[next]

RICHA BATRA

This Robot's Parts Are Helpless Alone, But Turn Smart as They Team Up
By Stephen Ornes

ScienceNews | Jun 3, 2019
https://www.sciencenewsforstudents.org/article/innovation-2019-robots-helpless-alone-as-team-smart

A new system called particle robotics is expanding what it means to be a robot.

See also in the TTI/Vanguard archive:

- Carlos Olguin: *Programming Matter across Domains and Scales*, Washington, D.C., September/October 2014.

ELISA BERTINO

New Flaws in 4G, 5G Allow Attackers to Intercept Calls and Track Phone Locations
Zack Whittaker

TechCrunch | February 24, 2019
https://techcrunch.com/2019/02/24/new-4g-5g-security-flaws/

A group of academics have found three new security flaws in 4G and 5G, which they say can be used to intercept phone calls and track the locations of cell phone users. The findings are said to be the first time vulnerabilities have affected both 4G and the incoming 5G standard, which promises faster speeds and better security, particularly against law enforcement use of cell site simulators, known as "stingrays." But the researchers say that their new attacks can defeat newer protections that were believed to make it more difficult to snoop on phone users.

See also in the TTI/Vanguard archive:

- Bruce Schneier: *Click Here to Kill Everybody*, Washington, D.C., September 2018
- Srdjan Capkun: *Authentication and Access Control through Secure Proximity Detection*, Washington, D.C., September 2016.

RENEE DIRESTA

Evidence of Russia-Linked Influence Operations in Africa

Stanford Internet Observatory | October 30, 2019
https://cyber.fsi.stanford.edu/io/news/prigozhin-africa

Russia's global strategy for reasserting itself as a geopolitical superpower has led to an increased presence in Africa, where it has broadened efforts to shape the continent's politics and pursue new economic opportunities to allay the effects of sanctions. While the presence of Russian military instructors and paramilitary groups in Libya and the Central African Republic is well documented, there is emerging evidence that Russian-linked companies are now active in the information space as well. Yevgeny Prigozhin, the oligarch perhaps best known for running the Internet Research Agency, is central to this expansion. In this post we identify a Facebook operation attributed to entities tied to Prigozhin—including, it appears, the Wagner Group (Частная военная компания Вагнера), a Russian organization that has served as a private military contractor in several African countries.

See also in the TTI/Vanguard archive:

Renee DiResta: Getting It There: The New Logistics, Detroit, Michigan, May 2015.

- Michael Hayden: *The Assault on Intelligence*, Washington, D.C., September 2018
- Eric Haseltine: *Can U.S. Elections Be Hacked*, Washington, D.C., September 2018.
- Judith Estrin: *Facing Up to the By-Products of Digitization*, Berkeley, California, March 2019.

JACK DONGARRA

The U.S. Once Again Has the World's Fastest Supercomputer
By Jack Dongarra

Washington Post | June 25, 2018
https://www.washingtonpost.com/opinions/united-states-wins-top-honors-in-supercomputer-race/2018/06/25/82798c2c-78b1-11e8-aeee-4d04c8ac6158_story.html

The United States has knocked China out of the No. 1 position in supercomputing. This week, when the latest ranking of the 500 fastest supercomputers in the world was released, the Energy Department's new Summit machine reclaimed a distinction that China has held for five years. The development is more than a matter of national pride; supercomputers are an indispensable tool for national security, technological progress and economic competitiveness.

See also in the TTI/Vanguard archive:

- Satoshi Matsuoka: *We Choose to Go Exascale, Not Because It's Easy, but Because It's Hard*, Tokyo, Japan, July 2012.

DANIEL FABER

Orbit Fab Becomes First Startup to Supply Water to ISS, Paving the Way for Satellite Refueling

By Darrell Etherington

TechCrunch | June 18, 2019
https://techcrunch.com/2019/06/18/orbit-fab-becomes-first-startup-to-supply-water-to-iss-paving-the-way-for-satellite-refueling/

Not even two years into its existence, orbital fuel supply startup Orbit Fab has chalked up a big win—successfully supplying the International Space Station with water, a first for any private company. It's a big deal, because providing water to the ISS involved a multi-day refueling process, done in microgravity, using processes and equipment Orbit Fab developed itself.

See also in the TTI/Vanguard archive:

- Erika DeBenedictis: *Propulsion Strategies and a New Range of Space Missions*, Vienna, Austria, July 2013.

KARL FRISTON

Active Inference, Curiosity and Insight

By Karl J. Friston, Christopher D. Frith, Giovanni Pezzulo, J. Allan Hobson, and Sasha Ondobaka

Neural Computation | 2017
https://www.mitpressjournals.org/doi/pdf/10.1162/neco_a_00999

This article offers a formal account of curiosity and insight in terms of active (Bayesian) inference. It deals with the dual problem of inferring states of the world and learning its statistical structure. In contrast to current trends in machine learning (e.g., deep learning), we focus on how people attain insight and understanding using just a handful of observations, which are solicited through curious behavior. We use simulations of abstract rule learning and approximate Bayesian inference to show that minimizing (expected) variational free energy leads to active sampling of novel contingencies. This epistemic behavior closes explanatory gaps in generative models of the world, thereby reducing uncertainty and satisfying curiosity. We then move from epistemic learning to model selection or structure learning to show how abductive processes emerge when agents test plausible hypotheses about symmetries (i.e., invariances or rules) in their generative models. The ensuing Bayesian model reduction evinces mechanisms associated with sleep and has all the hallmarks of "aha" moments. This formulation moves toward a computational account of consciousness in the pre-Cartesian sense of sharable knowledge (i.e., con: "together"; scire: "to know").

See also in the TTI/Vanguard archive:

- Kenneth Stanley: *Neuroevolution: How Evolving Neural Networks Contributes to the Quest for AI*, Brooklyn, New York, June 2018.
- Kenneth Stanley: *Why Greatness Cannot Be Planned: The Myth of the Objective*, Washington, D.C., September 2015.

- Elias Bareinboim: *Causal Inference and Fusion: Foundations of Intelligence, Learning, and Decision Making*, Brooklyn, New York, June 2018.
- Esther Meek: *Epistemological Therapy for the Workplace*, Pittsburgh, Pennsylvania, October 2012.

SAUL GRIFFITH

How Do We Decarbonize?
By Saul Griffith

Medium | May 23, 2019
https://medium.com/otherlab-news/how-do-we-decarbonize-7fc2fa84e887

Decarbonization can't come from partisan commitment to one and only one policy. The science and economics prove that a market-driven combination of electrification from renewable sources, supplementation with nuclear, strategic research into groundbreaking "miracle" solutions like fusion, a small amount of carbon sequestration and geoengineering, and a whole lot of will power is the realistic pathway to a sustainable future.

See also in the TTI/Vanguard archive:

- John Henry Clippinger: *2030 Blockchain for Zero Carbon and Economic and Social Resiliency*, Washington, D.C., September 2019.
- Amory Lovins: *Reinventing Fire: Bold Business Solutions for the New Energy Era*, Washington, D.C., October 2011.
- Saul Griffith: *Venture Technologists*, Seattle, Washington, December 2006.

JAGS KANDASAMY

AI's Shocking Carbon Footprint
By Manju Bansal

October 14, 2019
https://latentai.com/ais-shocking-carbon-footprint/

What do the melting glaciers of Greenland have in common with artificial intelligence? On the surface, not much. But if you dig just a bit deeper, the connection is scarier than you might imagine. Turns out that data is not only the new metaphoric oil, but it also has a carbon impact just as bad.

See also in the TTI/Vanguard archive:

- Lofti Belkhir: *The Impact of ICT on the Global Carbon Footprint*, Washington, D.C., September 2018.

GARY MARCUS

Excerpt from *Rebooting AI: Building Artificial Intelligence We Can Trust*
By Gary Marcus and Ernest Davis

Penguin, October 2019
https://www.penguinrandomhouse.ca/books/603982/rebooting-ai-by-gary-marcus-and-ernest-davis/9781524748258/excerpt

Since its earliest days, artificial intelligence has been long on promise, short on delivery. In the 1950s and 1960s, pioneers like Marvin Minsky, John McCarthy, and Herb Simon genuinely believed that AI could be solved before the end of the 20th century. "Within a generation," Marvin Minsky famously wrote, in 1967, "the problem of artificial intelligence will be substantially solved." Fifty years later, those promises still haven't been fulfilled, but they have never stopped coming.

See also in the TTI/Vanguard archive:

- Gary Marcus: *Why AI Is Harder Than You Think*, Brooklyn, New York, June 2018
- Gary Marcus: *The Future of AI; The Future of Neuroscience,* San Diego, California, February 2015.
- Marvin Minsky, Gary Marcus, and Doug Lenat: *How Far Are We from Strong AI?*, Boston, Massachusetts, April 2014.

MARKO PAPIC

A World Without America?

FIS Group | June 2017
https://www.fisgroup.com/wp-content/uploads/2017/07/A-World-Without-America.pdf

At his inaugural address, President Trump touted an inward looking, "America first" foreign policy. Arguably, this posture was a stunningly explicit (and perhaps misguided) recognition of a trend that had begun with the previous administration; whose reticence to engage in military adventurism relative to his predecessors was roundly criticized by establishment hawks. Below we argue that this foreign policy trajectory is consistent with historical precedent and will greatly alter the winners and losers going forward.

See also in the TTI/Vanguard archive:

- Michael Hayden: *The Assault on Intelligence*, Washington, D.C., September 2018.

BESSIE SCHWARZ

Flood Matters: Mapping Up a Storm

Hacking Finance | Jun 7, 2018
https://hacking.finance/read/flood-matters-mapping-up-a-storm/

Just how did Schwarz go from a curious teenager selling solar-system maps at the Discovery Channel Store to a scientist equipping clients such as the World Bank with flood-vulnerability data aimed to protect millions of flood-vulnerable people (and their possessions) in the developing world?

See also in the TTI/Vanguard archive:

- Jeremiah Pate, *Using Satellites to Better Mine the Earth*, Berkeley, March 2019
- Jennifer Mathieu: *Intelligent Cities: Internet of Things*, McLean, Virginia, September 2017.

KELLY WANSER

Marine Cloud Brightening Project

Geoengineering Monitor | April 6, 2018
http://www.geoengineeringmonitor.org/wp-content/uploads/2018/04/geoeng_briefing-MCBP.pdf

The Marine Cloud Brightening Project (MCBP) aims to test the premise that spraying a fine mist of sea water into clouds can make them whiter, reflecting more sunlight back into space. The MCBP, a form of Solar Radiation Management (SRM) began with indoor development and testing of spray nozzles, and is moving toward a land-based field test in 2018, followed by ship-based tests and a larger-scale sea test later on. After previous attempts to test "cloud brightening" as a geoengineering technique (e.g. the Silver Lining project) were cancelled after a public outcry, the project's leaders have taken a smaller-scale, more public relations savvy approach.

See also in the TTI/Vanguard archive:

- Richard Turco: *Global Geoengineering: Mitigating Future Climate Change*, Santa Monica, California, December 2007.
- James Lovelock: *Sustainable Retreat*, Washington, D.C., May 2007.

MITA YUN

Would You Swipe Right for an AI?

Would you swipe right for an AI?
By Shane Fernandes

New Gizmo Blog | Feb 8, 2019
https://newgizmoblog.com/2019/02/08/would-you-swipe-right-for-an-ai/

Valentine's Day is for the romantics. It provides an opportunity to spend time with that special someone. However, contrary to the commercialism, it is not a day for everyone. According to the US Census Bureau 47.3 % or approximate 115.78 million 18-year-olds or older are single. Perhaps it is too late for you to find that special someone this year. However, would you consider a robot or AI this Valentine's Day for companionship?

See also in the TTI/Vanguard archive:

- Christian Rudder: *Data: A Love Story,* Philadelphia, Pennsylvania, July 2015.

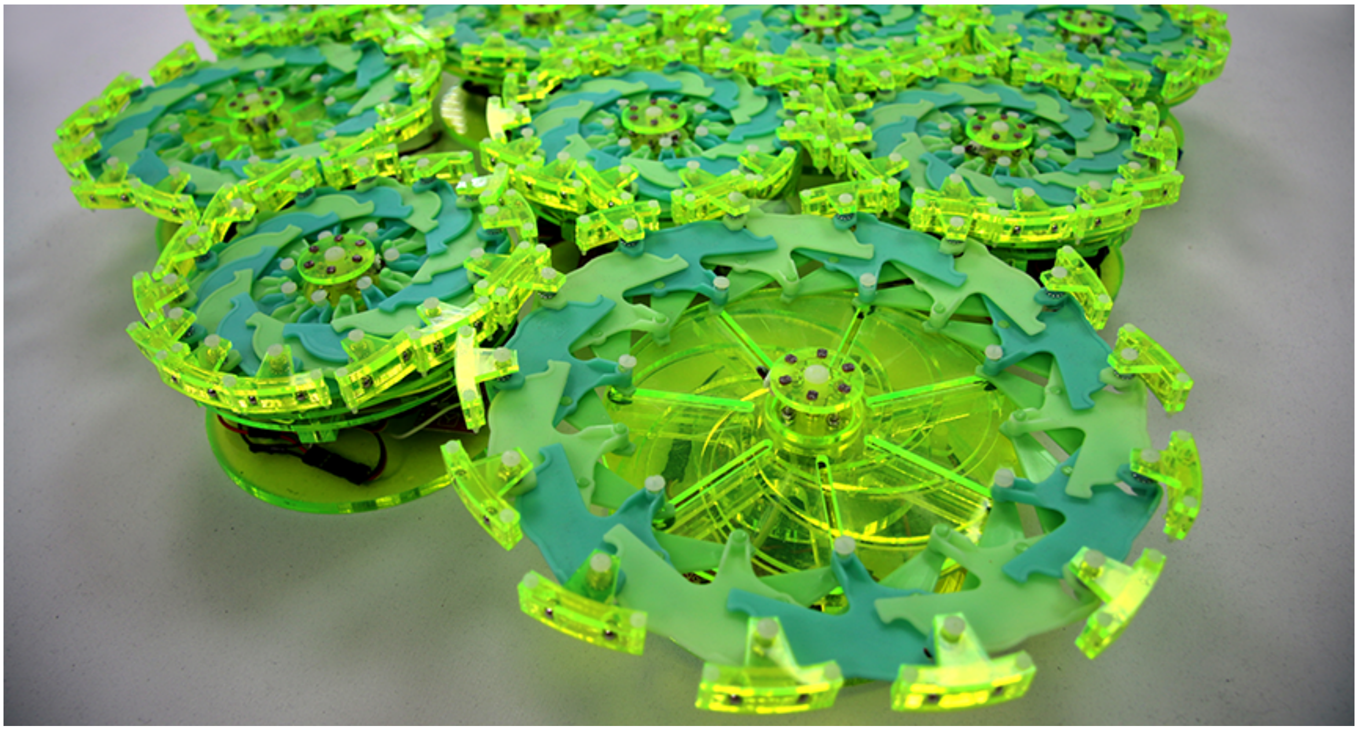
ScienceNews*for*Students

ROBOTICS COMPUTERS & ELECTRONICS

This robot's parts are helpless alone, but turn smart as they team up

A new system called particle robotics is expanding what it means to be a robot

BY **STEPHEN ORNES** JUN 3, 2019 — 6:45 AM EST



Individually, each of these disks can only expand and contract in place. But together, when loosely connected by magnets, they can complete a task like moving toward a light.
Shuguang Li/Columbia Engineering

This is one in a series presenting news on technology and innovation, made possible with generous support from the Lemelson Foundation.

When you imagine a robot, you might picture R2-D2 in *Star Wars,* the Omnidroid from *The Incredibles* or the big-armed machines that build cars on an assembly line. But there's a new robotic system that doesn't resemble any of these. Instead, it looks like some kids forgot to pick up their toys.

The robot is a collection of plastic, neon-green disks. Each is about 15 centimeters (6 inches) across. Alone, a single disk can't do much of anything. It can only expand and contract.

But when a bunch of disks huddle together, things change. Tiny magnets on the disks' outer rims make them stick together. When one disk expands or shrinks, it pushes or pulls on its neighbors. All of those small pushes and pulls add up. Suddenly the entire blob starts to move — very slowly.

Nature. In the new study, they also showed how such a particle robot can accomplish simple tasks, like shuffling toward a light.

"It's an innovative mechanism," says Katia Sycara. She's a computer scientist at Carnegie Mellon University in Pittsburgh, Pa., who designs multi-robot systems. She did not work on the new invention. But she says it illustrates the wild variety of ways that people can build robotic systems.

At one end of the spectrum of robots you find single-bodied devices. Think R2-D2. These are robots contained in just one body. At the other end of the spectrum are *modular* robots. These are groups of individual robots that each have their own job but together work on some common task. They include "swarm" robots, which talk to each other and share information about where and how they're moving.

The new system, says Sycara, is somewhere in between. The disks are individual units, but they bunch together to form a unified team. Their behavior results from their interactions and the laws of physics, not someone telling them what to do.

Natural inspiration

"We wanted to make robots that are very simple and that can respond to changes in the environment," says Richa Batra. She's a graduate student at Columbia University in New York City and part of a multi-university team behind the new particle-robotics system.

Scientists behind the project were inspired by nature, Batra explains. In the human body, for example, individual cells work together as muscle tissue. Many other types of cells also move together as a group.

The motion of the robot also reminds Batra of something else in the living world. The blob shuffles along "like a caterpillar moves," she says. "It bunches up a little, then stretches out."

Even though the disks don't communicate directly with each other, they can respond as a group to some signal. The scientists showed this by installing sensors on each disk that could detect light. Then they programmed the disks to expand and contract faster or slower, depending on how intense the light was. When the researchers shone a bright light, their robot crept toward it — the result of all those individual expansions and contractions.

To make sure the group of particles would not get stuck, the researchers had to consider how friction would affect the disks. Friction is the resistance between two surfaces rubbing together. The disks had to push hard enough to overcome friction. But they couldn't push each other so far away that their magnets stopped working.

Another challenge the researchers faced was deciding what the disks should look like. For help, they turned to Chuck Hoberman at Harvard University in Cambridge, Mass. He had created what are known as Hoberman Spheres. The clever plastic toys are made of interconnected arms that expand into giant spheres when thrown in the air, and then collapse back into small spheres when caught. The new robotics team recruited Hoberman to design the disks that would become their "particles." Like his spheres, these, too, get bigger and smaller with minimal effort.

Finally, the scientists had to create a system that could work at different scales. So far, they have built physical robots with more than two dozen disks. But they wanted to show what would happen with groups of hundreds, or even thousands, of particles. That's where Batra came in. For two years, she wrote computer programs that could predict the behavior of big groups. She showed how a system with 100,000 particles would move. Her software also predicted what would happen if individual disks in the group stopped working.

"That was one of the really beautiful things we were able to look at," she says. "How many of these particles could be killed off and still have it move?" A lot, as it turns out. Batra ran

Right now, the robot only moves across a flat surface. Batra says she wants to know what a three-dimensional system might look like. The researchers also don't know yet how their flat system might be used.

Still, that's normal for robotics, says Sycara. Each new approach adds to the toolbox that other researchers can later use.

Sycara predicts that future robots, such as this one, will continue to take cues from nature on how they might look and move. "We are going to be seeing more and more biologically inspired designs," she says.

New flaws in 4G, 5G allow attackers to intercept calls and track phone locations

Zack Whittaker@zackwhittaker • February 24, 2019
https://techcrunch.com/2019/02/24/new-4g-5g-security-flaws/

A group of academics have found three new security flaws in 4G and 5G, which they say can be used to intercept phone calls and track the locations of cell phone users.

The findings are said to be the first time vulnerabilities have affected both 4G and the incoming 5G standard, which promises faster speeds and better security, particularly against law enforcement use of cell site simulators, known as "stingrays." But the researchers say that their new attacks can defeat newer protections that were believed to make it more difficult to snoop on phone users.

"Any person with a little knowledge of cellular paging protocols can carry out this attack," said Syed Rafiul Hussain, one of the co-authors of the paper, told TechCrunch in an email.

