensive.

“Hywind can be used for water depths up to 800 meters, thus opening up areas that so far have been inaccessible for offshore wind. This project will pave the way for new global market opportunities for floating offshore wind energy,” says Irene Rummelhoff, executive vice president of the New Energy Solutions business area in Statoil.
A Carbon Trust report argues that floating wind technology is able to play a crucial role in further decreasing wind energy costs, especially for offshore projects.Recently, Statoil declared that its revolutionary floating offshore wind farm has had a capacity factor of 65 percent from Novem-

ber to January, performing better than the onshore wind farms. According to the Energy Information Administration (EIA), the most efficient onshore wind installation in the US enjoyed an average capacity factor of about 36.7 percent in 2017. Solar photovoltaic installations had an average capacity factor of 27 percent in 2017. Even combined-cycle coal and natural gas plants had a capacity factors of 54 to 55 percent in 2017.The comparison between Hywind's 65-percent capacity factor in the winter, when the wind is at its strongest, and other renewable installations over the whole year isn't quite fair. But Statoil says the typical capacity factor for an bottom fixed offshore wind farm is 45-60% in winter, suggesting that it is advantageous to use floating wind farms. In fact, the turbines can be placed farther out to the sea where wind is more consistent and stronger. In addition, in this first period Hywind withstood the Ophelia Hurricane, with a wind speed of 35 meter/seconds and the storm Caroline, even stronger, with gusts of 45 m/s (160 km/h) and waves as high as 8,2 meter.

Bader Al Lamki, executive director for Clean Energy at Masdar, said: “These outstanding results illustrate the durability of floating wind technology and its ability to perform safely and above target in the toughest conditions.”

Furthermore, Statoil and the Masdar partner announced the intention to improve energy management, thanks to the implementation of a new 1MWh lithium battery called Batwind, that will allow Hywind Scotland to work even more efficiently optimizing the supply and limiting the intermittences. This is the first battery storage system connected to a floating wind farm.

"As part of Statoil's strategy of gradually supplementing our oil and gas portfolio with profitable renewable energy, getting to understand energy storage is important. With more renewables coming into production it will be crucial to handle storage to ensure predictable energy supply in periods without wind or sun. Batwind has the potential to add value by mitigating periods without wind – and by that making wind a more reliable energy producer year around. This could expand the use and market for wind and renewables in the future," says head of Hywind Development in Statoil, Sebastian Bringsværd.

The new plant will not only contribute to reducing the environmental impact by providing "clean" energy: thanks to Hywind, Statoil intends to reduce the cost of energy produced up to 40-60 euros per MWh by 2030. This pilot project highlights the wind potential in Scotland and positions it at the forefront of the global race to develop the next generation of offshore wind technologies.

Furthermore, the commercialization of these floating turbines opens new frontiers to the offshore wind market, making available new marine spaces in the Mediterranean (France, Spain, Italy), in the Atlantic (Portugal, Spain, France, Great Britain, Scotland, Ireland), in the North Sea and the Baltic, as well as on the United States, both in the Atlantic and in the Pacific, and in the eastern seas for the countries bordering on them (China, Japan, Korea). Exiting times ahead. But what about the environmental impact? Very difficult to evaluate. Surely, positioning the turbines at least 15 kilometers from the coast would solve the acoustic and aesthetic problems. Regarding the consequences on the ecosystem and fauna, several studies, such as the 2012 Environmental Research Letters, have shown how wind installations offshore in the North Sea have had negligible impacts on the natural habitat and fauna.

Other studies have shown that wind turbines do not disturb birds.According to Plymouth University research, offshore wind could even have a positive impact on marine life, while turbine structures could recreate a similar habitat to natural reefs. In addition, fishing is prohibited in offshore wind farms, so fish could take refuge near the park. Wind energy can significantly reduce CO2 emissions without threatening energy security or marine wildlife.

According to the Martin Attrill report of the Plymouth University - Marine Institute, the spread of offshore wind is necessary to drastically reduce dependence on fossil fuels and to cut the harmful emissions that cause ocean acidification, global warming and all the consequences linked to climate change.

Views not shared by the Royal Society for the Protection of Birds, a charitable organisation who fights the project as likely to threaten resident and migratory birds: "From our own analysis and that of the Statutory Nature Conservation Bodies it is apparent that the environmental carrying capacity is already exceeded and protected areas, such as Fowlsheugh Special Protection Area, will see significant reductions in its protected kittiwake population as a direct result of offshore wind farm impacts. This population has seen dramatic declines across Scotland, up to 72 per cent loss since 1986, a decline that is reflected in the Fowlsheugh kittiwake numbers. Scottish Ministers must take account of these issues before making decisions on any further offshore wind". ONE

100% renewable electricity worldwide is a new cost-effective reality

A global power system fully based on renewable energy is no longer a long-term vision, but a tangible reality.

By HANS-JOSEF FELL and CHRISTIAN BREYER

Medium.com - The Beam Magazine

Last year, Costa Rica has beaten its own record. The Central American country has run 300 days on electricity generated solely from renewable energy. Following the steps of Norway and Iceland, Costa Rica is about to showcase to the world how an emerging country can succeed in transitioning to a fossil-free electricity system.

