Only Living Planet

A Citizens Guide to Successful Climate Transition

How to appreciate, respect, and act as stewards of the Earth

Richard Charter

Edited by Padi Selwyn

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"The world is not a problem to be solved; it is a living being to which we belong. The world is part of our own self and we are a part of its suffering wholeness. Until we go to the root of our image of separateness, there can be no healing. And the deepest part of our separateness from creation lies in our forgetfulness of its sacred nature, which is also our own sacred nature."

—**THÍCH NHẤT HẠNH**, *Spiritual Ecology: The Cry of the Earth*

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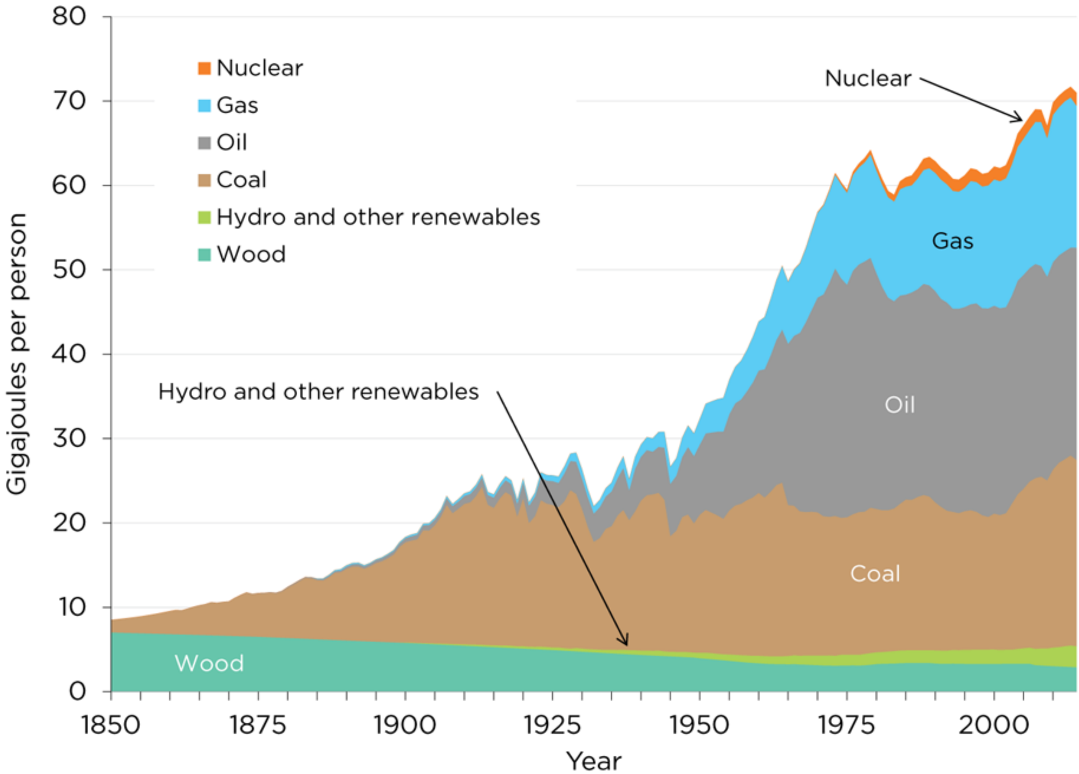

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Earth

Collective Illusions About Our Relationship to Our Home

Our world is shaped by what we're collectively taught to believe. As we heedlessly accept the corporate goal of converting the raw materials found in nature into marketable commodities, this singular practice now literally threatens the ability of our planet to support life. Conflict over the resources that build our industrial societies leads to war and undermines the viability of human survival. Humanity's habitual view of other species, and even of other societies, as expendable in our quest for profits has also come home to haunt us. We, as humans, are now literally the "canary in the coal mine".

Our ancestors who started the industrial revolution certainly didn't foresee or desire the climate-related problems we are now experiencing. Nonetheless, energy-related carbon emissions into our atmosphere have risen to their highest level in history, and the *Intergovernmental Panel on Climate Change*, or IPCC, has issued a report cautioning that global warming is happening so rapidly that humanity may no longer be able to adapt. We have documented that atmospheric carbon dioxide topped 420 parts per million (ppm) in May of 2022, which is 50% higher than the levels at the start of the Industrial Revolution, and we know that this level is now comparable to the era known as the Pliocene Climatic Optimum more than 4 million years ago. Our very survival now increasingly depends upon our ability to engage in social change at an almost unimaginable scale and pace. We must put the misconception that we live in an invincible natural world behind us, while implementing a way to collectively proceed into a new future with a lighter carbon footprint.

On the same day that the IPCC released its latest and most alarming working group report, United Nations Secretary-General António

Guterres declared it "moral and economic madness to invest in new fossil infrastructure", while ExxonMobil announced a US $10-billion final investment decision on an offshore oil drilling project in Guyana called Yellowtail.

An international treaty on climate change adopted by 196 parties at the *United Nations Climate Conference of the Parties* on December 12, 2015, the Paris agreement was entered into force on November 4, 2016. The treaty is legally binding and its goal is to limit global warming to well below 2 degrees Celsius, preferably to 1.5 degrees Celsius, (expressed as °C) in comparison with pre-industrial levels. To achieve this long-term temperature goal, countries aim to reach global peaking of greenhouse gas emissions as soon as possible in order to achieve a climate-neutral world by mid-century.

We know where we need to be going. A recent *UN Environment Program* report warns that unless global greenhouse gas emissions fall by 7.6% each year between 2020 and 2030, the world will miss the opportunity to get on track towards the 1.5° C temperature goal of the Paris Agreement. This means that if all current unconditional commitments under the Paris Agreement are implemented, global temperatures are expected to rise by 3.2° C, bringing even wider-ranging and more destructive climate impacts.

Collective efforts to curtail harmful greenhouse gas emissions must increase more than fivefold over current levels to deliver the cuts needed over the next decade for the 1.5° C goal. Hundreds of cities and private companies have already pledged to get to "net-zero" – removing as much carbon dioxide (CO_2) as they produce – by 2050, but in order to actually cut emissions, the carbon intensity of the energy mix must be reduced.

One of the biggest loopholes in corporate climate targets and pledges remains the reliance upon what are called *carbon offsets*. There are numerous ways that companies claim to cancel out their emissions, but a popular method is paying for landowners to not cut down trees that may not actually have been at any risk in the first place, or sponsoring emissions reductions for projects in which such reductions would have happened anyway. These kinds of measures are a weak substitute for the reality of actually cutting emissions from business operations themselves.

We know that in every existential challenge there is an opportunity. Our deepening scientific knowledge of how nature itself works is becoming more wholistic as our tools of observation improve. We have also broadened our ability to understand the often-hidden secondary implications of human endeavors. We can, if we choose, now find a constructive path forward. Our continued existence may well depend on it.

We need to reexamine the sequence of history that has pushed industrial society beyond our ability to ignore today's dangerous perturbations in global climate. The tragedy of looming extinctions, and the pressing need to transition to new lower-carbon energy sources, present the false appearance of imposing barriers, but these are really opportunities in disguise. A better understanding of the calculated corporate misinformation trajectory that led us to this impasse can guide us into a more promising future based on sound science and more sustainable technologies. But first, we need to know what brought us here to our present collective human dilemma and find a deeper understanding of the natural world and our connection to it.

The Paris Agreement and Carbon Capture and Storage

The Paris Agreement is the first time that a binding agreement has brought all nations into a common collective initiative to undertake ambitious efforts to combat climate change and adapt to its effects. The treaty itself works on a five-year cycle based on increasingly ambitious climate action carried out by each country. By 2020, countries each committed to submit their plans for climate action, which are known as *Nationally Determined Contributions* (NDCs).

The goal of achieving a threshold of *net-zero emissions* is part and parcel of limiting global warming, and is at the heart of the Paris Agreement itself. Progress will involve not only curtailing harmful emissions, but also on capturing those that will inevitably continue to be pumped into the atmosphere. Without a marked acceleration in cutting CO_2 emissions, plans to meet climate goals increasingly rely on capturing excess CO_2 emissions, processing them, and then storing them. This need to capture emissions leads to the still-developing technology of "Carbon Capture and Storage" (CCS), a process that involves capturing harmful CO_2 emissions from power plants and heavy industry only to then inject them in deep underground storage facilities.

Although CCS has been a topic in discussions about climate change mitigation for decades, there remain a range of mixed views on its future and real potential. Some view CCS as simply sweeping the "emissions problem" under the rug.

The City of Copenhagen is implementing CCS technologies in its waste facility systems as part of a larger effort to become the world's first carbon neutral city, while global companies such as Microsoft, United Airlines and others have also invested in CCS technologies to try to advance their corporate climate targets.

To date, the majority of proposed carbon-capture projects are to be used for "enhanced oil recovery," – meaning that this is yet another subsidy that will increase fossil fuel production. Simple logic tells us that it would make more sense to stop emitting instead of relying on new technologies that can capture carbon, which essentially takes society one step backward for every step forward. According to the *International Energy Agency's* (IEA) "Net-Zero by 2050: A Roadmap for the Global Energy Sector" report, current climate pledges made by governments will not bring global energy-related CO_2 emissions to net-zero by 2050.

This same report highlights the fact that, "Most of the global reductions in CO_2 emissions between now and 2030 in the net-zero pathway come from technologies readily available today. But in 2050, almost half the reductions come from technologies that are currently only at the demonstration or prototype phase."

Because these CCS technologies are, for the most part, still in the hypothetical planning phases of development, and although they are being tested and even used in some applications, they are still not widely available for commercial use. Some observers believe that large-scale deployment of CCS technology would allow countries to *decarbonize* effectively, but the precautionary principle indicates that overreliance on CCS technology could be dangerous and ultimately act as a distraction from more important tangible progress of actually lowering emissions in the first place.

In the U.S., continuing federal subsidies for the oil industry have lured the petrochemical complex into trying out this unproven technology. Pipelines being proposed through middle America for transport of CO_2 have generated controversy about prospective operator's efforts to route them through prime agricultural lands. Proponents of a $4.5 billion pipeline project to carry carbon dioxide away from ethanol plants in Minnesota and other Midwestern states claim it is necessary in order for those plants to remain competitive in a low-carbon future. Claims that the proposed 2,000-mile pipeline would make it possible for participating ethanol plants in five states to reduce their carbon scores and enter the low-carbon markets have not been verified. The proponents assert that absent such a pipeline, participating companies would be at a 40 to 50-cent disadvantage per gallon in selling fuels in markets with low-carbon regulations. Minnesota utility regulators have deemed carbon dioxide pipelines as hazardous, meaning they must get state approval to be built. The state's decision affects two multibillion-dollar CO_2 pipelines slated to cross Minnesota.

The Biden administration, meanwhile, is moving to streamline a path toward carbon dioxide storage on public lands as part of its larger climate agenda, releasing a new instructional memorandum for geologic carbon sequestration projects that details parameters for transporting, injecting and storing the greenhouse gas in *pore space* underground for 30-year, renewable terms. Such authorizations for carbon sequestration projects are to include considerations of the "pore space, pipelines, storage tanks, pumps, climate control buildings, compressor sites, power generation, electric transmission, injection wells and other associated facilities required for sequestration of CO_2" under a right of way section of the *Federal Land Policy and Management Act of 1976*.

Industry has called carbon pipelines the "Holy Grail of coal-fired power plants", placing their hopes in more comprehensive carbon capture, transit, and sequestration systems for coal generating plants and other industrial facilities. Traditional carbon-based industry envisions a potential future network of tens of thousands of miles of CO_2 pipelines and utilization or disposal sites.

Landowners along proposed CO_2 pipeline corridors have legitimate concerns about the risk of explosion, based in part on the rupture of a

CO_2 pipeline in Satartia, Mississippi, in 2020, which sickened dozens of residents. The Mississipi CO_2 release was the first of its kind anywhere in the world.

The natural environment has largely been left to pay the price of industrial pollution, but as the world heats up, the pressure to put a legitimate price on carbon pollution will inevitably increase. The misleading concept of a “carbon tax”, if not actually a straight tax on carbon, is flying beneath the public radar under the guise of a carbon-trading program that caps carbon pollution and then allows the market to establish a price for any pollution that exceeds the set limit. How quickly this will be fully implemented and the form carbon trading will take in the marketplace is still being debated in the U.S.

The Biden Administration’s anticipated policy path to net-zero in the *Build Back Better Act,* as passed by the U.S. House of Representatives, had been projected to rely on hundreds of billions of dollars in tax incentives to encourage the transition to clean energy. With the U.S. Senate reluctant to adopt these measures, the consequences of delay could be dire. Relevant studies project that inaction could mean 5 billion additional tonnes of carbon emissions are added to the atmosphere, meaning that the U.S. will fall dramatically short of a reasonable goal of carbon neutrality by 2050. Without the appropriate congressional action, there would likely be no real U.S. progress on climate for years to come, which could translate into lost years or even a lost decade in the battle against global warming. This would mean that the climate challenge can only become harder to tackle the longer it remains unaddressed. Every year of delay eats into our carbon budget, raises global temperatures, and makes the future path to any hoped-for progress that much more difficult to attain.

Environmental Justice and the False Hope Posed by Carbon Capture

Oil and gas companies are now targeting Louisiana for the underground disposal of millions of tonnes of industrial carbon waste. Industry's *"Carbon Capture and Storage Experiment"* presents a wide range of safety, health, and environmental risks for Louisiana communities. The global oil and gas industry has chosen this particular region as a destination for carbon capture mainly because of the state's large concentration of industrial facilities that emit vast amounts of CO_2. The current Louisiana Governor, John Bel Edwards, and the relevant state regulators, have all expressed support for carbon capture as a way to meet a goal of reducing greenhouse gas emissions to net-zero by 2050.

In Louisiana, the industrial corridor between Baton Rouge and New Orleans that's now being targeted for carbon capture is home to more than two hundred oil and gas refineries, petrochemical plants, and other industrial chemical facilities. This area is often known as "Cancer Alley" because decades of poor air and water quality from industrial pollution have elevated cancer rates and other health ailments among residents. The predominantly Black, Hispanic, and low-income communities in Cancer Alley suffer the brunt of these hidden health threats. Similarly, Indigenous and other marginalized groups on the Gulf Coast suffer poor health effects resulting from other pollution related to the petroleum industry. These same disenfranchised communities are now currently confronted by additional degradation from carbon capture and its associated industrial build-out.

As of 2021, there were 31 commercial CCS facilities in operation or under construction around the world with the capacity to capture 40 million metric tonnes of CO_2 per year. Research by the *Global CCS Institute* indicates that CCS worldwide will have to grow by more than a factor of 100 by the year 2050 if the Paris Agreement climate targets are to be met. This would entail the construction of 70 to 100 additional CCS facilities per year. Measures such as encouraging research and development, carbon pricing policies, subsidies, and clean energy standards using CCS technology could speed industry research and development of CCS and ultimately lead to faster implementation.

The burning of fossil fuels still accounts for a large share of global CO_2 emissions from the energy sector, but heavy industries such as cement, iron and steel, aluminum, pulp and paper, and refineries will inevitably continue to emit carbon. Implementing CCS technologies at these plants can help reduce their impact, with proponents saying that up to 85% to 90% of carbon emissions can be captured.

Achieving CCS can be broken down into three phases: capture, transportation, and storage. Storage of captured carbon requires transport and injection into suitable storage facilities such as depleted oil or gas reservoirs.

In the "capture" stage, carbon is taken directly from the source of the emissions. This means removing CO_2 from industrial exhaust waste flue gas contained in smokestack discharges – which is a mixture of combustion byproducts and includes water vapor, carbon dioxide, particulates, heavy metals and acidic gasses – using a variety of chemical processes and scrubbers to remove pollutants.

CCS differs from *Direct Air Carbon Capture and Storage* (DACCS) where CO_2 removal is not linked to the source of emissions, such as power plants, but is removed directly from the atmosphere. Although DACCS has the advantage that it can be deployed anywhere, including at the same site where storage will take place, it is more costly to capture CO_2 from the atmosphere, where one finds around 410 parts-per-million (ppm) CO_2, compared to capturing it from a flue gas, where levels are typically around 10% CO_2.

The conversion phase of CCS involves compressing and transforming the CO_2 into a fluid so that it can be transported to a storage site. This transport is done via pipelines, ships, or other vehicles.

Ultimately, the liquefied carbon has to be injected deep underground, usually into storage sites that include former oil and gas reservoirs, deep saline formations, and coal beds.

The concept is that CCS may help industry to continue functioning whilst lowering emissions. Captured carbon is not only being stored but can also be put to use – what is known as *Carbon Capture Utilization and Storage* (CCUS). In this process, captured carbon can be used to produce manufactured goods, as well as in industrial processes.

One of the main current uses of captured carbon is to accomplish what is called "Enhanced Oil Recovery" (EOR). EOR is a technique of oil extraction where CO_2 and water are used to drive oil up the well, improving oil recovery and sequestering the CO_2 underground. However, there is a certain irony in using captured carbon to extract even more fossil fuels, which undermines the claimed mitigation credentials of this approach.