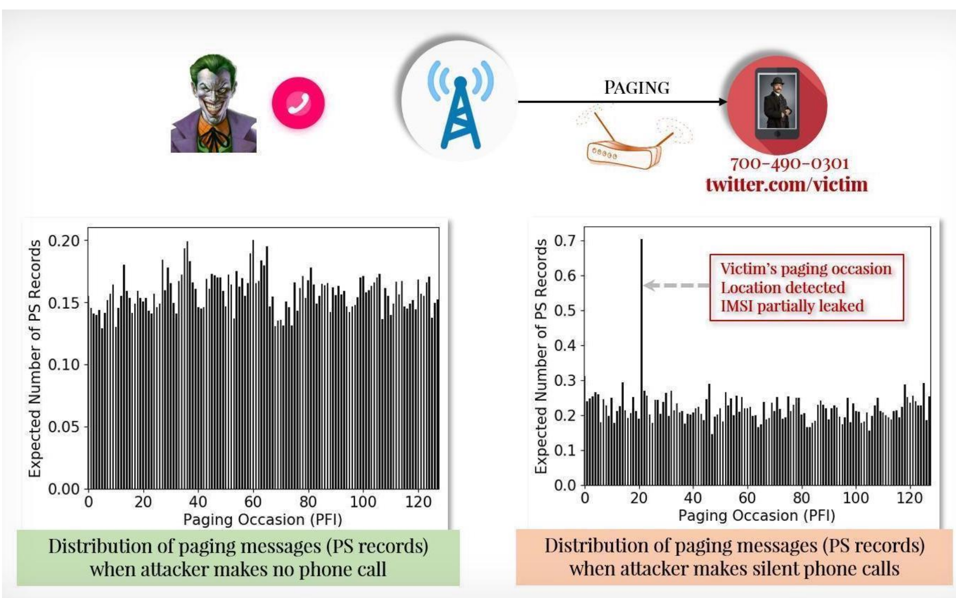
Hussain, along with Ninghui Li and Elisa Bertino at Purdue University, and Mitziu Echeverria and Omar Chowdhury at the University of Iowa are set to reveal their findings at the Network and Distributed System Security Symposium in San Diego on Tuesday.

The paper, seen by TechCrunch prior to the talk, details the attacks: the first is Torpedo, which exploits a weakness in the paging protocol that carriers use to notify a phone before a call or text message comes through. The researchers found that several phone calls placed and cancelled in a short period can trigger a paging message without alerting the target device to an incoming call, which an attacker can use to track a victim's location. Knowing the victim's paging occasion also lets an attacker hijack the paging channel and inject or deny paging messages, by spoofing messages like Amber alerts or blocking messages altogether, the researchers say.

Torpedo opens the door to two other attacks: Piercer, which the researchers say allows an attacker to determine an international mobile subscriber identity (IMSI) on the 4G network; and the aptly named IMSI-Cracking attack, which can brute force an IMSI number in both 4G and 5G networks, where IMSI numbers are encrypted.

That puts even the newest 5G-capable devices at risk from stingrays, said Hussain, which law enforcement use to identify someone's real-time location and log all the phones within its range. Some of the more advanced devices are believed to be able to intercept calls and text messages, he said.

According to Hussain, all four major U.S. operators — AT&T, Verizon (which owns TechCrunch), Sprint and T-Mobile — are affected by Torpedo, and the attacks can carried out with radio equipment costing as little as $200. One U.S. network, which he would not name, was also vulnerable to the Piercer attack.



*The Torpedo attack — or "**TR**acking via **P**aging m**E**ssage **D**istributi**O**n. (Image: supplied)*

We contacted the big four cell giants, but none provided comment by the time of writing. If that changes, we'll update.

Given two of the attacks exploit flaws in the 4G and 5G standards, almost all the cell networks outside the U.S. are vulnerable to these attacks, said Hussain. Several networks in Europe and Asia are also vulnerable.

Given the nature of the attacks, he said, the researchers are not releasing the proof-of-concept code to exploit the flaws.

It's the latest blow to cellular network security, which has faced intense scrutiny no more so than in the last year for flaws that have allowed the interception of calls and text messages. Vulnerabilities in Signaling System 7, used by cell networks to route calls and messages across networks, are under active exploitation by hackers. While 4G was meant to be more secure, research shows that it's just as vulnerable as its 3G predecessor. And, 5G was meant to fix many of the intercepting capabilities but European data security authorities warned of similar flaws.

Hussain said the flaws were reported to the **GSMA,** an industry body that represents mobile operators. GSMA recognized the flaws, but a spokesperson was unable to provide comment when reached. It isn't known when the flaws will be fixed.

Hussain said the Torpedo and IMSI-Cracking flaws would have to be first fixed by the GSMA, whereas a fix for Piercer depends solely on the carriers. Torpedo remains the priority as it precursors the other flaws, said Hussain.

The paper comes almost exactly a year after Hussain *et al* revealed ten separate weaknesses in 4G LTE that allowed eavesdropping on phone calls and text messages, and spoofing emergency alerts.

Stanford | Internet Observatory
Cyber Policy Center

October 30, 2019
https://cyber.fsi.stanford.edu/io/news/prigozhin-africa

Evidence of Russia-Linked Influence Operations in Africa

Stanford Internet Observatory

Russia's global strategy for **reasserting itself** as a geopolitical superpower has led to an increased presence in Africa, where it has broadened efforts to shape the continent's politics and pursue new economic opportunities **to allay the effects of sanctions**. While the presence of Russian military instructors and **paramilitary groups** in Libya and the Central African Republic is well documented, there is emerging evidence that Russian-linked companies are now active in the information space as well. Yevgeny Prigozhin, the oligarch perhaps best known for **running the Internet Research Agency**, is central to this expansion.

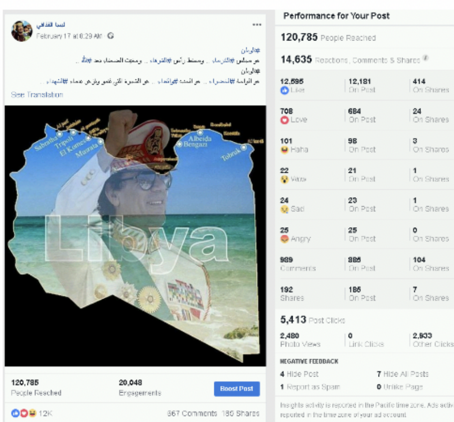
In this post we identify a Facebook operation attributed to entities tied to Prigozhin — including, it appears, the **Wagner Group** (Частная военная компания Вагнера), a Russian organization that has served as a private military contractor in several African countries. The first allusion to a social media influence operation tied to Prigozhin stemmed from **Daily Beast reporting** and a document shared with us by the **Dossier Center** that suggested the existence of a cluster of Facebook Pages tied to the Wagner Group. We identified an initial cluster of Pages which targeted Libya, and shared the find with the Facebook Threat Intel team. Facebook subsequently provided us with data on two related networks that they had been investigating previously. These networks have been targeting the Central African Republic, the Democratic Republic of the Congo, Madagascar, Mozambique, and Sudan, and included "news" Pages and websites, and Pages purporting to belong to political parties as well as individual politicians. The part of the operation we analyzed included seven Instagram accounts and 73 Facebook Pages. In total 1.72 million accounts liked the Facebook Pages, though we note that some of these likes are possibly from the same account across multiple Pages. The Page managers were quite active; in October 2019 alone there were 8,900 posts.

Приложение 2.

С начала 2019 года в Ливийском сегменте сети интернет «Компания» ведет информационную пропаганду, направленную на продвижение интересов России в Ливии.

По состоянию на март 2019 года, **создано 12 групп в социальной сети Facebook** по следующим направлениям: поддержка Сейфа Каддафи, новостные группы в основных регионах Ливии, поддержка генерала Халифа Хафтара. Число постоянной аудитории ливийских групп в социальной сети Facebook составляет **более 250 000 человек**, а **еженедельный охват публикаций - более 2 000 000 пользователей.**

Пример публикации в социальных сетях (тема «поддержка Каддафи»)



Патриотический пост про лучшее время Родины.

Дата размещения: 17.01.2019
120 785 просмотров
12 595 лайков

*Wagner Group document shared by the Dossier Center. The document included an example post from a Page called □□□□□□□ □□□□□ (Libya Gaddafi). The post was a photo of former president Muammar Gaddafi, overlaid on an outline of Libya. The document described the post as a "Patriotic post about the best time for the Motherland." (***High Resolution***)*

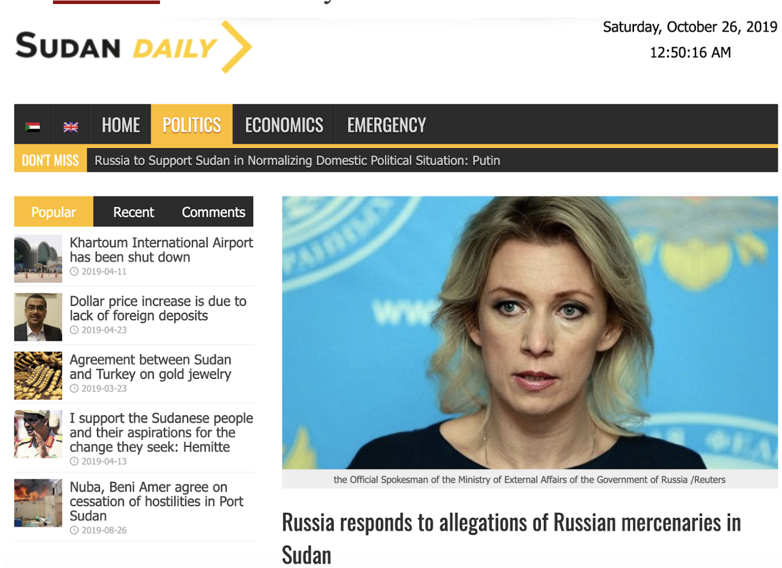
From our analysis of the social media activity, there are several key takeaways:

- The operation, conducted by Russia-linked organizations likely operating at least in part at the behest of a state actor, appears to have further relied on subcontractors who are native speakers and/or local to the region. This variety of nested obfuscation increases hurdles to attribution of disinformation campaigns.
- In addition to well-known social media platforms such as Twitter and Facebook, the actors leveraged public WhatsApp and Telegram groups. Whether more private chat channels were also used is an area for further research.
- The operation used social media engagement tactics designed to develop a close relationship with the audience, including Facebook Live videos, Google Forms for feedback, and a contest.

- The operation shared tactical similarities to Internet Research Agency activities; the operatives created several associated news sites (in one case staffed by reporters who appear to have spent time in Russia) as well as Facebook Pages that produced social-first content (memes, live videos). The attribution of such activity to non-IRA entities that nonetheless share an affiliation with Prigozhin leads to a significant unresolved question of what relationship, if any, exists between the IRA, Wagner, and Prigozhin's other companies, and to what extent Russia is distributing its active-measures capabilities across a myriad of organizations to hinder detection and attribution.

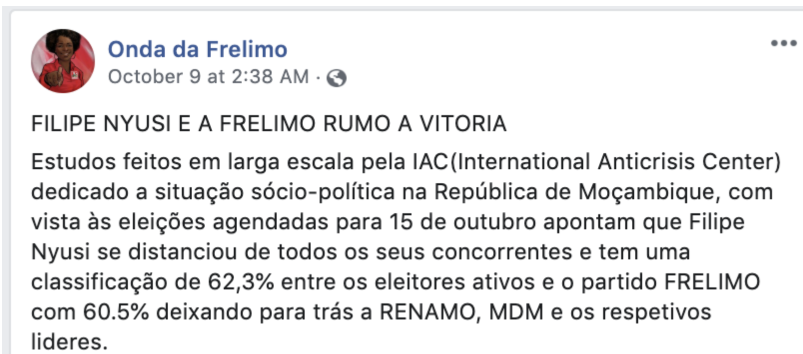
The activity and strategies varied by country:

- Libya: Russian actors are supporting two potential future presidential candidates: the rebel General Khalifa Haftar and Muammar Gaddafi's son, Saif al-Islam Gaddafi. The Facebook operation began in December 2018, and the Pages were run by administrators in Egypt. **Prior reporting** has indicated that the Wagner Group has at least 100 mercenaries fighting with Haftar's militias.
- Sudan: Facebook activity began in mid-2018, and has persisted since the April coup against Omar al-Bashir, transition to the Transitional Military Council, and transition to the Sovereign Council of Sudan. Content has been slightly supportive of whatever government is in power, and occasionally critical of protesters. Several of the Pages relate to two news websites, khartoumstar.com and sudandaily.org, the latter of which often re-posted Sputnik articles. There were additionally Facebook Pages purporting to be the official Pages of several political parties, along with "news" Pages for the Transitional Military Council and the Sovereign Council of Sudan. The former had the url facebook.com/transitionalmilitarycouncil, and at first glance appeared to be its official Page. Prigozhin-linked companies are known to have **mining agreements in Sudan** and **have trained** local military forces.



A Sudan Daily ***article****, reposted from Sputnik, saying that Russian mercenaries in Sudan have no connection to the Russian government. (***Link to full image***)*

- Central African Republic: A network of Facebook Pages was created to publicize and praise the **wide range of activities** undertaken by the Russian government in the CAR, from **military support** to **cultural events**. These Pages, most of which had administrators in Madagascar, seem to have been intended to appear organic and give CAR audiences the impression of widespread domestic support for the administration of President Touadéra and its Russian partners.
- Madagascar: Russian actors created several Pages in 2018, but only began posting in February 2019, just after the new president was inaugurated. The Pages bolstered the government. One Page was created for a specific parliamentary candidate.
- Mozambique: The Facebook operation began in September 2019, a few weeks before the country's presidential and parliamentary elections. The Pages posted content to support the incumbent president, and damage the reputation of the opposition – in at least one instance, with a fake news story.



*A post from Onda da Frelimo (Wave of Frelimo) describing the results of a poll purportedly conducted by the International Anticrisis Center, a Russian organization. The publication of such polls is illegal in Mozambique. Frelimo is the ruling party in Mozambique. (***High resolution***)*

- Democratic Republic of the Congo: Three Facebook Pages, created in 2019 after a contentious election, published content and memes mocking and criticizing key Congolese political figures, including the president. These Pages were not clearly aligned with the Russian government's public strategy.

The potential connection between the Libya operation and the Wagner Group is based on the leaked document obtained from the Dossier Center, which we cannot independently verify. We attribute these collective operations to actors tied to Yevgeny Prigozhin. Facebook's attribution supports our conclusion. This investigation demonstrates a fundamental challenge of attributing information operations: disentangling activity by domestic interested parties, foreign actors working on behalf of domestic parties and foreign actors working in support of their own geopolitical or commercial interests. Our initial analysis of this content suggests a complex mix of motivations and our understanding of the African political disinformation ecosystem continues to evolve. Our full analysis of the materials, including images and figures, is in the **linked whitepaper**.

The Washington Post

Opinions

The U.S. once again has the world's fastest supercomputer. Keep up the hustle.

The Titan supercomputer, the world's fastest in 2012, has been replaced by the Summit. (Courtesy of NVidia and Oak Ridge National Laboratory/COURTESY OF NVIDIA AND OAK RIDGE NATIONAL LABORATORY)

By **Jack Dongarra**

June 25, 2018

The United States has knocked China out of the No. 1 position in supercomputing. This week, when the latest ranking of the 500 fastest supercomputers in the world was released, the Energy Department's new Summit machine reclaimed a distinction that China has held for five years. The development is more than a matter of national pride; supercomputers are an indispensable tool for national security, technological progress and economic competitiveness.

How fast is the Summit? To begin with, it is roughly eight times faster than the previous U.S. titleholder, the Titan, from 2012. The Summit, developed for the Oak Ridge National Laboratory in Tennessee (where I work), has a peak performance capability of 200,000 trillion "floating point operations" — or petaflops — per second. That won't mean much to non-computer scientists, so think of it this way: The entire population of Earth would have to compute continuously for 305 days, performing one operation per second, to match what the Summit does in one second. The Summit exceeds China's fastest supercomputer by about 30 percent, prompting its ranking by TOP500, a project that I have been involved with since its inception in 1993, along with my colleagues Erich Strohmaier and Horst Simon of Lawrence Berkeley National Laboratory and Martin Meuer of Prometeus, a German technology company.

Supercomputers are systems that harness the power of multiple refrigerator-size units — the Summit uses an IBM system composed of 256 such cabinets, weighing a combined 340 tons and occupying 5,600 square feet — or about the size of two tennis courts. The development of supercomputers was fueled in the 1990s by the Energy Department's desire to maintain the readiness of America's nuclear stockpile without actual detonation testing. That required computer simulations capable of modeling nuclear processes down to tiny fractions of a second. No computer on the planet was capable of such precision, so the department embarked on a campaign that would raise the processing speed of the world's best computers by a factor of 10,000.

It is the supercomputer's simulation abilities that are invaluable in science and industry today. They are being applied to research in energy, advanced materials and artificial intelligence, in addition to military applications and other domains. The simulation powers allow scientists to pursue research that was previously impractical or impossible.

Supercomputing's practical applications are remarkably varied. A hospital in Kansas City, Mo., using high-performance computing to analyze 120 billion DNA sequences to narrow the cause of an infant's liver failure to two possible genetic variants, produced an accurate diagnosis that helped save the baby's life. Engineers at General Motors used supercomputers to simulate crash tests from every angle, to test seat belt and air bag performance, and to improve pedestrian safety. A Philadelphia consortium dedicated to energy efficiency used supercomputers to create more efficient and "greener" buildings by simulating thermal flows.

The current supercomputing speeds, known as "petascale," are staggeringly fast compared with what was available only a few years ago, but they will seem plodding beside the "exascale" supercomputers that are on the horizon. They will exceed a billion-billion operations per second — a decidedly new breed.

Reaching exascale speeds will not be easy. Even for today's supercomputers to be useful in a wide range of applications, they need to have enormous memories and the ability to store and read vast quantities of data at high speed. The supercomputers must also have a software environment that facilitates the efficient and productive use of the hardware and its underlying architectures. The centers that host them are laying the groundwork for exascale systems.

The quest for exascale is driven by the realization that it will provide even more capability in a broad range of industries, including energy production, pharmaceutical research and development, and aircraft and automobile design. National economic competitiveness relies on the ability to quickly engineer superior products — and supercomputing often has a spillover effect in consumer electronics. Today's smartphones still have a lot to learn.

And you can bet that the Chinese are working as industriously toward exascale as computer scientists are in the United States, in Japan and in the European Union, which are also serious competitors in supercomputing. The Summit might have brought the "world's fastest" honors back to the United States, but China — which in 2001 had no supercomputers — still dominates the field, holding the majority of entries in the TOP500 rankings.

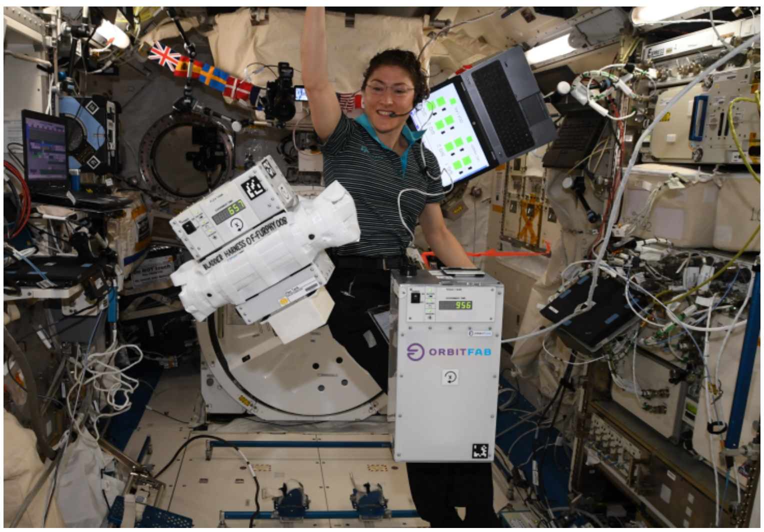
Beyond exascale supercomputing, scientists dream of quantum computing using principles of physics for calculations at speeds far beyond anything possible today. But there are many challenges to overcome before quantum computers are a reality for practical computations. The United States and its competitors are of course working intensely on overcoming those challenges. In the shorter term, the race is on to try to surmount the Summit as the world's fastest supercomputer.