Renewable energy is increasingly a success story in emerging and developing markets. Last year, they were leading in green energy investments. China will have added around 54 GW solar PV capacity in 2017—three times more than any other country has ever done, which tops China's total amount to 120 GW of solar PV installed capacity. India is catching up too, as its government announced to tender enough renewable energy projects to surpass 200 GW of new green capacity by 2022. According to financial analysts, by 2020 renewables will have become the cheapest form of power generation.

A global power system fully based on renewable energy is no longer a long-term vision, but a tangible reality. Yet, critics of renewable energy and fossil fuel as well as nuclear lobbyists often use solar and wind fluctuations as their major argument to hold on to the old system.

A new groundbreaking study by the Lappeenranta University of Technology (LUT) and the Energy Watch Group (EWG) refutes this argument once and for all.

The first of its kind study* simulates a global electricity system based entirely on renewable energy on an hourly basis throughout a whole year. Its results prove that the existing renewable energy potential and technologies, including storage, are able to generate sufficient and secure power supply worldwide by 2050. Under favourable political conditions, a full decarbonisation and nuclear phase out of the global electricity system can succeed even earlier than that. The study proves that a 100% renewable electricity is more cost effective than the existing system, which is largely based on fossil fuels and nuclear energy. Total levelised cost of electricity (LCOE) on a global average for 100% renewable electricity will decline to 52 €/MWh by 2050 (including curtailment, storage and some grid costs), compared to 70 €/MWh in 2015.

Due to rapidly falling costs, solar PV and battery storage will increasingly drive most of the electricity system, with solar PV reaching some 69%, wind energy 18%, hydropower 8% and bioenergy 2% of the total electricity mix in 2050 globally.

A 100% renewable global electricity system is also way more efficient. It can reduce global greenhouse gas emissions in electricity sector from about 11 GtCO2eq in 2015 to ZERO emissions by 2050. The total losses in a fully renewable electricity system are significantly lower than in the current system. And, the global transition to a 100% renewable electricity system will create 36 million jobs by 2050 in comparison to 19 million jobs in 2015.

The global energy transition scenario is carried out in five year time periods from 2015 until 2050 and provides handy roadmaps to 100% renewable electricity for major regions of the world: Europe, Eurasia, MENA, Sub-Saharan Africa, SAARC, Northeast Asia, Southeast Asia, North America and South America. These are unique roadmaps, also showing the way to fulfilling the Paris Agreement targets, signed by nearly all countries in the world.

The study shows that there is no reason to invest any single dollar in fossil fuel or nuclear power production. It also proves that energy transition is no longer a question of technical

feasibility or economic viability, but of political will.

The science has proved that it is feasible. It is now the turn of politicians, businesses and civil society to push for immediate actions, accelerating the transition.

Gaining public support is the first and most decisive prerequisite for a successful transition to renewable energy. Therefore, policy makers should adopt favourable political frameworks and instruments, promoting fast and steady growth of renewables on the one hand and phasing out all subsidies to fossil fuel and nuclear power generation on the other hand.

The German Renewable Energy Sources Act (EEG) with a fixed feed-in-tariff is one of the best-known and proven successful policies. We also need to implement new, innovative political measures encouraging investment in renewable energy, storage and network integration simultaneously. A reformed version of the EEG—a hybrid renewable power plant remuneration—enables just that.

On the economic side of the energy transition, sufficient flow of private investment in renewables and storage technologies needs to be ensured for a smooth, fast and cost-effective transition to 100% renewable energy.

Tendering procedures are most prominent nowadays when it comes to commissioning renewable power projects. Yet, science also shows that tendering is reasonable only for renewable energy capacities above 40 MW. Otherwise they limit investors to large companies and exclude investment from decentralised actors, such as cooperatives. Tenders also limit the overall installations, whereas the feed-in-tariffs allow more and faster dynamics in the deployment of renewables.

Last but not least, research and education in the sphere of renewable energy and zero-emission technologies needs to be boosted. This will ensure more effective power generation in the future and new technological breakthroughs in the field of renewables.

The study is part of a larger study, analysing the entire energy system, including electricity, heat, mobility, desalination and industrial demand. Lappeenranta University of Technology and the Energy Watch Group will publish the findings of the entire study in 2018..

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Wind power farm in Xinjiang, China.
Photo credit: Chris Lim

Can the Great Lakes become fishable, drinkable, and swimmable again?

A joint United States–Canada report maps out the way to clean up the world's largest freshwater ecosystem

By SUSAN COSIER
NRDC

As Mark Mattson waited to speak to Canada's minister for the environment, Catherine McKenna, about the Great Lakes last December, he could feel the weight of the 184-page report he carried in his shoulder bag. At the Toronto meeting, McKenna asked Mattson, founder and president of the Lake Ontario arm of the nonprofit Waterkeeper Alliance, what she could do to help protect the five massive basins. He handed her the contents of his bag, with the important parts underlined or highlighted.

"I told her, 'You need to look at this report and you need to take it very seriously," says Mattson.

The document, the First Triennial Assessment of Progress on Great Lakes Water Quality, was published in November by the International Joint Commission (IJC), a group formed in 1909 to help prevent disputes over transboundary waters. It is the first such appraisal of the largest freshwater ecosystem in the world since 2012, when the United States and Canada updated the bilateral agreement on water quality in the lakes. To compile the document, the six IJC commissioners drew on the latest science on the Great Lakes.