Energy developers are trying to cash in on what are called "45Q" tax credits, made available in the year 2008 to enable companies to earn around $30 per metric ton of CO_2 sequestered each year. That payment level is on track to increase to $50 per metric ton by 2026. Therefore, if an average coal-burning power plant is outfitted with the technology to capture and bury even just half of the plant's annual CO_2 emissions, developers involved would be eligible for an estimated $100 million in tax credits in a single year. To qualify for the credit, qualifying facilities must be built by 2026.

There is substantial difference in the quality of announced corporate net-zero announcements. Announced targets can vary by length, emissions addressed, regions included and much more. This means investors and other stakeholders lack a standardized way to measure the effectiveness of different net-zero plans. To help facilitate valid comparisons, BloombergNEF has developed a program to assess the commitments of 650 of the world's largest companies in the heaviest-emitting sectors.

Mining interests have even entered this dialog with a claim that the act of sprinkling rock dust - an abundant byproduct of mining - on farmland could eventually capture 45% percent of the carbon dioxide required to help the UK meet its 2050 net-zero targets. As nations now look anew at the ability of minerals to draw down carbon, while also replenishing agricultural soils, it appears that certain rocks present potential carbon sinks. The requisite carbon capture occurs through a process called chemical weathering, whereby atmospheric CO_2 becomes dissolved in raindrops, forming carbonic acid, which reacts with the rock minerals and causes them to break down and "weather". During that process, carbon also changes form and can become locked into the sediment as bicarbonate, which effectively strips it from the atmosphere and keeps it circulating in terrestrial and ocean systems for long periods of time.

The Petroleum Industry's Longstanding Greenwashing of Carbon Fuels

Clear warnings have long emerged about the ability of the burning of fossil fuels to arbitrarily alter the workings of global climate. As early as 1957, we were provided with compelling evidence that the ocean was incapable of absorbing all of the excess carbon dioxide being generated by human industrial activities. These obviously-alarming research findings temporarily made the requisite news headlines at that time, and then fell largely silent, in part because our petroleum-addicted society did not want to hear that our continued dependency on conventional fossil fuel energy sources was unsustainable. Similar messages have echoed periodically throughout the intervening decades, each time eliciting loud denials from those industries we have allowed to supply our addiction to fossil fuels.

As the cautionary evidence about global warming has grown harder to ignore, extractive industries have been diligently engaged in a well-funded public relations campaign to try to convince us that the "climate change problem" was only the misinformed product of unnecessarily alarmist concern. Altering our belief systems through the use of their well-financed efforts to hide the truth has long served extractive industries well - until their propaganda no longer provides an effective distraction. As we now stand amidst flooded cities, burning suburbs in the urban-wildland interface, and eroding coastlines, the reassuring words of the petro-lobby fall on deaf ears. Today, the full-blown climate crisis, emerging as it has in the form of year-round wildfire seasons in new regions, an increased frequency and intensity of superstorm events, and the inevitability of rising sea level on every coast, has become impossible to ignore. No amount of public relations effort by the petroleum industry effort can continue to hide the impacts of climate warming any longer.

The Source of the Climate Crisis

Burning coal remains by far the largest single source of global power generation, with more than 8,900 terawatt-hours (TWh) of electricity generated in 2020. Coal accounted for about 30% of worldwide CO_2 emissions in 2021, a substantial increase over 2020.

Globally, fossil fuels, including coal, oil, and natural gas received $5.9 trillion in subsidies during 2020, according to the *International Monetary Fund* (IMF), which adds up to about $11 million every minute. In the U.S., the fossil fuel industry receives $650 billion per year in direct and indirect taxpayer subsidies.

The less obvious environmental costs of fossil fuels - such as their impacts on air pollution and global warming, as well as their adverse effects on human health - are, in effect, also a kind of hidden subsidy, because polluters are not paying for the damage they cause.

Transitioning from Extractive Industry Coverups to a Nature-Centered Society

Meanwhile, humanity as a species seems to be experiencing widespread collective anxiety about the deteriorating state of natural ecosystems on our planet, obsessing over the role of humans as a cause of widespread environmental decline. Most visible amidst this societal guilt complex is the alarming number of endangered wildlife populations. Many dwindling species are now on the brink of extinction due to a combination of human-caused climate change occurring in combination with habitat destruction. In the U.S., a common way for government agencies to try to assuage such societal guilt is by throwing tax dollars at false solutions to a perceived problem. Frequently, the politically-correct illusion of righting past wrongs done by humans applies often-futile attempts to eradicate introduced non-native "invasive species". For example, the *U.S. Fish and Wildlife Service* continues to rely on the use of lethal means to try to kill such *invasive* plants or animals. This agency's misguided "eradication" efforts aimed at human-introduced mammals can instead poison entire ecosystems, unnecessarily killing non-target species in cruel ways, and in general result in a more damaging environmental imbalance than that caused by the misplaced species they are hoping to eliminate. Among the most inhumane of these poisons are the "Second-Generation Anticoagulant Rodenticides", or SGARS, due to the slow and painful death they cause to any and all exposed animals. Nonselective application of toxic chemicals is not a realistic path to remedy declines in native wildlife populations. Instead, rebuilding viable ecosystems will require a wholistic approach based on compassionate use of sound science. Nature itself is a powerful healer when not carelessly exposed to ecosystem poisons that spread in arbitrary ways throughout the entire food chain.

The Mistaken Path of "Better Living Through Chemistry"

An archeological dig comes to mind as we explore the history of how human society formulated and then adapted certain chemical compounds to fuel our industrial development and to provide raw materials for consumer goods. Many of the ingredients in the underlying chemical feedstocks originated in the petrochemical industry, often formulated from the residues of refining conventional fuels whose byproducts had previously been discarded because they had no commercial value. Layer upon layer of new inventions and discoveries, each with unanticipated toxic waste products and frequently causing hidden adverse impacts on human health, have brought us to our current dilemma.

Going forward, we need to take all due care that our attempts to quickly shift to new energy sources and a new approach to materials science do not also result in similarly unforeseen and unintended adverse ecological consequences.

We have obviously known for decades that excess emissions of carbon dioxide resulting from the combustion of fossil fuels are a primary driver of an artificial warming trend in the atmosphere planetwide. We've known for decades that fugitive emissions of methane from our natural gas wells and gas distribution infrastructure also produce a very strong warming effect on our atmosphere. But the petrochemical industry's massive political campaign contributions, combined with clever media slogans perfected with the messaging guidance of hand-picked focus groups, have sadly led our elected officials - and our society as a whole - to dangerously defer any meaningful policy changes in response to climate warming.

In the face of incontrovertible evidence of warming of the global climate, we see previously-unknown disease vectors undermining human health, we observe society's constructed infrastructure now exposed to unprecedented natural disasters and a rising ocean, and we find ourselves beset with an unexpected constellation of threats from what appears to be an increasingly hostile natural world. This strategy of denial has led us to what is called the "Anthropocene" era, the geological epoch dating from the commencement of significant human impact on Earth's geology and ecosystems.

The immediate reaction of industrialized society to all of this includes what often appear to be panic-driven efforts to find quick and easy solutions, evidenced by a desperate rush to transition into new and untried technologies. This shift is leading to a virtual stampede to harvest new energy sources directly from nature, often without fully understanding the consequences. What has emerged is now a search for sustainable methodologies aimed at continuing to exploit our natural resources, always in pursuit of the fantasy of causing fewer adverse impacts on our planetary life-support systems. The precautionary principle applies now more than ever.

In this current moment, however, “haste makes waste”, as the saying goes, and we need to exercise care that our impending transition to what we hope can be a more benign and nature-based future does not inadvertently become a threat all its own. Sourcing new kinds of energy, and harvesting the raw materials needed by a renewables-based industrial economy, have their own pitfalls. We need to focus on securing human needs without harm to the natural systems we depend upon. Clearly, achieving true sustainability is emerging as the fundamental technological challenge of our time.

How Industrial Society Got Hooked on Conventional Oil and Gas

As recently as 1972, Sperm whale oil could be found in any hardware store and was used to hone kitchen knives, while whales were winding up as a main ingredient in certain commercial brands of dogfood. Dolphins were regularly rounded up and slaughtered in tuna nets, and commercial firms were capturing orcas and marketing them to theme parks to be used as profitable entertainment. After two centuries of commercial whaling, many whale species were headed toward extinction.

Since the itinerant wanderings of our migratory ancestors, humans have exhibited a strong tendency to move around. In search of better food supplies, fleeing past climate disruptions, or trying to avoid conflict with others of our own species, we have kept moving. During recent North American history, it has been horsepower, utilized by literally riding on horseback or provided by a mule team or a team of horses pulling a wagon or a surrey, that has given us our primary means of transportation, while the U.S. Mail crossed the Western United States from Missouri to California on horseback, via the Pony Express, advertised to arrive in ten days or less.

Seeking an alternative to whale oil, society then transitioned to the use of petroleum products for heat and light. Until the invention of the gasoline engine in the late 19th century, humans used petroleum products for basic needs like lighting, heating, and lubricating mechanical devices. In 1859 in Titusville, Pennsylvania, Col. Edwin Drake drilled the first oil well to a depth of 69 feet. Since the objective was to compete with whale oil for illumination, the "useless" byproducts from extracted petroleum, such as gasoline and naptha, were long considered waste products. They were often allowed to simply evaporate into the atmosphere, in unlined dirt waste pits.

Crude oil is composed of a multitude of chemical compounds, each of which turns to vapor at a different temperature. Manufacturers soon realized that the heavier parts of the crude oil could be used as fuel oil for process heating in manufacturing and for space heating in buildings. This led to early refining processes, processing one batch at a time, essentially cooking the contents of a tank of oil to achieve a vaporized state, and then cooling the resulting gaseous hydrocarbons through a chilled condenser back to once again achieve a liquid state of the different "fractions" of the petroleum. The earliest automobiles. like the infamous *Stanley Steamer*, were steam-driven, fueled by a kerosine-heated boiler.

As of 1890, various cars with internal combustion engines were being marketed that required a light fuel, in the form of gasoline. By 1908, Henry Ford had sent the affordable Model T Ford rolling off of his assembly lines, and as of 1910, half-a-million gasoline-powered cars were being driven on U.S. roads. By the era of Prohibition in 1920, the technology transfer from alcohol distillation long perfected in the outlawed Spirits industry had found its way into petroleum refining and the efficiency of separating crude oil from its constituents increased by 25%. The refined product, known colloquially as gasoline, became a very efficient transportable fuel, packing a lot of energy in a small volume. As multi-cylinder gasoline engines became the norm, automotive manufacturers were searching for a chemical that would reduce engine knock. In 1921, automotive engineers working for General Motors discovered that tetraethyl lead (better known as lead) provided octane to gasoline, preventing engine knock. In the following decades, mounting evidence that the lead spread throughout human communities by automobile exhaust was causing serious health consequences, particularly in harming the developing brains of children, was continually ignored by the petroleum and auto industries. Children with greater lead levels have problems with learning and reading, delayed growth, and hearing loss. Finally, effective as of January 1, 1996, leaded gasoline was banned by the Clean Air Act for use in new vehicles other than aircraft, racing cars, farm equipment, and marine engines.

During the 1950's and 1960's, many of the most popular private automobiles became what were the affectionately known as "gas hogs", heralding a period during which low gasoline prices led to the popularity of large displacement eight-cylinder vehicle engines that were aggressively marketed for the thrill of their rapid acceleration and high top-end speed. Individual personal identity somehow became associated with the make and model, and even the color, of the car one owned. By 2000, the U.S. had 228 million licensed drivers and today there are roughly 290 million cars and trucks in America.

Some parts of industrial society are still in the process of transitioning from coal to oil, driven in part by the extreme dangers to human health posed by coal mining itself, and by the pollution of water, land,

and air resulting from burning coal. Beyond coal's severe damage to the atmosphere, utilities in the U.S. and elsewhere are being allowed to leave millions of cubic feet of toxic coal ash submerged in groundwater at poorly-maintained "disposal sites" that are often surrounded by failing containment levees. While the continued burning of coal remains one of the primary villains now causing the current climate crisis, many modern societies have been gradually moving away from coal and toward increasing use of oil and natural gas. The next inevitable shift - to renewable energy sources - motivated by basic economics, is now finally gathering commercial momentum.

As of December 2021, cumulative motor vehicle sales in the U.S. totaled 2.32 million highway legal plug-in electric cars, led by all-electric cars. Nationwide, about 322,000 electric vehicles (EVs) were sold in America in 2020, while in 2021 over 310,000 electric vehicles were sold in just the first six months of the year. California alone added 121,000 EVs in the same six-month period. 36 million vehicles in California still rely on hydrocarbon fuels, compared to one million EVs that instead depend on electrical connectivity to the power grid. There is clearly more work to be done on creating the necessary roadside electrical charging infrastructure for EVs, since today, beyond individual residential charging stations installed at private homes, there are approximately 114,000 EV charging stations in the U.S., of which about 41,000 are in California. EVs cost less than half as much to maintain as fossil-fuel powered cars. The sophisticated engineering that enables the responsive power curve of the electric motors in most of the new generation of EVs offers the rapid acceleration long coveted by American drivers, thus many today find enhanced status and identity by driving an EV. Globally, micromobility, in the form of traditional bikes, mopeds, e-bikes and scooters – is also predicted to grow in popularity to sustain a $500 billion industry.

Carbon-Intensive Air Travel

The commercial airline industry is one of the largest, if not the largest, emitters of greenhouse gases of any transportation consumer. In fact, aviation alone accounts for 2.5% of all global carbon emissions. The use of airplanes for transportation purposes is projected to grow going forward, with the *United States Energy Information Administration* predicting that aviation will consume 230 billion gallons of fuel annually by 2050 (compared to 106 billion gallons in 2022). This would mean that the increase in carbon emissions from this sector can be expected to easily offset any fossil fuel reductions achieved by switching to EVs. In an effort to remain competitive, airlines are obviously interested in substituting alternative, lower-carbon fuels, which some observers predict may achieve a 25% to 50% market penetration rate by 2050. Electrically-powered commuter route aircraft to serve regional feeder air routes in the 350-400 mile range are already on the drawing boards. This market is important because of the 4.5 billion air tickets sold worldwide during 2019, more than half were for routes under 350 miles.

A company named *Zero Avia* has announced that it has signed a memorandum of understanding (MoU) with *Shell*, its strategic investor, for the design and construction of two commercial-scale mobile hydrogen refueling stations for general aviation use. ZeroAvia's announcement follows positive forecasts regarding the dropping price trend for hydrogen and increased U.S. government efforts to build *hydrogen hubs* as the Department of Energy gets ready to receive bids for such facilities from across the country.

This collaboration is intended to provide ZeroAvia's flight testing program with U.S. development support. The project is intended to move the aircraft solution company's *Hydrogen Airport Refueling Ecosystem*

(HARE) ahead to a larger scale. The company's zero-emission planes would be powered by hydrogen in a fuel cell that uses chemical reactions to generate electricity. That electricity is used for powering electric motors which cause aircraft propellors to rotate. The only emissions produced by this process are water and heat.

It is important to keep in mind that it requires only 20% of the energy used by air travel to transport people via high-speed rail. Long a mainstay of efficient travel in the EU and in Japan, high-speed rail easily beats air transport in terms of fuel consumption and is actually faster, when travel time is considered "door-to-door". For trips under about 430 miles, the process of checking in and going through airport security, as well as traveling to and from the airport, makes the total air journey time equal to or slower than high-speed rail.

The Social Costs of Dependency on Fossil Fuels

America has a population of about 334 million people. Approximately 70% of the U.S. economy is a function of consumer spending. As of 2022, the U.S. used nearly 20 million barrels of oil (one barrel equals 42 gallons) per day – far more than any other nation on Earth. America's closest competitor in terms of oil consumption is China, which uses less than 13 million barrels per day.

Controversy over America's overdependence on oil is nothing new. There are those who have been warning for decades that we can't drill our way out of this problem and that the only viable solution will be found in developing sustainable alternatives to fossil fuels.

The U.S. has had more than enough time to make progress in solving the oil dependency problem and has essentially been prevented from doing so by the ability of conventional refiners and marketers of oil and gas to deliberately blind us to our situation.

This is a quote from a paper analyzing efforts to develop solar energy during the Eisenhower administration (1953-1961).

"In 1952, the Paley Commission suggested that the United States begin the development of solar energy and other alternative sources of energy to retard a growing American dependence on Middle Eastern oil, but rejecting these recommendations, the Eisenhower administration refused to increase federal support for solar energy and terminated support for synthetic fuels. During the 1950s, the funding for solar research was limited to $100,000 per year, and the Eisenhower administration torpedoed [bipartisan] legislation proposed in the 1950s to increase solar funding to $1 million per year."

Since the climate alarm was first sounded, the U.S. oil industry has made trillions of dollars, while our planet has overheated to the present dramatic levels due to excessive carbon dioxide and methane emissions. Meanwhile, in spite of the intervening decades after the Paley Commission's cogent 1952 recommendations, we still produce most of our electricity from fossil fuels (gas and coal) and about 90% of our transportation energy is derived from petroleum products.

The petroleum industry anticipates that the overall demand for both crude oil and natural gas is expected to rise going forward. In spite of society's newfound focus on sustainability and carbon reduction, according to the International Energy Agency, the global demand for natural gas will increase by 29% and the global demand for crude oil will increase by 7% over the next twenty years.