Jack Dongarra is University Distinguished Professor at the University of Tennessee in Knoxville and a Distinguished Research Staff member at Oak Ridge National Laboratory.

TechCrunch

Orbit Fab becomes first startup to supply water to ISS, paving the way for satellite refueling

Darrell Etherington • June 18, 2019
https://techcrunch.com/2019/06/18/orbit-fab-becomes-first-startup-to-supply-water-to-iss-paving-the-way-for-satellite-refueling/



Not even two years into its existence, orbital fuel supply startup **Orbit Fab** has chalked up a big win — successfully supplying the International Space Station with water, a first for any private company. It's a big deal, because providing water to the ISS involved a multi-day refueling process, done in microgravity, using processes and equipment Orbit Fab developed itself.

The key ingredient here, per ISS U.S. National Laboratory COO Kenneth Shields, which was the contracting agency for Orbit Fab's refueling test, is that this method of resupply is totally out of spec in terms of how this process was designed to work on the ISS. By creating and successfully demonstrating a system that the ISS designers never conceived, Orbit Fab has shown that both private companies and NASA have the flexibility needed to build business models on existing space infrastructure.

The technology Orbit Fab developed and demonstrated has broader applications than just moving water around in space. Water was used in this example specifically because it's one of the most inert propellants used in spaceflight thrusters, but the methods could extend to other common propellants, and make it possible to refuel satellites in orbit. Orbit Fab is working toward establishing standards for satellite refueling interfaces to be used in orbital hardware, which could go a long way toward making it common practice to develop reusable satellites, instead of sticking with the more or less disposable hardware model used today.

Startups like Orbit Fab are the key to unlocking true commercialization of space, by identifying points in the value chain where innovation or improvement can lead to cost or resource efficiencies and ensure that space business is actually also viable business, in terms of profit potential.

ARTICLE **Communicated by Stefan Kiebel**

Active Inference, Curiosity and Insight

Karl J. Friston
k.friston@ucl.ac.uk
Marco Lin
marco.lin91@gmail.com
Wellcome Trust Centre for Neuroimaging, Institute of Neurology, University College London WC1N 3BG, U.K.

Christopher D. Frith
c.frith@ucl.ac.uk
Wellcome Trust Centre for Neuroimaging, Institute of Neurology, University College London WC1N 3BG, and Institute of Philosophy, School of Advanced Studies, University of London EC1E 7HU, U.K.

Giovanni Pezzulo
giovanni.pezzulo@gmail.com
Institute of Cognitive Sciences and Technologies, National Research Council, 7-00185 Rome, Italy

J. Allan Hobson
allan_hobson@hms.harvard.edu
Wellcome Trust Centre for Neuroimaging, Institute of Neurology, University College London WC1N 3BG, U.K., and Division of Sleep Medicine, Harvard Medical School, Boston, MA 02215, U.S.A.

Sasha Ondobaka
s.ondobaka@ucl.ac.uk
Wellcome Trust Centre for Neuroimaging, Institute of Neurology, University College London WC1N 3BG, U.K.

This article offers a formal account of curiosity and insight in terms of active (Bayesian) inference. It deals with the dual problem of inferring states of the world and learning its statistical structure. In contrast to current trends in machine learning (e.g., deep learning), we focus on how people attain insight and understanding using just a handful of observations, which are solicited through curious behavior. We use simulations of abstract rule learning and approximate Bayesian inference to show that minimizing (expected) variational free energy leads to active sampling of novel contingencies. This epistemic behavior closes explanatory gaps in generative models of the world, thereby reducing uncertainty and

Neural Computation **29, 2633–2683** (2017)
doi:10.1162/NECO_a_00999

satisfying curiosity. We then move from epistemic learning to model selection or structure learning to show how abductive processes emerge when agents test plausible hypotheses about symmetries (i.e., invariances or rules) in their generative models. The ensuing Bayesian model reduction evinces mechanisms associated with sleep and has all the hallmarks of "aha" moments. This formulation moves toward a computational account of consciousness in the pre-Cartesian sense of sharable knowledge (i.e., *con*: "together"; *scire*: "to know").

1 Introduction

This article presents a formal (computational) description of epistemic behavior that calls on two themes in theoretical neurobiology. The first is the use of Bayesian principles for understanding the nature of intelligent and purposeful behavior (Koechlin, Ody, & Kouneiher, 2003; Oaksford & Chater, 2003; Coltheart, Menzies, & Sutton, 2010; Nelson, McKenzie, Cottrell, & Sejnowski, 2010; Collins & Koechlin, 2012; Solway & Botvinick, 2012; Donoso, Collins, & Koechlin, 2014; Seth, 2014; Koechlin, 2015; Lu, Rojas, Beckers, & Yuille, 2016). The second is the role of self-modeling, reflection, and sleep (Metzinger, 2003; Hobson, 2009). In particular, we formulate curiosity and insight in terms of inference—namely, the updating of beliefs about how our sensations are caused. Our focus is on the transitions from states of ignorance to states of insight—namely, states with (i.e., *con*) awareness (i.e., *scire*) of causal contingencies. We associate these epistemic transitions with the process of Bayesian model selection and the emergence of insight. In short, we try to show that resolving uncertainty about the world, through active inference, necessarily entails curious behavior and consequent 'aha' or eureka moments.

The basic theme of this article is that one can cast learning, inference, and decision making as processes that resolve uncertainty about the world. This theme is central to many issues in psychology, cognitive neuroscience, neuroeconomics, and theoretical neurobiology, which we consider in terms of *curiosity* and *insight*. The purpose of this article is not to review the large literature in these fields or provide a synthesis of established ideas (e.g., Schmidhuber, 1991; Oaksford & Chater, 2001; Koechlin et al., 2003; Botvinick & An, 2008; Nelson et al., 2010; Navarro & Perfors, 2011; Tenenbaum, Kemp, Griffiths, & Goodman, 2011; Botvinick & Toussaint, 2012; Collins & Koechlin, 2012; Solway & Botvinick, 2012; Donoso et al., 2014). Our purpose is to show that the issues this diverse literature addresses can be accommodated by a single imperative (minimization of expected free energy, or resolution of uncertainty) that already explains many other phenomena–for example, decision making under uncertainty, stochastic optimal control, evidence accumulation, addiction, dopaminergic responses, habit learning, reversal learning, devaluation, saccadic searches, scene construction, place cell activity, omission-related responses, mismatch negativity, P300 responses, phase-precession, and theta-gamma coupling (Friston, FitzGerald et al., 2016; Friston, FitzGerald, Rigoli, Schwartenbeck, & Pezzulo, 2017). In what follows, we ask how the resolution of uncertainty might explain curiosity and insight.

1.1 Curiosity. Curiosity is an important concept in many fields, including psychology (Berlyne, 1950, 1954; Loewenstein, 1994), computational neuroscience, and robotics (Schmidhuber, 1991; Oaksford & Chater, 2001). Much of neural development can be understood as learning contingencies about the world and how we can act on the world (Saegusa, Metta, Sandini, Sakka, 2009; Nelson et al., 2010; Nelson, Divjak, Gudmundsdottir, Martignon, & Meder, 2014). This learning rests on intrinsically motivated curious behavior that enables us to predict the consequences of our actions: as nicely summarized by Still and Precup (2012), "A learner should choose a policy that also maximizes the learner's predictive power. This makes the world both interesting and exploitable." This epistemic, world-disclosing perspective speaks to the notion of optimal data selection and important questions about how rational or optimal we are in querying our world (Oaksford, Chater, Larkin, 2000; Oaksford & Chater, 2003). Clearly, the epistemic imperatives behind curiosity are especially prescient in developmental psychology and beyond: "In the absence of external reward, babies and scientists and others explore their world. Using some sort of adaptive predictive world model, they improve their ability to answer questions such as what happens if I do this or that?" (Schmidhuber, 2006). In neurorobotics, these imperatives are often addressed in terms of active learning (Markant & Gureckis, 2014; Markant, Settles, & Gureckis, 2016), with a focus on intrinsic motivation (Baranes & Oudeyer, 2009). Active learning and intrinsic motivation are also key concepts in educational psychology, where they play an important role in enabling insight and understanding (Eccles & Wigfield, 2002).

1.2 Insight and Eureka Moments. The Eureka effect (Auble, Franks, & Soraci, 1979) was introduced to psychology by comparing the recall for sentences that were initially confusing but subsequently understood. The implicit resolution of confusion appears to be the main determinant of recall and the emotional concomitants of insight (Shen, Yuan, Liu, & Luo, 2016). Several psychological theories for solving insight problems have been proposed—for example, progress monitoring and representational change theory (Knoblich, Ohlsson, & Raney, 2001; MacGregor, Ormerod, & Chronicle, 2001). Both enjoy empirical support, largely from eye movement studies (Jones, 2003). Furthermore, several psychophysical and neuroimaging studies have attempted to clarify the functional anatomy of insight (see Bowden, Jung-Beeman, Fleck, & Kounios, 2005), for a psychological review and Dresler et al., 2015, for a review of the neural correlates of insight in dreaming and psychosis). In what follows, we offer a normative framework that complements psychological theories by describing how curiosity engenders insight. Our treatment is framed by two questions posed by Berlyne (1954) in his seminal treatment of curiosity: "The first question is why human beings devote so much time and effort to the acquisition of knowledge. . . . The second question is why, out of the infinite range of knowable items in the universe, certain pieces of knowledge are more ardently sought and more readily retained than others?" (p. 180).

In brief, we will try to show that the acquisition of knowledge and its retention are emergent properties of active inference—specifically, that curiosity manifests as an active sampling of the world to minimize uncertainty about hypotheses—or explanations—for states of the world, while retention of knowledge entails the Bayesian model selection of the most plausible explanation. The first process rests on curious, evidence-accumulating, uncertainty-resolving behavior, while the second operates on knowledge structures (i.e., generative models) after evidence has been accumulated.

Our approach rests on the free energy principle, which asserts that any sentient creature must minimize the entropy of its sensory exchanges with the world. Mathematically, entropy is uncertainty or expected surprise, where surprise can be expressed as a free energy function of sensations and (Bayesian) beliefs about their causes. This suggests that creatures are compelled to minimize uncertainty or expected free energy. In what follows, we will see that resolving different sorts of uncertainty furnishes principled explanations for different sorts of behavior. These levels of uncertainty pertain to plausible states of the world, plausible policies that change those states, and plausible models of those changes.

The first level of uncertainty is about the causes of sensory outcomes under a particular policy (i.e., sequence of actions). Reducing this sort of uncertainty corresponds to perceptual inference (a.k.a. state estimation). In other words, the first thing we need to do is infer the current state of the world and the context in which we are operating. We then have to contend with uncertainty about policies per se that can be cast in terms of uncertainty about future states of the world, outcomes, and the probabilistic contingencies that bind them. We will see that minimizing these three forms of expected surprise—by choosing an uncertainty resolving policy—corresponds to information-seeking epistemic behavior, goal-seeking pragmatic behavior, and novelty-seeking curious behavior, respectively. In short, by pursuing the best policy, we accumulate experience and reduce uncertainty about probabilistic contingencies through epistemic learning—namely, inferring (the parameters of our models of) how outcomes are generated.

Finally, curious, novelty-seeking policies enable us to reduce our uncertainty about our generative models per se, leading to structure learning, insight, and understanding. Here, a generative model constitutes a hypothesis about how observable outcomes are generated, where we entertain

Table 1: Sources of Uncertainty Scored by (Expected) Free Energy and the Behaviors Entailed by Its Minimization (Resolution of Uncertainty through Approximate Bayesian Inference).

Source of Uncertainty	Free Energy (Surprise)	Minimization	Active Inference
Uncertainty about hidden states given a policy	$F(\pi) = F(\tilde{o}, \mathbf{s}_\tau^\pi, \mathbf{a}\|\pi)$	With respect to expected states $\mathbf{s}_\tau^\pi$	Perceptual inference (*state estimation*)
Uncertainty about policies in terms of expected: Future states (*intrinsic value*) Future outcomes (*extrinsic value*) Model parameters (*novelty*)	$G(\pi) = G(\mathbf{s}_\tau^\pi, \mathbf{a}\|\pi) =$ $\mathbf{o}_\tau^\pi \cdot \widehat{\mathbf{o}}_\tau^\pi + \mathbf{H} \cdot \mathbf{s}_\tau^\pi +$ $\mathbf{o}_\tau^\pi \cdot \mathbf{C}_\tau +$ $\mathbf{o}_\tau^\pi \cdot \mathbf{W} \cdot \mathbf{s}_\tau^\pi$	With respect to policies $\boldsymbol{\pi}$	Epistemic planning Intrinsic motivation Extrinsic motivation Curiosity
Uncertainty about model parameters given a model	$F(\tilde{o}, \mathbf{s}_\tau^\pi, \boldsymbol{\pi}, \mathbf{a}\|m)$	With respect to parameters $\mathbf{a}$	Epistemic learning (*active learning*)
Uncertainty about the model	$F(\tilde{o}, \mathbf{s}_\tau^\pi, \boldsymbol{\pi}, \mathbf{a}\|m)$	With respect to model m	Structure learning (*insight and understanding*)

competing hypotheses that are, a priori, equally plausible. In short, the last level of uncertainty reduction entails the selection of models that render outcomes the least surprising, having suppressed all other forms of uncertainty. All but the last process require experience to resolve uncertainty about either the states (inference) or parameters (learning) of a particular model. However, optimization of the model per se can proceed in a fact-free, or outcome-free, fashion, using experience accumulated to date. In other words, no further facts or outcomes are necessary for this last level of optimization: facts and outcomes are constitutive of the experience on which this optimization relies. It is this Bayesian model selection we associate with fact-free learning (Aragones, Gilboa, Postlewaite, & Schmeidler, 2005) and the emergence of insight (Bowden et al., 2005).

Table 1 provides a summary of these uncertainty-reducing processes, where uncertainty is associated with free energy formulations of surprise such that uncertainty-resolving behavior reduces expected free energy. To motivate and illustrate this formalism, we set ourselves the task of simulating a curious agent that spontaneously learned rules—governing the sensory consequences of her action—from limited and ambiguous sensory evidence (Lu et al., 2016; Tervo, Tenenbaum, & Gershman, 2016). We chose abstract rule learning to illustrate how conceptual knowledge could be accumulated through experience (Botvinick & Toussaint, 2012; Zhang & Maloney, 2012; Koechlin, 2015) and how implicit Bayesian belief updating can be accelerated by applying Bayesian principles not to sensory samples but to beliefs based on those samples. This structure learning (Tenenbaum et al., 2011; Tervo et al., 2016) is based on recent developments in Bayesian model selection, namely, Bayesian model reduction (Friston, Litvak et al., 2016). Bayesian model reduction refers to the evaluation of reduced forms of a full model to find simpler (reduced) models using only posterior beliefs (Friston & Penny, 2011). Reduced models furnish parsimonious explanations for sensory contingencies that are inherently more generalizable (Navarro & Perfors, 2011; Lu et al., 2016) and, as we will see, provide for simpler and more efficient inference. In brief, we use simulations of abstract rule learning to show that context-sensitive contingencies, which are manifest in a high-dimensional space of latent or hidden states, can be learned using straightforward variational principles (i.e., minimization of free energy). This speaks to the notion that people "use their knowledge of real-world environmental statistics to guide their search behavior" (Nelson et al., 2014). We then show that Bayesian model reduction adds an extra level of inference, which rests on testing plausible hypotheses about the structure of internal or generative models. We will see that this process is remarkably similar to physiological processes in sleep, where redundant (synaptic) model parameters are eliminated to minimize model complexity (Hobson & Friston, 2012). We then show that qualitative changes in model structure emerge when Bayesian model reduction operates online during the assimilation of experience. The ensuing optimization of model evidence provides a plausible (Bayesian) account of abductive reasoning that looks very much like an "aha" moment. To simulate something akin to an aha moment requires a formalism that deals explicitly with probabilistic beliefs about states of the world and its causal structure. This contrasts with the sort of structure or manifold learning that predominates in machine learning (e.g., deep learning; LeCun, Bengio, & Hinton, 2015), where the objective is to discover structure in large data sets by learning the parameters of neural networks. This article asks whether abstract rules can be identified using active (Bayesian) inference, following a handful of observations and plausible, uncertainty-reducing hypotheses about how sensory outcomes are generated.

1.3 Active Inference and the Resolution of Uncertainty. Active inference is a corollary of the free energy principle that tries to explain action and perception in terms of minimizing variational free energy. Variational free energy is a proxy for surprise or (negative) Bayesian model evidence. This means that minimizing free energy corresponds to avoiding surprises or maximizing model evidence, and minimizing expected free energy corresponds to resolving uncertainty. The active aspect of active inference emphasizes that we are the embodied authors of our sensations. This means that the consequences of action must themselves be inferred (Baker, Saxe, & Tenenbaum, 2009). In turn, this implies that we have (prior) beliefs about our behavior. Active inference assumes that the only (self-consistent) prior belief is that we will minimize free energy; in other words, we (believe we) will resolve uncertainty through active sampling of the world (Friston, Mattout, & Kilner, 2011; Friston et al., 2015). Alternative prior beliefs can be discounted by *reductio ad absurdum*: if we do not believe that we will resolve uncertainty through active inference, and active inference realizes beliefs by minimizing uncertainty (i.e., fulfilling expectations), then active inference will not minimize uncertainty.

From a technical perspective, this article introduces generalizations of active inference for discrete state-space models (i.e., hidden Markov models and Markov decision processes) along two lines, both concerning the parameters of generative models that encode probabilistic contingencies. First, posterior beliefs about both hidden states and parameters are included in expected free energy, leading to epistemic or exploratory behavior that tries to resolve ignorance, in addition to risk and ambiguity. In other words, policies acquire epistemic value in virtue of resolving uncertainty about states and outcomes (risk and ambiguity) or resolving uncertainty about contingencies (ignorance)—in other words, "what happens if I do this or that?" (Schmidhuber, 2006). Second, we consider minimizing the free energy of the model per se (as opposed to model parameters), in terms of prior beliefs about which parameters are necessary to explain observed outcomes and which parameters are redundant and can be eliminated. As with our previous treatments of active inference, we pay special attention to biological plausibility and try to link optimization to neuronal processes. These developments can be regarded as rolling back the implications of minimizing variational free energy under a generic internal or generative model of the world.

1.4 Overview. This article has three sections. The first briefly reviews active inference and relates the underlying objective function (expected free energy) to established notions like utility, mutual information, and Bayesian surprise. The second describes the paradigm used in this article. In brief, we require agents to learn an abstract rule, in which the correct response is determined by the color of a cue whose location is determined by another cue. By transcribing task instructions into the prior beliefs of a simulated subject, we examine how quickly the rule can be learned—and how this epistemic learning depends on curious, uncertainty-reducing behavior that resolves ignorance (about the meaning of cues), ambiguity (about the context or rule in play), and risk (of making a mistake). In the third section, we turn to Bayesian model reduction or structure learning and consider the improvement in free energy—and performance—when competing hypotheses about the mapping between hidden states and outcomes are tested against the evidence of experience (Nelson et al., 2010). This evidence is accumulated by posterior beliefs over parameters and can be examined offline to simulate sleep and the emergence of eureka moments. We conclude with a brief illustration of communicating prior beliefs to others (i.e., sharing of knowledge) and discuss the implications for active inference and artificial intelligence.

2 Active Inference and Free Energy

Active inference assumes that every characteristic (variable) of an agent minimizes variational free energy (Friston, 2013). This leads to some surprisingly simple update rules for perception, planning, and learning. In principle, the active inference scheme described in this section can be applied to any paradigm or choice behavior. It has been used to model waiting games (Friston et al., 2013), two-step maze tasks (Friston et al., 2015), evidence accumulation in the urn task (FitzGerald, Schwartenbeck, Moutoussis, Dolan, & Friston, 2015), trust games from behavioral economics (Moutoussis, Trujillo-Barreto, El-Deredy, Dolan, & Friston, 2014), addictive behavior (Schwartenbeck, FitzGerald, Mathys, Dolan, Wurst, Kronbichler, & Friston, 2015), saccadic eye movements in scene construction (Mirza, Adams, Mathys, & Friston, 2016), and engineering benchmarks such as the mountain car problem (Friston, Adams, & Montague, 2012). It has also been used with computational fMRI (Schwartenbeck, FitzGerald, Mathys, Dolan, & Friston, 2015). In short, the simulations used to illustrate the emergence of curiosity and insight below follow from a single principle: the minimization of free energy (i.e., surprise) or maximization of model evidence.