They also reached out to communities across the region to come up with steps government bodies can take to ensure that the water becomes drinkable, fishable, and swimmable—the highest standard for freshwater. Sure, the Great Lakes are a lot cleaner than they were back in the 1960s, when a Cleveland newspaper pronounced Lake Erie dead due to the huge amount of industrial and agricultural pollution and sewage that had flowed into it. But as recently as 2014, pollution rendered Toledo's water unsafe to drink. And the dead zone that materializes in Lake Erie every summer serves as a reminder that the lakes still aren't clean enough to meet the drinking water, recreational, and aquaculture needs of the surrounding communities.

"I think Lake Erie is the perfect example of how, if we aren't diligent and we don't keep constant pressure on governments and agencies to maintain the quality of the lakes, we see what happens," says IJC's public affairs officer, Sally Cole-Misch.

Many people are shocked to learn that communities along the Great Lakes' shores still dump untreated sewage into the water. In just one year, the authors note, 20 cities in the United States and Canada allowed 92 billion gallons of untreated sewage and stormwater to course into the lakes. Phosphorus, mostly in runoff from farm fields, continues to wash into the lakes and contribute to algae blooms.

In Ohio, the agricultural community did adopt voluntary measures to reduce the amount of pollution from fertilizer in Lake Erie, but it isn't subject to mandatory limits. The IJC now recommends these. In Michigan, the state government recently


Lake Erie. Photo credit: Daytripsanddaydreams.com

designated its portion of Lake Erie "impaired," allowing the EPA and the state Department of Environmental Quality to limit the amount of agricultural nutrient that can wash into the waterway. That step marks the first time a Great Lakes state has taken such an action against a non-point source of pollution. Wisconsin has set nutrient pollution caps for waterways, but not specifically for Lake Michigan.

A warming climate only exacerbates the problems facing the Great Lakes, says Cole-Misch. Stronger storms that come with higher temperatures soak the region and can overwhelm infrastructure in places like Chicago, whose Deep Tunnel project is designed to prevent floodwater and sewage from surging into rivers and Lake Michigan. But even that massive public work may not be able to catch the amount of water that cascades into the system as storms intensify.

Invasive species and pollutants like microplastics and flame retardants already threaten the lakes, and more should be done to address even bigger problems likely to occur down the line, the commissioners argue. "Preventing harm in the first place is a new imperative for all of us," says Cam Davis, a former EPA chief liaison to the U.S. Congress for the Great Lakes who now works as a consultant.

The commission's suggestions, however, are just that. States are not required to implement them. But following the panel's counsel would keep the lakes safer for the 34 million people who depend on their waters—as well as the 65 million pounds of fish pulled from their depths each year. More people would be drawn to the region, a sure way to create more environmental stewards, says Mattson.

Already, citizens help monitor the lakes for pollution. Every month, up to 75 members of Buffalo Niagara Waterkeeper, for example, monitor water quality in the Niagara River watershed, which acts as a drain for Lake Erie into Lake Ontario. The group also publishes annual water quality reports and maps. In the new report, IJC recommends establishing a new binational monitoring program that would make information about potential health hazards in all of the Great Lakes available to the public.

Government officials would be wise to act on that suggestion and the report's other recommendations, says Mattson, or risk losing "the people who are connected to the lake, are using the lake, and are caring about it." At stake, he says, is "a generation of people who are going to help us restore it."

Canada's environment minister McKenna seems to be listening: After Mattson handed her the IJC report, her government informed the Waterkeeper Alliance that it will soon announce new initiatives, actions, and funding for the Great Lakes. Mattson's confident they'll be in line with the report's recommendations

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This is how Big Oil will die

By SETH
Perspicacity.xyz

It's 2025, and 800,000 tons of used high strength steel is coming up for auction.

The steel made up the Keystone XL pipeline, finally completed in 2019, two years after the project launched with great fanfare after approval by the Trump administration. The pipeline was built at a cost of about $7 billion, bringing oil from the Canadian tar sands to the US, with a pit stop in the town of Baker, Montana, to pick up US crude from the Bakken formation. At its peak, it carried over 500,000 barrels a day for processing at refineries in Texas and Louisiana. But in 2025, no one wants the oil.

The Keystone XL will go down as the world's last great fossil fuels infrastructure project. TransCanada, the pipeline's operator, charged about $10 per barrel for the transportation services, which means the pipeline extension earned about $5 million per day, or $1.8 billion per year. But after shutting down less than four years into its expected 40 year operational life, it never paid back its costs. The Keystone XL closed thanks to a confluence of technologies that came together faster than anyone in the oil and gas industry had ever seen. It's hard to blame them – the transformation of the transportation sector over the last several years has been the biggest, fastest change in the history of human civilization, causing the bankruptcy of blue chip companies like Exxon Mobil and General Motors, and directly impacting over $10 trillion in economic output.

And blame for it can be traced to a beguilingly simple, yet fatal problem: the internal combustion engine has too many moving parts.
Let's bring this back to today: Big Oil is perhaps the most feared and respected industry in history. Oil is warming the planet – cars and trucks contribute about 15% of global fossil fuels emissions – yet this fact barely dents its use. Oil fuels the most politically volatile regions in the world, yet we've decided to send military aid to unstable and untrustworthy dictators, because their oil is critical to our own security. For the last century, oil has dominated our economics and our politics. Oil is power.

