

# Some perspectives on marine geoengineering from the (wider) NGO community

David Santillo, Greenpeace Research Laboratories  
(Greenpeace International)

Science Day 2023: Emerging technologies in marine geoengineering, 16 March 2023

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**'Manifesto' against geoengineering field experiments and deployment**

**HANDS OFF**

**MOTHER EARTH**

**195 SIGNATORIES 45 COUNTRIES**

**AN INTERNATIONAL CIVIL SOCIETY CAMPAIGN AGAINST GEOENGINEERING**

**SIGNATORIES**

To date, 195 organizations from 45 countries have signed the HOME Manifesto.

**International Organizations:**

- Alianza por la Biodiversidad en América Latina
- Amigos de la Tierra de América Latina y el Caribe (ATALC)
- Asian Peoples Movement on Debt and Development (APMDD)
- Biofuelwatch
- Climate Justice Alliance
- Corporate Accountability International
- Corporate Europe Observatory
- Development Alternatives with Women for a New Era (DAWN)
- ETC Group
- Focus on Global South
- Friends of the Earth International
- Global Forest Coalition
- Grain
- Grassroots Global Justice Alliance
- Heinrich Boell Foundation
- Indigenous Environmental Network
- International Oil Working Group
- JVE International
- La Via Campesina
- Navdanya, International
- Oilwatch Latinoamérica
- The Gaia Foundation
- Third World Network
- Transnational Institute
- World Indigenous Women's Alliance (TONATIERRA)
- World March of Women, Americas
- World Rainforest Movement
- Oil Change International

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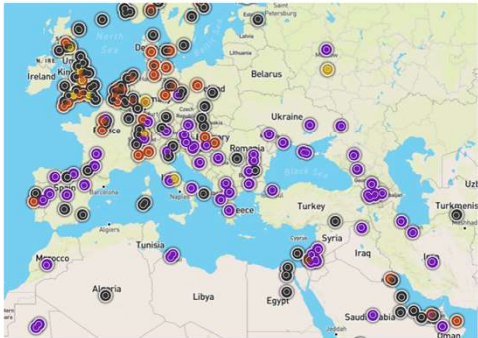
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# GEOENGINEERING MONITOR

Home What is geoengineering? Oppose Resources Get Involved

## MAPPING GEOENGINEERING PROJECTS

NOV 08 2017



**RECENT POSTS**

- Press release from Don't Geoengineer Africa: A Warning Call from African Civil Society Organizations
- By prohibiting solar geoengineering experiments, Mexico sets a global example of precaution
- Over 80 civil society organizations call on CBD COP15 to reinforce precaution against geoengineering to protect biodiversity and

<https://map.geoengineeringmonitor.org>

Interactive map from ETC Group and Heinrich Boell Foundation shows growth of climate control efforts

This interactive geoengineering map, prepared by ETC Group and the Heinrich Boell Foundation, is an attempt to shed light on the worldwide state of geoengineering by showing the scope of research and experimentation. There is no complete record of weather and climate control projects so this map is necessarily partial.

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Filter by Date: 2018 2023

2000 and earlier recent projects

Search 1159 Filter all 716 Greenhouse Gas Removal 16 Solar Radiation Management 63 Weather Modification 364 Other About

mapbox etc HEINRICH BÖLL STIFTUNG

© Mapbox © OpenStreetMap Improve this map

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### Scaling Seaweed (Macroalgae) as a Carbon Dioxide Removal Technofix: The Theory.

**THE HYPE:**

“We have all these global problems and no solutions on land. Seaweed is the greatest untapped resource that we have,”  
- Vincent Doumeizel, The Seaweed Manifesto

“By 2050, seaweed production could absorb 135m tons of CO2 a year and 30% of all nitrogen entering the oceans from land-based pollution.”  
= Safe Seaweed Coalition

“X-prize winning company Pull to Refresh believes kelp can store one trillion metric tons, enough to reverse climate change.” –Discover Magazine

**THE PITCH:**

**Seaweed is “fast biomass”:** Common claims kelp grows 2-3 feet per day.

**Seaweeds scale-up:** Proponents imagine “basin-scale” operations.

**Seaweed Sequesters:** Up to 10% of carbon fixed by natural seaweeds is sequestered (including in deep sea sediment) - claimed to be 173 million metric tonnes carbon annually.