Russia is a major exporter of fossil fuels, and the European Union's dependency has grown to account for 40 percent of the EU's natural gas supplies and more than a quarter of its oil. Russia's tragic 2022 invasion of Ukraine, which has left untold numbers of civilian casualties and vast destruction, has generated immense pressure on Western nations to cut their energy ties to Moscow. U.S. imports of energy resources from Russia have made up only a small slice of America's energy universe - roughly 8% in 2021, of which only about 3% was crude oil. Russian oil imports dropped to zero as U.S. companies cut ties with Russia, effectively implementing their own ban.

The European Union reached an agreement in principle to cut oil imports by 90% from Russia by the end of 2022, after settling an impasse with Hungary over the sanction on Moscow. The adopted restriction on EU petroleum imports applies to more than 2/3 of oil imports from Russia. The partial ban, which covers crude and petroleum products, has been included in the sixth package of sanctions by the *European Council on Russia* in response to the invasion of Ukraine. This embargo contains a temporary exemption for Russian crude oil delivered via pipeline. The EU imports two-thirds of Russian oil via tanker and one third through the Druzhba pipeline. Landlocked European countries, including Hungary, Slovakia, and the Czech Republic, are dependent on the southern leg of the Druzhba pipeline for Russian oil imports. The exception granted under the latest EU embargo decision is intended to provide extra time for these landlocked countries to implement measures to cut oil supplies from Russia.

Since the EU has become so reliant on natural gas from Russia, the war-related loss of gas from Russian sources is creating a rapid increase in the EU demand for imports of Liquid Natural Gas (LNG) from friendly nations. Expanded pipeline networks intended to move excess natural gas from north to south in the U.S. are being pursued so that new facilities to convert it into Liquid Natural Gas can then load LNG tankers bound for global destinations, including Europe. Unfortunately for our environment, conversion of natural gas into LNG, transport of LNG via tanker, and regassification of the LNG at destination ports are all extremely inefficient processes, wasting a lot of energy and creating additional methane releases and posing serious industrial risks at each step.

Given the traditional dependence of many of the EU nations on natural gas from Russia, America has pledged to work with international partners to supply the EU with more LNG. The U.S. and partners will supply at least 15 billion cubic meters of LNG in 2022, though it is not clear how much of that will come from the United States. The *European Commission* has also committed to working with EU member states to fulfill a demand of roughly 50 billion cubic meters of LNG until at least 2030. Efforts to cut off Russian fuels after the country's invasion of Ukraine clearly have the potential to speed up the global clean energy transition.

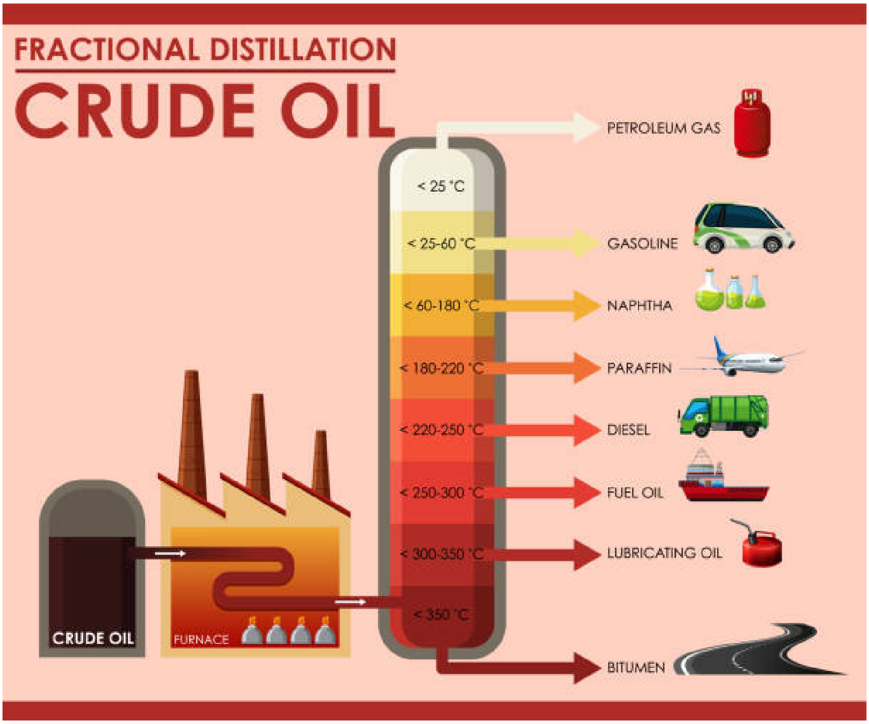
The EU may be able to reduce its dependence on Russia's natural gas by two-thirds during 2022 and to cut off Russian fuels entirely by the end of the decade, or even sooner if possible. The EU has also separately proposed a ban on Russian coal imports. The plan for reducing reliance on Russian natural gas includes a range of policies to promote clean energy rather than climate-warming fossil fuels, though the plan also calls for finding alternate sources of natural gas. The EU's plan calls for replacing about 16 to 32% of the amount of gas that it imported from Russia last year with hydrogen by 2030. The EU's proposal also pushes for more rooftop solar panels and energy efficient heat pumps, calls for speeding up permitting for renewable energy projects, while promoting the import and domestic production of renewable hydrogen energy.

This will likely accelerate the implementation of more offshore wind and more hydrogen, which in turn may be expected to lower the cost of those technologies.

The International Energy Agency has reported that methane emissions from the energy sector, including coal, grew by just under 5% during 2021. Significant methane emissions were confirmed in the Permian basin in Texas, where 30% of U.S. oil and gas is produced and processed, and in parts of Central Asia, with the amount wasted equal to all the gas used in Europe's power sector, the IEA said.

While nations have been trying in the short term to figure out where to buy oil and natural gas from sources other than Russia, the Ukraine invasion could in the long-term lead nations, particularly in Europe, to move toward other sources of energy entirely.

Carbon


FRACTIONAL DISTILLATION
CRUDE OIL
< 25 °C
< 25-60 °C
< 60-180 °C
< 180-220 °C
< 220-250 °C
< 250-300 °C
< 300-350 °C
< 350 °C
PETROLEUM GAS
GASOLINE
NAPHTHA
PARAFFIN
DIESEL
FUEL OIL
LUBRICATING OIL
BITUMEN
CRUDE OIL
FURNACE

Promises, Promises

A 2022 report released by the organization *Earthworks* tracks climate commitments from eight of the leading oil and gas companies operating in the United States—Shell, BP, ExxonMobil, Chevron, Equinor, Occidental, TotalEnergies, and ConocoPhillips—and compares their rhetoric to actions taken to reduce global climate pollution.

The Earthworks "Tricks of the Trade - Oil and Gas Accountability Report" finds that in 2021 between 40-60% of the claimed emissions reductions for Shell, BP, Total, and ConocoPhillips were from divestiture of polluting assets, which means that, while pollution emissions disappear from major producers' books, it does not actually reduce pollution in our atmosphere. The report also found that every company's climate ambitions fell far short of the IPCC directive to cut emissions in half by the end of the decade, and that no company is providing the data necessary to compare its commitments to reality or to understand what they are committing to in terms of total emissions, especially for their most immediate and critical 2030 goals. Every company studied is calculating emissions reductions using a reporting process that is known to underestimate methane emissions by as much as 100%, and every company analyzed is falling short of achieving the goals they have set.

This report includes climate commitments from each company in their own words and—where possible—attempts to calculate what those commitments mean in terms of absolute emissions reductions. It also compares those estimates to important IPCC benchmarks that must be achieved to keep global warming below 1.5° C.

This well-documented analysis also examines common industry trends that help companies overstate their emission reductions or create an illusion of progress. The contrast between companies' actions and words come just as the IPCC is signaling a code red for humanity demonstrating that strong government oversight will be needed to truly reduce methane emissions and begin the significant decline of fossil fuels.

Planetwide, urban areas account for more than 70% of all greenhouse emissions caused by humans. Los Angeles, for example, has the fifth largest carbon footprint in the world. The amount of CO_2 being emitted from the west side of Los Angeles, where industry, ports, and highways are concentrated, is about twice the global average. Los Angeles has a plan to become carbon-neutral by 2050, and obviously has substantial work to do to attain that goal.

In the geopolitical arena, oil producers have always been an easy target at the United Nations' annual climate summits, but in the context of Russia's war in Ukraine boosting demand for fossil fuels, the oil industry is positioning itself to fight back. As Western economies wisely seek alternatives to Vladimir Putin's exports, many are working to increase supplies of energy—whether it's clean or not.

President Biden ordered an unprecedented release of crude oil from the U.S. emergency stockpile and decided to allow gasoline with a higher percentage of ethanol to be brought to market, and Poland has signaled it wants to utilize coal beyond the European Union's 2050 date to reach net-zero emissions. Meanwhile, former U.K. Prime Minister Boris Johnson and President Biden have separately both travelled to Saudi Arabia to ask for an increase in oil production. There is a risk in increasing fossil fuel supplies in ways that lock in production beyond the current geopolitical crises, however, making it more difficult to reach the Paris Agreement's central goal of limiting global warming to 1.5° C from preindustrial levels.

Oil Consumption by Country:

https://www.worldometers.info/oil/oil-consumption-by-country/

Excerpt from article on the work of the Paley Commission:

https://online.ucpress.edu/tph/article-abstract/6/2/37/90115/Eisenhower-sSolar-Energy-Policy?redirectedFrom=fulltext

U.S. electricity generation by energy source:

https://www.eia.gov/tools/faqs/faq.php?id=427&t=3

U.S. energy sources used in transportation (90% petroleum):

https://www.eia.gov/energyexplained/use-of-energy/transportation.php

Hidden Risks from Fracking

As more easily-reached deposits of petroleum found in traditional geologic "traps" among subterranean rock formations have become more thoroughly exploited, the oil and gas industry has pivoted to pursue the high-pressure injection of proprietary chemicals in fracking fluids that have the ability to create small fissures in the rocks through which methane gas can be pushed to the wellbore for extraction. The petroleum industry has long adopted the public stance that continued production of natural gas, obtained via fracking, is an absolute necessity that the petroleum industry calls a "transition fuel". The messaging problem is that this industry never got around to the "transition" part of that equation.

Fracking can easily contaminate freshwater aquifers that may be intercepted by the wellbore, so particular attention to the physical integrity of the steel well casing is necessary to try to prevent cross-contamination into drinking water supplies. And, as the spent toxic frack fluid exits the wellhead after breaking open the subterranean rock formations, this highly-polluted wastewater also contains elevated levels of radioactive minerals, called "Naturally Occurring Radioactive Materials", or NORMS, which inevitably find their way throughout the surrounding environment.

The tempting profitability of terrestrial oil and gas well fracking has led to substantial industry investment in influencing public opinion by hiding the threats this activity poses to water quality and to the atmosphere itself. In order for the industry to conduct fracking at all, in 1997 the petroleum industry had to secure a waiver of a key provision of our *U.S. Safe Drinking Water Act*. By forcing through an exemption known as the "Halliburton Loophole", the oil industry became the only industry in America that is allowed by EPA to inject known hazardous materials — unchecked — directly into or adjacent to underground drinking water supplies. Certain oil and gas producing states have their own regulations governing some aspects of hydraulic fracturing but rarely, if ever, are the companies required to provide detailed information on types and quantities of chemicals being used, and whether the amount injected underground returns to the surface or remains underground. In addition, in most states companies do not have to prove that fractures they have created in the rock have stayed within the target formations. Nor are companies required to monitor water quality when there are drinking water formations in close proximity to areas where hydraulic fracturing occurs.

The lack of safe disposal of leftover radioactive NORMS wastes and toxic fracking fluids now presents ecological and human health challenges that can no longer be ignored. Injection wells for pushing these poisons deep into the earth are being implicated in the resulting contamination of groundwater aquifers and even entire watersheds, not to mention triggering associated earthquakes. Disposal of fracking waste cannot continue to simply be pushed around from one state to another. Instead, some reasonable overarching federal authority needs to make disposal safer with a coherent national policy. At the same time, communities in the path of fracking or fracked well wastewater disposal need to maintain their authority over the health impacts of these hazardous waste materials on their families and communities.

As fracking of oil wells has moved into the ocean on offshore drilling rigs, disposal of spent fracking fluids remains of concern. Off the Southern California coast, the petroleum industry did not even bother to notify the responsible state agency, the *California Coastal Commission*, when oil companies were conducting enhanced well stimulation procedures from offshore platforms, but rather just proceeded with the fracking process at will. The U.S. 9th Circuit Court of Appeals blocked fracking off the California coast in June of 2022, ruling that the federal government must complete a full environmental review before approving permits for such offshore oil drilling platforms. This court decision prevents the Interior Department and other federal agencies from issuing permits for "well stimulation" through hydraulic fracturing until a complete environmental impact statement is issued "rather than the inadequate [environmental assessment] on which they had relied."

Lapses in pipeline safety remain an unresolved issue in virtually every technological society, whether the pipeline be transporting crude oil, gas, bitumen, oil shale, fluids, refined products, or even, as recently demonstrated, CO_2. While pipeline transport of energy-related fluids and gases could theoretically provide incrementally safer fuel transport than trains, trucks, or tank vessels, the safety record of the pipeline industry is not reassuring. Absent proper engineering oversight of new pipeline construction, combined with remedying the failure to conduct the timely inspections and maintenance that need to be rigorously pursued by industry, unnecessary leaks, spills, and explosions appear to remain an inevitable part of the pipeline industry throughout the world, even in the tightly-regulated U.S. system.

Meanwhile, toxic tailings ponds resulting from the mining of the tar sands in Alberta in Canada, the massive poisonous lakes made to store the byproducts of mineral and oil sands extraction, are more than just unsightly and damaging to the ecosystems in which they are constructed - they also produce huge volumes of greenhouse gases. Alberta has roughly 20 oil sands tailings ponds, which contain enough toxic waste to fill 400,000 Olympic sized swimming pools. Together, the underlying Athabaskan oil sand deposits lie under 54,000 sq miles of boreal forest and muskeg (peat bogs) and contain about 1.7 trillion barrels of bitumen-in-place, comparable in magnitude to the world's total proven reserves of conventional petroleum.

But even as fracking and its toxic wastes and tar sands exploitation have threatened air quality, polluted groundwater aquifers, and further accelerated climate warming with new releases of methane, the petroleum industry has not substantially invested in any significant advances toward a cleaner energy future.

Arctic Oil and Gas Drilling

Drilling for oil and gas on land in Alaska presents specialized technical problems as well as unconventional kinds of drilling risks, compared with terrestrial drilling in more temperate locations. Well pads for drilling operations in Arctic settings are often based on frozen tundra, and massive amounts of gravel must be taken from remote Arctic lakes to cover the necessary roadways and well pads. The movement of drill rigs and other heavy equipment to remote locations along Alaska's North Slope consumes a vast amount of fuel to power equipment transport vehicles and then to power the rig itself. Chronic air pollution is an inevitable byproduct of Arctic drilling and lingers in the cold stratified air, often trapped by inversion layers. Alaska's *Gross Greenhouse Gas* (GHG) emissions increased 30% from 1990 to 2005, while the total U.S. national GHG emissions rose by 16% during this period. The growth in Alaska's emissions from 1990 to 2005 is primarily associated with transportation, industrial fuel use, and associated fossil fuel industry sectors.

On the North Slope, when oil is discovered and readied for production, produced natural gas accompanying the oil has historically had no route by which to reach world markets. When the *Trans-Alaska Pipeline System* (TAPS) was constructed between 1974 and 1977, no parallel gas pipeline was built since the price of natural gas was too low to make an accompanying gas pipeline economically attractive to industry at that time. But vast quantities of oil have been produced on Alaska's North Slope, transported to the Valdez oil terminal via the TAPS pipeline, and shipped from there via tanker to markets. One of these single-hulled supertankers, the *Exxon-Valdez*, became an unfortunate legend for causing a catastrophic 1989 oil spill amidst the pristine fisheries and sensitive wildlife of Alaska's Prince William Sound, a place where some of the damaged species and unique habitats still have not yet fully recovered. In the fragile waters of Cook Inlet near Anchorage, offshore drilling continues to result in persistent long-term natural gas leaks from pipelines and other petroleum facilities, even as expansive new federal subsea offshore oil and gas leasing is being proposed there.

Lying eastward of the current onshore petroleum development in Alaska's North Slope oil fields is the *Arctic National Wildlife Refuge,* long protected from oil and gas leasing. A debate still rages in the U.S. Congress over industry initiatives to begin petroleum activities there. The last great undeveloped natural wilderness in the U.S., the Arctic Refuge is seen as a bellweather of just how much risk the Congress and several sequential Administrations in Washington have been willing to take to try to restore the gradual downturn in the flow of oil throughput of the TAPS pipeline as depletion of existing North Slope oilfields has led to declines in production there.

What to do with produced natural gas remains a largely unaddressed question in the Arctic. Building a natural gas pipeline alongside the TAPS oil pipeline, distanced somewhat in case of fire or explosion, still appears beyond economic or environmental viability. Since the early days of North Slope oil production, unquantified volumes of natural gas have been casually flared, or burned off, just to dispose of this resource. In recent years some of the excess gas has been used to power petroleum processing plants and related facilities on the North Slope. But part of the produced gas is still reinjected into the ground to lift heavy oil, an incredibly wasteful process from which not all of the injected natural gas will ever be recoverable in the future. Discussions about the construction of a land-based or floating LNG conversion facility on the North Slope have surfaced from time to time, but unless a substantial port for shipping any produced LNG were to be constructed, there is still no way to transport the resulting LNG to markets.