Yet I argue here that technology is about to undo a century of political and economic dominance by oil. Big Oil will be cut down in the next decade by a combination of smartphone apps, long-life batteries, and simpler gearing. And as is always the case with new technology, the undoing will occur far faster than anyone thought possible.

To understand why Big Oil is in far weaker a position than anyone realizes, let's take a closer look at the lynchpin of oil's grip on our lives: the internal combustion engine, and the modern vehicle drivetrain.

Cars are complicated.

Behind the hum of a running engine lies a carefully balanced dance between sheathed steel pistons, intermeshed gears, and spinning rods – a choreography that lasts for millions of revolutions. But millions is not enough, and as we all have experienced, these parts eventually wear, and fail. Oil caps leak. Belts fray. Transmissions seize.

To get a sense of what problems may occur, here is a list of the most common vehicle repairs from 2015:
Replacing an oxygen sensor – $249
Replacing a catalytic converter – $1,153
Replacing ignition coil(s) and spark plug(s) – $390
Tightening or replacing a fuel cap – $15
Thermostat replacement – $210
Replacing ignition coil(s) – $236
Mass air flow sensor replacement – $382
Replacing spark plug wire(s) and spark plug(s) – $331
Replacing evaporative emissions (EVAP) purge control valve – $168
Replacing evaporative emissions (EVAP) purging solenoid – $184
And this list raises an interesting observation: None of these failures exist in an electric vehicle.

The point has been most often driven home by Tony Seba, a Stanford professor and guru of "disruption", who revels in pointing out that an internal combustion engine drivetrain contains about 2,000 parts, while an electric vehicle drivetrain contains about 20. All other things being equal, a system with fewer moving parts will be more reliable than a system with more moving parts.

And that rule of thumb appears to hold for cars. In 2006, the National Highway Transportation Safety Administration estimated that the average vehicle, built solely on internal combustion engines, lasted 150,000 miles. Current estimates for the lifetime today's electric vehicles are over 500,000 miles. The ramifications of this are huge, and bear repeating. Ten years ago, when I bought my Prius, it was common for friends to ask how long the battery would last – a battery replacement at 100,000 miles would easily negate the value of improved fuel efficiency. But today there are anecdotal stories of Prius's logging over 600,000 miles on a single battery.

The story for Teslas is unfolding similarly. *Tesloop*, a Tesla-centric ride-hailing company has already driven its first Model S for more 200,000 miles, and seen only an 6% loss in battery life. A battery lifetime of 1,000,000 miles may even be in reach. This increased lifetime translates directly to a lower cost of ownership: extending an EVs life by 3-4 X means an EVs capital cost, per mile, is 1/3 or 1/4 that of a gasoline-powered vehicle. Better still, the

cost of switching from gasoline to electricity delivers another savings of about 1/3 to 1/4 per mile. And electric vehicles do not need oil changes, air filters, or timing belt replacements; the 200,000 mile Tesloop never even had its brakes replaced. The most significant repair cost on an electric vehicle is from worn tires.

For emphasis: the total cost of owning an electric vehicle is, over its entire life, roughly 1/4 to 1/3 the cost of a gasoline-powered vehicle. Of course, with a 500,000 mile life a car will last 40-50 years. And it seems absurd to expect a single person to own just one car in her life. But of course a person won't own just one car. The most likely scenario is that, thanks to software, a person won't own any.

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Here is the problem with electric vehicle economics: a dollar today, invested into the stock market at a 7% average annual rate of return, will be worth $15 in 40 years. Another way of saying this is the value, today, of that 40th year of vehicle use is approximately 1/15th that of the first.

The consumer simply has little incentive to care whether or not a vehicle lasts 40 years. By that point the car will have outmoded technology, inefficient operation, and probably a layer of rust. No one wants their car to outlive their marriage. But that investment logic looks very different if you are driving a vehicle for a living. A New York City cab driver puts in, on average, 180 miles per shift (well within the range of a modern EV battery), or perhaps 50,000 miles per work year. At that usage rate, the same vehicle will last roughly 10 years. The economics, and the social acceptance, get better. And if the vehicle was owned by a cab company, and shared by drivers, the miles per year can perhaps double again. Now the capital is depreciated in 5 years, not 10. This is, from a company's perspective, a perfectly normal investment horizon.

A fleet can profit from an electric vehicle in a way that an individual owner cannot. Here is a quick, top-down analysis on what it's worth to switch to EVs: The IRS allows charges of 53.5¢ per mile in 2017, a number clearly derived for gasoline vehicles. At 1/4 the price, a fleet electric vehicle should cost only 13¢ per mile, a savings of 40¢ per mile. 40¢ per mile is not chump change – if you are a NYC cab driver putting 50,000 miles a year onto a vehicle, that's $20,000 in savings each year. But a taxi ride in NYC today costs $2/mile; that same ride, priced at $1.60 per mile, will still cost significantly more than the 53.5¢ for driving the vehicle you already own. The most significant cost of driving is still the driver. But that, too, is about to change. Self-driving taxis are being tested this year in Pittsburgh, Phoenix, and Boston, as well as Singapore, Dubai, and Wuzhen, China.

And here is what is disruptive for Big Oil: Self-driving vehicles get to combine the capital savings from the improved lifetime of EVs, with the savings from eliminating the driver. The costs of electric self-driving cars will be so low, it will be cheaper to hail a ride than to drive the car you already own.