**CDR THEORY/BUSINESS PLAN:**

- Grow large quantity of macro algae.
- Move algal biomass grown at surface/coast to long cycle storage in the deep oceans.
- \$\$ Generate carbon credits \$\$

*“All we are is a supply chain. And the attribute that we sell is tons of carbon removed. We partner with nature to make that happen ... Instead of offloading ships at port, we’re offloading carbon at sea.”*  
- Running Tide.

**A NEW INDUSTRY EXPLODES:**

>**Quarter billion Investment:** \$168 million dollars investment in seaweed ventures in 2021 plus \$100 million from Bezos earth fund (to WWF)

> **New players:** 182 startups since 2015 - most in the last 3 years

> **Market Prize:** Hope to realize a new industry in the hundreds of billions of dollars size.

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### Scaling Seaweed (Macroalgae) as a Carbon Dioxide Removal Technofix: The Plans

**1. Scale-up Coastal Seaweed Farming** - primarily kelp.

- Globally (theoretically ) 4.8 billion hectares of coastal waters “potentially ecologically suitable for macroalgae” - 6 times the size of Australia.
- Companies scaling up farming of kelps on lines - similar to the larger Chinese seaweed farms - to increase overall macroalgal biomass
- Presented as ‘kelp forest restoration’

Example: **Kelp Blue** plans to create the worlds largest seaweed farm off the coast of Namibia (70,000 ha), **Cascadia** aims for 6000 acres. **Amazon.com** working with **NorthSea Farmers**, **WWF/Bezos** with **Ocean Rainforest**

**2. Moving Seaweed to Open Ocean** - both kelp and sargassum.

- Create artificial open ocean floating kelp islands

Example. **Climate Foundation’s** ‘marine permaculture’ platforms (Elon Musk /X-Prize).  
**Seaweed Solutions** ‘seaweed carrier’ platform. (funded by WWF/Bezos)

- Deliberately grow and farm Sargassum.

Example – **Seafields** - Plan to grow 55,000 sq km of sargassum in Southern Atlantic. Using artificial upwelling pipes in gyres to fertilise their sargassum farm. Test in 2023.

**3. Sinking Seaweed in deep ocean.** - both kelp and sargassum.

- Growing giant kelp in coastal waters then bringing to open ocean to sink in deep ocean
- Growing or capturing sargassum – (eg in Great Atlantic Sargassum Belt) and then sinking it.
- Sinking achieved using marine robots with nets , ballast or processing and baling the macroalgae.

Examples: **Running Tide** , **Pull to Refresh**, **Seaweed Generation**, **SOS Carbon**, **Phykos**. **Seafields** also plans to sink their farmed sargassum

NB: Many Seaweed startups make climate claims via substituting fossil carbon (fuel, plastics, etc.) with algal biomass – not CDR

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### Scaling Seaweed (Macroalgae) as a Carbon Dioxide Removal Technofix: The Reality.