Active inference rests on a generative model of observed outcomes. This model is used to infer the most likely causes of outcomes in terms of expected states of the world. These states are called latent, or hidden because they can only be inferred through observations that are usually limited. Crucially, observations depend on action (e.g., where you are looking), which requires the generative model to entertain expectations about outcomes under different sequences of action (i.e., policies). Because the model generates the consequences of action, it must have expectations about future states. These expectations are optimized by minimizing variational free energy, which renders them the most likely states of the world given current observations. Crucially, the prior probability of a policy depends on the free energy expected when pursuing that policy. The (expected) free energy is a proxy for uncertainty and has a number of familiar special cases, including expected utility, epistemic value, Bayesian surprise, and mutual information. After evaluating the expected free energy of each policy; and implicitly their posterior probabilities, the most likely action can be selected. This action generates a new outcome, and the (perception action) cycle starts again.

The resulting behavior represents a principled sampling of sensory cues that has both epistemic and pragmatic aspects. Generally, behavior in an ambiguous context is dominated by epistemic imperatives until there is no further uncertainty to resolve and pragmatic (prior) preferences predominate. At this point, explorative behavior gives way to exploitative behavior. In this article, we are interested in epistemic behavior, and use prior preferences only to establish a task or instruction set—namely, report a choice when sufficiently confident.

The formal description of active inference that follows introduces many terms and expressions that might appear a bit daunting at first reading. However, most of the technical material represents a standard treatment of Markov decision processes in terms of belief propagation or variational message passing that has been described in a series of previous papers. Furthermore, the simulations reported in this article and previous papers use exactly the same routines (see the software note at the end of the article). We have therefore tried to focus on the essential ideas (and variables) to provide an accessible and basic account of active inference, so that we can focus on curiosity (epistemic novelty-seeking behavior) and insight (Bayesian model reduction). People who want a more detailed account of the basic active inference scheme can refer to Table 2 (for a full glossary of terms described in the appendix) and Friston, FitzGerald et al. (2016) and Friston et al. (2017).

2.1 The Generative Model. Figure 1 provides a schematic specification of the generative model used for the sorts of problems considered in this article. This model is described in more detail in the appendix. In brief, outcomes at any particular time depend on hidden states, while hidden states evolve in a way that depends on action. The generative model is specified by two sets of high-dimensional matrices or arrays. The first, A^m, maps from hidden states to the mth outcome or modality—for example, exteroceptive (e.g., visual) or proprioceptive (e.g., eye position) modalities. These parameters encode the likelihood of an outcome given their hidden causes. The second set, $\mathbf{B}^n$, prescribes transitions among the nth factor of hidden states, under an action specified by the current policy.[1] These hidden factors correspond to different attributes of the world, like the location, color, or category of an object.[2] The remaining parameters encode prior beliefs about future outcomes $\mathbf{C}^m$ and initial states $\mathbf{D}^n$. The probabilistic mappings or contingencies are generally parameterized as Dirichlet distributions, whose sufficient statistics are concentration parameters. Concentration parameters can be thought of as counting the number of times a particular combination of

[1] Parameter matrices in bold denote known parameters. In this article, we consider that all model parameters are known (or have been learned), with the exception of the likelihood mapping; namely, the A parameters.

[2] Implicit in this notation is the factorization of hidden states into factors, whose transitions can be modeled with separate probability transition matrices. This means that the transitions among the levels or states of one factor do not depend on another factor. For example, the way an object moves does not depend on its color.

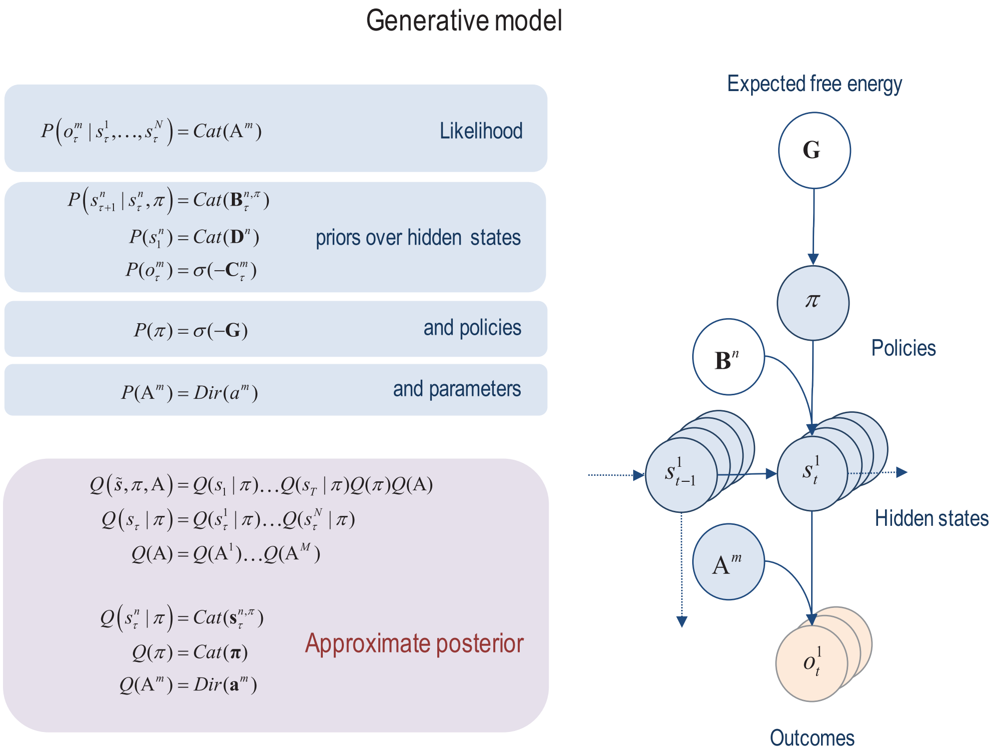


Figure 1: Generative model and (approximate) posterior. A generative model specifies the joint probability of outcomes or consequences and their (latent or hidden) causes. Usually the model is expressed in terms of a likelihood (the probability of consequences given causes) and priors over causes. When a prior depends on a random variable, it is called an *empirical prior*. Here, the likelihood is specified by a high-dimensional array **A** whose components are the probability of an outcome under every combination of hidden states. The empirical priors in this instance pertain to transitions among hidden states **B** that may depend on action, where actions are determined probabilistically in terms of policies (sequences of actions denoted by π). The key aspect of this generative model is that policies are more probable a priori if they minimize the (path integral of) expected free energy **G**. Bayesian model inversion refers to the inverse mapping from consequences to causes—estimating the hidden states and other variables that cause outcomes. In variational Bayesian inversion, one has to specify the form of an approximate posterior distribution, which is provided in the lower panel. This particular form uses a mean-field approximation in which posterior beliefs are approximated by the product of marginal distributions over hidden states or factors. Here, a mean-field approximation is applied both to posterior beliefs at different points in time and factors. (See the appendix and Table 2 for a detailed explanation of the variables.) The Bayesian network (right panel) provides a graphical representation of the dependencies implied by the equations on the left. Here (and in subsequent figures), t denotes the current time point, and τ indexes all possible time points.

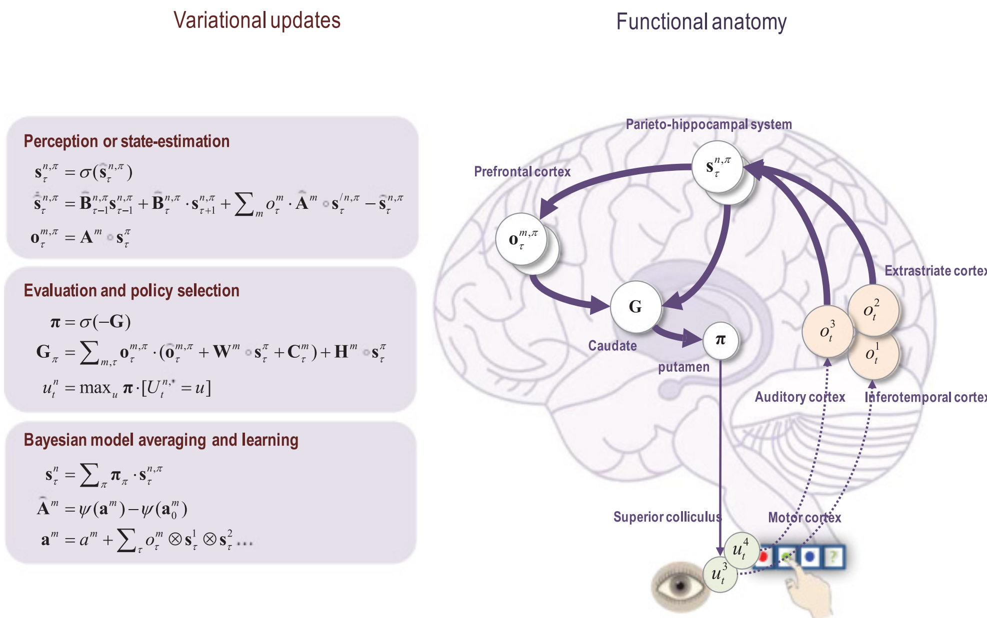


Figure 2: Schematic overview of belief updating. The left panel lists the belief updates mediating perception (i.e., state estimation), policy selection, and learning; while the right panel assigns the updates to various brain areas. This attribution is purely schematic and serves to illustrate a crude functional anatomy. Here, we have assigned observed outcomes to visual representations in the occipital cortex, with visual (*what*) modalities entering a ventral stream and proprioceptive (*where*) modalities originating a dorsal stream. Auditory feedback is associated with the auditory cortex. Hidden states encoding context have been associated with the hippocampal formation and association (parietal) cortex. The evaluation of policies, in terms of their (expected) free energy, has been placed in the caudate. Expectations about policies, assigned to the putamen, are used to create Bayesian model averages of future outcomes (e.g., in the frontal eye fields and supplementary motor area). Finally, expected policies specify the most likely action (e.g., via the deep layers of the superior colliculus). The arrows denote message passing among the sufficient statistics of each factor or marginal. The appendix and Table 2 explain the equations and variables.

states and outcomes has been observed. In this article, we focus on learning the likelihood model and therefore assume that state transitions and initial states are known (or have been learned).

The generative model in Figure 1 means that outcomes are generated in the following way. First, a policy is selected using a softmax function of the expected free energy for each policy. Sequences of hidden states are generated using the probability transitions specified by the selected policy. Finally, these hidden states generate outcomes in one or more modalities. Figure 2 (left panel) provides a graphical summary of the dependencies implied by the generative model in Figure 1. Perception or inference about hidden states (i.e., state estimation) corresponds to inverting a generative model given a sequence of outcomes, while learning corresponds to updating the parameters of the model. Perception therefore corresponds to optimizing expectations of hidden states and policies with respect to variational free energy, while learning corresponds to accumulating concentration parameters. These constitute the sufficient statistics of posterior beliefs, usually denoted by the probability distribution $Q(x)$, where $x = \tilde{s}, \pi, A$ are hidden or unknown quantities.

Medium

How do we decarbonize?

We don't need a miracle. Everything we need to solve climate change is already here.

Saul Griffith

May 23, 2019
https://medium.com/otherlab-news/how-do-we-decarbonize-7fc2fa84e887

Decarbonization can't come from partisan commitment to one and only one policy. The science and economics prove that a market-driven combination of electrification from renewable sources, supplementation with nuclear, strategic research into groundbreaking "miracle" solutions like fusion, a small amount of carbon sequestration and geoengineering, and a whole lot of will power is the realistic pathway to a sustainable future.

Summary

How to decarbonize appears to still be a contentious issue, whereas if we move past the "this, not that" arguments that plague the politics of the carbon transition, reasonable thinking leads to an approach that doesn't require magical thinking or an over-commitment to any single technology. We don't need a miracle technology — all we really need to do is to commit to massive electrification. Vested interests, however, want you to continue to believe in miracles because it means we can lean back and wait for the miracle to happen.

The actual miracle is that solar and wind are now the cheapest energy sources, electric cars are better cars than those we already have, electric radiant heating is better than our existing heating systems, and the internet was a practice run and blueprint for the electricity network of the future. Regardless of the minutiae of how we do it exactly, the beginning and the first half of decarbonization will most likely look the same: a commitment to solar and wind, batteries, electrification of homes, heat pumps, electric vehicles, ground-source geothermal and research into better biofuel sources and biofuels from waste, as well as research into better, cheaper, safer nuclear.

A carbon tax isn't a solution; at best it will just accelerate solutions. It's likely that un-subsidizing fossil fuels will be just as effective. By the time we have the political stomach for a carbon tax, the cheapest solutions will be electric vehicles, electrified homes, and wind and solar anyway.

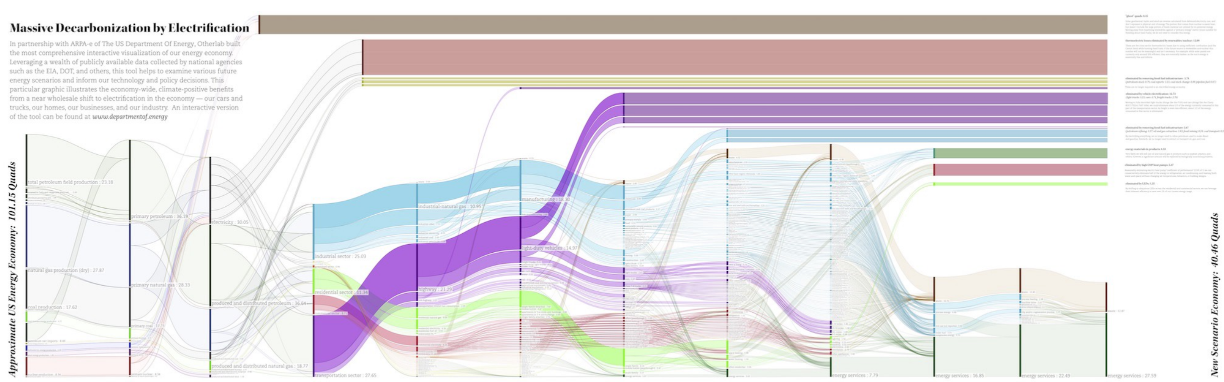
We haven't shown any inclination to drastically cut our consumption in the 40 years since Jimmy Carter asked us to wear sweaters.

Efficiency is great, but, like a carbon tax, it still isn't a solution. Overwhelmingly, the largest efficiency wins aren't LED lighting, double-glazed windows and heavier building insulation (each which is good but not nearly enough), but rather the electrification of cars and trucks, the electrification of our homes, and eliminating thermo-electric losses from the burning of fossil fuels to create electricity.

Nuclear power vs. renewables doesn't become an issue during the first half of the transition to mass electrification, and by then nuclear might be too expensive (compared to wind and solar).

Coal or natural gas with carbon sequestration is expensive and won't scale to the size of the problem. We know fracking leaks and that sequestered CO2 will leak too. The mere fact that compressed CO2 is much larger by volume than the oil and gas that come out tells us the simple story that we don't have enough holes to stuff it into. Additionally and specifically, natural gas is a bridge to nowhere; fossil fuels already burned that bridge.

Renewables are disrupting fossil fuels, and if the US does not win that technology game it will no longer be the leading world power. No one is looking forward to that existential crisis.



In partnership with ARPA-e of The US Department of Energy, Otherlab built the most comprehensive interactive visualization of our energy economy. Leveraging a wealth of publicly available data collected by national agencies such as the EIA, DOT, and others, this tool helps to examine various future energy scenarios and inform our technology and policy decisions. This particular graphic illustrates the economy-wide, climate-positive benefits of a near wholesale shift to electrification in the economy- our cars and trucks, our homes, our businesses, and our industry. An interactive version of the tool can be found at www.departmentof.energy and you can download a detailed pdf version of this graphic at https://www.dropbox.com/s/i5uqmlaw12744wc/MassiveElectrificationSankey.pdf?dl=0

How do we decarbonize?

Decarbonization sounds difficult and intimidating, and people still seem to hope for something magical to absolve us all of this challenge of climate change. While we don't have every single decarbonization option on the table right now, we have most of them, and reasonable and applied efforts will render the others tractable. Much of what needs to happen is already in full swing: the shift to electric cars and plummeting costs of wind, solar, and batteries.

The actual miracle is that solar and wind are now the cheapest energy sources, electric cars are better cars than those we already have, electric radiant heating is better than our existing heating systems, and the internet was a practice run and blueprint for the electricity network of the future.

For no particularly good reason, many people would like to make the decarbonization conversation binary: “this, not that.” The nuclear vs. renewables debate borders on religious. If nothing else, this piece is written to describe the gross high-level choices as a way of seeing that it’s not a binary choice: we sit before a smorgasbord of options, and we need to prioritize how to fill our plate.

There are good reasons (mostly cost) that some of the options at the smorgasbord will take a larger share of the decarbonized end game (I’m talking about you, solar). Similarly, there are good reasons that we’ll continue to hedge on higher-risk solutions (I’m talking about you, fusion) as their potential, *if they work*, is too high to ignore. Ultimately, this informs how one prioritizes solving climate change: we should prefer the things we know now will work and are cost-effective over those things we think might work, and obviously junk those things we can tell already will never work.

I’ll focus specifically on the energy side of climate change (carbon emissions) as that’s my specialty. That’s about 80% of the problem. The other ~20% is agriculture, land use, waste, and industrial processes[1]. This 20% is dominated by the methane emissions of the meat sector, the industrial processes that produce most steel and cement, refrigerants being lost from our refrigerators and air-conditioners[2], and landfill[3] and land-use (clearing and deforestation).

The short version of how we’ll decarbonize is through massive electrification–of all transportation as well as heat for buildings and industry — and that electricity will come from wind, solar, hydroelectric, and nuclear. *I’ve written about massive electrification in much greater detail in my earlier article: The Green New Deal: The enormous opportunity in shooting for the moon.*

The mid-length version is that in reality, how that electrification happens depends on local population density (urban vs. suburban vs. rural), climatic region (hot climate, cold climate, temperate climate) and cultural and local resource influences. Locations with relatively low population density, mild climates, and good solar resources (like Australia, California, New Mexico, and Texas) can almost completely solve the challenge with well-managed solar alone. High-population-density cold climates and hot climates will probably need to lean more heavily on nuclear power, or some version of imported energy, which could be renewably generated hydrogen[4] or biofuels.

Once we have that detail, we need to decide on a high-level strategy for how to create the non-carbon energy and have an understanding of how we are going to use it. This is the supply and the demand question of energy. That is what we’ll discuss in this piece.

The Options:

Roughly speaking, the supply choices presented as debatable extremes can be defined as:

1. **All renewables, all the time**
2. **Nuclear, nuclear, nuclear**
3. **Fossil fuels with massive carbon sequestration**
4. **Miracle technology saves the day**
5. **Deprivation and efficiency**
6. **Apathy with geoengineering**
7. **Carbon tax**

It's hopefully obvious that no one solution will be the entire answer, and we'll use some of everything, but we present the extreme version of each in order to be able to argue why there is a fairly obvious pathway to success.

1. All renewables, all the time?

All renewables can work[5], but this strategy relies upon nascent storage technologies to align the demand with the variable supply. Renewables will also need to pervade our built environment due to the scale of energy our modern lifestyles enjoy — this was true for the ancient Greeks also, whose entire town planning and architecture were centered around making maximum use of (passive) solar energy. To power all of America on solar, for example, would require ~1% of the land area dedicated to solar collection. We currently dedicate 1% to roads and 0.5% to rooftops, so this is not impossible, but it will undoubtedly become a pervasive part of the fabric of our lives.