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Today we view automobiles not merely as transportation, but as potent symbols of money, sex, and power. Yet cars are also fundamentally a technology. And history has told us that technologies can be disrupted in the blink of an eye. Take as an example my own 1999 job interview with the Eastman Kodak company. It did not go well.

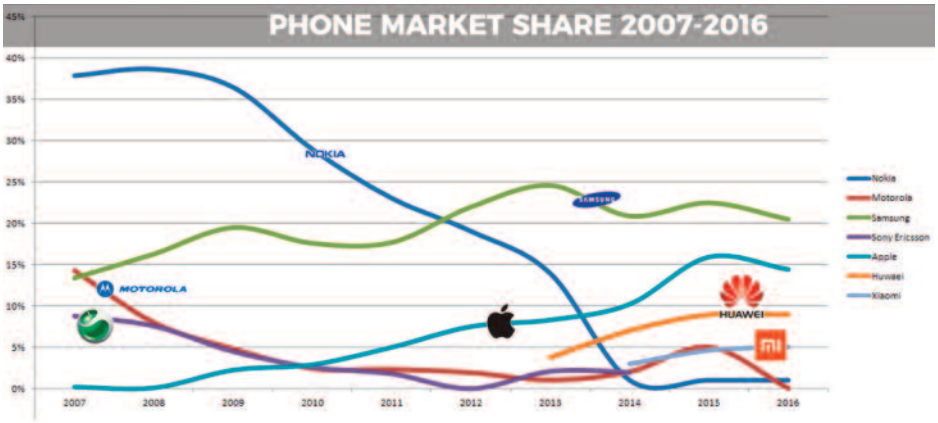
At the end of 1998, my father had gotten me a digital camera as a present to celebrate completion of my PhD. The camera took VGA resolution pictures – about 0.3 megapixels – and saved them to floppy disks. By comparison, a conventional film camera had a nominal resolution of about 6 megapixels. When printed, my photos looked more like impressionist art than reality. However, that awful, awful camera was really easy to use. I never had to go to the store to buy film. I never had to get pictures printed. I never had to sort through a shoebox full of crappy photos. Looking at pictures became fun.

I asked my interviewer what Kodak thought of the rise of digital; she replied it was not a concern, that film would be around for decades. I looked at her like she was nuts. But she wasn't nuts, she was just deep in the Kodak culture, a world where film had always been dominant, and always would be. This graph plots the total units sold of film cameras (grey) versus digital (blue, bars cut off). In 1998, when I got my camera, the market share of digital wasn't even measured. It was a rounding error. By 2005, the market share of film cameras were a rounding error.

In seven years, the camera industry had flipped. The film cameras

went from residing on our desks, to a sale on Craigslist, to a landfill. Kodak, a company who reached a peak market value of $30 billion in 1997, declared bankruptcy in 2012. An insurmountable giant was gone.

That was fast. But industries can turn even faster: In 2007, Nokia had 50% of the mobile phone market, and its market cap reached $150 billion. But that was also the year Apple introduced the first smartphone. By the summer of 2012, Nokia's market share had dipped below 5%, and its market cap fell to just $6 billion. In less than five years, another company went from dominance to afterthought.



A summary of Nokia's market share in cell phones. From Telephonesonline.co.uk

Big Oil believes it is different. I am less optimistic for them. An autonomous vehicle will cost about $0.13 per mile to operate, and even less as battery life improves. By comparison, your 20 miles per gallon automobile costs $0.10 per mile to refuel if gasoline is $2/gallon, and that is before paying for insurance, repairs, or parking. Add those, and the price of operating a vehicle you have already paid off shoots to $0.20 per mile, or more. And this is what will kill oil: It will cost less to hail an autonomous electric vehicle than to drive the car that you already own.

If you think this reasoning is too coarse, consider the recent analysis from the consulting company RethinkX (run by the aforementioned Tony Seba), which built a much more detailed, sophisticated model to explicitly analyze the future costs of autonomous vehicles. Here is a sampling of what they predict:

Self-driving cars will launch around 2021
A private ride will be priced at 16¢ per mile, falling to 10¢ over time. A shared ride will be priced at 5¢ per mile, falling to 3¢ over time.

By 2022, oil use will have peaked
By 2023, used car prices will crash as people give up their vehicles. New car sales for individuals will drop to nearly zero.
By 2030, gasoline use for cars will have dropped to near zero, and total crude oil use will have dropped by 30% compared to today. The driver behind all this is simple: given a choice, people will select the cheaper option.

Your initial reaction may be to believe that cars are somehow different – they are built into the fabric of our culture. But consider how people have proven more than happy to sell seemingly unyielding parts of their culture for far less money. Think about how long a beloved mom and pop store lasts after Walmart moves into town, or how hard we try to "Buy American" when a cheaper option from China emerges.

And autonomous vehicles will not only be cheaper, but more convenient as well – there is no need to focus on driving, there will be fewer accidents, and no need to circle the lot for parking. And your garage suddenly becomes a sunroom.

For the moment, let's make the assumption that the RethinkX team has their analysis right (and I broadly agree): Self-driving EVs will be approved worldwide starting around 2021, and adoption will occur in less than a decade.

How screwed is Big Oil?