<p><b>Reality Check:</b></p> <p><b>1. Seaweed ecosystems are a net carbon source (not a sink).</b>                  JB Gallagher (2022): “We estimate [CO2 emissions] could be potentially as high as 150 tonnes emitted to the atmosphere per km<sup>2</sup> every year, in contrast to previous estimates that seaweed absorbs 50 tonnes per km<sup>2</sup>.”                  + Calcification changes alkalinity (absorbtion) + carbon not from air.</p> <p><b>2. The ocean is not ‘empty’</b> - Competition with other coastal uses , shading sea grasses, take nutrients, sunlight etc.                  P Boyd (2022): “The purposeful occupation for months of open ocean waters by macroalgae, which do not naturally occur there, will probably affect offshore ecosystems through a range of biological threats, including altered ocean chemistry and changed microbial physiology and ecology. “</p> <p><b>3. Seaweed for CDR Doesn’t really scale efficiently</b>                  W Burns (2022): “Even sequestering 0.1 gigaton of carbon dioxide annually would require an area equivalent to the land mass of Ireland or if sited in coastal regions, a 100-meter-wide continuous belt encompassing 63% of the global coastline.”</p> <p><b>4. Kelp doesn’t really grow 2-3 feet every day.</b> &gt; bad calculations.</p>	<p><b>Other considerations:</b></p> <ul style="list-style-type: none"> <li>• <b>Diversion of nutrients</b> through macroalgae instead of phytoplankton could have implications for the nutrient cycle and secondary productivity (Phillips 1990).</li> <li>• <b>Impacts of sinking biomass on deep ocean</b> is poorly understood. Also we don’t know impact on upper or mid column of ocean</li> <li>• <b>Real risk from escape, invasive species, new pests</b> accompanying scale-up. World’s largest algal blooms in Yellow Sea –result from escaped commercial seaweed strains <i>N. yezoensis</i> from large scale seaweed farms.</li> <li>• <b>Loss of wild genetic diversity/contamination</b> - introducing non-native strains could negatively impact natural macroalgae population</li> </ul> <p><b>++ Problem of rapid commercial speculation.</b>                  Many new seaweed startups are already offering carbon credits based on poor claims - purchased by Stripe, Shopify. Trialling of seaweed carbon credit credit methodologies by Verra, BlueCs etc. Climate Foundation issues ‘kelp coin’ digital crypto token.</p>
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## Marine Geoengineering in International Fora

<p><sup>1</sup>IPCC AR6:</p> <p>UNFCCC Article 6.4:</p> <p>Human Rights Council Advisory Committee:</p>	<p>(WGIII) Ocean Fertilisation, Enhanced Rock Weathering, Ocean Alkalinity Enhancement</p> <p>Ocean Fertilisation, Enhanced Rock Weathering, Ocean Alkalinity Enhancement</p> <p>Ocean Fertilisation, Enhanced Weathering, Marine Cloud Brightening, Surface Albedo Enhancement</p>
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## Slide 8

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- 1 mention how the technologies are being discussed?  
Serayna Solanki, 13/03/2023

UNFCCC Process > The Paris Agreement > Article 6.4 Mechanism

## Article 6.4 Mechanism.



Credit: Unsplash/Melissa Bradlev

**Latest info:**  
 - Article 6 Capacity Building Work Programme and Online Course launches at COP27  
 - Article 6.4 Decision adopted at CMA 4; Decision -/CMA.4 (Advance unedited version)

Article 6 of the Paris Agreement establishes three approaches for Parties to voluntarily cooperate in achieving their emission reductions in their national climate action plans under the Paris Agreement (Nationally Determined Contributions, or NDCs). One of these is the **6.4 Mechanism**, a mechanism "to contribute to the mitigation of greenhouse gas emissions and support sustainable development, in accordance with Article 2, paragraph 2c, of the Paris Agreement, Article 6, paragraph 4).

The Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA), at their third session in Glasgow, adopted the rules, modalities and procedures for the mechanism established by Article 6, paragraph 4, of the Paris Agreement ("the mechanism") which allows a company in one country to reduce emissions in that country and have those reductions credited so that it can sell them to another company in another country. That second company may use them for complying with its own emission reduction obligations or to help it meet net-zero.

The CMA also designated a 12-member body (Supervisory Body) to supervise the mechanism under the authority and guidance of the CMA and be fully accountable to the CMA.