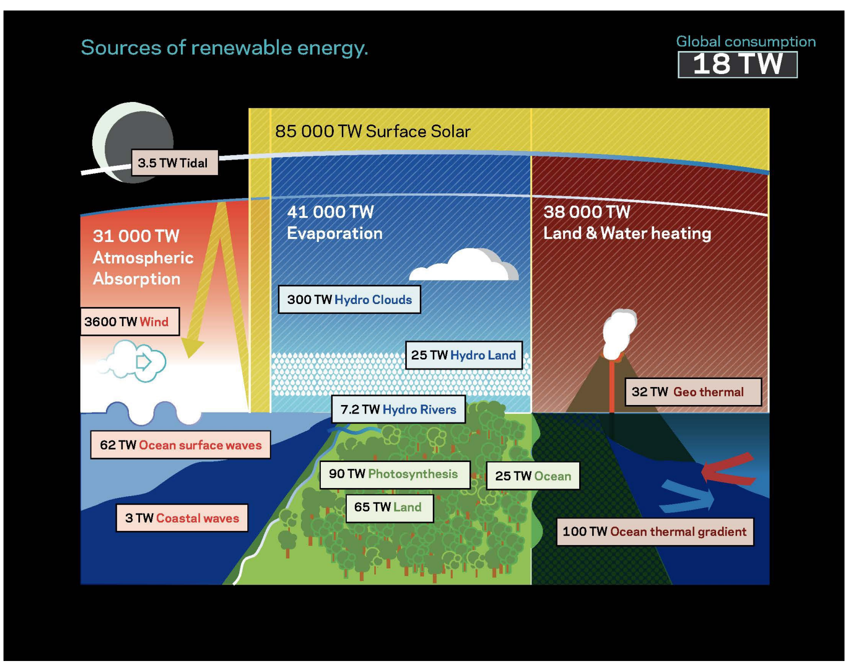


Figure 2: Summary of global renewables potential. There is ample solar and wind, a lot but not really enough biofuels (photosynthesis), and a small amount of hydroelectricity, geothermal, wave, and tidal.

Source data: http://web.stanford.edu/group/gcep/cgi-bin/gcep-research/

There is enough **wind** in the world to supply the entire world's energy needs. **Solar** supply exceeds even that by many times and is by far the largest renewable resource. In reality, wind is a second-order effect of solar energy anyway — the sun differentially heats the oceans, atmosphere, and land, and these thermal differences create the wind. This wind, in turn, makes **waves**; while there is, in fact, a lot of energy in the waves of the deep ocean, there is very little nearer to shore. Even if we captured all of the waves hitting every coastline on the planet, that's not enough to meet humanity's demand for energy. The ocean is a fragile ecosystem and capturing large portions of wave energy would negatively affect the oxygenation of the oceans, among other effects.

In theory, we could supply all of our energy with **biofuels.** The total photosynthetic output of life on earth is about 90TW — that's about five times humanity's total power consumption of ~16TW. Unfortunately, given the inefficiency of combustion (25–50%), we would need to burn nearly everything that grows every year to do it and with horrible ecosystem consequences and air quality compromises.

Geothermal energy is great, where it is near the surface and easy to get. The reality is that it can only supply a small fraction of our power supply. The killer application for geothermal is via ground-sourced heating and cooling: using the earth as a source of constant temperature for heating and cooling our buildings. This ground-sourced heat isn't what many people think of when they think geothermal energy. Geothermal energy is the energy generated in the earth's core — which is part radioactive decay and part latent heat from the creation of the earth from space dust. Ground-sourced heat takes advantage of the fact that the ground about six feet beneath us holds a relatively constant year-round temperature of 50–60 degrees Fahrenheit. It's better to use that temperature to cool our houses rather than trying to cool 100-degree desert air. It's also easier to bring 60-degree water up to 75 degrees to heat our houses than it is to heat freezing cold winter air.

Renewables will also need to pervade our built environment due to the scale of energy our modern lifestyles enjoy — this was true for the ancient Greeks also.

So clearly, renewables can do it for us, with solar as the biggest player, followed by wind. Fortunately, they are largely complementary since they are available at different times of the day. A small amount of wave power and geothermal power will help in localities with those particular resources. Ground-source heat will be useful nearly everywhere to aid our HVAC systems. Biofuels, while not really capable of solving the whole energy challenge, will be critical for things like long-distance flight and some of the more challenging transportation options requiring a high-density liquid fuel. Biofuels can also go a long way, if not all the way, to help bridge the seasonal storage problem since storing energy for 6 months at a time is a very difficult technical and economic proposition for batteries. The seasonal storage problem is the challenge that we use more energy in winter (light and heat) than we do in the summer and that this inconveniently happens at the time of year with the least solar energy.

2. *Nuclear, nuclear, nuclear?*

Nuclear, nuclear, nuclear can work, but 50 years of debating about it have passed and we still haven't agreed on the best way to deal with proliferation and waste issues. It's not too cheap to meter[6]; in fact, it is likely more expensive than renewables if we fully account for dealing with the associated waste and security.

Photo by Frédéric Paulussen on Unsplash

While it has lots of boosters[7] [8], it has similar numbers of detractors[9] [10] [11] and it's worth reading the most vocal of them.

We don't have enough fissile material to last forever[12] — estimates vary between 200 and 1000 years depending on what portion of the supply it will meet, and whether we stick with light water reactors (that don't produce weaponizable by-products) or whether we move to breeder-reactors that do. Arguably we can increase this runway by extracting fissile material from seawater[13] but that isn't exactly simplifying things.

The reality is that nuclear has been a very reliable source of 'baseload power,' though experts argue just how important that is[14]. I for one am a strong advocate that we need less baseload power than people think, and perhaps none at all because of:

- the inherent storage capacity of our electric vehicles
- the shiftable thermal loads in our homes and buildings
- commercial and industrial opportunities to load-shift and store energy
- the potential capacity of back-up biofuels and batteries

Scaling up nuclear power quickly could be very difficult. Yes, nuclear plants come in massive sizes, with a typical plant outputting GW of electricity. In fact, the 60-ish nuclear facilities and 100-ish reactors in the US already deliver roughly 20% (~100GW) of all the electricity that is delivered (~450GW.) The problem is that the plants take decades to plan and build. In 2016, Watts Bar unit 2 was connected to the grid, 43 years after construction began[15]. It was the first new reactor in the US since 1996[16]. Only a relative handful of new plants are being planned. The US Energy Information Administration (EIA) itself projects nuclear capacity in the US to decline through mid-century[17].

We could build the plants faster. We could make them cost less by changing the regulatory environment. We could develop next-generation technologies. We could use mass production techniques and economies of scale to lower their cost. That's a lot of coulds. It is unlikely that we'll collectively achieve the conviction to build a lot more nuclear power before solar, wind, renewables and batteries prove themselves to be more cost-effective. Japan shut down its plants. So did Germany. China is cooling on the technology. This is not because nuclear doesn't work (it does) but because the socio-political-ecological-economic question marks that surround nuclear make it a hard, long road. To bet big on nuclear at this point is to bet against the grain. The Department of Energy (DOE) itself has set targets of 5c/kWh for rooftop solar, 4c for commercial solar and 3c/kWh for utility-scale solar by 2030 (download the DOE: Solar Energy Technologies Office Fiscal Year 2019 Funding Program[18]). It's difficult to imagine any energy source competing with these costs.

On the other hand, I doubt for one principal reason that we'll ever eliminate nuclear entirely in the US: it's a national security and strategic question. It makes sense to have a nuclear power industry if you are going to have a nuclear armaments capacity. They serve each other. I don't see a moment in the future when we'll completely disarm, so I don't think it's realistic to imagine the US pulling out of nuclear power. For this reason, I believe it's most likely that in order to address climate change, we'll mildly increase nuclear (fission) power capacity in the US, but it won't become the dominant energy source.

3. *Fossil fuels with massive carbon sequestration?*

It is highly unlikely that fossil fuels and carbon sequestration can work at massive scale. The simplest version of the argument against them is that when you pull fossil fuels out of the ground they mix with oxygen (that's what combustion is) and in so doing they become much larger (and also a gas). Even if you squeeze them back down into a liquid, which costs you yet more energy, the volume is much larger (around 5X) than the volume that came up. We simply can't stuff it back in the hole from whence it came. Those holes we also know to leak[19].

Steam rising from the Nesjavellir Geothermal Power Station in Iceland. Source: Wikipedia

The economic argument against sequestration is that renewables are already competitive with coal and natural gas in most energy markets, and the added expense of carbon sequestration is not going to help fossil fuels compete. As my long-time colleague and collaborator in zero-carbon technology Pete Lynn says, "the expense of carbon sequestration may well be the death knell of fossil fuels."

Put bluntly, the existing fossil fuel industry has an enormous interest in having people believe there is a pot of carbon-free gold at the end of this rainbow. There almost certainly isn't. We have made a small amount of progress on capturing emissions at the exhaust pipe of power plants where they are concentrated. By using additional energy (created with fossil fuels), we then capture, concentrate, and pressurize that CO_2 into a liquid that can (in theory) be injected back into the ground. Each of those steps costs yet more energy. The CO_2 will and does leak from out of the ground.

By injecting this CO_2 into the ground we can force more fossil fuels back up; in fact, most of the CO_2 that we have sequestered so far has been used to help with "enhanced" oil and fossil fuel recovery. This should temper enthusiasm for most of these headlines about sequestration which are cover-stories for what is really going on: the perpetuation of fossil fuel reliance.

We haven't made progress in capturing the more diffuse emissions of CO_2 — such as that from the tailpipe of your car, or from the furnace in your basement, or the range in your kitchen. Those emissions are so diffuse (at the ends of the 4.4 million miles of the US's natural gas pipeline distribution network and our 260 million tailpipes) that it is unimaginably difficult to collect it and render it into a form that doesn't end up in the atmosphere.

The existing fossil fuel industry has an enormous interest in having people believe there is a pot of carbon-free gold at the end of this rainbow.

Natural gas sounds benign. It almost sounds organic, granola, kale. It isn't. Coal gets more air-time as the evil-doer, but natural gas is where the front-line of the battle for climate change really is. It is an unsafe, collapsing bridge to nowhere. Carbon-captured natural gas plants are the new panacea for some[20], but they gloss over fugitive emissions[21] from mining the natural gas (fracking) and they gloss over where we will store all that CO_2. There are any number of other underlying problems with mining natural gas as well, such as water table pollution and seismic instabilities. (For the record, I would advocate for one of these plants to be built and tested and truly understood for its full-cycle of emissions and environmental effects, but strongly believe it isn't the giant answer its proponents would have it be.) While natural gas might turn out to be economic for some brief blip, it certainly doesn't scale well enough to solve the giant climate challenge. It is unlikely to compete with the future costs of solar and wind. Also remember that any precious capital going to these projects is not going to the things that we know to be zero carbon like solar, wind, electric vehicles, and heat pumps.

Direct air-capture of carbon is an enticing notion (see "CO_2 Conversion and Utilization" by Chunshan Song[22] and "Sucking carbon out of the air won't solve climate change" by David Roberts[23]). It is energetically difficult because you have to sort through a million molecules to find the 400 that are carbon, then convince those 400 to become something they don't naturally want to be: a liquid, or better yet, a solid. That sorting and conversion costs energy. Even if we make it work reasonably, we'll have to install zero-carbon energy just to run it, which is sort of like using zero-carbon energy to run society anyway, except more expensive and more complicated. I'm willing to give it a chance and believe we should fund the research, but let's fund it reasonably and with skepticism, and understand that it's a miracle technology that we'd like to have, but don't technically need, and probably can't afford.

4. *Miracle technology saves the day?*

Photo by Alistair MacRobert on Unsplash

Miracle technologies[24] include fusion, next-generation nuclear fission, direct solar rectification, deep offshore wind power, synthetic meat, high-efficiency thermo-electric materials, ultra-high-density batteries, a hydrogen economy, industrially scalable synthetic-biology-based materials, direct air capture of carbon at very low cost, and miracles we can't yet imagine. All of these miracle technologies would, in fact, help with various components of decarbonization and we should invest in them as research topics; with good management, some of them might come to fruition. However, it would be unwise to bet our future on miracle technologies, as our timeline for climate change solutions is too short. If we are planning the 50 years *after* the 20 crucial years immediately in front of us, then these certainly are a healthy part of sensible national research priorities. Let's just not bet the planet on them in the short term. Just as our analysis of direct air-capture showed previously, we can get most of the way to decarbonization without any miracles, and the miracles are "nice to haves," not "must haves."

5. *Deprivation and efficiency?*

This last choice isn't really a choice, because you can't deprive or efficiency your way to a total solution — and even if you could, we haven't shown any inclination to drastically cut our consumption in the 40 years since Jimmy Carter asked us to wear sweaters. The focus on efficiency as a solution has its intellectual history in the oil crises of the 1970s. At that moment in time, the problem was weaning the USA off foreign (particularly Middle Eastern) fossil fuels, and efficiency improvements were enough to achieve American energy independence[25]. The emphasis on efficiency ever since is defensible, and bipartisan, as almost no-one can defend outright waste, and most everyone agrees that double-glazed windows, more aerodynamic cars, more insulation in our walls, and better machinery will make things easier and better. They all do. But we've conflated two types of efficiency for too long. You can make a big car more efficient with a more efficient engine, or you can get a smaller car that is more efficient because of its smallness. Most efficient of all is a small, efficient car that you don't drive very much.

President Jimmy Carter — Report to the Nation on Energy, 1977. Photo source: MCamericanpresident on YouTube

For most machines, "efficiency" usually means thermodynamic efficiency: how efficiently a car engine turns gasoline into motion, how efficiently a power plant makes electricity from fossil fuels. Thermodynamics states machines can only get more efficient to a point called the Carnot limit. Practically, this limits the efficiency of machines powered by fossil fuels to 25–60%. Electrical machines do not suffer the same fate which is why wholesale electrification of the economy is the biggest efficiency win of all. (Small fossil fuel machines, like cars and trucks, are about 33% efficient, large ones, like airplanes and power plants, are about 50% efficient. Their electrical equivalents are about 3 times and 2 times more "efficient".) Moving to electric cars, electric heat pumps, and electric everything else will lower the amount of energy required by the US economy by more than half. Furthermore, these substitution technologies are actually better for consumers than what they replace. Electric car owners are not going back to fossil fuel cars once they've sampled a quieter, more spirited, more reliable electric car. People with heat-pump-driven radiant hydronic heating systems will never go back to forced air heating with its associated noise and respiratory problems. It then just becomes a question of how to make and deliver and store the electricity that drives this better future.

Efficiency is still never a bad idea, but it's not a solution. Electrification of everything is the biggest efficiency win, after which smaller things (smaller houses, smaller cars) and more insulation are the big wins.

6. *Apathy and geoengineering?*

This is obviously not a decarbonization strategy. This is a manage-the-carbon-in-the-atmosphere-in-another-way strategy. Many of the early arguments for studying geoengineering[26] were that we should know how just in case the world does turn out to be apathetic on climate change and transforming our energy economy. The logic goes that we might then desperately need geoengineering and we should know how to do it properly; therefore, let's investigate. We now know multiple paths to geoengineering climate change — most of them amount to managing the incoming flux of energy from the sun. In my office, we occasionally day-dream crazy geoengineering schemes; giant wave-driven propellers that fertilize the oceans with deep-water nutrients that create biomass that will sink to the bottom and store carbon, for example. (Yes, all geoengineering ideas start off sounding crazy like that.) In an ecosystem as complex as that of earth, they all will have unintended effects that could be good, or bad. The problem, of course, is that geoengineering can make us dependent-on then always-needing geoengineering in the future. If it works, and we do it, we'll take the pressure off the rest of the solutions proposed above.

The problems are many and perhaps obvious:

- Who sets the temperature? Low-lying islanders and people who love coral or northern Europeans who might benefit from a bit more climate change
- Once we become dependent, and the CO_2 concentration goes through the roof, can we keep civilization stable enough to do it forever? Once started, you can't really stop.
- We don't really know all of the unintended consequences environmentally, climate-wise, socially, and politically.

It is a good idea to study geoengineering schemes, and it does help us understand earth systems better, but this is also not a realistic permanent solution, and likely only a fraught band-aid.

7. Carbon tax?

It is probably worth addressing a carbon tax as a solution. I initially wasn't going to include it because it isn't a technology fix, it's a market fix meant to motivate all of the other solutions to compete. It is ideologically pure for some people who believe the market will fix everything and solve every problem. It is ideologically damned by others because it is a giant market-manipulation.

By the time we have the political will to implement a carbon tax, renewables will probably already be cheaper than fossil fuels.

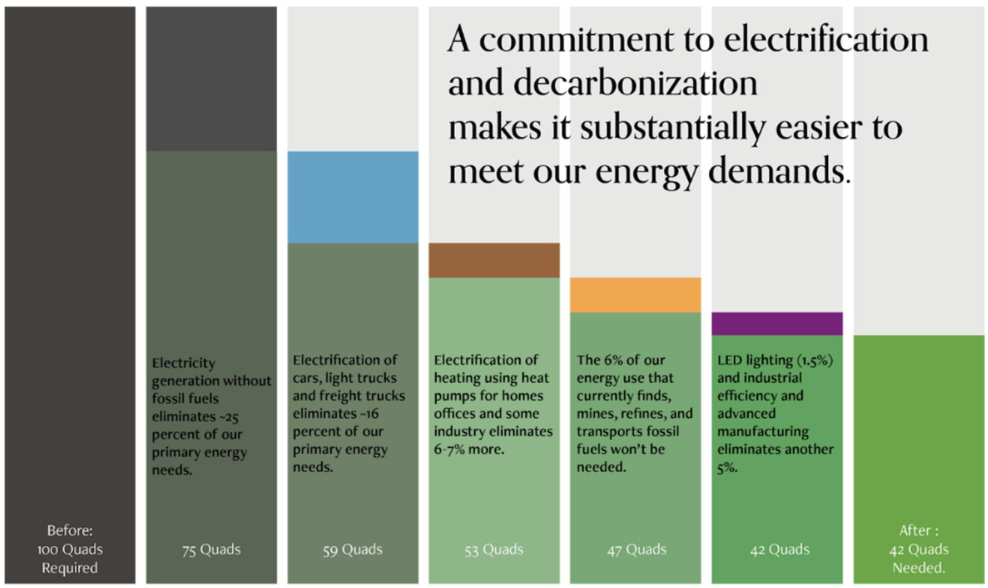
A high enough carbon tax would make all of the fossil fuels more expensive than at least some of the other solutions, and then a perfectly rational market would use those solutions. That's probably true-ish. Who ensures the tax is high enough though? Who does the tax go back to? The government? Refunded to the people? How is it collected and at what point?

It is difficult to say the idea of a carbon tax is bad; it isn't. It's much more difficult to know exactly how to implement it. It is probably just as effective to eliminate fossil fuel subsidies[27], which in many markets would tip the scales in favor of alternatives anyway. As mentioned previously by the time we have the political will to implement a carbon tax, renewables will probably already be cheaper than fossil fuels.

Back in the real world.

If these simplified choices are our smorgasbord, then some combination of **all renewables, all the time** with *moderate* **nuclear, nuclear, nuclear** is the likeliest solution, and hopefully, some **miracle technology saves the day** if we invest in the right R&D in sufficient quantity and get a little lucky.

We should focus on biofuels and waste conversion (trash and sewage) instead of **fossil fuels with massive carbon sequestration** to meet the liquid fuel demands we will still have. Things like long-haul aviation and shipping are difficult without a high-energy-density fuel, and the good news is that our food waste, sewage, and agricultural byproducts are more than enough to produce diesel and gasoline type liquids for these purposes. We should accept that **deprivation and efficiency**, while useful in lowering total energy need, doesn't work as a net-zero carbon strategy and that it will distract capital from the replacement technologies.



From [The Green New Deal: The enormous opportunity in shooting for the moon.]

We won't solve climate change with 80mpg vehicles that still emit CO_2, we'll solve it with electric cars powered by zero-carbon wind and solar. The biggest efficiency happens merely by committing to massive electrification, which likely more than halves the total primary energy we use[28].

Don't be fooled by those who will profit from confusion — ideas like natural gas as a bridge fuel. We have the technology we need, today, to solve climate change.

If we can agree on the assertions above, then we can let the market decide the balance of the solution and avoid a needless and counterproductive debate about which there will be more of. This allows for a miracle in carbon sequestration or fusion or something even more incredible to emerge, but not all our eggs are in that one miraculous basket. Right now the sensible money is on very large amounts of solar and wind, both of which have had a precipitous cost drop since 2000. Nuclear's price hasn't fallen and is notoriously difficult to calculate because it's unclear how the security expenses associated with the fuels and wastes fits in an all accounts ledger. Even so, it's a safe bet that we'll do more nuclear than we do today, it will become cheaper, and we'll grow more accustomed to it as we more responsibly deal with the waste. With this clarity, we can move forward with a realistic solution to climate change without the high-degree of time and capital waste that is things like corn biofuel programs and coal with carbon sequestration.