In addition to conventional oil and gas, the unique Arctic geology harbors frozen natural gas deposits known as methane hydrates, also known as methane clathrates, which, if someday found to be commercially developable, may hold more energy potential than all of the remaining conventional oil and gas on the planet. The technology for safely thawing gas hydrate deposits to permit extraction of gaseous methane is still being perfected, and the conundrum of transporting any produced gas from hydrates to distant markets would still remain unresolved.

How Offshore Oil and Gas Drilling Inevitably Pollutes the Sea and Air

Underground geologic structures containing accumulations of oil and gas, when located along the coastline of a continent, often continue seaward and trend offshore, extending out under nearby coastal waters. The petroleum industry logically followed this feature of local geology where it was found and in 1897 began drilling oil wells from wooden piers extending from the shore out into the ocean. By 1949, it was drilling from isolated fixed platforms further at sea.

Contamination of the marine environment from offshore drilling is considered a common occurrence that happens at every phase of this technology. Routine ocean dumping of spent drilling muds, the material used to lubricate the drill bit during the drilling operation, combined with rock cuttings from the borehole, have historically meant that mercury, lead, cadmium, and zinc are discharged in toxic plumes that trail down-current of each rig. Even with technological improvements aimed at diminishing the waterborne mercury content of drill muds, combined with diverting - or shunting - the discharge plume of spent drilling mud to a point deeper in the water column, the sheer volume of discharged drill muds and cuttings from offshore oil wells remains of grave concern to biologists and the fishing industry.

If petroleum is found at a particular location, and production of oil begins, each step of the processing and transportation process poses its own environmental risks. Atmospheric pollution occurs with the release of methane and nitrous oxides into the air from both the produced oil and gas as well as from compressors and pumps used to move gases and fluids around on the rig and into pipelines. Produced oil can be sent to shore via pipeline, or by “lightering” using barges and tankships, posing a spill risk at every point on the marine transportation route. While subsea petroleum pipeline transport can sometimes be considered to be generally safer than lightering via tankers, over time poor maintenance and lax inspections of hard-to-reach pipelines on the seafloor lead to unnecessary oil leaks and spills. The costly October 2021 Long Beach oil spill is just the most recent example of this type of event, in which a seafloor pipeline supposedly required to have been buried and covered when it was constructed decades ago and then rigorously monitored, instead seems to have turned out not to have fully complied with the applicable requirements.

Major oil spills associated with offshore drilling operations unfortunately present a serious problem, as evidenced in 2010 by the tragic *Deepwater Horizon* incident, from which the ongoing environmental consequences are still being quantified in the Gulf of Mexico. And the efforts by the oil industry to cover up their mistakes using vast quantities of an also-toxic chemical dispersant called COREXIT, while perhaps improving the optics of the disaster by keeping shocking oiled wildlife video footage off of the television news, inevitably further damaged human health and magnified the pollution of the marine environment.

Leaking oil into the Gulf of Mexico since 2004, the still-ongoing *Taylor Energy Oil Spill* is a tragic example of what can go wrong with an improperly decommissioned offshore drilling operation. The result is a continuous seafloor oil leak located 11 miles off the coast of Louisiana, resulting from the destruction of a Taylor Energy oil platform during Hurricane Ivan in 2004. This event has had the longest duration of any oil spill in U.S. history. This spill was first brought to broader public attention when contamination at the site was noticed in 2010 by those monitoring the nearby Deepwater Horizon oil spill. A report by the Associated Press in 2015 challenged the understated estimates of the extent of the leak provided by the company and the

U.S. Coast Guard, which were then revised to be around 1,000 times greater than initially reported.

Estimates of the cumulative volume of this spill between 2004 and 2017 have been calculated to be between 855,421 and 3,991,963 gallons that have been lost over that period in the life of the disaster, affecting an area as large as 8 square miles. As of 2018, it was estimated that 300 to 700 barrels of oil per day were still being spilled, making it one of the worst modern oil spills in the Gulf of Mexico by volume. Efforts to use mechanical devices to intervene in this release of oil by capturing part of it, separating out the water, and taking it away on tankers each month, have managed to gather what the Coast Guard estimates to be a million gallons of oil in the past three years. The subterranean petroleum reserves at this site are likely sufficient for the spill to continue for up to another 100 years, unless it can somehow be sealed. Currently, there is no known affordable technology that can completely stop this discharge at its source on the seafloor.

Efforts by the Petroleum Industry to Avoid Responsible Offshore Rig Decommissioning

About 3,500 petroleum-related structures currently stand in the Gulf of Mexico; of these, over 3,200 remain active. Off of the Southern California coast, there are twenty-three offshore drilling structures in federal waters beyond three miles from shore, and four such rigs within the three-mile state waters. Off California's coastline, many of these existing offshore drilling rigs have reached the end of their economic life and will soon be candidates for responsible decommissioning. At the time the petroleum industry initially secured California's present federal and state offshore drilling leases, the companies leasing these tracts also entered into binding contractual agreements to assure the public that, upon the end of the oil platform's useful life, the entire structure would be removed, the well-bores tightly sealed with concrete, and the seafloor restored as near to the prior pre-lease conditions as possible.

The term *rig decommissioning* refers to ending oil and gas operations at an offshore platform and removing it from its lease tract, ultimately returning the ocean and seafloor to its pre-lease status. The applicable federal law, known as the *Outer Continental Shelf Lands Act* (OCSLA), along with the associated implementing regulations, establish decommissioning obligations to which an offshore operator must commit when they sign a U.S. federal oil lease.

These Outer Continental Shelf (OCS) leases typically require the operator to remove seafloor obstructions such as offshore platforms within one year after lease termination, or prior to termination of the lease if either the operator or the U.S. Department of the Interior deems the structure to be unsafe, obsolete, or no longer useful for operations. The relevant regulatory and lease requirements for decommissioning offshore platforms are designed to minimize the environmental and safety risks inherent in leaving unused structures in the ocean, and to reduce the potential for conflicts with other users of federal waters (i.e., activities like commercial fishing, offshore aquaculture, military activities, the maritime transportation industry, or other oil and gas or renewable energy operations).

Decommissioning an offshore drilling platform generally entails plugging all wells supported by the platform with cement and severing the well casings 15 feet below the seafloor mudline, cleaning and removing all production and pipeline risers supported by the platform, removing the platform from its foundation by severing all bottom-founded components at least 15 feet below the seafloor mudline and then disposing of the platform in a scrap or fabrication yard for recycling the metal.

By instead substituting a controversial practice that the drilling industry has cleverly named “Rigs to Reefs”, the operator of an offshore oil rig can realize financial savings of up to 50% of their anticipated decommissioning cost if they can somehow manage to avoid the requirement for full decommissioning. Certain standards are supposed to guide the federal government review of each offshore oil and gas structure removal application that includes such a Rigs-to-Reefs proposal. The U.S. Department of the Interior must review each such plan to ensure that all requirements are met.

Since 1986, the U.S. Department of the Interior has approved over 550 of these Rigs-to-Reefs proposals and has denied only six. The reasons given by this agency for denying a reefing proposal were mainly due to proximity to other seafloor petroleum infrastructure, especially active oil or gas pipelines. Additionally, the Interior Department has rejected such “reefing” proposals where the proposed reef site was located in a potential seafloor mudslide area or where the site was located outside of what’s called a “reef planning area”.

Curtailing Fugitive Methane Releases

Since carbon dioxide accounts for the majority of global greenhouse gas emissions, it’s understandable that curbing CO_2 is the first social priority. But there’s another dangerous greenhouse gas that most people don't fully appreciate: methane, also known as natural gas. Although the second leading contributor to global emissions, methane is the more potent greenhouse gas because it has a higher ability to trap heat in the atmosphere. Methane has more than 80 times the warming power of carbon dioxide over the first 20 years after it reaches the atmosphere.

In the U.S. there are 70 million fossil-fueled furnaces, many of them using natural gas. This is in addition to 60 million fossil-fueled water heaters, 20 million gas clothes dryers, and 50 million gas stoves. Electrification of all of these appliances could reduce 80% of associated U.S. emissions by 2035.

Normal procedures for drilling oil and gas wells for the extraction of petroleum fluids or methane, and the related processing of produced oil and gas, consistently result in the uncontrolled release of methane gas into the atmosphere. Even a carefully maintained gas-fueled kitchen stove emits methane into the atmosphere during normal use. In this context, stopping leaks of "fugitive" methane gas is thought to represent the most readily available and economically-achievable way to slow the increase in global climate warming, since methane sets the pace for climate warming in the near term. Unfortunately, controlling these fugitive methane emissions is often viewed by government agencies as something of which the public is generally unaware, so citizen pressure to take action is seen as lacking. Improperly abandoned oil and gas wells, whether onshore or offshore, are often a significant source of continual day-and-night venting of methane emissions into the atmosphere, so effective plugging of spent oil or gas wells with cement is essential.

Mainly due to the precedent set by early IPCC reports, climate scientists usually measure global warming potential — the heat absorbed by any greenhouse gas in the atmosphere — over a 100-year period. That makes sense for carbon dioxide, which remains in the atmosphere for centuries. But methane has a lifetime of only around a decade, so some scientists have argued that we should instead measure its impact over a shorter time frame of 20 years. Future climate-warming scenarios in which temperature peaks at 1.5 degrees C occur, on average, around 2046 — only 24 years in the future. Evaluated over that 24-year time frame, methane is 75-times worse than carbon dioxide if our goal is limiting global warming to the desired threshold of 1.5° C. By underestimating methane's impact on global warming, the largest sources of methane pollution from human activity — such as the liquefied natural gas and dairy industries — artificially seem to appear less detrimental to the climate than they actually are. This undervaluation of the climate damage attributable to methane releases unfortunately disincentivizes methane emission reductions or removal.

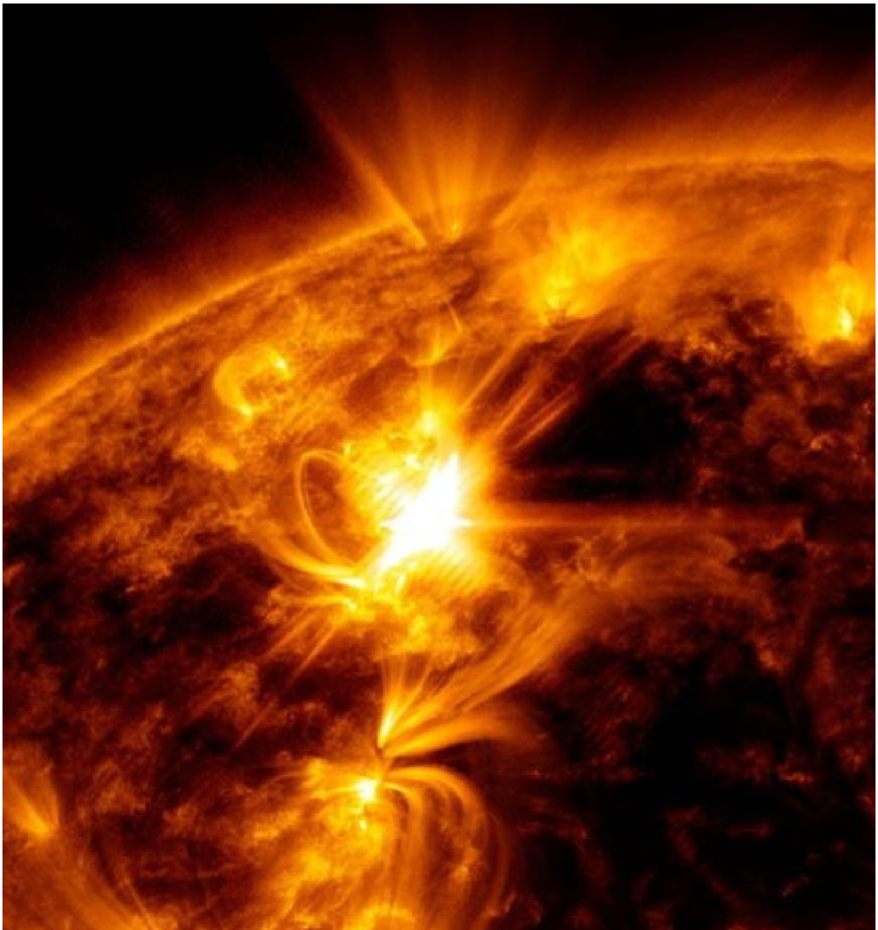
California's *Air Resources Board* has been trying to be a leader in fighting climate change, and this state agency could be an early adopter of the 24-year time frame and align its valuation of methane with the important 1.5° C goal. This simple change of reference would help prioritize the cleanup of California's major methane problem. Los Angeles was the site of the largest methane leak in U.S. history, while recent satellite imagery has shown many methane super-emitters to be still scattered throughout the state.

It has become obvious that, simply put, gas always leaks. It leaks outside, in many neighborhoods, from crumbling pipes underneath city streets. Gas leaks from its production sites and along hundreds of miles of pipelines, invisibly damaging our climate. Methane reductions would provide significant climate benefits in the short-term, slowing the pace of global warming relatively quickly. In addition to halting wasteful flaring of natural gas, the sealing and cementing-in of what are known as abandoned "orphan wells" should be one of our most obvious top priorities as we move to curtail fugitive methane emissions.

Social and Environmental Justice Issues in the Petroleum Sector

The ongoing human health problems that permeate what are called "fenceline communities" that surround oil and petrochemical processing facilities are often treated with less urgency than a sudden offshore oil spill that captures nationwide headlines. When California's October 2021 oil spill from a broken seafloor pipeline off of Orange County occurred, the outcry from the community was immediate. Citizens and the press not only wanted accountability, they sought answers about how this kind of accident could be prevented in the future, which makes sense because most people understand how harmful oil is, and they wanted to make sure that wildlife, beaches, and families would be protected. By comparison, at the Marathon Oil Refinery just off the 405 Freeway in Carson, California, one sees the smokestacks, we all know that those constant fumes—not only from the refinery but also from the freeway—are toxic to the people living close by. One event prompts action, the other sadly provokes complacency. It's morally unacceptable that slow-rolling harm to marginal communities is treated with so much less urgency than an offshore oil spill that captures nationwide headlines.

The Sun



Solar Power from Photovoltaic Cells

Approximately 1.1 billion people around the world live in communities not yet connected to an electrical power grid. Whether or not a connection to centralized power makes sense at all, even when it becomes available, is a logical question. A residential photovoltaic system, once acquired, amounts to roughly a quarter-century supply of electricity. Hundreds of millions of kerosene lamps are now used worldwide for lighting, and together these lamps contribute substantial carbon dioxide emissions.

Solar photovoltaic electricity now accounts for about 3.1% of global electrical generation, a total of 855 terawatt-hours (TWh) in 2021. As the cost of photovoltaic-generated electricity has declined, rooftop solar is clearly now a competitive alternative to highline power from the grid in many regions. Estimates by the International Energy Agency predict that the global contribution of solar energy may reach 6,970 TWh by 2030.

The *California Public Utilities Commission* (CPUC) has created a *Net Energy Metering* (NEM) program intended to accelerate adoption of rooftop solar photovoltaic systems throughout the state. The NEM program pays rooftop solar customers for excess electricity they generate and export to the grid. The California NEM system has delivered over 11 gigawatts (GW) of solar capacity to California's homes and buildings. How NEM policies are implemented going forward will be very important to the future attainment of the state's renewable energy goals. On May 8, 2022, California made history by producing enough renewable electricity to power 100% of the state.

The future of solar panels is even more promising than present technologies now in use. The photovoltaic effect of ferroelectric crystals can be increased by a factor of 1,000 if three different materials are arranged periodically in a lattice. This approach has been described in a study by researchers at Martin Luther University Halle-Wittenberg. Scientists there achieved this by creating crystalline layers of barium titanate, strontium titanate and calcium titanate which they alternately placed on top of one another.

Because most solar cells are currently silicon based, however, their efficiency is limited, prompting researchers to explore new materials, such as ferroelectrics like the aforementioned barium titanate, a mixed oxide made of barium and titanium. Innovative new research is being conducted to improve efficiency of solar cells and the production of solar panels.

Energy Directly from Concentrated Solar Power

Concentrating reflectors can be used to focus the heat of the sun directly on a boiler to convert water to steam to run a turbine to generate electricity. These devices can also heat a "working fluid" in the same manner. This application of focused solar heat using concentrating reflectors to vaporize water or some other liquid, then drive steam turbines that turn conventional electrical generators, is increasingly finding commercial application throughout the world. Conservative estimates indicate that there are enough solar thermal resources potentially available in the U.S. Southwest to satisfy America's electricity needs as much as four-fold. While this technology's large arrays of reflecting mirrors don't cover as much land area as needed for photovoltaic cells, energy planners still need to consider the environmental importance of unique and representative habitats for species long-evolved to live in harsh climates. And certain species of birds seem to inevitably fly into the superheated path of the focused beam of heat at these concentrated solar facilities, with predictably deadly results. Again, a "least harm" approach, avoiding impacts on natural systems where feasible, and thoughtfully mitigating such impacts as much as possible where they are unavoidable, will require sound science that learns from past experience with similar existing installations to make future projects less damaging to natural ecosystems.