**"Through this mechanism a company in one country can reduce emissions in that country and have those reductions credited so that it can sell them to another company in another country. That second company may use them for complying with its own emission reduction obligations or to help it meet net-zero."**

Initially included a number of marine geoengineering techniques, including OF, in a relatively unqualified way

Now more nuanced, and with specific reference to decisions and ongoing work under LC-LP and CBD

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## Local reactions to marine geoengineering techniques

<p>Alaska Native Organizations react to Arctic Ice Project:</p>	<p>An Alaska Native delegation of leaders held a protest outside a fundraiser for the California-based Arctic Ice Project, delivering a collective letter articulating their call to cease research, specifically citing the lack of tribal consultation and absence of Free, Prior and Informed Consent (FPIC). The delegation also held a press conference in the area with local campaigners.</p>
<p>FishNet Alliance, Africa:</p>	<p>FishNet Alliance, a network of artisanal fishermen across the African continent on Sunday kicked against the concept of Ocean Geoengineering as an option to address climate change at the ongoing COP 27 Climate Conference in Egypt.</p>
<p>Small Scale Fisher Workers, India:</p>	<p>India's National Platform for Small-Scale Fish Workers Rejects Ocean Geoengineering Calls Upon All States to Stop Resorting to False Solutions and Experimentations to Resolve Climate Crisis. See statement here</p>

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Royal Society of Chemistry—Environmental Chemistry Group—Bulletin—July 2016 16

Article

## How can geoengineering research be regulated?

David Santillo (Greenpeace Research Laboratories, d.santillo@exeter.ac.uk) and Paul Johnston (Greenpeace Research Laboratories)

The term climate engineering (or geoengineering) refers to a broad range of concepts, some with a history of practical research, others still largely theoretical. These concepts range from artificially enhanced mineral weathering and large-scale ocean fertilisation to modifying the chemistry of the upper atmosphere or making croplands or seas more reflective. Assessments of their likely effectiveness in mitigating climate change and their potential for adverse effects have highlighted substantial uncertainties and unknowns (1, 2). In 2009, the Royal Society concluded that although "geoengineering of the Earth's climate is very likely to be technically possible... the technology to do so is barely formed, and there are major uncertainties regarding its effectiveness, costs, and environmental impacts" (3). Seven years on, that assessment remains just as valid.

In response to the limited knowledge and understanding of what might happen in a geoengineered world, some call for an expansion and acceleration of research (4), including stepping beyond modeling studies to the design and conduct of field experiments or even proof of concept engineering trials. By definition, such experiments would need to be carried out at scales sufficient to generate measurable effects that could be distinguished from background variability, and the area (or volume) of impact could neither be precisely defined nor contained. This raises the questions of whether and, if so, how such proposed research could be properly assessed, regulated, controlled and monitored. How could research at scale be distinguished from actual deployment of a geoengineering technique? And who would bear responsibility for the review and authorisation of such research and would ultimately be liable for any damages or other impacts caused?

Unless studied with theoretical models or in contained laboratory experiments, geoengineering experiments will not respect geographical boundaries. In fact, it is the potential for transboundary impacts, which may be uncontrollable and possibly irreversible, that has led to strong international concerns regarding proposals for field research into geoengineering concepts. For the same reasons, any mechanisms put in place to provide independent oversight and control of such research must also be international in nature, incorporating elements of cautious and consistent assessment and consultation. This may sound like an impossible task in a world in which collective action to tackle climate change itself has been so painfully (and dangerously) slow, but recent efforts to regulate ocean fertilisation studies provide a relevant precedent in international environmental law.

Ocean fertilisation was first proposed as early as the 1960s as a way of boosting fisheries production to feed a growing population. About 15 offshore field experiments have been carried out in the last couple of decades, driven by various hypotheses. These experiments have tended to confirm that adding iron as a nutrient to offshore waters, in which algal populations are lower than expected given the supply of nitrogen and phosphorus, commonly boosts their growth. What happens to the plankton community from there, however, appears far less predictable, not least because the final outcome depends heavily on the starting conditions and on the weather and oceanography as the experiment progresses (5).