The Australian energy market is already one where it no longer makes any sense to use fossil fuels at all[29]. Many of the more remote energy markets (like Hawaii) increasingly have the same dynamic where solar and battery combinations beat out fossil fuels. Yes, these two places are sunny examples, but as renewables continue to dramatically come down in cost this will become true almost everywhere.

For the rest of us, the best place to engage is by making sure our local regulations are compatible with solving climate change.

Don't be fooled by those who will profit from confusion — ideas like natural gas as a bridge fuel. We have the technology we need, today, to solve climate change. If carbon-free isn't already the cheapest form of energy, it's very very close to it, and soon will be. The biggest barriers remaining have the same origin: inertia, the stubborn insistence of the incumbent way of doing things. This manifests as fossil fuel subsidies and massive misinformation campaigns. It's also buried in old ways of doing things, like the state-sponsored utility monopoly. The utility business model is to get the state to guarantee low-interest rates to build large projects and have the populace pay for it. That model needs to be challenged and upset so that every household can become a generator and a consumer of electricity as well as part of the national grid-scale battery. Let's give the households the same low-interest rate that the utility gets; that would lower the cost and increase the speed of the carbon-free transition.

The old way of doing things is embedded in legislation and thinking everywhere: building codes that aren't friendly to solar, electrical codes that artificially increase the cost of solar and home and vehicle electrification, net metering regulations, road rules, gasoline taxes and speed limits, homeowner association charters, and tax incentives. We will solve climate change if we don't let the bureaucratic crud and mental laziness of 100 years of writing regulations for a fossil fuel-based economy get in the way of a verdant decarbonized future for our children. For most people, this last point is where you can make the biggest difference on climate change. A few driven tech nerds will make the electric cars, air conditioners and electric furnaces, solar power plants, and bio-reactors of our future. For the rest of us, the best place to engage is by making sure our local regulations are compatible with solving climate change. We certainly can't deliver the change required on schedule if we are waiting for Town Hall to issue us the permits.

Footnotes and links:

[1] https://www.c2es.org/content/international-emissions/

[2] https://globalcoolingprize.org/the-ac-industry-conundrum/

[3] https://www.sciencedirect.com/science/article/pii/030626199390059X

[4] I continue to be asked by people "what about hydrogen?" Hydrogen is part and parcel of electrification. It takes electricity to produce hydrogen via hydrolysis. The hydrogen is then a battery or storage mechanism. The hydrogen battery then discharges its energy through a fuel cell which converts it back to electricity. This is to say if we can make a hydrogen economy work it's because of electrification of everything anyway.

[5] https://cleantechnica.com/2018/02/08/new-jacobson-study-draws-road-map-100-renewable-energy/

[6] https://public-blog.nrc-gateway.gov/2016/06/03/too-cheap-to-meter-a-history-of-the-phrase/

[7] *“Power to Save the World” by Gwyneth Cravens*

[8] *“Whole Earth Discipline” by Steward Brand*

[9] *“Nuclear: Why Even Think About It” by Kelly Vaughn*

[10] *“Fourteen Alleged Magical Properties That Coal and Nuclear Plants Don’t Have and Shouldn’t Be Paid Extra for Providing” by Amory Lovins*

[11] *“Nuclear Energy Debate” with USA Today editors and Amory and Hunter Lovins*

[12] *https://www.scientificamerican.com/article/how-long-will-global-uranium-deposits-last/*

[13] *https://newatlas.com/nuclear-uranium-seawater-fibers/55033/*

[14] *https://energypost.eu/dispelling-nuclear-baseload-myth-nothing-renewables-cant-better/*

[15] *https://www.google.com/url?q=https://en.wikipedia.org/wiki/Watts_Bar_Nuclear_Plant&sa=D&ust=1558394928464000&usg=AFQjCNFg0rnvB0pJpKG1YfJJOmPeT1FUpw*

[16] *https://www.eia.gov/energyexplained/index.php?page=nuclear_use*

[17] *https://www.eia.gov/energyexplained/index.php?page=nuclear_use*

[18] *https://eere-exchange.energy.gov/FileContent.aspx?FileID=d2f56f78-decb-4cc1-9a88-0f6241708508*

[19] *https://www.sciencedaily.com/releases/2018/06/180621141154.htm*

[20] *https://www.vox.com/energy-and-environment/2018/6/1/17416444/net-power-natural-gas-carbon-air-pollution-allam-cycle*

[21] *http://science.sciencemag.org/content/361/6398/186*

[22] *https://pubs.acs.org/doi/pdf/10.1021/bk-2002-0809.ch001*

[23] *https://www.vox.com/energy-and-environment/2018/6/14/17445622/direct-air-capture-air-to-fuels-carbon-dioxide-engineering*

[24] *https://www.renewableenergyworld.com/ugc/articles/2017/03/19/bill-gates-an-energy-miracle.html*

[25] *https://en.wikipedia.org/wiki/Project_Independence*

[26] *https://www.technologyreview.com/s/416809/why-geoengineering/*

[27] *https://www.sciencedirect.com/science/article/abs/pii/S0305750X16304867*

[28] *https://medium.com/otherlab-news/decarbonization-and-gnd-b8ddd569de16*

[29] *https://www.greentechmedia.com/articles/read/study-fossil-fuel-generation-has-no-business-case-in-australia#gs.2v9mnr*

LatentAI

by Manju Bansal
Posted October 14, 2019
https://latentai.com/ais-shocking-carbon-footprint/

AI's Shocking Carbon Footprint

How Techniques First Invented in the 1920s are Changing That

Introduction

What do the melting glaciers of Greenland have in common with artificial intelligence? On the surface, not much. But if you dig just a bit deeper, the connection is scarier than you might imagine. Turns out that data is not only the new metaphoric oil, but it also has a carbon impact just as bad.

There is no other way to put it, AI is simply everywhere these days. Whether it is being used in autonomous vehicles, in diagnosing various kinds of cancers, or in doing more mundane things like prioritizing which bills to pay first, the use cases of AI are well documented and growing fast. Speaking of the mundane, there is even a toothbrush powered by AI (not sure why the world needs such a device, but I am sure it is an incredible toothbrush nonetheless!).

More Emissions Than 5 Cars

What most people don't realize, however, is the tremendous carbon impact that AI has.

An article published recently in the MIT Technology Review tags the impact of training a single large-sized AI model at "626,000 pounds of carbon dioxide equivalent i.e. nearly five times the lifetime emissions of the average American car (and that includes the manufacture of the car itself)". Granted this was for a seminal model that forms the basis of natural language processing (Transformer 213M parameters w/ neural architecture search), but even very simple models ended up with a carbon impact much larger than flying from San Francisco to New York City. And since there is never just one model that gets trained, you can imagine the cumulative energy consumption impact of such exercises.

Datacenters are Energy Hogs

If all the energy consumed by a data center was from renewable sources, we wouldn't need to worry much about the carbon impact of AI models. However, according to the U.S. Department. of Energy, renewables are only 17% of the energy mix and most data centers don't run 100% on renewable energy (except Google, which went 100% renewable in 2017).

The other option is to alter the way we train AI models, i..e., make that process becomes much less compute-intensive. This is a huge area of opportunity and where companies like Latent AI are driving the innovation.

Quantization

This brings me to the almost 100-year old mathematical technique that can help relieve the carbon impact of AI.

Quantization has been around since the days of Niels Bohr and Max Planck, mostly referenced in the context of energy waves and quantum mechanics. The earliest references of the term go back to the early 1920s. Only in the past few decades, however, since the emergence of digital signal processing, has this technique been more commonly used.

Essentially, quantization is a bit of an umbrella term that refers to quantitative methods that can convert input values from a large data set to output values in a much smaller set. While sampling, for example, only picks a few items from a given set of values, quantization picks every data point but, say, rounds it off from 15 decimal points down to only two.

When you do such an exercise in deep learning, some information is lost but with the right training, the loss in accuracy can be managed. So, one can convert from 32-bit floating point to an 8-bit fixed integer, which reduces the amount of data that needs to be moved on and off the chip. This has a significant reduction in the compute horsepower, the memory needed and ultimately the energy needed to run the machine.

The challenge is to do it well enough such that you can retain 85%-90% model accuracy while delivering on the computational efficiency. And that is where Latent AI excels.

Enabling Adaptive AI™ for a Smarter Edge

Latent AI develops core technologies & tools to enable AI at the edge by optimizing deep neural networks to perform efficiently in resource-constrained environments. Their solutions optimize AI models for compute, memory, and power consumption while supporting a seamless integration to leading AI/ML infrastructure and frameworks. Latent AI's technology is about training neural networks with the target device in mind and compiling the trained model to run as an executable object in the target environment. Their tools build models and provide compilers targeting any hardware, be it Intel x86, ARM, DSP or Micro-controllers.

Conclusion

The average American consumes about 55 lbs of beef annually, which translates to about 1,500 lbs of CO2 produced per year, roughly the same impact per passenger as a single airplane flight from San Francisco to Chicago. It may also be worth noting that according to some estimates, a typical Internet search uses as much energy as illuminating a 60-watt bulb for 17 seconds. Given that Google alone processes over 2 trillion searches annually, that's a lot of lightbulbs on all the time.

Not to mention that it also leads to some very interesting conundrums – does a meat eater who is not online all the time have a lower carbon footprint than a vegan hipster who is hooked to his devices?

On a global basis, power generation remains the single biggest contributor of greenhouse gases. As the world evolves to being more automated, data-driven and AI-led, the carbon impact of this new paradigm will be non-trivial. Which is why what Latent AI is doing becomes even more critical.

By Manju Bansal, Advisor, Latent AI

Rebooting AI
Building Artificial Intelligence We Can Trust

https://www.penguinrandomhouse.ca/books/603982/rebooting-ai-by-gary-marcus-and-ernest-davis/9781524748258/excerpt

By
Gary Marcus
and
Ernest Davis

From Chapter 1:

MIND THE GAP

Since its earliest days, artificial intelligence has been long on promise, short on delivery. In the 1950s and 1960s, pioneers like Marvin Minsky, John McCarthy, and Herb Simon genuinely believed that AI could be solved before the end of the twentieth century. "Within a generation," Marvin Minsky famously wrote, in 1967, "the problem of artificial intelligence will be substantially solved." Fifty years later, those promises still haven't been fulfilled, but they have never stopped coming. In 2002, the futurist Ray Kurzweil made a public bet that AI would "surpass native human intelligence" by 2029. In November 2018 Ilya Sutskever, co-founder of OpenAI, a major AI research institute, suggested that "near term AGI [artificial general intelligence] should be taken seriously as a possibility." Although it is still theoretically possible that Kurzweil and Sutskever might turn out to be right, the odds against this happening are very long. Getting to that level—general-purpose artificial intelligence with the flexibility of human intelligence—isn't some small step from where we are now; instead it will require an immense amount of foundational progress—not just more of the same sort of thing that's been accomplished in the last few years, but, as we will show, something entirely different.

Even if not everyone is as bullish as Kurzweil and Sutskever, ambitious promises still remain common, for everything from medicine to driverless cars. More often than not, what is promised doesn't materialize. In 2012, for example, we heard a lot about how we would be seeing "autonomous cars [in] the near future." In 2016, IBM claimed that Watson, the AI system that won at *Jeopardy!,* would "revolutionize healthcare," stating that Watson Health's "cognitive systems [could] understand, reason, learn, and interact" and that "with [recent advances in] cognitive computing . . . we can achieve more than we ever thought possible." IBM aimed to address problems ranging from pharmacology to radiology to cancer diagnosis and treatment, using Watson to read the medical literature and make recommendations that human doctors would miss. At the same time, Geoffrey Hinton, one of AI's most prominent researchers, said that "it is quite obvious we should stop training radiologists."

In 2015 Facebook launched its ambitious and widely covered project known simply as M, a chatbot that was supposed to be able to cater to your every need, from making dinner reservations to planning your next vacation.

As yet, none of this has come to pass. Autonomous vehicles may someday be safe and ubiquitous, and chatbots that can cater to every need may someday become commonplace; so too might superintelligent robotic doctors. But for now, all this remains fantasy, not fact.

The driverless cars that do exist are still primarily restricted to highway situations with human drivers required as a safety backup, because the software is too unreliable. In 2017, John Krafcik, CEO at Waymo, a Google spinoff that has been working on driverless cars for nearly a decade, boasted that Waymo would shortly have driverless cars with no safety drivers. It didn't happen. A year later, as *Wired* put it, the bravado was gone, but the safety drivers weren't. Nobody really thinks that driverless cars are ready to drive fully on their own in cities or in bad weather, and early optimism has been replaced by widespread recognition that we are at least a decade away from that point—and quite possibly more.

IBM Watson's transition to health care similarly has lost steam. In 2017, MD Anderson Cancer Center shelved its oncology collaboration with IBM. More recently it was reported that some of Watson's recommendations were "unsafe and incorrect." A 2016 project to use Watson for the diagnosis of rare diseases at the Marburg, Germany, Center for Rare and Undiagnosed Diseases was shelved less than two years later, because "the performance was unacceptable." In one case, for instance, when told that a patient was suffering from chest pain, the system missed diagnoses that would have been obvious even to a first year medical student, such as heart attack, angina, and torn aorta. Not long after Watson's troubles started to become clear, Facebook's M was quietly canceled, just three years after it was announced.

Despite this history of missed milestones, the rhetoric about AI remains almost messianic. Eric Schmidt, the former CEO of Google, has proclaimed that AI would solve climate change, poverty, war, and cancer. XPRIZE founder Peter Diamandis made similar claims in his book *Abundance,* arguing that strong AI (when it comes) is "definitely going to rocket us up the Abundance pyramid." In early 2018, Google CEO Sundar Pichai claimed that "AI is one of the most important things humanity is working on . . . more profound than . . . electricity or fire." (Less than a year later, Google was forced to admit in a note to investors that products and services "that incorporate or utilize artificial intelligence and machine learning, can raise new or exacerbate existing ethical, technological, legal, and other challenges.")

Others agonize about the potential dangers of AI, often in ways that show a similar disconnect from current reality. One recent nonfiction bestseller by the Oxford philosopher Nick Bostrom grappled with the prospect of superintelligence taking over the world, as if that were a serious threat in the foreseeable future. In the pages of *The Atlantic,* Henry Kissinger speculated that the risk of AI might be so profound that "human history might go the way of the Incas, faced with a Spanish culture incomprehensible and even awe-inspiring to them." Elon Musk has warned that working on AI is "summoning the demon" and a danger "worse than nukes," and the late Stephen Hawking warned that AI could be "the worst event in the history of our civilization."

But what AI, exactly, are they talking about? Back in the real world, current-day robots struggle to turn doorknobs, and Teslas driven in "Autopilot" mode keep rear-ending parked emergency vehicles (at least four times in 2018 alone). It's as if people in the fourteenth century were worrying about traffic accidents, when good hygiene might have been a whole lot more helpful.

[. . .]

PublisherPantheon

FIS GROUP
FORESIGHTS

June 2017

A World without America?

Tina Byles Williams
CIO & CEO

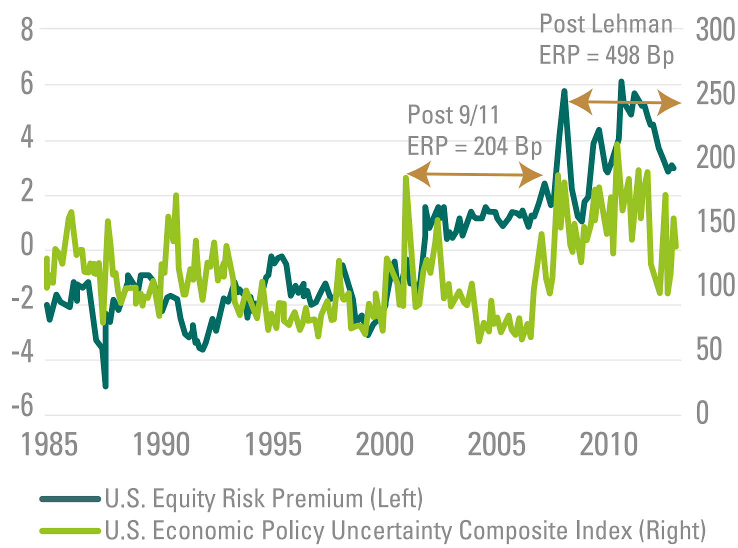
"The world is going to hell in a basket. On the other hand, our basket sales are soaring!"

CartoonStock.com

At his inaugural address, President Trump touted an inward looking, "America first" foreign policy. Arguably, this posture was a stunningly explicit (and perhaps misguided) recognition of a trend that had begun with the previous administration; whose reticence to engage in military adventurism relative to his predecessors was roundly criticized by establishment hawks. Below we argue that this foreign policy trajectory is consistent with historical precedent and will greatly alter the winners and losers going forward.

But first, why should investors care about changes in American foreign policy and more broadly, fundamental changes in the geopolitical order? We would posit that structural changes in the geopolitical landscape and world order is foundational to the long-term risk premia attached to investment assets. For example, the 30 plus year bond bull market is as much a result of the deflationary impact of trade globalization (catalyzed in particular by China's 2001 entry into the World Trade Organization), as Fed policy. Similarly, the relatively low equity market risk premia between the end of the Cold War in 1991 and 2007 (often referred to as the "age of modulation") was also underpinned by relative geopolitical stability. (See the CHART in the next column).

The "Great Modulation's" Support of Risk Assets was Underpinned by Geopolitical Peace Dividend from America's Global Hegemony



Source: Bloomberg, FactSet, BCA Research and FIS Group Professional Estimates

In order to understand both the historical context and long term investment implications of the current period of political tumult, we turned to the works of thinkers outside of the traditional gaggle of investment analysts, such asThomas Freidman's, *Thank You For Being Late: An Optimist's Guide to Thriving in the Age of Acceleration*, Peter Zeihan's *The Absent Superpower* and various research reports by Marko Papic, geopolitical strategist for BCA research. Each in their own way point to 3 themes:

1. As in the early part of the 20th century which marked the end of the 70 year reign of the British empire as the singular global hegemon, we are witnessing the closing chapters of the unparalleled 100 plus years of American hegemony. By providing expensive global public goods – such as funding international institutions, dictating global commercial arrangements and arbitrating regional disputes, securing sea lanes as well as providing the world's reserve currency – not only did both superpowers amass heretofore unparalleled wealth and power, but they also allowed other countries to focus inwards, industrialize and eventually catch up with their hegemonic patron.

Additionally, in both cases, the expenses associated with their hegemonic responsibilities as well inevitable campaigns of militaristic overreaches, exacerbated their economic decline relative to countries who were free to focus on internal development and export competitiveness under the safe harbor of relative stability provided by the hegemonic superpower.

America's upstart trade competitors have been Japan (in the 1970s and 1980s), Germany, and China. The British empire's primary upstart competitor was Germany. The following quote from 1896 is therefore hauntingly familiar.

"The industrial glory of England is departing, and England does not know it. These are spasmodic outcries against foreign competition, but the impression they leave is fleeting and vague…German manufacturers…are undeniably superior to those produced by British houses. It is very dangerous for men to ignore facts that they the better vaunt their theories…..This is poor patriotism."