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Perhaps the metaphors with film camera or cell phones are stretched. Perhaps the better way to analyze oil is to consider the fate of another fossil fuel: coal.

The coal market is experiencing a shock today similar to what oil will experience in the 2020s. Below is a plot of total coal production and consumption in the US, from 2001 to today. As inexpensive natural gas has pushed coal out of the market, coal consumption has dropped roughly 25%, similar to the 30% drop that RethinkX anticipates for oil. And it happened in just a decade.

Coal production
Coal consumption has dropped 25% from its peak. From the Kleinman Center for Energy Policy. The result is not pretty. The major coal companies, who all borrowed to finance capital improvements while times were good, were caught unaware. As coal prices crashed, their loan payments became a larger and larger part of their balance sheets; while the coal companies could continue to pay for operations, they could not pay their creditors. The four largest coal producers lost 99.9% of their market value over the last 6 years. Today, over half of coal is being mined by companies in some form of bankruptcy.

Coal market cap
The four largest coal companies had a combined market value of approximately zero in 2016. This image is one element of a larger graphic on the collapse of coal from Visual Capitalist.
When self-driving cars are released, consumption of oil will similarly collapse.

Oil drilling will cease, as existing fields become sufficient to meet demand. Refiners, whose huge capital investments are dedicated to producing gasoline for automobiles, will write off their loans, and many will go under entirely. Even some pipeline operators, historically the most profitable portion of the oil business, will be challenged as high cost supply such as the Canadian tar sands stop producing.

A decade from now, many investors in oil may be wiped out. Oil will still be in widespread use, even under this scenario – applications such as road tarring are not as amenable to disruption by software. But much of today's oil drilling, transport, and refining infrastructure will be redundant, or ill-fit to handle the heavier oils needed for powering ships, heating buildings, or making asphalt. And like today's coal companies, oil companies like TransCanada may have no money left to clean up the mess they've left.

An estimated crowd of 35-50,000 gathers near the Washington Monument to protest the Keystone XL pipeline.
Photo credit: Jmcdaid

Of course, it would be better for the environment, investors, and society if oil companies curtailed their investing today, in preparation for the long winter ahead. Belief in global warming or the risks of oil spills is no longer needed to oppose oil projects – oil infrastructure like the Keystone XL will become a stranded asset before it can ever return its investment. Unless we have the wisdom not to build it.

The battle over oil has historically been a personal battle – a skirmish between tribes over politics and morality, over how we define ourselves and our future. But the battle over self-driving cars will be fought on a different front. It will be about reliability, efficiency, and cost. And for the first time, Big Oil will be on the weaker side.

Within just a few years, Big Oil will stagger and start to fall. For anyone who feels uneasy about this, I want to emphasize that this prediction isn't driven by environmental righteousness or some left-leaning fantasy. It's nothing personal. It's just business.

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The Three Meanings Of E=mc^2, Einstein's Most Famous Equation

Three parts law that we still use today, governed by one of the simplest but most powerful equations ever to be written down

By ETHAN SIEGEL

Forbes

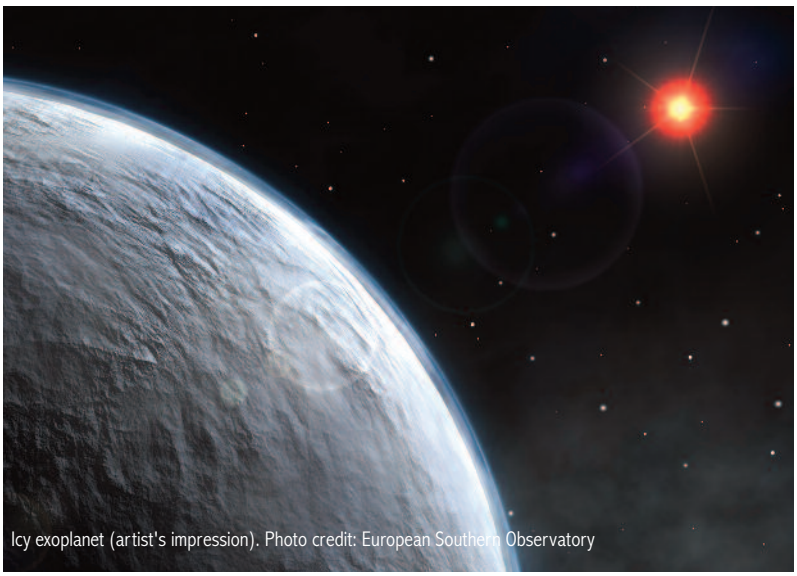
For hundreds of years, there was an immutable law of physics that was never challenged: that in any reaction occurring in the Universe, mass was conserved. That no matter what you put in, what reacted, and what came out, the sum of what you began with and the sum of what you ended with would be equal. But under the laws of special relativity, mass simply couldn't be the ultimate conserved quantity, since different observers would disagree about what the energy of a system was. Instead, Einstein was able to derive a law that we still use today, governed by one of the simplest but most powerful equations ever to be written down, *E = mc2.*

There are only three parts to Einstein's most famous statement:

E, or energy, which is the entirety of one side of the equation, and represents the total energy of the system.
m, or mass, which is related to energy by a conversion factor.
And *c2*, which is the speed of light squared: the right factor we need to make mass and energy equivalent.