Despite these limitations, promotion of iron fertilisation as a method of stimulating the drawdown of carbon dioxide from the atmosphere became more prominent at the turn of the millennium. From the start, many marine scientists warned about harmful consequences for marine ecosystems (6). It was in 2007, however, that the

one earth

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## Marine geoengineering: a dangerous distraction from real climate action

Climate

David Santillo, PhD  
Biologist

Proposals to 'geoengineer' marine ecosystems, whether floated on claims to tackle climate change, boost fisheries or even 'restore ecosystems', have raised concerns among scientists for as long as they have been conceived. The term 'marine geoengineering' covers a diverse array of ideas, ranging from proposals to change ocean chemistry on a vast scale, through schemes to alter circulation patterns, to attempts to reflect more sunlight back from the ocean surface or the clouds above it. What they all share is the notion that we can deliberately manipulate natural systems, already under pressure from human activities, with the intent to engineer 'benefits' for society. In that endeavor, what is all too often lost is an appreciation that our oceans are complex and delicately balanced living systems, not simply volumes of water in which we can predictably 'tune' the physics, chemistry or biology to our own ends.

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Questions...?  
(and perhaps even some answers)

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## Marine Geoeengineering Projects/Initiatives

### Marine Carbon Dioxide Removal (CDR)

#### Ocean fertilization

- [WhaleX](#), Australia
- UK-based [Center for Climate Repair at Cambridge](#) and partners in South Korea, India and Hawaii experimenting with artificial whale poo <sup>1, 2</sup>
- [OPR Alaska Inc. \(former Planktos Inc.\)](#) to conduct OF experiments in Alaska, USA
- Canada-based [Oceaneos](#) attempting to conduct experiments in Chile, Peru and Argentina
- US-based [Climos Inc.](#) with a goal of conducting large-scale OF in the high seas in the northwest Pacific [...] or the sub-polar Southern Ocean
- R&D by US-based [Nualgi America Inc.](#) proposing large-scale ocean fertilization with its self-manufactured fertilizers

#### Artificial Upwelling

- US-based [Ocean-Based Climate Solutions](#) testing of wave-powered artificial upwelling technology in Morro Bay, California and in the Atlantic Ocean south of the Canary Islands
- US DOE-sponsored [Blue Fields project](#) (cancelled)
- US-based TROFX (formerly known as [Trophic](#)) intends to build a larger offshore algae farm for biomass production using wave-driven artificial upwelling
- US-based [The Climate Foundation](#) ocean experiments in Hawaii, Philippines, with plans in Storm Bay, Tasmania and Southern California in the eastern Pacific Ocean
- R&D by [Zhejiang University](#) in China, testing at various lakes and bays in the country

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## Marine Geoeengineering Projects/Initiatives

#### Enhanced Weathering

- US-based [Project Vesta](#) to test and scale EW with olivine on beaches along US States
- GEOMAR Germany coordinated- [OceanNETs](#) project doing field trials in Spain, Norway
- German research "CO2 Removal by Alkalinity Enhancement: Potential, Benefits and Risks" ([RETAKE](#) project)
- R&R by Canada-based [Planetary Technology Inc.](#)
- UK-based [CQuestr8](#) working with partners in the University of Nottingham and the University of Malaysia
- UK-based diamond producer and trader [De Beers Group](#)'s Project Minera and successor project CarbonVault
- Canada based (X-Prize funded) Planetary Technology, aims to [dump mining waste](#) in St Ives, UK

#### **Other marine CDR activities**

- UK-led research Sea Carbon Unlocking and Removal ([SeaCURE](#)) project aiming to make seawater temporarily more acidic so that the CO2 in the water 'bubbles out', captured, concentrated, compressed and then 'stored'.
- [Enhanced Silicate Weathering](#) R&D, modelling, and controlled trials by Antwerp University, in Wilrijk, Belgium
- [Solid Carbon: A Climate Mitigation Partnership Advancing Stable Negative Emissions](#) ocean CCS R&D led by Ocean Networks Canada aiming to do a demonstration project in the open ocean, in the Cascadia Basin off the coast of Vancouver Island
- US-based [Ebb Carbon](#) seeking to commercialise an electrochemical process for removing acid from seawater, with the goal of fixing more CO2 in the form of bicarbonate in the oceans and reducing ocean acidification
- [SEA MATE](#) research supported by US NOAA and led by universities to explore electrochemical process for removing acid from seawater, with the goal of fixing more CO2 in the form of bicarbonate in the oceans and reducing ocean acidification.
- US-based [SeaChange](#) aiming to develop an electrochemical process to capture carbon from seawater. Pilot tests were done in California and Singapore.
- Belgium-based [Out of the blue](#) aiming to commercialise a process to remove CO2 directly from seawater.