The Obvious Use of Rooftop Solar Water Heating

Throughout Florida, in Southern California, and in large portions of the American Southwest, entire suburban communities with simple solar hot water heaters placed on residential and commercial rooftops were not uncommon during the 1950's. A dark metal panel, often copper, with sealed channels through which water for residential use or space heating was conducted, is not an advanced technology. Unfortunately, the advent of cheap, subsidized electricity and centralized methane gas distribution led residents and planners to remove such residential solar hot water and space heating panels from rooftops under the misguided impression that the cost of fossil fuels and nuclear power would not increase.

Americans did continue to use solar hot water panels for heating swimming pools, so the underlying technology never left the marketplace. Shifting back to the broader residential use of space and water heating directly from the warmth of the sun is a readily available segment of the energy transition now in progress worldwide, for obvious reasons. Viewed in the context of today's world, the EU's long-term potential use of solar thermal, estimated at 1,200 thermal gigawatts, could easily meet most of Europe's low-temperature heating needs. Other nations are joining Israel, Spain, and Portugal in requiring that all new buildings incorporate rooftop solar hot water heaters.

Painless Conservation - Energy We Don't Waste, We Don't Need to Get

Entirely new ways of thinking about overarching energy sources and consumption are needed. Energy gained through conservation is not functionally different than power generated by burning fuel or collecting incoming solar energy. Achieving sources of energy that minimize damage to the environment, while using the energy thus achieved in the most efficient manner, lies at the core of our new world. Opportunities for painless energy conservation exist throughout our society, from retrofitting more effective insulation into existing buildings, installation of "green windows", and by literally sealing the wasteful cracks and leaks found throughout our energy infrastructure. Technological advances in materials science, more sensitive heat sensing devices and control systems, and advancements in our understanding of the role of thermal mass in heat retention in built structures all contribute to new possibilities for painless energy conservation. The fundamental concepts associated with *Green Buildings* are now thoroughly understood and encapsulated in the popular LEED building certification process. We also need to place a new value on the importance of trees in our cityscapes as a way of mitigating the "heat island" effect in which overheated buildings and rooftops create an unnecessary requirement for wasteful air conditioning in our cities.

Reducing Power Transmission Losses

In the context of the antiquated condition of parts of America's electrical transmission infrastructure, the present analog distribution system for commercialization of electricity wastes a massive amount of energy that simply dissipates as heat. Our produced electricity currently encounters substantial resistance loss in inefficient conductors and outdated manual control systems, while making the present distribution grid overly vulnerable to major power outages. In many parts of the U.S. where climate change has brought about longer dry seasons with accompanying year-round wildfire risks, flaws in the grid have been implicated in triggering destructive wildfires, apparently often due to poor power system design, inadequate transmission system inspections, and deferred vegetation maintenance by utilities. Utilities' proposals for the burial of major electrical transmission lines underground in the name of preventing wildland fires sparked by power lines will inevitably prove to be so expensive that entirely new approaches to electrical transmission are likely to provide a better answer than undergrounding cables. Localized high-tech *microgrids* instead hold the potential to enable more efficient electrical transmission to facilitate a more reliable power grid, while enabling the efficient use of nearby renewable energy sources. These microgrids could provide a quicker path to safer and more reliable power transmission strategies. Modernization of the existing electrical grid with solid-state control systems, artificial-intelligence-based switching capabilities, and more efficient transformers could save vast amounts of electrical energy that today simply adds heat to the atmosphere as a result of excessive electrical resistance overheating the old and outmoded equipment.

“Least Harm” Approach to Transitioning to Electrical Generation from Offshore Wind

It is estimated that harnessing one-fifth of earth’s available wind energy would potentially provide up to seven times as much electricity as the world currently consumes. More than 70 nations now harness wind turbine arrays – both onshore and offshore - to help satisfy their electrical demand, with a total of about 743 gigawatts (GW) of wind power capacity currently in service worldwide. This existing renewable electrical production helps to avoid over 1.1 billion tonnes of carbon dioxide emissions globally. The deployment of the giant wind turbine blades, electrical generators, support towers, and transmission and anchor cable networks itself consumes substantial energy and metals, plus this infrastructure obviously results in substantial carbon emissions in the manufacturing process. But the theoretically-sustainable nature of the available offshore wind resource tends to indicate that the total net reduction of our carbon footprint from its use could potentially be a major contributor to achieving our goal of net-zero carbon emissions over time. There are, however, nagging questions about how much energy can be safely extracted from Earth’s natural systems, particularly from wind flowing over our oceans, without, in the process, harming the natural ecosystems on which life in the ocean relies for survival.

The U.S. is thought to have enough potential land-based wind energy to satisfy national electricity needs equivalent to several times current demand. Offshore, America’s Atlantic Coast has the wind energy potential to generate on the order of 30 gigawatts (1 gigawatt is equal to 1,000 megawatts) by 2045. The rapid pace of government leasing of the nearshore U.S. federal seabed for emplacement of offshore wind energy generation is now being given a high priority by the responsible U.S. agencies and by many states as well. The rapid proliferation of largescale offshore wind turbines, both fixed to the seabed on piles in the first installations on the Atlantic Coast, or instead mounted on floating steel platforms as planned on the Pacific Coast and now also spreading to the Atlantic and Gulf Coasts, will need to be pursued with great care. In the midst of our present haste to commercialize this resource, a precautionary approach is needed from the initial design work all the way to the installation and operational phase.

To date, the energy industry has developed only a minimal understanding of the prospective ecological impacts of hundreds of large-scale wind turbines removing gigawatts of energy from the natural movement of atmospheric high-pressure areas into zones of low atmospheric pressure (i.e.; the wind). Prevailing ocean wave patterns downwind of large wind generator arrays are physically altered by the removal of energy from the wind regime. Biologically productive ocean upwelling systems that underly the coastal waters with the highest potential for the extraction of wind energy are also absolutely essential to bringing up the cold, nutrient-rich waters that provide the foodsource on which much of our nearshore fisheries and other marine life depend. These essential upwelling centers, driven by wind moving across the water's surface, lift up cold, nutrient-rich water from deep in the ocean to the water's surface. As these deep sea nutrients reach the surface, sunlight works to transform them into the primary food source at the base of the ocean food chain upon which virtually all of our nearshore marine life depends. These rare upwelling systems are a virtual cradle of life in our oceans, and they may be found to have a finite limit as to how much wind energy can be extracted from their natural processes without inadvertently interfering with the very basis of the marine food web itself.

What we don't know, and have not yet done the research necessary to find out, is whether or not the overharvest of energy from the wind from above our coastal waters will, at some unpredictable threshold, potentially interfere with the actual functioning of our ocean upwelling systems themselves. In the ocean, as is the case elsewhere on our planet, everything is interconnected. What might at first seem to be free energy from the wind might in fact be anything but free.

Along the U.S. Atlantic Coast, the hasty deployment of fixed piling-mounted offshore wind generation arrays has, to date, relied primarily on often-irrelevant data derived from prior installations of wind turbine arrays off of the EU. Since that distant region's physical environment and its marine biota are quite different, any decisions based on experience gained at previous EU installations may not turn out to be relevant to similar industrial installations on the U.S. Atlantic coast.

As large-scale planning for floating wind energy now moves offshore all along America's Pacific Coast, on the Gulf Coast, and is now spreading to the Atlantic coast, a multi-agency effort by the U.S. Department of Interior's Bureau of Ocean Energy Management, the State of Oregon, the State of Washington, and California's State Energy Commission and Ocean Protection Council are in part focused on creating what are called "fuzzy logic" computer models.

These computer models hypothetically enable the use of online technologies to help energy planners study visual overlays depicting wind energy density, seasonal and diurnal wind availability, wind array deployment feasibility, existing ocean uses like commercial fishing, as well as a host of environmental considerations such as endangered marine mammals and concentrations of at-risk seabirds. The users of this modeling technology must thus far rely on often-deficient data layers for substantial portions of their visualizations. Available data sets developed for unrelated purposes clearly do not have the ability to capture ephemeral ocean phenomena such as the seemingly arbitrary movement of "bait ball" marine food source concentrations or the unpredictable seasonal foraging habits of various kinds of sensitive seabirds and other marine life. These partial computer models cannot yet show the dynamic systems that make up foodsources, complex habitats, and surface and deepwater ocean current patterns in our fragile coastal waters.

The space-use conflicts between floating offshore wind arrays and the multiple service vessel trips that they require and the often-variable locations where artisanal commercial fishing takes place are also difficult to predict. Wind energy lease tracts lost to fishing by the cumulative introduction of offshore industrial activities are just that, lost. Ship strikes, ocean noise, and fishing gear entanglement already top the list of hazards posed to sensitive whale populations while construction work, and increasing vessel traffic around offshore wind projects, will compound these dangers.

It is important to acknowledge that valuable information is missing from the types of generalized visualization tools now being used in planning for offshore wind. This lack of site-specific information ultimately limits the utility of such models in the analysis of potential offshore wind array locations. This kind of modeling represents a paradigm shift in ocean planning that translates the traditional ecosystem services and ecological values provided by the ocean into purely mathematical data. Technological systems accomplish their goals in a manner driven primarily by theoretical models of the amount of useable energy potential that might be harvested from a given offshore lease tract, but are as yet unable to accurately weigh the potential for extractable energy against irreversible impacts to natural systems that we do not yet fully understand. It is clear, however, that some protected species in West Coast waters have great potential to occur within what have come to be called the formal "wind energy areas" off of Northern and Central California. During May of 2022, the Biden Administration issued a Proposed Notice of Sale for these sites and both areas now being targeted for irrevocable leasing to industry as early as fall of 2022.

Wind energy companies with the technical expertise and manufacturing capabilities to bid on, engage in exploration, and build wind turbines using floating platforms include a "who's who" of the conventional offshore oil and gas drilling industry. While Atlantic Coast and Gulf Coast wind turbine arrays are primarily going to continue to be based on piling-supported fixed seabed structures, on the Pacific Coast, several major oil and gas drilling companies are likely to be awarded offshore wind tracts for floating turbine arrays in deeper water, since they are already major players in building and supplying offshore oil rigs similar to the floating devices needed by the emerging offshore wind industry off of California, Oregon, and Washington State. In exploring the seabed itself to better understand the geologic suitability of the ocean floor for large wind turbine anchoring systems, it is plausible that the seismic survey ships, seafloor "grab samples, and *Lidar* seabed profiling devices will also gather some evidence with their advanced seafloor remote-sensing technologies that might also point to subsea geologic targets having the potential for offshore oil and gas extraction in these same long-protected geographic areas.

Federal offshore lease tracts previously thought by the petroleum industry to exhibit little potential for producing recoverable oil and gas may, in the future, instead be found to contain economically-extractable hydrocarbon resources made more attractive with the advent of sophisticated offshore fracking and well-enhancement techniques. As offshore wind leases are let by the federal government to the oil companies that have now also become wind energy companies, stringent operational restrictions on the leases will be critical to ensure that partial rights to exploit the wind resource are not later expanded to become offshore oil and gas drilling rights as well. For this reason, provisions in any leases granted for offshore wind energy will need to carefully delineate strict limits on the types of activities granted access with each leasehold.

Large arrays of seabed-anchored floating wind turbines pose as-yet-unknown acoustical and entanglement threats to migrating whales. Multiple anchoring and transmission cables linking the turbines to the seabed, to each other, and to the shore may present the cetacean equivalent of a chainlink steel fence capable of altering the path of essential whale migration patterns. In addition, certain at-risk seabird populations are known to be fatally attracted to nighttime artificial lighting on any kind of offshore industrial structure.

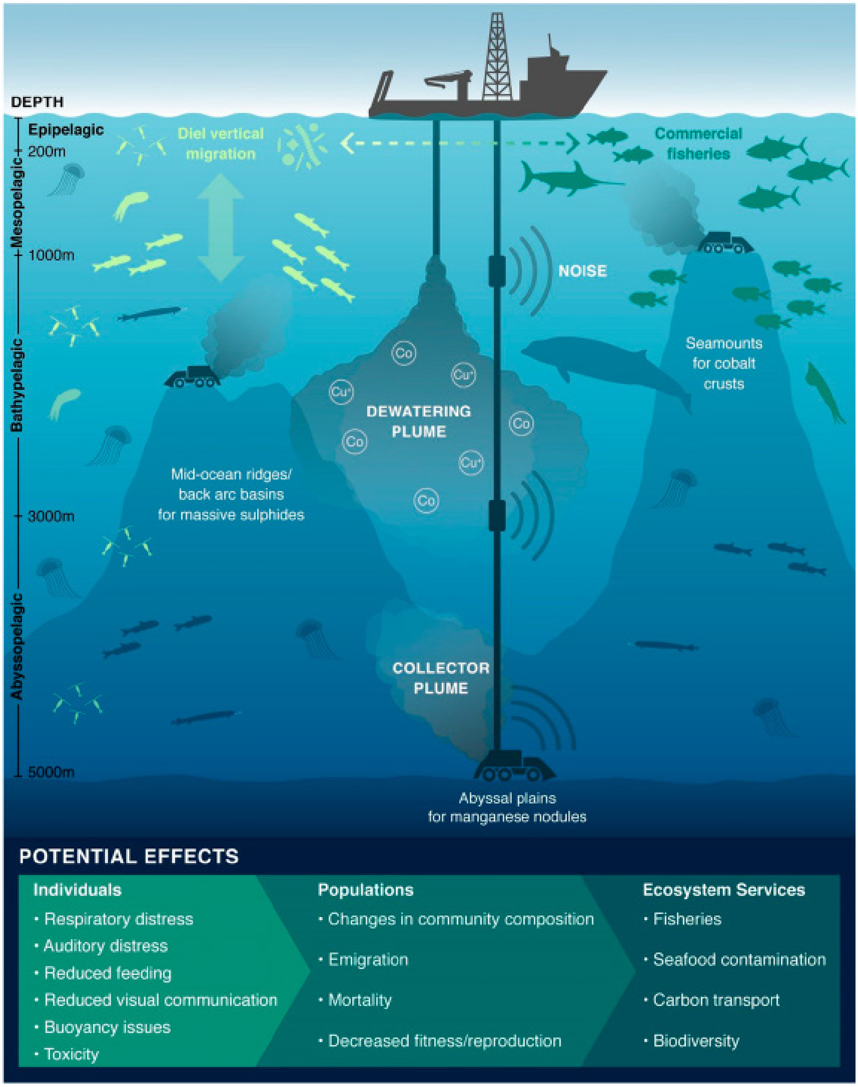
It has been estimated that the California coast could be producing 20 GW by the year 2045. It is generally estimated that large wind turbine arrays can slow wind speeds down by as much as 42%-50%. Studies done for California's proposed Morro Bay offshore wind lease area have indicated that modest changes to wind speeds can be expected downwind from these proposed wind farms (as much as an approximately 5% reduction), a decrease in wind velocity which could be expected to lead to an approximately 10-15% decrease in upwelled volume transport and a resulting restriction of nutrient supply to the coastal zone. Removing this much energy from the wind field may also have an impact on surface water temperature – with commensurate effects on biota - as well as on inland weather patterns, including rainfall and other regional meteorological phenomena.

The 373,268 acres of California's offshore waters now referred to as "Wind Energy Lease Areas" at Humboldt Bay and Morro Bay had first been estimated by the Bureau of Ocean Energy Management to be targeted for the initial development of 5 GW of electrical generating capacity by 2030. Recent legislative and regulatory pressures from the offshore wind energy industry are instead aiming at increasing these anticipated production thresholds substantially, while quietly pushing behind the scenes to secure installation of their subsea power cables and other supporting industrial facilities within existing U.S. National Marine Sanctuaries. This proposed increase in the federal offshore wind production goals for the state's coastal waters would almost certainly necessitate the additional opening of new portions of Northern California's Mendocino and Del Norte County coastlines to be included in further future federal offshore wind lease offerings.

The jurisdiction of the *California Coastal Commission* over proposed offshore wind projects has unfortunately been undermined by an unusual bifurcated federal strategy of initially obtaining early state approval for "only the lease sales". Thus far, the Coastal Commission has already approved the act of leasing offshore wind tracts in the Humboldt County region, followed by its subsequent state approval of offshore wind leasing in the Morro Bay area. Splitting the state's role into two sequential regulatory steps for each of these two geographic areas in this manner will leave the California Coastal Commission under future political pressure to approve the more impactful physical and ecological effects of the construction and operation of these vast wind turbine arrays in a separate follow-up decision. This next regulatory step will unfortunately occur only after the legal rights granted to the companies acquiring these leases have already been formally conveyed and the wind industry has thereby achieved partial ownership. This incremental dual-step approval process thereby relegates the State of California to later consenting to the much more significant environmental consequences that will be posed by the actual coastal and offshore industrial development itself. By the time their true impacts on the California coast are adequately understood, these extensive wind array projects will have already gained significant forward momentum. It will thus be difficult for California decisionmakers to subject these big wind proposals to appropriate permit conditions that might otherwise be needed to try to help mitigate some of each project's inevitable adverse environmental consequences. The resulting initial state approval of wind leases as considered independently from that of building and operating these machines represents a dangerous policy precedent as we enter the experimental era of industrialized oceans.