What this equation means is as Einstein himself put it: *It followed from the special theory of relativity that mass and energy are both but different manifestations of the same thing — a somewhat unfamiliar conception for the average mind.*

Here are the three biggest meanings of that simple equation.



Icy exoplanet (artist's impression). Photo credit: European Southern Observatory

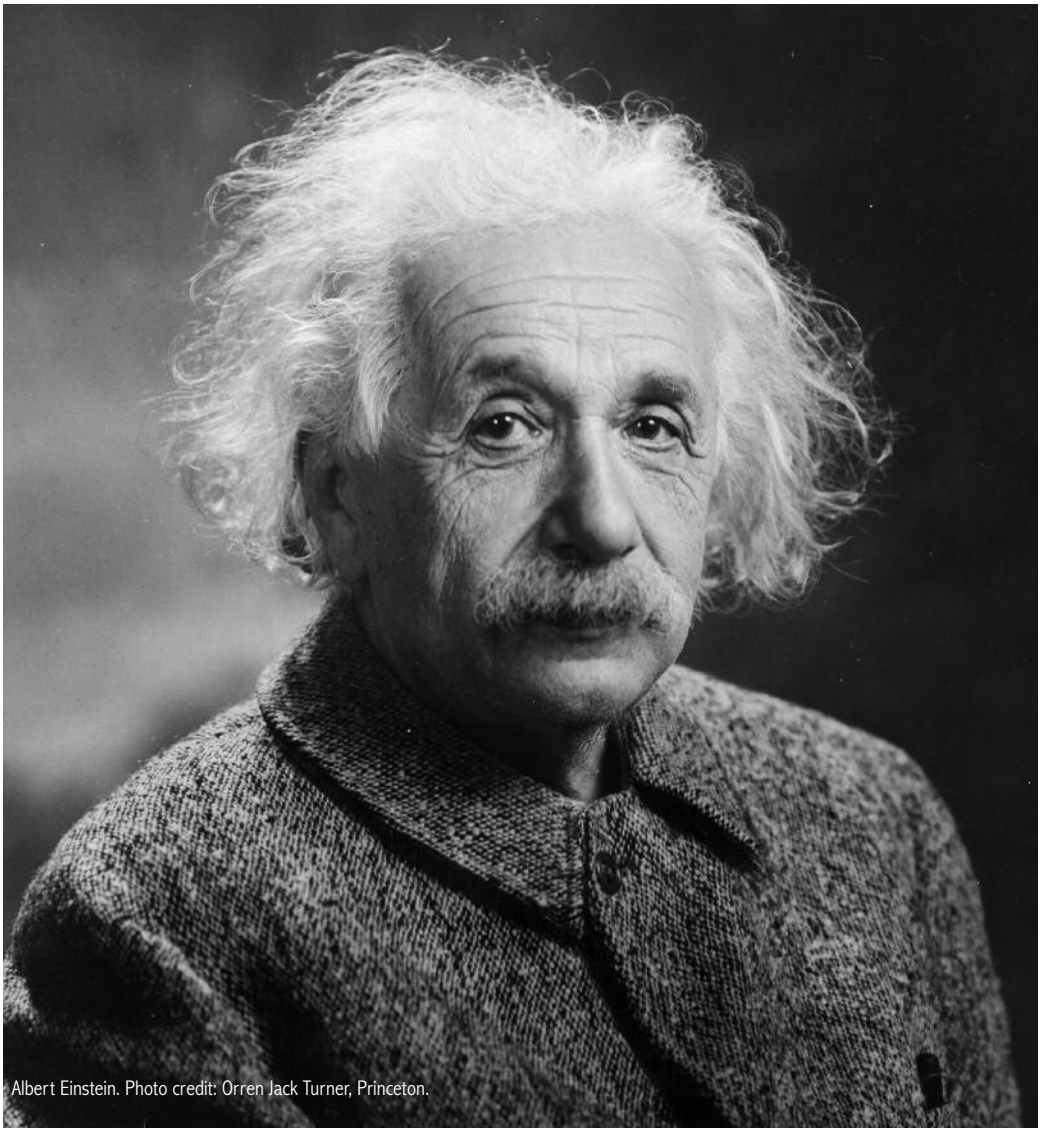
Even masses at rest have an energy inherent to them. You've learned about all types of energies, including mechanical energy, chemical energy, electrical energy, as well as kinetic energy. These are all energies inherent to moving or reacting objects, and these forms of energy can be used to do work, such as run an engine, power a light bulb, or grind grain into flour. But even plain, old, regular mass at rest has energy inherent to it: a tremendous amount of energy. This carries with it a tremendous implication: that gravitation, which works between any two masses in the Universe in Newton's picture, should also work based off of energy, which is equivalent to mass via E = mc2.

Mass can be converted into pure energy. This is the second meaning of the equation, where E = mc2 tells us exactly how much energy you get from converting mass. For every 1 kilogram of mass you turn into energy, you get 9 × 1016 joules of energy out, which is the equivalent of 21 Megatons of TNT. When we experience a radioactive decay, or a nuclear fission or fusion reaction, the mass of what we started with is greater than the mass we wind up with; the law of conservation of mass is invalid. But the amount of the difference is how much energy is released! That's true for everything from decaying uranium to fission bombs to nuclear fusion in the Sun to matter-antimatter annihilation. The amount of mass you destroy becomes energy, and the amount of energy you get is given by E = mc2.