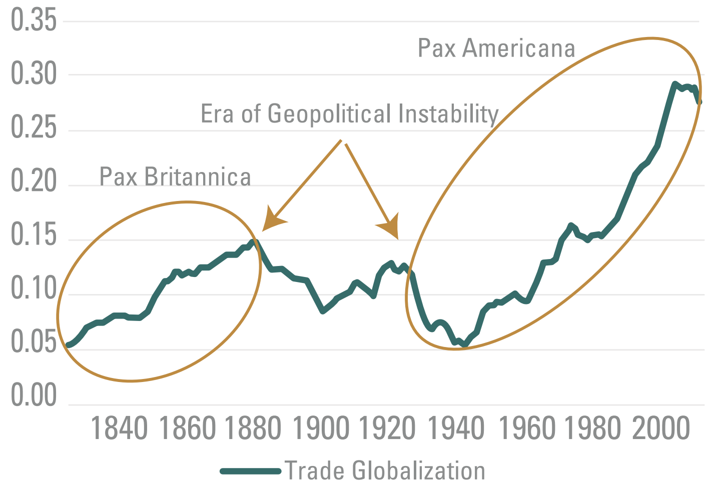
–Earnest Edwin Williams, Made in Germany (1896)

2. Both eras did not end well because for better or for worst, the diffusion of power caused by the decline of a more inwardly focused global hegemon leaves a power vacuum for other countries to assert their own regional agendas. Thus both World Wars were symptomatic of Britain's decline as the only superpower which mattered. Today, Russia's increasing aggression to reassert its regional hegemony over its former vassal states; China's assertions in the South China Sea and Japan's consequent efforts to re-militarize; as well as Saudi Arabia and Iran's competition for regional hegemony are all symptomatic of controlled fissures that have re-erupted as a result of their increasing geopolitical significance or insecurity as well as America's relative retreat from being the global policeman to a more insular focus.

   America's inward pivot will not only expose poorly governed and uncompetitive nation states that were propped up by its (and during the Cold War, Russia's) competition for geopolitical control, but it will destabilize the current world order (as each nation would need to bear more of the burden for their own economic, social and geopolitical security). Geopolitical uncertainty increases because the world transitions from one of relative cooperation under the rules and institutions imposed by the superpower (such as the WTO, NATO, the IMF and the World Bank) to a less stable zero sum order. This period of instability will continue until a new hegemonic nation state or states arise and impose their rules and institutions (perhaps China or a combination of the US and China?).

3. The relative decline in both superpower hegemons led to increased geopolitical instability and a retreat in trade globalization. (See the CHART on top of next column).

A Superpower Underpins Relative Geopolitical Stability and Globalization



Source: BCA Research

In some ways, a retreat to a more mercantilist world benefits those countries that are least dependent on trade for their economic survival. In this regard, the relatively insular American economy, where exports represent only 12% of GDP, and is protected by its geographical isolation would be least vulnerable in such an environment.

However, Friedman in particular argues that the retreat in traditional trade of goods and services is and will continue to be vastly superseded by digital interconnectivity. So while the world grows more mercantilist in terms of the traditional trading of goods and services, it will flatten and become more interconnected, despite the attempts of policy makers to erect or reinforce national boundaries and trade protections. For example, according to the 2013 McKinsey Digital Flows study, back in 1990, "the total value of global flows of goods, services, and finance amounted to $ 5 trillion, or 24 percent of world GDP. The public Internet was in its infancy. Fast-forward to 2014: some $ 30 trillion worth of goods, services, and finance, equivalent to 39 percent of GDP, was exchanged across the world's borders." Cross-border bandwidth [terabits per second] has grown 45 times larger since 2005 and is projected to grow by another nine times in the next five years as digital flows of commerce, information, searches, video, communication, and intra-company traffic continue to surge.

This phenomenon will change the calculus of winners and losers away from countries and organizations that control the greatest "stock" of physical resources on which they can impose economic rents, to those who control and harness the greatest amount of digital "flows" of information and technological innovations. On a micro level, think of the difference between traditional media companies and Facebook, whose digital reach has propelled what started out as mere social interaction platform to arguably, one of the most influential media companies globally.

On a country level, the Obama Administration's "pivot" away from the Middle East was accommodated by technological innovations in fracking, horizontal mining as well as renewable energy which lessened America's dependence on oil from the Middle East. This pivot along with lower oil prices ushered in by the increased global energy supply has in essence, defanged OPEC as the monopoly price setter, made Gulf oil producers (who relied on high oil prices for imposing domestic social stability and American oil dependence for geopolitical protection) more vulnerable; which in turn has ratcheted up regional Middle East tensions.

Freidman would probably also challenge Freihan's assumptions around the primacy of the protections that arise from America's geographical isolation. One need only to look at new modes of warfare, such as cyberattacks and drone technology to understand that the game has shifted. Global interconnectedness, also leaves all countries and financial markets more vulnerable to less powerful bad actors.

CONCLUSION AND INVESTMENT THEMES

From an investment point of view, a few themes come to mind as likely to do well in the evolving world order. These themes are in large part similar to those expressed in our Q1 2017 Outlook:

1. **America First!** while demanding equity valuations for US equities relative to other regions make them less attractive for the intermediate period, as mentioned previously, a more mercantilist world should benefit the large and more domestically powered U.S. economy. Additionally, America, like Switzerland, is a relatively low beta market which typically outperforms in times of geopolitical uncertainty. This is in part why Zeihan and Papic believe that the next decade will belong to America. On the other hand, highly trade dependent countries such as the Asian tiger countries and much of the Emerging World that benefited from globalization would be expected to underperform. However, within the emerging world, countries whose economy are more domestically driven, such as India, would be least vulnerable.

   A significant risk to this theme is that America's assets not only comprise of its large domestic economy and geographical isolation, but also its technological innovation fostered by its educational institutions, its attractiveness to bright and entrepreneurial minds all over the world (according to the American Enterprise Institute, despite representing around 10% of population, 40% of America's Fortune 500 companies were founded by immigrants or their children) as well its laissez faire creative destruction. It is these features that have allowed America to dominate the rapidly expanding digital economy. To the extent that federal policy undermines these attributes, America will be weakened.

2. **Investors should re-acquaint themselves with higher risk premia and a greater likelihood and frequency of left-tail risk events** catalyzed by an uptick in geopolitical instability. The combination of more interconnected global markets and the increasing market relevance of algorithmic funds and high frequency trading strategies could amplify such events. This is because many of these strategies embed similar algorithms that tend to close their positions when market volatility increases. To the degree that their positions are highly levered (which is a worrying unknown at a total market level), these strategies could become the epicenter of a systemic market shock.

3. **US Small Cap over Large Cap** The conflicts will stall global trade, so companies with predominantly domestic revenues should be better positioned than companies with global sales. Historically, small cap stocks fit that bill.

4. **Energy** The structure of the oil market has changed. In the 1970s, and even up to the early 2000s—the OPEC cartel agreed to production quotas in order to defend the market shares of its members. The approach worked because the principal competition was among oil producers, and in particular between Opec and non-Opec producers. Today, the biggest competitive threat to any one oil producer is not other producers, but alternative sources of energy. These alternative sources have become the marginal price setters. Therefore the trading range of oil will be capped at the marginal cost of shale production (currently around $60/bbl). That said, instability in the Middle East will add a geopolitical premium to oil and natural gas prices. This should be particularly profitable for the American shale industry.

5. **Defense** This one is the highest conviction calls from our January outlook. A more unstable world will have more conflicts; armies will need to buy their weapons from someone. Cyber defense companies will also outperform.

6. **Increasing Inflation.** Globalization is inherently deflationary as it allows corporations to source labor and resources from the most inexpensive sources. Therefore, a retreat from globalization will stem the deflationary impulse which has suppressed global bond yields and underpinned the 30 plus year bond bull market. This should support inflation sensitive real assets, such as real estate, infrastructure and gold; which has the added benefit of being a safety asset.

7. **Declining profit margins.** Globalization expanded sales and reduced costs; which shifted the economic pie towards corporate profits and away from labor in developed countries. Therefore, a more mercantilist world would be expected to reverse this trend.

Important Disclosures:

This report is neither an offer to sell nor a solicitation to invest in any product offered by FIS Group, Inc. and should not be considered as investment advice. This report was prepared for clients and prospective clients of FIS Group and is intended to be used solely by such clients and prospects for educational and illustrative purposes. The information contained herein is proprietary to FIS Group and may not be duplicated or used for any purpose other than the educational purpose for which it has been provided. Any unauthorized use, duplication or disclosure of this report is strictly prohibited.

This report is based on information believed to be correct, but is subject to revision. Although the information provided herein has been obtained from sources which FIS Group believes to be reliable, FIS Group does not guarantee its accuracy, and such information may be incomplete or condensed. Additional information is available from FIS Group upon request.

All performance and other projections are historical and do not guarantee future performance. No assurance can be given that any particular investment objective or strategy will be achieved at a given time and actual investment results may vary over any given time.

Hacking Finance

https://hacking.finance/read/flood-matters-mapping-up-a-storm/

FLOOD MATTERS: MAPPING UP A STORM

Bessie Schwarz didn't exactly mean to become a tech entrepreneur building the world's largest database of flood maps.

In fact, the 32-year-old cofounder/chief executive of the on-demand flood vulnerability mapping startup Cloud To Street kicked off her career about as far as you can get from software engineering and Silicon Valley. Armed with a B.A. in Philosophy and Environmental Studies from Carleton College, she was a community organizer driven by idealism and a desire to hit the ground to preserve the land she loved.

Just how did Schwarz go from a curious teenager selling solar-system maps at the Discovery Channel Store to a scientist equipping clients such as the World Bank with flood-vulnerability data aimed to protect millions of flood-vulnerable people (and their possessions) in the developing world?

As she left her Brooklyn climbing gym en route to her office for the afternoon—a coffee shop—we spoke about her semi-accidental journey to become founder of Cloud To Street, along with the future she sees for the company.

Hacking Finance: Bring us back to the very beginning, before you became an environmental organizer, a scientist, and a tech entrepreneur. What was your very first job?

Bessie Schwarz: My favorite first job was working at the Discovery Channel Store. I grew up in suburban New Jersey, and prior to that I'd worked at summer camp and babysat. But this was in the mall, and it was my job to get parents hyped about all this interesting stuff in the store's children's section—like the Howard Zinn book The People's History of the United States and maps of the solar system. I found real joy in that—not exactly from selling, but from getting people excited about something interesting.

Hacking Finance: Was protecting the environment baked into your aspirations early on? Where'd that stem from?

Bessie Schwarz: I went on a seven-week hiking trip one summer in Maine where we pretty much didn't leave the woods. I was 15, and when I got home to New Jersey, I saw land around me that had been destroyed and realized that just because the types of places I'd seen in Maine all summer are so precious doesn't mean that they will always be there. It profoundly moved something in me. That's when I decided to commit myself to the environment. I realized we have to protect the things we love.

Hacking Finance: Is protecting the environment—those woods you hiked through as a teenager—still a big motivator for you?

Bessie Schwarz: It's been an evolution realizing how much protecting the environment is about protecting people. There's deep inequity and power imbalance in how the natural world and its resources are used and who uses them. Certain people, frankly, get disproportionately screwed by environmental degradation.

Hacking Finance: How did you line up your first full-time job post-graduation? Had community organizing been on your radar?

Bessie Schwarz: I had this sense that after college most people lose their idealism—their belief that they can make the kind of change that they've seen needs to happen. My feeling at the time was: Whatever profession lets you keep that belief, I am into it.

I didn't really understand what it meant to be an organizer, but Green Corps, a program designed specifically to show people that environmental community organizing is a profession, recruited at my college. When I met their team, I loved that these older people interested in hiring me were talking like 22-year-olds.

Hacking Finance: What did that 22-year-old talk sound like?

Bessie Schwarz: Like they were going to change the world and that it was possible if we brought everybody together. Oftentimes people learn about organizing and find that they have been organizing non-professionally. That was definitely the case for me.

Hacking Finance: How did you like organizing? What'd you learn?

Bessie Schwarz: Even when I started, I still didn't totally understand what it meant. But it made so much sense to me when I first hit the pavement. It was this realization of: "Oh, it's my job to get people to realize their own agency and power within a system in which they are underserved so that together we can shift those power dynamics and get them what they need." That's when it clicked.

Hacking Finance: Now that you're a decade out from your college experience, has the chase for idealism stuck with you? Did you lose any of your 22-year-old idealism upon turning 23?

Bessie Schwarz: It's funny. It's as much of a struggle as I sort of intuited it would be when I was 22 and noticing most older people weren't as idealistic. So yes, that is still an emotional North Star for me. But it's definitely difficult.

Hacking Finance: How have you balanced staying true to that North Star in your transition from community organizer to startup CEO?

Bessie Schwarz: I think there are probably many pivots in here. I loved being an organizer. I had the chance to work with coastal communities in Florida, lower-income communities in the Midwest, and a lot of other weather-vulnerable communities across the U.S. That's when I realized that the sort of methods I was using—going into communities to talk to people and empowering them – were just not going to scale. We were up against a changing landscape of a lot of power fighting climate change in this country.

Hacking Finance: How'd you respond to that realization around the limits of scale?

Bessie Schwarz: I went back to graduate school to look for new ways to scale this work that could help protect people left behind and hit first.

Hacking Finance: What did getting a Master's in Science—with a focus on climate change psychology and natural resources decision-making—equip you with?

Bessie Schwarz: I studied risk perception and social psychology around climate change, with disasters being the epitome of the impact, and then I also studied spatial analysis. I discovered that both of those areas could be powerful tools for protecting people—for rebalancing power and giving people what they need.

Hacking Finance: Tell us more about the genesis of Cloud To Street. How did you and your cofounder get started?

Bessie Schwarz: My cofounder Beth Tellman's background is in disaster relief. She had moved to El Salvador before a major hurricane, and some remote communities where she had been working were hit hard. She went back to school for hydrology, and that's when we met. She and I were sitting in an auditorium when Google came to Yale to promote this crazy new remote-sensing platform they were working on. Beth realized she could use that technology to help farmers in communities she'd been working with, and I thought it sounded like a really powerful organizing tool.

Hacking Finance: What came next? Did you enlist the help of software engineers?

Bessie Schwarz: Beth and I started building this algorithm. We had never really coded before, so we taught ourselves and presented the algorithm [at Google's office] in Mountain View later that summer.

There was a clear need for the data we were working to surface. Google helped us go to a development conference in Kenya to show what was possible using the platform, and they'd given us some core funding for the science so we could keep building it. We took on side projects, and we started getting requests from people at the World Bank and other development agencies who had heard through word-of-mouth that we could help get them the data they needed, too.

Hacking Finance: Was Google sending you to Kenya to demo the product a big game-changer? Did you commit to building the Cloud To Street platform once you finished your Master's?

It actually did not come for years after that. We basically tried not to do this. Beth and I thought, "Who are we? This is so experimental."

In 2013, a single flood killed 6,000 people in India, and we began working with the World Bank a year later because the state government still didn't have flood maps that they needed to prepare for the next one.

I graduated in 2014, which is both when I pitched a Yale professor on a separate idea I had for a consultancy (basically a research and development project for American climate change movement), and when Google gave Beth and me our first grant. So for the first two years, my main focus was the consultancy at Yale's Program on Climate Change Communication. In 2016, it switched to Cloud To Street.

Hacking Finance: What prompted that switch?

Bessie Schwarz: When we got an Echoing Green fellowship for Cloud To Street in the summer of 2016, we had to decide if we were going to fully dedicate ourselves to this.

There were still many holes in the maps where some of the most at-risk people lived because traditional flood mapping is too expensive and slow. Yet there are satellites circling Earth every day that are gathering useful information. We realized this massive data gap was too important and that we'd need to fully commit ourselves to building Cloud To Street. It was hard to choose, but we're very happy we did.

Hacking Finance: What does Cloud To Street offer today, and how is the service you're providing different from traditional flood modeling?

Bessie Schwarz: We help fix critical gaps in disaster data in developing countries so people, governments, and organizations can better prepare for and respond to flooding. We're focused on building safety nets around disaster, because that's where marginalized people are feeling the worst impacts of climate change.

Cloud to Street has identified four governments with well over a million people at high risk for future floods. Our goal within the next five years is to get ten million people protected under insurance or some other new safety net within their countries. We are going to need to expand our team to do that. We're hiring a bunch right now.

Hacking Finance: What does your business model look like? Your customer base?

Bessie Schwarz: We're halfway between a SaaS and a custom model, so we mostly sell premium products on top of a SaaS. We're moving towards being more exclusively subscription.

We focus on two markets. The first is governmental disaster managers in developing countries affected by floods. We need to make sure that the kinds of data we are providing are actually helping these managers make decisions. The second is building an equitable insurance market in places where it doesn't exist that are hit by floods quite a bit.

On the insurance side of it, we are working to understand what people will need and what kind of services it will take [for stakeholders] to have a profitable business model in insurance in a new place. We're trying to shape a whole new market there, which is unusual for a data provider.

Hacking Finance: Where does your data come from?

Bessie Schwarz: Our maps are created from public and private global satellites and cloud-computing, and they can snap into action anytime. We set up projects for specific locations, and we currently have active projects in six countries: Senegal, Argentina, Sudan, South Sudan, India, and Ethiopia.

Hacking Finance: What do you find most powerful about this work and the challenge you're addressing?

Bessie Schwarz: Ninety percent of the economic losses from disasters in the developing world are uninsured, yet the number of people exposed to flooding is going to double by 2030. That part of the problem really shocks me. But the other fact that really inspires me is that we can now regularly see critical disaster patterns in new corners on Earth. We see its flood exposure through a satellite and other forms of big data and try to provide that information to people who need it.

Hacking Finance: What are the implications of mapping both biophysical and social flood vulnerability?

Bessie Schwarz: Disasters so clearly reveal underlying marginalization of already vulnerable communities. In addition to all the flood exposure and the physical hazards there are to think about, we study the social dynamics of disasters: What are the socio-demographic, economic struggles and cultural conditions that somebody lives in that makes them less likely to survive a flood than your neighbor who is more privileged?

We have this paper coming out showing which U.S. communities would see more death and damage just because of their social conditions if a 500-year flood were to hit every community in the U.S. completely equally. The map wouldn't shock you, but it really reveals the inequities that we live in and create.

Hacking Finance: To what extent is your business tied to current events? Are there other use cases for the platform—beyond flooding—that you may explore down the road?

Bessie Schwarz: As far as current events, an NGO in Bangladesh recently reached out about the Myanmar refugee crisis [in which hundreds of thousands of Rohingya refugees have settled in flood-vulnerable camps over the Bangladesh border]. We rapidly mapped that area. We think that the floods there are going to be very different. We're monitoring the precipitation there, which is changing. We can see what settlements are in the floodplain. We've also started to do some landslide social vulnerability analysis.

Flooding impacts more people than any other natural disaster, and now we can reveal and help counteract injustices in the systems. But we also have the potential to map drought vulnerability and more slow onset disasters, and to support more search and rescue and humanitarian aid operations.

Hacking Finance: Going back to activism and your work to address inequity, what were the biggest blockers you found yourself up against as an organizer? Any overlap with the blockers you face as a founder today?

Bessie Schwarz: Most people want to protect some open space, and most people think that global climate change is a problem and that we should protect people. So why aren't we getting our act together? That was confusing to me because I studied science, and at the beginning I thought this was probably a scientific problem.

Early on, though, I started realizing: "You know we would have solved this if science was really the only problem—we would start finding solutions to it." There are powerful people and incentives that stand in the way. There are a lot of corollaries between organizing and entrepreneurship. I still very much consider myself an organizer at my core.

Hacking Finance: Would you say you're an entrepreneur at your core too?

Bessie Schwarz: I don't want to sound cliché, but that is sort of my orientation toward things. Even going back to working at the Discovery Channel Store, I thought, "OK, I can sit around here answering questions when people come to me, or I can create an exciting department and build relationships with people who then come back." That's the kind of person I am. I see a big new thing—a problem or some exciting new solution where I am not exactly sure how it is going to go or how it is going to work out. But if I think I can make a platform to do something about it, let's just go full steam ahead. In my training as an organizer, I had that exact same mentality.

Hacking Finance: How might others look to apply some of the skill-sets and knowledge you've acquired in the tech world to, for example, community organizing?

Bessie Schwarz: Oh, wow—I've actually thought about that in the reverse quite a bit, like how being an organizer is helpful for business. But in the other direction, I have been most impressed by the power of living and dying by your user's feedback. The financial life blood of your organization is dependent upon whether or not someone finds it valuable and will pay you for it. You have to be brutally focused on what value you're delivering. In nonprofits, it's less direct, and you're optimizing—necessarily and thankfully—for something that is often harder to measure and is outside of the market. We can think we listen and then do what is best for those we serve…but the end users or beneficiaries don't decide. I think the best nonprofits do incorporate real user input into their core model. That realization would be really useful if I went back to organizing.