California is likely to soon face similar permitting decisions for other major industrial projects to be also administered by BOEM along its coastline, especially if federal plans for proposed polymetallic-sulfide ocean mining proceed for what's known as the Gorda Ridge hydrothermal vent feature, a mineral-rich subsea geologic region shared by Northern California and Southern Oregon. No cumulative impact analysis of the combination of offshore wind leases with electrical transmission cable landfalls and wind turbine generator arrays—considered in conjunction with disruptive seabed mining—is likely to be forthcoming under the present state regulatory scenario. Both the envisioned offshore wind arrays and the subsea mining activities would need to rely on new shoreline industrial facilities and major dredging as part of expanding the limited harbor entrance and port facilities at Humboldt Bay in order to serve these two emerging industries.

Water



Impacts of Seabed Mining

The Power of the Waves

The possibility of harvesting the mechanical energy of wave motion in water has long enticed the global engineering community. The process of converting the power of the ocean waves into mechanical energy, and then translating that mechanical energy to power rotary generators is called "hydrokinetic" energy. The first known patent to use energy from ocean waves was filed in Paris in 1799.

Wave power differs from tidal power, which instead captures the energy of the differential in water levels caused by the gravitational pull of the sun and the moon. Waves and tides are also distinct from ocean currents which are caused by other forces including breaking waves, wind, the Coriolis effect, an ocean circulation phenomenon known as "cabbeling", and differences in temperature and salinity.

Waves are generated by wind passing over the surface of the sea. As long as the waves propagate more slowly than the wind speed just above the waves, there is an energy transfer from the wind to the waves. Both air pressure differences between the upwind and the lee side of a wave crest, as well as friction on the water surface by the wind, combine to cause water to go into the *shear stress* that causes the growth of the waves.

Wave height is determined by wind speed, the duration of time the wind has been blowing, fetch (the distance over which the wind excites the waves) and by the depth and topography of the seafloor, which can focus or disperse the energy of the waves. A given wind speed has a matching practical limit over which time or distance will not produce larger waves. When this limit has been reached the sea is considered to be "fully developed".

In general, larger waves are more powerful, but wave power is also determined by wave speed, wavelength, and water density. Oscillatory motion is highest at the water surface and diminishes exponentially with depth. However, for standing waves near a reflecting coast, wave energy is also present as pressure oscillations at great depth, producing microseisms in the seafloor. Oceanic microseisms are small oscillations of the ground itself, or tiny earth tremors, in the frequency range of 0.05–0.3 Hz, associated with the occurrence of energetic ocean waves of half the corresponding frequency. These pressure fluctuations at greater depth in the ocean are too small to be harvestable, from the perspective of commercialization of wave power.

Waves propagate on the ocean surface, and the wave energy is also transported horizontally with the group velocity. The mean transport rate of the wave energy through a vertical plane of unit width, parallel to a wave crest, is called the wave energy flux (or wave power, not to be confused with the actual power generated by a wave energy harvesting device).

An emerging project called *Tahiti Wave Energy Challenge* is committed to promoting wave energy to accelerate the transition of island and coastal regions to zero-carbon and circular economies. This effort is designed to determine the best wave energy converters in tropical island settings, while raising global awareness of the wave energy sector. As a case study for Pacific Islands, the project will address the technical, social, environmental, regulatory, and financial barriers that limit the adoption of this technology as a key component of island energy mixes so that wave energy can be scaled up throughout French Polynesia utilizing public-private partnerships involving local communities.

As wave energy devices and both fixed and floating offshore wind turbine arrays proliferate throughout our coastal waters, we of course will need to pay attention to unintended consequences and learn on-the-fly from each project. Done right, this shift to cleaner energy could potentially offer a hopeful transition away from the worsening climate disaster resulting from burning fossil fuels. But done carelessly, in the wrong places, this industrialization of sensitive ocean upwelling systems amidst prime fisheries and sensitive marine habitats could instead serve to dangerously amplify the damaging climate impacts already facing our nearshore marine environment.

Energy Efficiency

By definition, painless energy conservation and built-in energy efficiency should consistently be an integral part of any viable renewable energy future, including retrofitting of thermal insulation of our existing buildings, incorporating accepted principles of efficient LEED building design in new construction, improved insulating windows, and, where appropriate, onsite solar and geothermal heat pumps for heating and cooling. The Biden Administration has announced an ambitious new national solar energy goal of providing 45% of America's power by 2050. In general, rooftop solar is the least-impactful of all of the emergent clean energy technologies. Built out at scale, large commercial solar facilities will encounter certain limited site constraints as hyper-sensitive locations and at-risk species present their own ecological impediments. Such ecosystems must be duly respected and an approach using due care to protect natural ecosystem values needs to be tailored to each site.

Using Heat from the Earth

The geothermal heat in the upper six miles of the crust of our planet is estimated to contain fifty-thousand-times as much energy as can be extracted from all of earth's remaining recoverable oil and gas. Since the petroleum and coal industries fail to include the costs of climate change and harm to human health and our environment in their cost equation, the development of available geothermal energy has been artificially discouraged in many places. But Iceland, the Philippines, Indonesia, and El Salvador each obtain about a quarter of their electricity from this source. The U.S. is considered to have enough energy potential in geothermal alone to meet its energy requirements 2,000 times over.

Ground-source heat pumps represent yet another opportunistic technology that can be utilized virtually anywhere for both heating and cooling, using the normal ambient thermal differential of any site to provide space heat, air conditioning, residential hot water, heat greenhouses, and provide energy for aquaculture.

Mining Critical Minerals Necessary for the Energy Transition

The conversion of our transportation network from fossil fuels to electricity lies at the nexus of ocean and climate, thereby raising the profile of industrial access to certain minerals in the global environmental conversation. Large batteries will inevitably be a key enabler for society's transition towards electrification and decarbonization in our efforts to tackle climate change. While lithium-ion batteries represent the most promising emerging technology today, even more efficient energy storage solutions are also being actively pursued.

Improved batteries in hybrid and EV vehicles and throughout the power grid, long distance power transmission cables, and large-scale generator components all will increasingly rely on what are called *strategic minerals*. The alkalai metal lithium is a key material needed to power phones, laptop computers, and electric vehicles. The demand for lithium has increased by about 8.9% annually, and will almost certainly continue rising as more electric vehicles emerge into the marketplace, and as utilities and end-users attempt to curb carbon emissions and reduce the effects of climate change. Lithium sources are often found in terrestrial deposits of igneous rock, and in salt brines that accumulate in the residual geologic formations surrounding dry lakebeds. Existing lithium supply chains have been plagued by uncertainties that could compromise mineral security for the United States and other nations.

Most of America's present lithium supply comes from Argentina, Chile, Russia and China. China is currently the leader in lithium processing and actively procures lithium reserves from other major producers. Chinese state mining operators often own mines in other countries, which produce other vital minerals needed for renewable energy systems, including cobalt and nickel.

Russia's war in Ukraine and the emerging competition for critical metals with China, as well as close political ties between Russia and China, underscore the global geopolitical challenges associated with the mineral-intensive clean-energy transformation. Shifting our energy dependency from fossil fuels to a similar dependency on critical minerals can be expected to alter the global balance of power.

Lithium is the raw ingredient for manufacture of lithium-ion batteries, which power electric vehicles and provide energy storage. Demand for these batteries is quickly rising. The ability to recover critical minerals from geothermal brines in the U.S. could have important implications for domestic energy and mineral security.

There is currently one operational lithium production facility in the U.S. That facility, located in Nevada, extracts saline liquid and concentrates the lithium by allowing the water to evaporate in large, shallow ponds. The process for extracting lithium while producing geothermal energy can also return the water and brines to the earth. Adding another domestic source of lithium could improve energy and mineral security for the United States and its allies.

A shift to geothermal energy has long been eclipsed by relatively cheap solar and wind power, despite its proven potential. Geothermal technologies may also have the potential to unlock vast quantities of lithium from naturally occurring hot brines beneath places like California's Salton Sea. If an expansion of geothermal energy is to take place, enhanced care to avoid resultant air pollution and heavy-metals contamination of associated watersheds will need to accompany this technology.

Tests are planned to determine whether battery-grade lithium can be economically extracted from these available geothermal brines. If the economics prove favorable, the eleven existing geothermal plants along the Salton Sea alone could have the potential to produce enough lithium metal to provide about tenfold the current U.S. demand.

Upon reaching their full production capacity, these same 11 existing electrical power plants, which currently generate about 432 megawatts of electricity, could also potentially produce about 20,000 metric tonnes of lithium metal per year. The annual market value of this metal would be over $5 billion at current prices.

Geothermal power today represents less than 0.5% of the utility-scale electricity generation in the U.S. Geothermal power has the ability to complement solar and wind energy as a baseload power source – it is constant, unlike sunshine and wind – and can help to provide energy and mineral security. Adding the production of critical metals like lithium, manganese and zinc from geothermal brines could provide geothermal electrical power operators a new competitive advantage.

In apparent anticipation of society's new demand for hard mineral mining operations, the political arm of the American mining industry roughly doubled its lobbying spending as Congress has taken up legislation to overhaul the law that allows a category of mining companies, unlike oil and gas firms, to operate on federal land without paying reasonable royalties.

The Dangers of Seabed Mining of Metals

Ores of cobalt, nickel, and copper can be found on oceanic structures and on the seafloor itself. Gathering these materials using giant remote-controlled seabed excavators and massive hydraulic ore recovery shovels inevitably tears up the seabed and destroys deeper seafloor structures while generating highly toxic plumes of pollutants that can travel on midwater and deepwater ocean currents for hundreds of miles.

The mining of minerals, other than sand and gravel, from the sea is just starting to occur. By 2023, 5% of the world's minerals, including cobalt, copper and zinc, may be coming from the ocean floor. This could rise to 10% by 2030. It may also ultimately become economically feasible to extract dissolved minerals, such as boron or lithium, from seawater. The most potentially valuable of these minerals are found in metallic sulphides which emerge from hydrothermal ore deposits (commonly called “black smokers”) in volcanically-active seafloor zones. The temperatures and pressures in these regions are extreme and the impact of disturbance on these hot spots of marine biodiversity, which under the *UN Convention on the Law of the Sea* should be carefully protected, remains unpredictable.

Adding a new set of seabed mining-induced pollutants and stressors to an already-compromised ocean environment raises new types of ethical questions for society. Can industrial users legitimately destroy seafloor ecosystems - the workings of which, and the usefulness to humanity - have not yet been discovered? Known in the emerging global regulatory framework as “The common heritage of humanity”, these deep sea organisms and the ecosystems in which they live may one day lead us to discover the cure for cancer, or help us achieve some similarly critical biomedical understanding beneficial to our own species.

Marine biotech has the potential to address a suite of global challenges such as sustainable food supplies, human health, energy security and environmental remediation. Marine bacteria are already a rich source of pharmaceutical drugs. In 2011, there were over 36 marine derived drugs in clinical development, including 15 for the treatment of cancer. One area where marine biotech may make a critical contribution is the development of new antibiotics.

The potential benefits of marine biotech are as yet difficult to fully quantify. By 2006, more than 14,000 novel chemicals had been identified by marine bio-prospecting and 300 patents registered on marine natural products. We know little about the unexplored and understudied nature of much of the underwater world. Our lack of awareness means that the capacity of marine organisms other than fish and shellfish to provide inputs to the *Blue Economy* is only just beginning to be appreciated, partly through new gene sequencing technologies for living organisms. There have already been some impressive pharmaceutical successes. The anti-viral drugs *Zovirax* and *Acyclovir* were derived from nucleosides isolated from Caribbean sponges. *Yondelis*, developed from small soft-bodied marine animals, became the first drug of marine origin to fight cancer. In the very short term, the marine sector is expected to emerge as a niche market focused on high-value products for the health, cosmetic, and industrial biomaterials arena.

By 2023, marine biomaterials could grow as a medium-sized market, expanding towards the production of metabolites and primary compounds (including lipids, sugars, polymers, and proteins) as inputs for the food, feed and chemical industries.

Unfortunately, with only 20% of the seafloor mapped to date, seabed mining has the potential to destroy important ecological niches before we even know they are there. For this and related reasons, deep sea mining needs to proceed within the confines of its own scientific knowledge base, and not allow its destructive technologies to get ahead of passive scientific exploration itself. Meanwhile, a robust compensation mechanism for all existing marine users who may be injured (including fisheries and marine-dependent local economies) must precede any actual seabed mining activity.

Deep sea mining also needs a mechanism of compensation for other, perhaps less obvious, injuries, such as lost marine genetic resource potential, lost ecosystem services and carbon uptake, in addition to related damages not now foreseeable. Since deep sea mining can be anticipated to impact ocean acidification and consequently shellfish production, a system of compensatory mitigation ought to be developed for this and related impacts.

Blue Carbon Accounting and sustainable *Blue Finance* need to be weighed against what is known and what is not yet known about seabed mining, about most proposed mechanisms for carbon dioxide removal in the ocean, and about the construction of seawalls and other similar infrastructure. It is also highly likely that substantial carbon releases from whatever energy source is used by the country-of-origin conducting the seabed mining operation needs to be a factor considered in any comprehensive environmental assessment of seabed mining.

Once a better understanding of deep ocean ecosystems has been achieved, it may be possible to designate irrevocable archival seafloor Marine Protected Areas, but the dangerous pollution plumes from many of the proposed seafloor mining techniques are known to travel great distances and therefore pose threats even to distant deepwater habitats.

Given the rate of population growth, a 10% penetration of electric vehicles into the automotive market by 2030 would require the mining industry to produce about ten times more metals than what it currently produces.

Dams and Hydropower

Roughly 16% of the world's electricity comes from hydropower, primarily from large dams. The hidden environmental costs of existing hydroelectric dams are resulting in drastic population declines in economically-critical food fish, warming temperatures in river systems as global warming heats up surrounding habitat, and a dangerous lack of oxygen in affected rivers. These and related factors are leading to carefully-planned removal of some obsolete U.S. dams, resulting in some encouraging ecological success stories.

In Washington State, following two decades of planning, the largest dam removal in U.S. history began on September 17, 2011. Six months later the Elwha Dam was gone, followed by the nearby Glines Canyon

Dam in 2014. Today, the Elwha River once again flows freely from its headwaters in the Olympic Mountains to the Strait of Juan de Fuca.

On Northern California's Klamath River, logging, mining, ranching, and dam building have brought what once was the Pacific Coast's third-largest salmon fishery to its last death throes. If salmon are allowed to disappear here, at least 137 other fish and wildlife species that depend upon salmon's life cycle would suffer as well. Salmon bring critical nutrients upstream that they've consumed in the ocean, as they spawn and then die in the river's upper watershed. Orcas, brown and black bears, bald eagles, and river otters depend in various ways on salmon. The salmon carcasses and those of other keystone species nourish trees on the riverbanks whose limbs shade juvenile fish habitat and whose root systems help prevent streambank erosion. After decades of effort by Tribal and fishing interests, the Klamath River is now finally nearing the beginning of its own long-sought dam removal process.

Increasingly longer dry seasons, and the persistent drought in many Western regions, are bringing about calls for building new dams, even in the face of compelling evidence of the widespread ecological damage that they cause. These calls for building new hydroelectric dams, and similar initiatives to elevate the embankments of existing dams, are simply the last gasp of an obsolete dam building mentality in the U.S. As a newly-built dam fills with water during its first few years, large-scale methane emissions from dying trees and other vegetation inevitably occur. This source of additional carbon emissions applies even to the recent practice of building "off-river" water storage impoundments now gaining the newfound attention of dam builders.

The Hydrogen Illusion

Hydrogen as a fuel produces primarily water vapor as a byproduct of combustion, which is a difficult fact to ignore during our current climate crisis. Hydrogen can be produced from diverse domestic resources, including fossil fuels, biomass, and water electrolysis with electricity. The environmental impact and energy efficiency of hydrogen depends on how it is produced.

Green hydrogen is hydrogen that applies renewable wind and solar energy, using the process of electrolysis, to split water into hydrogen and oxygen. Green hydrogen may be able to help to replace the more than 70 million metric tonnes of hydrogen now produced globally each year for use in oil refining, fertilizer manufacturing, and other industrial activities, almost all of which is made from methane via a process that emits significant amounts of greenhouse gases into the atmosphere. Some industries view Green hydrogen as a tool that might be able to limit greenhouse gas emissions from hard-to-decarbonize sectors like steelmaking, commercial shipping, and the manufacture of chemicals.

Efforts to use hydrogen as a substitute for natural gas to heat buildings, or even to fuel power plants, could waste precious time and money that would be better directed to more realistic and cost-effective options to reduce carbon emissions.

In the past two years, utility efforts to replace fossil fuel gas in pipelines with some percentage of hydrogen have been expanding. Currently there are at least 26 such pilot projects, many of them aimed at injecting hydrogen into existing gas pipelines. These pilot projects range from individual utilities testing new hydrogen production and storage technologies to a major experimental Department of Energy proposal that involves multiple utilities and several federal research labs. The stated hope for these pilot projects would be to repurpose existing fossil gas pipeline networks to use hydrogen that is manufactured using methods that don't increase greenhouse gas emissions.