The particle tracks emanating from a high energy collision at the LHC in 2014. Composite particles are broken up into their components and scattered, but new particles are also created from the available energy in the collision.

Energy can be used to make mass out of nothing... except pure energy. The final meaning is the most profound. If you take two billiard balls and smash them together, you get two billiard balls out. If you take a photon and and electron and smash them together, you get a photon and an electron out. But if you smash them together with enough energy, you'll get a photon, and electron, and a new matter-antimatter pair of particles out. In other words, you will have created two new massive particles: a matter particle, such as an electron, proton, neutron, etc., and an antimatter particle, such as a positron, antiproton, antineutron, etc., whose existence can only arise if you put in enough energy to begin with. This is how

particle accelerators, like the LHC at CERN, search for new, unstable, high-energy particles (like the Higgs boson or the top quark) in the first place: by making new particles out of pure energy. The mass you get out comes from the available energy: m = E/c2. It also means that if your particle has a finite lifetime, then due to Heisenberg uncertainty, there's an inherent unknowability to its mass, since ΔEΔt ~□, and therefore there's a corresponding Δm from Einstein's equation, too. When physicists talk about a particle's width, this inherent mass uncertainty is what they're talking about.


Albert Einstein. Photo credit: Orren Jack Turner, Princeton.

The fact of mass-energy equivalence also led Einstein to his greatest achievement: General Relativity. Imagine that you've got a particle of matter and a particle of antimatter, each with the same rest mass. You can annihilate them, and they'll produce photons of a specific amount of energy, of the exact amount given by E = mc2. Now, imagine you had this particle/antiparticle pair moving rapidly, as though they had fallen from outer space, and then annihilated close to the surface of Earth. Those photons would now have extra energy: not just the E from E = mc2, but the additional E from the amount of kinetic energy they gained by falling.

If two objects of matter and antimatter at rest annihilate, they produce photons of an extremely specific energy. If they produce those photons after falling deeper into a gravitational field, the energy should be higher. This means there must be some sort of gravitational redshift/blueshift, the kind not predicted by Newton's gravity, otherwise energy wouldn't be conserved.

If we want to conserve energy, we have to understand that gravitational redshift (and blueshift) must be real. Newton's gravity has no way to account for this, but in Einstein's General Relativity, the curvature of space means that falling into a gravitational field makes you gain energy, and climbing out of a gravitational field makes you lose energy. The full and general relationship, then, for any moving object, isn't just E = mc2, but that E2 = m2c4 + p2c2. (Where p is momentum.) Only by generalizing things to include energy, momentum, and gravity can we truly describe the Universe.

When a quantum of radiation leaves a gravitational field, its frequency must be redshifted to conserve energy; when it falls in, it must be blueshifted. Only if gravitation itself is linked to not only mass but energy, too, does this make sense.

Einstein's greatest equation, E = mc2, is a triumph of the power and simplicity of fundamental physics. Matter has an inherent amount of energy to it, mass can be converted (under the right conditions) to pure energy, and energy can be used to create massive objects that did not exist previously. Thinking about problems in this way enabled us to discover the fundamental particles that make up our Universe, to invent nuclear power and nuclear weapons, and to discover the theory of gravity that describes how every object in the Universe interacts. And the key to figuring the equation out? A humble thought experiment, based on one simple notion: that energy and momentum are both conserved. The rest? It's just an inevitable consequence of the Universe working exactly as it does.

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Astrophysicist and author Ethan Siegel is the founder and primary writer of Starts With A Bang!

Photo credit: Diego Celso

HUMBERSTONE AND SANTA LAURA

Two former saltpeter refineries located in northern Chile, in the Atacama Desert. Founded in 1872, the Saltpeter works and the towns constructed around them became obsolete fifty years later, after two German scientists Fritz Haber and Carl Bosch, synthesized ammonia, which meant fertilizers could be produced more efficiently and more cheaply.

In 1970, after becoming ghost towns, Humberstone and Santa Laura were declared national monuments and opened to tourism. One year later, president Salvador Allende declared also Chacabuco a Historic Monument of Chile, but in 1973, after the military coup, Pinochet turned it into a concentration camp until the end of 1974. Still a dangerous place today, Chacabuco is surrounded by landmines left by the Chilean army. In 2005 Humberstone and Santa Laura were declared a World Heritage Site by UNESCO, whereas Chacabuco remains a hidden evidence of industrial decay and regime brutality. ONE

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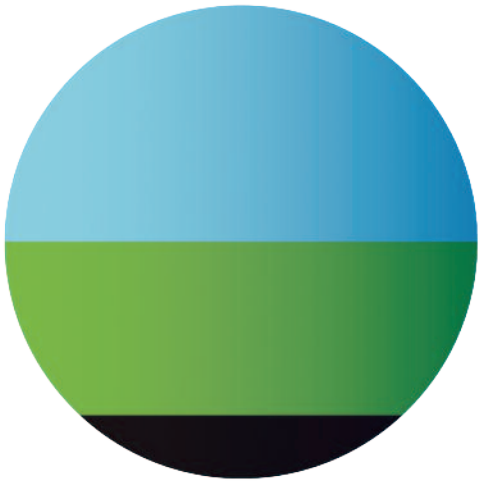

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www.sotacarbo.it

www.onlynaturalenergy.com
info@onlynaturalenergy.com