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## Marine Geoengineering Projects/Initiatives

### Solar Radiation Management (SRM) in marine environments

#### Reflective substance for covering glaciers

- US-Based [Arctic Ice Project](#) [1](#), [2](#), [3](#), [4](#), [5](#), [6](#), [7](#), [8](#), [9](#) testing at various lakes in the United States and Canada, mostly within indigenous territories
- US-Based [Bright Ice Initiative](#) to conduct field experiments in the Himalayan glaciers

#### Marine Cloud Brightening

- [MCB trial in the Great Barrier Reef](#), Australia
- [Larger-scale MCB in the Great Barrier Reef](#), Australia
- [MCB trial beside Broadhurst reef](#), Australia
- [Marine Cloud Brightening Project \(MCBP\)](#) by the University of Washington, the Pacific Northwest National Laboratory (PNNL), a team of engineers from Silicon Valley, the Palo Alto Research Centre and further research partners
- [MCB with sea water by Stephen Salter](#), based at Edinburgh University

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## Marine Geoengineering Projects/Initiatives

### Combination of approaches

- China's Xiamen University [ONCE project](#) is investigating Ocean Alkalinity Enhancement (OAE) and artificial upwelling
- UK-based [Seafields Solutions Ltd.](#) to supply seaweeds with nutrients through artificial upwelling, with small-scale testing in Mexico and St. Vincent

### CO2 storage in oceans

- German funded and led research [AIMS3](#) project is investigating the storage of CO2 in the upper ocean crust
- Norway-based [Ocean GeoLoop](#) claims that its technology can capture almost 100% of CO2 from flue gas based solely on an electrical process, without the use of chemicals. In 2022, the company commissioned its first carbon capture pilot plant at the Norske Skog's Skogn, Norway.

### Other marine geoengineering promoters & activities

- US-based [Ocean Visions](#) established by several US universities and educational institutions has developed roadmaps to accelerate the development and testing of ocean-based CDR approaches. They regularly organize workshops, events, participate in various international conferences/forums, and collaborate with international organizations like the [Ocean Visions – UN Decade Collaborative Center for Ocean-Climate Solutions](#).
- The [Sabin Center](#) and Ocean Visions will jointly [host](#) a series of stakeholder workshops where members of the scientific community, government agency representatives and other interested parties can provide their input to support the development of model legislation for ocean-based carbon dioxide removal.
- Newly formed [Exploring Ocean Iron Solutions \(ExOIS\)](#) conducted the forum "What's Next? R&D Planning for Ocean Iron Fertilization" in September 2022.
- [NOAA Earth's Radiation Budget \(ERB\) Initiative](#) is a US government research program on solar radiation management (SRM), with emphasis on Marine Cloud Brightening (MCB) and Stratospheric Aerosol Injections (SAI)

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## Marine Geoengineering Projects/Initiatives

### 2 Algae

- [Running Tide Technologies Inc.](#)
- [Brilliant Planet](#)
- [Pull to Refresh](#)
- [Kelp Blue](#)
- [Fearless Fund](#)
- [Seaweed Carbon Solutions](#)
- [Carbon Kapture Ltd.](#)
- [Omega Green](#)
- [Global Algae Innovations](#)
- [Pond Technologies](#)
- [Chinese ENN Research and Development Co. Ltd.](#)
- [Seabiotic Ltd.](#)
- [Seaweed Generation Ltd](#)

## Slide 17

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- 2 maybe these examples can be used in the slides that Jim/ETC Group will provide  
Niki Miranda-Martinez, 25/02/2023