Blending hydrogen with fossil gas may turn out to be a non-starter for supplying buildings with gas for heating, cooking and other indoor uses. The study of the potential for hydrogen blending to decarbonize the present natural gas system is finding that many appliances today may operate successfully on the existing natural gas system if there's a blend, but current data indicates that existing pipelines and appliances can only handle a mix containing up to about 20% hydrogen before requiring major upgrades. Thus far, the limits of such blending remain unknown.

Hydrogen is a very different molecule from the conventional methane that makes up the majority of fossil gas. It's composed of the smallest molecule in existence, which makes it more difficult to contain in pipelines, increasing the risk of leaks. It's also known to weaken the strength of steel used for large-scale gas pipelines, and can be ignited far more easily than methane can. One anticipated problem is that blending hydrogen into existing natural gas distribution systems can be expected to require major retrofits and replacements of existing pipelines and entirely new end-use appliances.

There are also some important atmospheric implications of increased hydrogen use. Hydrogen could potentially be one of humanity's key weapons in the war against carbon dioxide emissions, but it must be treated with care because fugitive hydrogen emissions can indirectly produce warming effects 11 times worse than those of CO_2.

Hydrogen can be used as a clean energy carrier, and running it through a fuel cell to produce electricity produces nothing but water as a by-product. Hydrogen carries far more energy for a given weight than lithium batteries, and it's faster to refill a tank than to charge a battery, so hydrogen is viewed as a potentially promising green option in several difficult-to-decarbonize applications where batteries are inappropriate – for example, aviation, shipping and long-haul trucking.

But when it's released directly into the atmosphere, hydrogen itself can interact with other gases and vapors in the air to produce powerful warming effects. It is becoming apparent that hydrogen's global warming potential is about twice as damaging to the atmosphere as previously understood. Over a 100-year time period, a ton of hydrogen in the atmosphere will warm the Earth some 11 times more than a ton of CO_2, with an uncertainty factor of ± 5.

Hydrogen itself also acts like a greenhouse gas by extending the lifetime of atmospheric methane. Hydrogen reacts with the same tropospheric oxidants that "clean up" methane emissions. Methane is an incredibly potent greenhouse gas, causing some 80 times more warming than an equivalent weight of CO_2 over the first 20 years. But the normally-occurring hydroxyl radicals in the atmosphere clean it up relatively quickly, while CO_2 remains in the air for thousands of years, so CO_2 is actually a bigger problem in the long run.

When hydrogen is present, however, those atmospheric hydroxyl radicals react with the hydrogen instead. There are fewer cleanup agents to go around, so there's a direct rise in methane concentrations, thus the methane stays in the atmosphere longer. The presence of hydrogen increases the concentration of both tropospheric ozone and stratospheric water vapor, boosting a "radiative forcing" effect that also pushes temperatures higher.

How does hydrogen escape into the atmosphere? Hydrogen stored in a compressed gas cylinder will lose between 0.12% and 0.24% of the gas every day. Hydrogen will also leak out of pipes and valves if distributed using conventional means, losing some 20% more volume than the methane gas that's now running through municipal pipelines – although since hydrogen is so much lighter than methane, this larger volume equates to just 15% of the weight. Where hydrogen is transported as a cryogenic liquid, boil-off is unavoidable, and it will lose an average of about 1% of it's volume per day, vented to the atmosphere. Since venting and purging operations are the usual protocols across the hydrogen life cycle, escape of fugitive hydrogen takes place as part of electrolysis, during compression of the gas, in refueling operations, and during the process of conversion back into electricity through a fuel cell.

During venting or purging, the percentages of lost hydrogen are greater than what's lost through simple leakage – for example, current electrolysis procedures using venting and purging are assumed to lose between 3.3 - 9.2% of all hydrogen produced, a loss dependent upon how often the process starts up and shuts down.

An important UK study known as the Frazer-Nash report anticipates that between 1-1.5% of all hydrogen in its central modeling scenario will be emitted into the atmosphere, with transport emissions responsible for around half of that, and emissions at the production and consumption ends taking up roughly a quarter each.

Under different assumptions, this same Frazer-Nash Report indicates that we should anticipate somewhere between 1% and 10% of all hydrogen in its global utilization scenario to be emitted into the atmosphere.

These findings indicate that the use of Green hydrogen, while appearing to provide an incremental improvement over conventional fuels, can be anticipated to lead to a net increase in equivalent CO_2 emissions based on 1% and 10% hydrogen leakage rate offsets representing approximately 0.4 and 4% of the total equivalent CO_2 emission reductions, respectively. This means it will be critical to very carefully control H_2 leakage within a hydrogen economy.

Large corporate players, such as EQT, Equinor, Shell Polymers, and U.S. Steel are promoting their efforts as members of what is being touted as the "Hydrogen Industrial Hub". Meanwhile, the U.S. Department of Energy is providing approximately $5 billion for the development of hydrogen generation and carbon capture sequestration. The states of Pennsylvania, Ohio and West Virginia will be providing additional matching funds on the order of another $1 - $2 billion.

Norway is developing simulation software development for underground CO_2 injection into depleted oil and gas reservoirs and saline aquifers, in a joint industry project that aims to develop an intuitive automated controller program which can integrate and manage the interaction between currently separated well and reservoir systems.

Some global petroleum corporations are now trying to portray themselves as "green" energy companies, and some of these have actually devoted a significant amount of time, effort, and capital to the development and deployment of renewable sources of energy. The South African company called Sasol has committed to reducing the carbon emissions from its operations by 30% by 2030 and to achieving net-zero emissions by 2050. This is a more optimistic position than any other major energy company has thus far adopted. There is, of course, growth potential in the area of renewables, especially in South Africa. This comes from the fact that currently about 80% of all electricity consumed in South Africa is generated by coal, while only about 8.8% of the region's electricity is produced from renewable sources.

The Question of Food vs Fuel

If America's meat and milk industry were a country, it would be the world's twelfth largest greenhouse gas emitter. Most of this industry's indiscriminate use of toxic pesticides and fertilizers pollutes our water, while the routine overuse of unnecessary antibiotics contributes to the development of new Superbugs. The meat industry tries to distract from their climate change contributions with a new "low carbon beef" label. But beef that meets this label would still be the worst climate change choice at the supermarket.

While greenhouse gas emissions from energy and transportation may have periodically fallen slightly, emissions from agriculture have climbed 12% since 2000. By 2050, the meat industry could easily account for one-third of U.S. emissions. Organic alternatives now emerging throughout agriculture represent a major opportunity to curtail emissions that contribute to global warming.

The Threat of Palm Oil

Rapid expansion of the cultivation of oil palm plantations for food or fuel represents another major threat to biodiversity, creating a host of ecological problems. Palm oil is derived from the oil palm tree (Elaeis guineensis Jacq.), which is native to West Africa and grows best in tropical climates where it requires abundant water. Three-quarters of the total palm oil produced is used for food, particularly cooking oil and processed oils and fats. It is also used in cosmetics, cleaning products, and biofuel.

Between 1980 and 2014, global palm oil production increased by a factor of fifteen-fold, from 4.5 million tonnes to 70 million tonnes. This growth was driven by the high yield and relatively low production costs of palm oil. Industrial-scale oil palm plantations have occupied an area of 18.7 million hectares worldwide (as of October 2017), with smallholder oil palm plantations also occupying a significant area. Palm oil demand is expected to grow at 1.7% per year until 2050.

Sadly, it has been estimated that oil palm expansion could affect 54% of all threatened mammals and 64% of all threatened birds globally. It dangerously reduces the diversity and abundance of most native species. For example, it has played a major role in the decline in keystone wildlife species such as orangutans and tigers. Palm oil production also leads to an increase in human-wildlife conflict as populations of large animals are squeezed into increasingly isolated fragments of their natural habitat.

PFAS, The Forever Chemicals

We now know that a certain class of chemicals used in processing and manufacturing don't break down in the environment and take "almost forever" to leave the human body. These per- and polyfluoroalkyl substances (PFAS) are known as *forever chemicals* and are used in many different kinds of consumer products. Unfortunately, PFAS chemicals are now found in every person in modern countries and in every source of water. Many of the water-resistant and stain-proof home furnishings and apparel that we purchase contain these PFAS that are linked to a range of health problems, including liver and heart damage, immune disorders, cancer, and hormone disruption.

Independent research laboratories conducted chemical tests on 60 products in three categories – including outdoor apparel, bedding, and tablecloths and napkins – purchased from 10 major retailers. All of the products tested by the group *Toxic-Free Future* were imported from countries in Asia, then sold in the United States and online. Researchers have detected PFAS in a wide variety of products that included rain jackets, hiking pants, shirts, mattress pads, comforters, tablecloths and napkins.

The U.S. Environmental Protection Agency is now moving quickly to adopt a recently revised industry standard that added PFAS into its methods for assessing potentially polluted properties, clearing the way to apply this standard as they seek to win Superfund liability waivers at certain brownfield sites under what is known as the *"All Appropriate Inquiry"* (AAI) rule. This policy change is significant because it could provide liability relief to prospective purchasers and other potentially responsible parties at brownfields or other contaminated sites right at the moment that the agency is poised to list two well-known PFAS as hazardous substances under the Superfund law, a measure that is expected to drive massive new cleanup liability at many sites.

In the state of Ohio, all residents who have small amounts of per- and polyfluoroalkyl substances (PFAS) in their blood have been deemed eligible as a class action to pursue a suit against chemical manufacturers, while opening the door for residents of other states to be included. These types of class action suits, which seek medical monitoring and other scientific assessments, have been a significant driver for development of new science on the risks posed by PFAS and clear the legal pathway for impacted citizens in other regions. Such lawsuits could also provide a roadmap for future Superfund litigation once EPA lists two additional well-known PFAS chemicals as hazardous substances.

Overseas, the presence of PFAS in New Zealand wastewater, coastal waters, and surface waters has been confirmed by University of Auckland researchers. This is not surprising, researchers there say, as PFAS are found everywhere on the planet. But how these chemicals have gotten into New Zealand's water system specifically is unknown. "We have no known PFAS manufacturing industry in New Zealand," says Dr. Lokesh Padhye, a research team member from the university's Faculty of Engineering. "So we can only assume they come from imported products and historical use." Finding out which products, and how chemicals from these products end up in the water cycle, is the next urgent step, he says. The study found PFAS concentrations in the areas monitored were low in comparison to those reported overseas. We do not yet know what level of PFAS, if any, is safe. Guidelines for safe levels are not available for all PFAS, and the guidelines we do have are being revised constantly as more ecotoxicological and health data becomes available.

EPA is indicating that the agency is in the process of releasing *Significant New Use Rules* limiting applications of some 150 different PFAS approved before Congress overhauled the toxics law in 2016, alongside previously announced test orders for another block of 24 perfluorinated chemicals. EPA has previously approved many of these substances under the pre-reform *Toxic Substances Control Act* using only consent orders - which apply restrictions on a chemical's use to a specific company rather than the industry as a whole - to limit their risks.

The Biden Administration has announced that it is drastically lowering the levels at which four PFAS chemicals are considered safe in drinking water, marking the latest regulatory adjustment that could have major implications for municipalities and the military.

Toxics Spread by Storms

Accidental toxic releases during extreme weather events are also coming under heightened government scrutiny by the Biden Administration. EPA has announced that the agency will propose new requirements for facilities that deal with certain toxic substances at risk of release due to extreme weather events. Such releases are often made worse by climate change and, in discharge scenarios during disaster events like floods or hurricanes, those chemicals can seep out into nearby communities. “As climate change increases the frequency and severity of extreme weather events, planning and preparedness for these incidents are especially important,” said Carlton Waterhouse, EPA deputy assistant administrator for the Office of Land and Emergency Management, in a published statement. Under the proposed rule, chemical and other facilities that deal with hazardous substances regulated under the *Clean Water Act* must develop facility response plans for a worst-case discharge scenario. The rule would apply to “facilities that could reasonably be expected to cause substantial harm to the environment”, based on their location. That includes sites where significant amounts of a dangerous substance are located near navigable water, with the potential for notable harm. Waterhouse has also noted that many of the areas nearest to facilities containing hazardous waste are already vulnerable to contaminants.

Nuclear Power in a New Disguise, with the Same Radioactive Threat

In spite of the haunting specters of the 3-Mile Island, Chernobyl, and Fukushima nuclear disasters, the Biden administration has launched a $6 billion effort to rescue existing domestic nuclear power plants at risk of closing. The *U.S. Department of Energy* has announced a certification and bidding process for a civil nuclear credit program that is intended to bail out financially distressed owners or operators of nuclear power reactors, representing the largest federal investment in saving financially compromised nuclear facilities ever offered. Owners or operators of nuclear power reactors that would otherwise be expected to shut down for economic reasons can apply for funding to avoid closing prematurely. The first round of awards will prioritize reactors that have already announced plans to close. California's Governor Gavin Newsom appears to be rethinking the state's stance on the planned closure of the aging Diablo Canyon nuclear plant and has announced plans to seek a share of the Biden administration's funding package geared toward rescuing existing nuclear reactors. Diablo Canyon is the single largest producer of electricity in the state, generating roughly 9% of California's power in 2021. PG&E, which owns Diablo Canyon, had previously announced plans to shutter the plant in 2016 once the licenses for its reactors expire in 2024 and 2025, as part of an agreement between labor unions, conservation groups and nuclear stakeholders. The California Public Utilities Commission approved the joint proposal in 2018.

Looking to the future in the what they claim to be the context of global climate goals, dozens of U.S. companies are continuing to develop what they tout as *advanced reactor designs* that the nuclear industry asserts will bring enhanced safety, efficiency, and economics to the nuclear energy industry. One elusive goal of this research is called the Pebble Bed Reactor, a high-temperature gas-cooled reactor that the industry claims is incapable of melting down. These nuclear reactors would be fueled by a specialized uranium-based "pebble" fuel that could potentially be made available as early as the late 2020's.

The device being envisioned would be an advanced modular reactor with each unit designed to produce around 76 megawatts of electric power. The reactor core would be composed of graphite and filled with 15.5% enriched fuel pebbles. Each "pebble" would be roughly the size of a billiard ball and would contain thousands of specially coated Tristructural Isotropic (TRISO) uranium fuel particles. This so-called TRISO coating creates what is supposed to be an airtight seal around the uranium kernel. This coating is claimed to help retain nuclear fission products and radioactive gases that are produced during operation of the reactor.

The developers claim that such a plant could then be safely constructed within 500 meters of factories or urban areas. The fresh fuel pebbles would be put in the reactor in the manner of a gumball machine and helium gas then pumped down through the pebble bed to extract the heat into a steam generator that produces electricity. The reactor would then continuously refuel by adding fresh pebbles daily into itself at the top, as older pebbles are discharged from the bottom of the core. Each pebble would remain in the core for about three years and eventually be circulated through the core up to six times to achieve more thorough burnup.

The spent fuel would subsequently be placed directly into *dry casks* for containment and then stored on-site, since no offsite long-term storage option for nuclear waste has been implemented. Such Pebble Bed reactor designs would be configured to operate at high temperatures in an effort to produce electricity more efficiently. The high-temperature helium gas could theoretically also be used in energy-intensive industrial processes that currently rely on fossil fuels, such as hydrogen production and petroleum refining.

The structural graphite to be used in this type of reactor is combustible at high temperatures, raising an important lesson that humanity learned during the Chernobyl accident when the graphite core itself caught fire. And helium, needed by a Pebble Bed reactor as its working fluid, is quite rare and must be manufactured, in an energy-intensive process, from conventional natural gas.

This type of experimental nuclear reactor also claims to utilize passive cooling through natural conduction, thermal radiation and convection in the case of a loss of helium coolant—in the hope that such reactors wouldn't need to rely on large local water sources, electric pumps, or similar types of safety systems to prevent fuel damage.

America's Oak Ridge National Laboratory is the only facility actively producing TRISO fuel today and the pebble project was granted U.S. Department of Energy financial assistance to design a commercial scale "TRISO-X" fuel fabrication facility and submit a Nuclear Regulatory Commission license for the facility. Since the TRISO uranium particle is the basis for multiple advanced reactor fuel designs, the TRISO-X Facility could become a key enabler for deployment of an U.S. "advanced reactor" technology in future years.

These types of Pebble Bed reactors, were they to be eventually scattered throughout our cities and even small towns, would present an almost indefensible risk of terrorism, and any accidental radioactive release would take place amidst urban centers. A complex transit network carrying the radioactive pebbles to each reactor on highways and railroads would also present complicated transportation safety challenges.

Another so-called "alternative" reactor design is the controversial sodium fast nuclear reactor called *Natrium* that would utilize liquid sodium as the heat transfer fluid. Liquid sodium at high temperatures will spontaneously burn upon contact with air, and sodium's violent and exothermic reaction with water produces highly corrosive sodium hydroxide and hydrogen that can cause hydrogen explosions. A 1995 sodium leak accident at Japan's *Monju* fast breeder reactor, and other similar reactor incidents, led to policies that significantly curtailed the use of sodium as a coolant due to its unacceptable fire and explosion risk to essential reactor cooling and containment components and its severe respiratory and burn hazard to emergency response personnel.

The Kelp Problem

Kelp is the fastest growing living organism on Earth, gaining as much as two feet of new growth per day. A climate-amplified spread of "sea star wasting disease" wiped out many species of starfish over the entire West Coast, from Baja to Alaska, resulting in vast urchin barrens – virtual seafloor deserts – comprised of almost no life except purple urchins. Due to a multiyear marine heat wave, purple urchins became superabundant and kelp did very poorly.