As she passes a gaggle of rowdy students at play on New York City's first real spring-feeling afternoon, Schwarz laughs. After all, going from educational toy store salesperson to organizer to scientist to tech entrepreneur and back to tech-enabled community organizer would really be full circle.

Geoengineering briefing

Marine Cloud Brightening Project

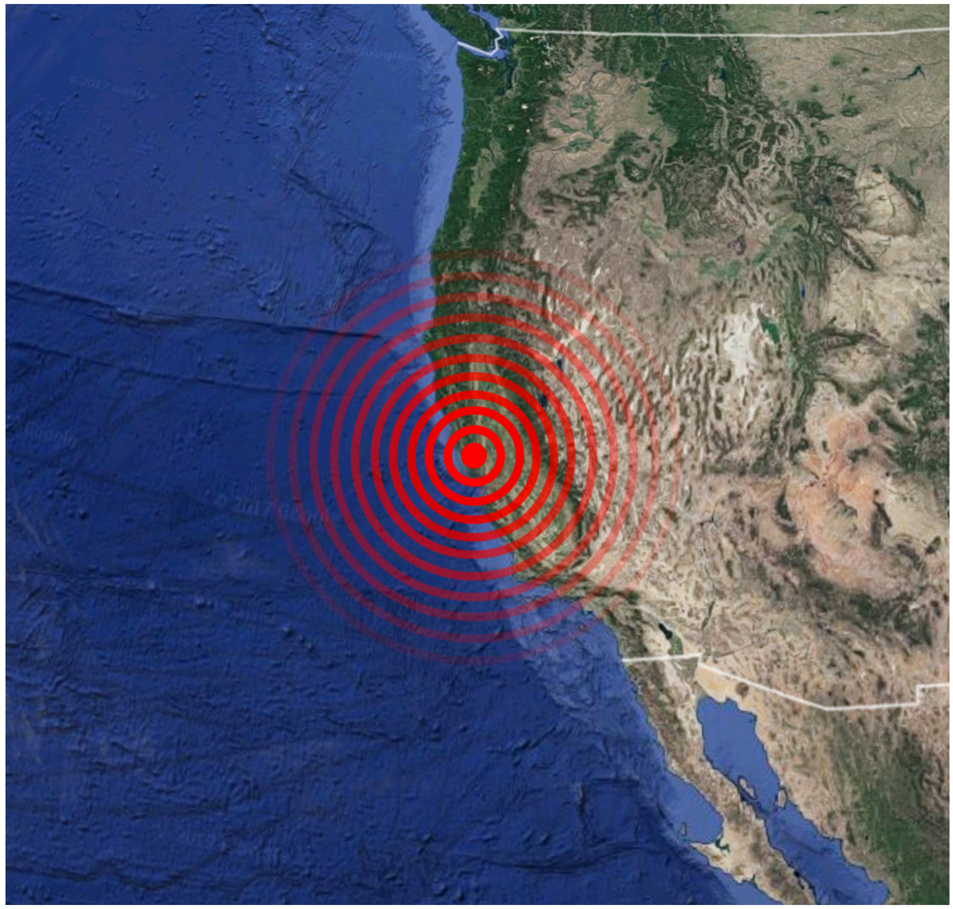
Location:
Moss Landing, California, USA
(Between Monterey and Santa Cruz)

Budget:
$16.3 million

The Marine Cloud Brightening Project (MCBP) aims to test the premise that spraying a fine mist of sea water into clouds can make them whiter, reflecting more sunlight back into space. The MCBP, a form of Solar Radiation Management (SRM) began with indoor development and testing of spray nozzles, and is moving toward a land-based field test in 2018, followed by ship-based tests and a larger-scale sea test later on.

After previous attempts to test "cloud brightening" as a geoengineering technique (e.g. the Silver Lining project) were cancelled after a public outcry, the project's leaders have taken a smaller-scale, more public relations savvy approach.

Funding:
Initial support for development of hardware came from the Bill Gates-backed Fund for Innovative Climate and Energy Research (FICER). It is unclear where the funding for the project's planned field tests is coming from.



Impacts of geoengineering projects on the California coast have the potential to have global effects.

Key dates:
Field tests were initially slated for as early as 2016, but have been delayed for lack of funding. The first land-based experimental use of cloud brightening hardware is now expected to take place in August 2018. The project hopes to move to ship-based tests within 2 years and then a large cloud brightening experiment 2-3 years after that.

Regulatory status:
The UN Convention on Biodiversity has passed a moratorium on geoengineering deployment and experimentation (2010) that covers SRM, including experiments like this one. However, the US is not a party to the CBD. The US is a party to the London Convention and Protocol (on marine pollution) that has declared itself competent to rule on "marine geoengineering." While spraying from land is not "marine." future ship-based steps do clearly fall under the London Convention.

The US is also a party to the UN Environmental Modification Convention (ENMOD) prohibits hostile use of environmental modification technology globally.

etc GROUP
monitoring power
tracking technology
strengthening diversity

Marine tests are also governed by the provisions of the UN Convention on the Law of the Sea (UNCLOS) and as tests move offshore, the current negotiations over activities affecting Biodiversity Beyond National Jurisdiction (BBNJ) become highly relevant.

Under US Federal law (National Weather Modification Policy Act of 1976), any modification of the weather is required to be reported to the National Oceanic and Atmospheric Administration, and the results of research must be made public.

The proposed tests are taking place on Popeloutchom, the traditional territory of the Amah Mutsun Tribe, an Indigenous group dedicated to protecting its terestrial and aquatic ecosystems. Future large-scale marine cloud brightening trials could potentially affect the weather and airspace of several Indigenous communities in California's central coast region.

For Indigenous Nations, territorial sovereignty spans land, underground and airspace as a whole. When it comes to legal precedent, one California-based lawyer has made a persuasive case that tribal governments' sovereignty extends to the airspace over their lands under US law as well.

Armand Neukermans discusses his plans with a Bay Area TV station.

Possible impacts:
The effects of large-scale testing of MCB geoengineering techniques are unknown, but could affect rainfall in the immediate area, as well as creating unpredictable changes to regional weather patterns at a distance. For example, marine cloud brightening in the Pacific and elsewhere may lead to reduced rainfall in the Amazon basin.

The area surrounding Moss Landing is also a major strawberry growing region, a form of agriculture that depends heavily on rainfall, and has been experiencing prolonged drought. If precipitation is altered by cloud brightening, this could negatively affect agriculture in the region. The proponents have said that the first experiments will not directly whiten clouds (only test out the hardware) but later experiments will do so.

"We could... consider the climate system as a piano in which the spray regions are the keys, some black some white, on which a wide number of pleasant (or less unpleasant) tunes could be played if a pianist knew when and how hard to strike each key."

–Stephen Salter

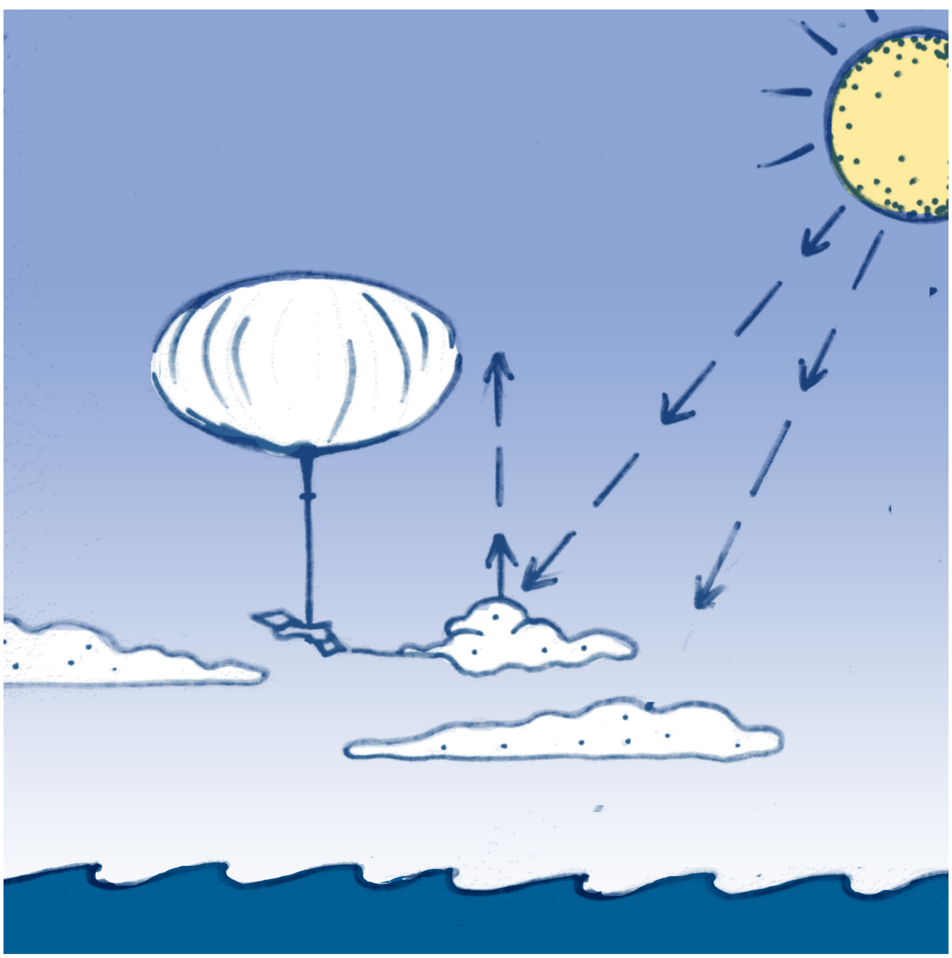
So far, cloud brightening has struggled to find funding due to the controversial nature of its proposals, but a successful small-scale test could help to legitimize geoengineering research and open the door to larger-scale implementations and much more funding. If the tests proceed, and lead to full implementation, the implications could become planetary in scale. These experiments are the first step on a path to unilateral implementation of geoengineering, exploitation of "alternatives" to reducing greenhouse gas emissions by fossil fuel companies, and military uses of the technology.

The California coast (and the entire Pacific coastline down to Peru) are regarded as some of the most promising locations for SRM projects. If larger tests and deployment proceed, the North and South American Pacific coastal regions are the most likely locations.

The vision of the key players remains the creation of a planetary scale technology that can change the global temperature and be flexibly operated to cool and alter different regions. As MCB proponent and researcher Stephen Salter put it in a research paper, "We could... consider the climate system as a piano in which the spray regions are the keys, some black some white, on which a wide number of pleasant (or less unpleasant) tunes could be played if a pianist knew when and how hard to strike each key."

Project details:
The first major open-air experiment was to be overseen by a US Silicon Valley entrepreneur Kelly Wanser, who established a company, Silver Lining Inc, later renamed The Silver Lining Project, in San Francisco. Leading Geoengineering researchers David Keith and Ken Caldeira steered some funding from the Bill Gates-backed FICER fund to project leader Armand Neukerman – the inventor of the earliest inkjet printers who worked at Xerox Labs and Hewlett Packard. Neukerman's goal has been to develop the nozzle for ships that would fire saltwater as tiny particles into the clouds, at a rate of trillions per second. The nozzle must emit particles that are small enough - 0.2 to 0.3 micrometers - to rise and remain suspended in air. In 2010,

Wanser announced a large-scale experiment involving 10 ships and 10,000 square kilometres of ocean that would take place in three or four years. But after media reported on the experiment, including the involvement of Gates in funding Neukerman's work, all traces of the project and its scientific collaborators disappeared from the Projec's website.



Cloud brightening is on of an array of geoengineering techniques that aim to reflect sunlight back into space on a mass scale.

Key players in MCBP:

Thomas Ackerman
Professor in Atmospheric Sciences, University of Washington

Robert Wood
Professor of Atmospheric Sciences, University of Washington

Philip J. Rasch
Pacific Northwest National Laboratory (PNNL)

Armand Neukermans
Former engineer at Xerox Labs, HP

Kelly Wanser
CEO of Luminus Networks

Stephen Salter
Emeritus Professor of Engineering Design, University of Edinburgh

John Latham
Professor emeritus at the University of Manchester (UK)

A few years later, the same proposals resurfaced as the Marine Cloud Brightening Project, still with Kelly Wanser as the executive director. In media coverage, they have focused on presenting themselves not as a commercial outfit but as a folksy collection of harmless, retired engineers tinkering in their labs instead of hitting the golf range – referring to themselves as the "Silver Linings." Thomas Ackerman, a scientist at Washington University and one of the formulators of the Nuclear Winter theory, joined the project as a principal investigator in 2014.

Under the aegis of the University of Washington, their first land-based field experiment is slated to take place at Moss Landing, Monterey Bay, California. Tom Ackerman told a geoengineering conference in 2014 that they would set up nozzles on the shoreline and spray clouds as they roll in, observing if they were whitened, while sensors on the land would assess if this led to less incoming solar radiation.

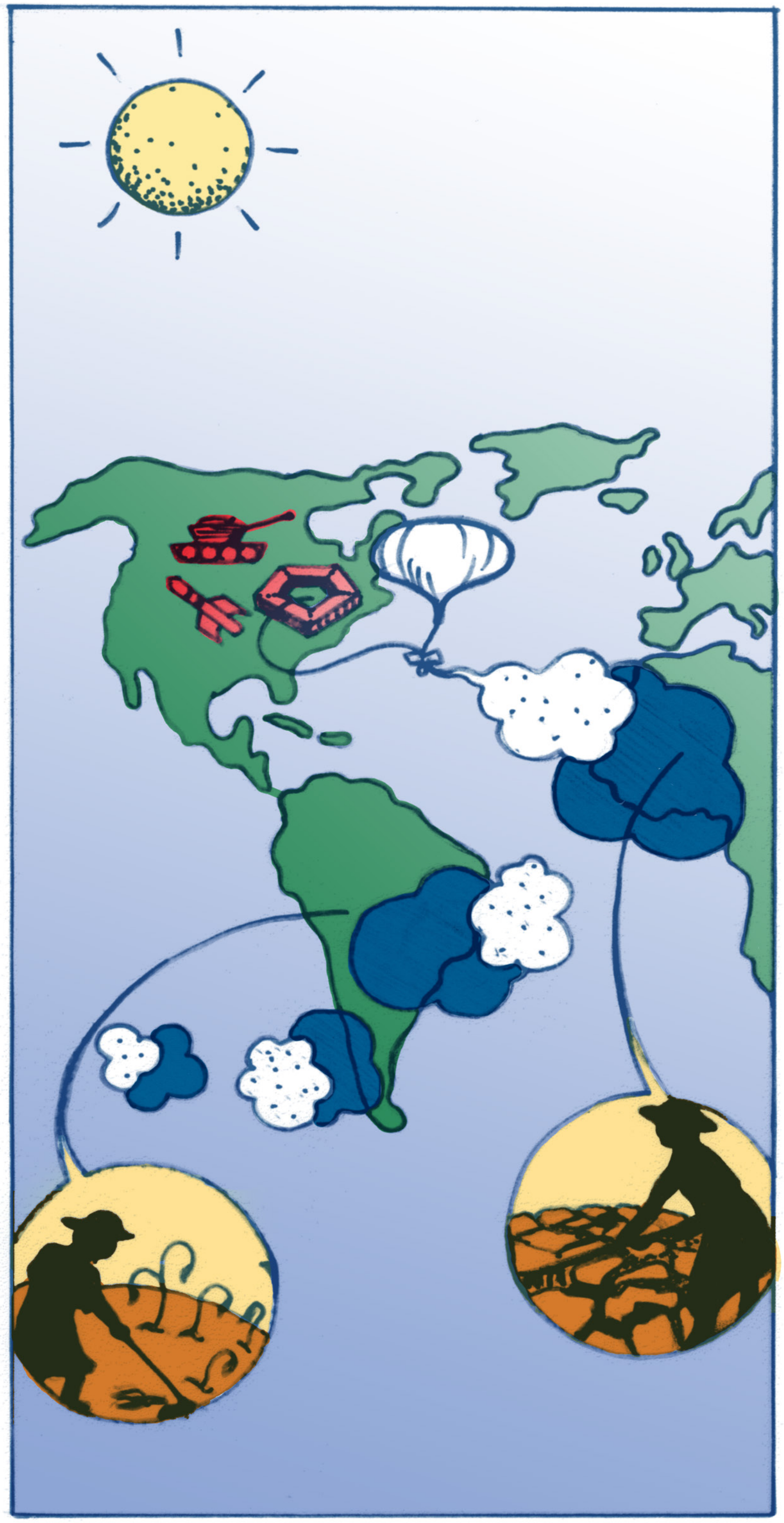
More recent press reports include the test organisers stressing that the first experiments will not whiten any actual clouds, just test the hardware. They have already conducted wind-tunnel testing of a prototype nozzle in 2015 in the California's Bay Area. Reports have also emerged that Kelly Wanser has been scouting to hire for a public relations whiz for the Monterey experiment – perhaps with the hope of not replicating the Silver Linings Project media fiasco. They would then move experimentation to sea, for a 2-3 year phase propelling droplets from a small ship. After that, the project would move to a larger at-sea cloud whitening test initially slated for the summer of 2017, but has since been delayed. The land-based experiment has been delayed for lack of funding but is expected to move ahead in August 2018.

Sources:

http://digitalcommons.law.ou.edu/cgi/viewcontent.cgi?article=1022&context=ailr

http://www.washington.edu/news/2017/07/25/could-spraying-particles-into-marine-clouds-help-cool-the-planet/

http://www.mercurynews.com/2015/07/11/cloud-brightening-experiment-tests-tool-to-slow-climate-change/



Blocking sunlight on a scale on a scale big enough to modify global temperatures would have massive effects on weather patterns, which could lead to weaponization of geoengineering. Computer models suggest that Solar Radiation Management methods like cloud brightening could lead to drought in the Sahel region of Africa or South America. In the likely scenario that SRM creates winners and losers in terms of rainfall or other weather factors, the techniques would inevitably become a tool of geopolitics.

For more information, visit **GeoengineeringMonitor.org** and see our report **The Big Bad Fix** (etcgroup.org/content/big-bad-fix).

Contact: etc@etcgroup.org

New Gizmo Blog
News and reviews about cutting edge Technology
https://newgizmoblog.com/2019/02/08/would-you-swipe-right-for-an-ai/

Would you swipe right for an AI?

By **Shane Fernandes | Feb 8, 2019**

Would you swipe right for an AI?

Valentine's Day is for the romantics. It provides an opportunity to spend time with that special someone. However, contrary to the commercialism, it is not the day for everyone. According to the US Census Bureau 47.3 % or approximate 115.78 million 18 year olds or older are single. Perhaps it is too late for you to find that special someone this year. However, would you consider a robot or AI this Valentine's Day for companionship?

Should we Fear or Love AI?

I know that there are a multitude of movies about the future where AI and Robots have become self-aware. Most of them (Terminator, Blade Runner, I-Robot) talk about the potential doom they will bring to humanity. And most recently Elon Musk warned that

> *"As AI gets probably much smarter than humans, the relative intelligence ratio is probably similar to that between a person and a cat, maybe bigger"*

At CES this year, California based, Zoetic AI unveiled a learning, self evolving AI Tech that it hopes will provide you with a different perspective. Running on Zoetic OS (a robotics-oriented custom Linux distribution), Kiki is an extremely cute AI powered pet robot. A mixture of a cat and a more affectionate R2D2.

AI is a great companion

Robots and AI have always been thought of, as a wonderful tool to address issues of isolation and loneliness. AI such as Kiki can definitely be an amazing technological companion . It will make life more fun for its owner. No apartment Is too small and no house is too big for this *Next Gen* pet. And unlike traditional pets, Kiki does not need to be cleaned up after and would not be an issue for those with allergy problems.

Kiki has 16 touch sensors spread over its head, neck and body. Kiki will recognize its own and will respond to movements, audio input and even background noise. Kiki will also react to another Kiki. Almost human like Kiki's IPS screen displays emotion. Mita Yun (CEO, Co-founder Zoetic AI), indicated:

> *"Kiki just loves to have fun. Although all Kiki 's start out the same. Kiki's personality will grow and adapt based on the interaction you provide it. Eventually each Kiki will be uniquely different"*

So perhaps this Valentine's, swipe right on your new high-tech companion. The Kiki AI.