The resulting collapse of much of the kelp forest on the Northern California coast virtually eliminated critical nearshore habitat for economically important fisheries and intertidal life. Kelp can disappear very quickly when the predator-prey interactions on which it depends are artificially interrupted, in combination with unprecedented changes in vertical heat gradients and altered thermal geography in the water column.

Similar marine heat waves are becoming more intense and frequent due to the hotter atmospheric climate. Lost along with the kelp forest is the lush subtidal ecosystem that it normally supports. The longstanding Northern California fishery for Red abalone, dependent on kelp, is now closed. As an indicator species, the loss of kelp on the Pacific Coast offers a solemn harbinger, reminding society of the urgent need to develop workable responses to other unprecedented climate impacts. For reasons not yet understood, some portions of California's historic kelp beds appear to be beginning to slowly recover, so lessons learned there may be applicable to other ocean ecosystems under similar types of thermal stress planetwide.

Resilient Coral Gardens as an Essential Climate Goal

Restoring damaged corals is increasingly becoming a climate priority. Increased public attention to coral bleaching and other factors causing the global deterioration of coral reefs is opening up opportunities for both restoration of corals as well as enhanced protections for existing natural coral structures. Scientists are experimenting with the substitution of heat-tolerant algae strains within corals that appear to be able to resist bleaching as way of keeping coral reefs alive. Finally, the U.S. is coming to the realization that our baseline of still-healthy coral reefs is an irreplaceable national treasure, as evidenced by the recent substantial boundary expansion of the Flower Gardens National Marine Sanctuary off the coast of Texas. Since we will only protect what we understand, ensuring the strongest possible protection for critical coral habitats now becomes within reach of current environmental priorities and supportive federal agencies.

The *U.S. National Park Service* also plays a key role in protecting some of America's unique coral habitats. In Florida's *Biscayne National Park*, the park has designated a critical coral habitat within the unique *Biscayne Bay Coral Reef Reserve.* One of the most effective tools the park can use to restore the coral reef ecosystem is a Marine Reserve Zone. The zone is to be approximately 6% of park waters and encompass less than 30% of its coral reefs. This zone will give the reefs a chance to recover, while providing visitors who snorkel, dive, and visit by glass-bottom boat the opportunity to experience a natural, healthy reef with more and bigger fish. Timing for formal implementation of the marine reserve zone is still pending, and will be based on available funding and staffing, and the development of regulations that will address access within the zone.

The *National Oceanic and Atmospheric Administration* (NOAA) also has other opportunities to protect endangered corals. Although the Oculina Coral Reef off the central-eastern coast of Florida was the first Marine Protected Area in the nation and has been protected since 1984, it is now at risk.

The *South Atlantic Fishery Management Council* has been counterintuitively proposing an amendment to the *Coral, Coral Reefs, and Hard Bottom Fishery Management Plan* that would open part of the *Oculina Bank Habitat Area of Particular Concern* to bottom trawling. The Oculina Bank is the only known location in the world where the deep-sea coral species known as "Oculina varicose" form reef structures. This one-of-a-kind ecosystem supports marine life throughout the region well beyond the reef itself. Removing decades-old protections for this deep-water coral ecosystem would unnecessarily harm the last remaining and recovering parts of this unique marine environment, while undermining the durability of habitat protections.

The health of Oculina Reef is also critical to many important species. If trawling vessels are allowed to drag their nets and heavy equipment along the ocean floor, they will cover the coral in sediment from the seabed, blocking the sunlight from above that the coral depends on for survival. The Oculina Coral Reef is home to over 230 species of mollusks, 50 species of decapod crustaceans, and 70 species of fish. The Oculina Reef also provides spawning areas for young fish, such as grouper and red snapper. Opening this protected area up to damaging industrial fishing activities will have disastrous effects on its delicate ecosystem and all the species that depend on it.

The U.S. federal government also needs to defend prior protections for other unique and sensitive parts of our marine environment. *The Northeast Canyons and Seamounts Marine National Monument* is located within the New England and mid-Atlantic regions, 130 miles southeast of Cape Cod. This National Monument comprises a total area of 4,913 square miles, and protects four underwater seamounts or submarine mountains, named Bear, Mytilus, Physalia, and Retriever, in addition to three submarine canyons located right on the edge of the continental shelf.

Seamounts are exceptionally important ecologically, but their role in the ocean environment is poorly understood. Because they project out above the surrounding seafloor, they disturb standard water flow, causing eddies and associated hydrological phenomena that ultimately result in water movement in an otherwise still ocean bottom. Ocean currents around such structures have been measured at up to 0.9 knots, or 48 centimeters per second. Because of this upwelling phenomenon, seamounts often carry above-average plankton populations, thus seamounts serve as centers where the fish that feed on them aggregate, in turn falling prey to further predation. This localized food chain effect makes seamounts important biological hotspots. Seamounts provide habitats and spawning grounds for larger animals. Some fish species have been shown to occur more often on seamounts than anywhere else on the ocean floor. Marine mammals, sharks, tuna, and cephalopods (squid, octopus, cuttlefish or nautilus) all congregate over seamounts to feed, as well as some species of seabirds when the features are particularly shallow. Unfortunately, seamounts often generally have metallic ores as a resource potential because of various enrichment processes during the seamount's life, making their sensitive biological communities vulnerable to damage from ocean mining.

As noted, recognizing the importance of protecting intact corals in U.S. waters, on January 19, 2021, the *National Oceanic and Atmospheric Administration* issued the Final Rule for long-sought expansion of *Flower Garden Banks National Marine Sanctuary*, which took effect March 22, 2021. NOAA's action protects 14 additional reefs and banks, slightly adjusts the boundaries of the sanctuary's original three banks, and expands the sanctuary from 56 square miles to a total of 160 square miles.

This final rule applies existing National Marine Sanctuary regulations to all of the new areas, providing protection to limit the impact of activities related to fishing with bottom-tending gear, ship anchoring, oil and gas exploration and production, and salvage for sensitive biological resources. These areas include critical habitat for recreationally and commercially important fish, as well as threatened or endangered species of manta rays, sea turtles, and corals in the Gulf of Mexico.

On the Central California Coast, NOAA is presently considering the potential designation of the *Chumash Heritage National Marine Sanctuary*, which would be the first native-nominated site in the system. Also of indigenous origin, the rich ecosystem of the *St. George Unangan Heritage National Marine Sanctuary* nomination in Alaska's Pribilof Islands remains in NOAA's inventory of areas that the agency may consider for national marine sanctuary designation.

Durability, Recycling, Traceability, and the Need for a Circular Supply Chain

With the global environment stressed as a result of human extraction of raw materials, the need to build consumer products to last, and to diligently recycle goods from prior uses, are paramount social priorities. A closed-loop system, often called "circularity", is about to create a traceable supply chain with circular data identification of manufactured goods that extends all the way from raw source materials to disposal or reuse of the material in a completely new product. If every product with a human use were to have a scannable identification mechanism integrated into it, using tools like tiny inexpensive RFID chips or a printed QR code, the consumer could quickly scan the product to find out how to resell it, or if it is at the end of its lifecycle, quickly locate the nearest drop-off location for recycling it.

The increased recoverability that can result from this circularity will, of course, diminish the need for raw materials that would otherwise need to be mined or pumped or cut from the earth, inevitably creating pollution in the process. Localization of manufacturing can also curtail long transportation links that waste energy and time in the supply chain. This digital passport is a part of what is now coming to be known as the "Internet of Things". Circularity is part of an emerging sustainable business model transformation, now well underway.

Circularity Meets Renewables

Logically, we need to pay attention to what happens to obsolete solar panels when they've served their time as energy-producing members of society and are ready to retire.

It turns out that the way most current solar panels are designed makes disassembly and recovery of the various components — from glass to the various precious metals in them, such as cadmium, gallium, germanium, indium, selenium and tellurium — a complicated process. Most discarded solar panels end up at shredders or going into landfills, because the market for selling the glass and aluminum they contain doesn't yet make economic sense.

There is now research proceeding at *Arizona State University* in an effort to develop a solar panel recycling process that makes it simpler to recover materials such as silicon and silver from photovoltaic technology in a way that can make recycling of spent solar panels economically feasible.

A handful of energy companies are also trying to redesign wind energy to prevent the major components from being disposed of in landfills. In the European Union, obsolete wind turbine blades are often burned or buried. The wind energy industry needs to develop practical options for recycling, although some major developers, such as the company Orsted, have pledged to recover, recycle or reuse the turbine blade components decommissioned from its projects. As this company reports: "Today, between 85% and 95% of a wind turbine can be recycled, but recycling of wind turbine blades remains a challenge, as the blades are designed to be lightweight, yet durable, making them challenging to break apart."

The wind energy industry is just starting full-scale structural lifetime testing of new resin materials to evaluate the turbine blade's performance and feasibility for future sustainable production. Liquid thermoplastic resin is commonly utilized for the manufacturing of large industrial parts by resin infusion, combined with certain high-performance fabrics made by Owens Corning. The resulting composite material is said to deliver a similar level of performance to thermoset resins that have long been favored for their light weight and durability. These new forms of composite components can be recycled using an advanced method called chemical recycling that enables industry to fully depolymerize the resin, separate the fiber from the resin and recover a new virgin resin for reuse, a process which could enable a circular economy loop for the wind energy sector. *End Of Life Recycling* methods will also need to be validated, as well as ways of recycling production waste during the original manufacturing phase.

The electric vehicle market may provide the harbinger of the future for applied circularity. In its national blueprint for lithium batteries for 2021 to 2030, the U.S. government puts a heavy strategic emphasis on recycling lithium-ion EV batteries, citing research showing that batteries that use recycled materials can cut costs by 40%, water consumption in the production process by 77%, and energy use by 82%. A new EV battery joint venture has been established by General Motors and LG Chem to set up a processing facility within a huge new Ohio battery plant complex, telling investors that this facility expects to be recovering battery-grade materials from the equivalent of 15,000 tonnes of lithium-ion batteries annually by 2023.

The artificial economics of profit-motivated supply chain disruptions has inevitably led to higher inflation as a result of a supply system that was built to fail by corporate strategies, combined with the ongoing disruptions related to the COVID-19 pandemic. Some corporations have taken advantage of these supply chain disruptions to escalate retail prices, making claims to their investors about their ability to pass on costs to consumers. Investors are benefitting from stock buybacks, while the general public and even some of the companies' own employees suffer from the resulting artificially-amplified inflationary spiral.

Prospering as a Post-Carbon Society

We can no longer afford to carry our obsolete preconceptions about cheap energy into a post-carbon future. The natural systems on our planet have undergone unmistakable adverse changes. Our environment now shows dramatic signs of more frequent and more severe weather. We can observe sea level rising, and as a result, we are facing a global need to relocate our critical infrastructure inland to higher ground.

There are basically three ways to respond to the climate impacts we are all now experiencing, one is to use less energy while curtailing waste, the second way is to design benign technologies to harness our energy from less-harmful sources, and the third path forward, whether we like it or not, is to adapt to the threats to our coastlines and our ocean by accommodating the inevitability of the obvious changes in sea level.

Adaptive Coastal Management in the Face of Sea Level Rise

The ability of the Earth's oceans to absorb excess carbon may be helpful for the atmosphere, but it's clearly not so good for life in the ocean nor for those human communities nearest the coast. Average sea level along America's shoreline is projected to rise around 10-12 inches in the next 30 years (2020-2050). In terms of impacts of flooding, most U.S. coastlines will see minor high tide flooding become a normal occurrence by 2050 and more damaging moderate high tide flooding occurring more often than minor flooding occurs today. Salt from intruding seawater will get into groundwater. Storms will become even worse. When confronted with irreversible impacts like these, humanity has no choice at this point but to adapt. Fortunately, the planning strategy of adaptive management, as it's called, has become fairly sophisticated.

The concept of planned retreat, in which a community anticipates the impacts of sea level rise before it happens, means that regional zoning can be used to gradually move critical infrastructure back inland, away from the edge of the ocean. Planning for the inevitable, including the present localized flooding of low-lying areas during what are called "King Tides", is not complicated to execute during this era of sophisticated GIS planning tools.

A new study has found that climate change fueled stronger, wetter storms during an unusually active Atlantic hurricane season in 2020. The damage caused by hurricanes and flooding in the U.S. will likely soar over the next seventy years and could cost federal taxpayers nearly $100 billion a year by 2100, according to a recent White House report.

The relevant analysis by the *White House Office of Management and Budget* shows that increasing damage from coastal disasters is the single most severe threat to U.S. taxpayers related to climate change. The White House report includes an analysis of four federal expenditures expected to increase due to climate change, and projects future costs under several climate scenarios. Under each one, coastal disasters account for at least 75% of the total costs. By 2100, coastal disasters would cost taxpayers $94 billion per year in a worst-case climate scenario involving a 10-foot rise in sea levels. In a best-case scenario involving less warming, lower population growth and more technological innovation, coastal disasters would cost taxpayers $32.5 billion a year.

The "Megadrought" Problem

The frequency and intensity of droughts have been exacerbated by warming temperatures, reduced precipitation, and rising greenhouse gases brought on by climate change. Severe droughts lead to a number of predictable consequences: failed crops, water restrictions, fish kills, and longer and more severe wildfire seasons. They also carry potentially severe public health implications—from drinking water shortages and poor-quality drinking water to impacts on air quality, sanitation, hygiene, food, and nutrition. Droughts can also exacerbate mass human migrations, and even contribute to precipitating wars.

The Future

Plastic in a Throwaway Marketplace

Natural gas, crude oil, coal, salt, and cellulose are the primary feedstocks for the manufacture of many types of plastics, and an estimated 8.8 million tons of plastic goes into the ocean every year. That means that the equivalent of about two garbage trucks full of plastic enters our global ocean every minute. Eventually, about 5% of all plastic winds up in the ocean. If plastics were a country, it would be the fifth largest emitter of greenhouse gases. Of all of the plastic discarded by society to date, 9% has been recycled, 12% has been incinerated, and the remainder has either been disposed of in landfills or released into the environment. Plastic waste can take anywhere from 20 to 500 years to decompose, and even then, it never fully disappears; it just breaks into smaller and smaller pieces. The resulting microplastics are tiny particles that resemble an ongoing oil spill, posing a dangerous threat to our ocean. Microplastic particles pervade not only the ocean but are found on land and in the air, from the top of Mount Everest to the bottom of the Mariana Trench, seven miles deep on the seafloor. Nearly 1,300 marine species, from miniscule plankton to the major whale species, have been found to ingest plastic. It has been estimated that each human being on Earth ingests the equivalent of a credit card of plastic each week. Between 2% and 13% of indoor particulate air pollution is plastics. In a paper published in the publication *Environment International,* researchers found plastic in the blood of 17 of 22 of study participants, or about 77%. In this study, researchers took blood samples from anonymous, healthy adults, and looked for plastics that were between 700 and 500,000 nanometers (nm) in size. 700 nm is around 140 times smaller than the width of a human hair.

Recent research by the Utah Agricultural Experiment Station indicates that microplastic waste has become so prevalent in the environment that it is being picked up and transported by the wind and the rain. A paper called "Plastic Rain in Protected Areas of the United States" by J. Brahney, M. Hallerud, E. Heim, M. Hahnenberger, and S. Sukumaran, published in Science (80-.) 368, 1257-1260 (2020), carefully cites studies of plastic fallout rates with air-mass movements that have contributed to a better understanding of where plastics are coming from, how far they are travelling, and how much of these substances are raining out of the sky.

There are several possible pathways for plastic emissions to the atmosphere. A likely prominent source is comprised of emissions from the marine environment, where evaporation and wave sea spray can emit plastics into the atmosphere. Roads may also contribute to plastic emissions, not just from tire-wear plastic particles, but also from debris collected on the road surface and broken down to fine dust. Another likely prominent source is the erosion of agricultural soils that have been fertilized with biosolids gathered at wastewater treatment plants. Because the filtration systems in these wastewater treatment plants are effective at retaining microplastics in the solid fraction, the produced fertilizer also contains high amounts of microplastics.

To examine the type and source of microplastic in the atmosphere, the study quantified plastic fallout due to gravity (dry deposition) and plastic fallout within rain (wet deposition). Researchers collected the samples at monthly (dry) and weekly (wet) intervals at 11 National Park and Wilderness areas across the western United States. The study counted microplastics in 339 wet and dry samples collected over a 14-month period. Plastics were separated by color, size, and fiber/particle. Primary plastics are those formed in the size and shape they are found in the environment, like microbeads, whereas secondary plastics are derived from the fragmentation of larger plastic pieces.

98% of the samples collected contained microplastics. Further analyses showed that about 4% of the aerosol particles in the atmosphere are now composed of plastic instead of natural components like minerals and insect parts. The total deposition rates were estimated between 1,000 and 4,000 metric tonnes per year, which would equate to between 120 and 450 million water bottles. The study indicated that about 70% of the atmospheric microplastics were fibers, likely sourced from textiles. The remainder were mostly derived from the fragmentation of commonly used plastics from unknown sources. Since about 30% of the particles were brightly colored microbeads, due to the size and color distribution, it is likely that these beads are derived from paints and coatings where they have been used to create texture and visual effects. Toiletries and hair products are also often major contributors to microplastic pollution.

Scientists have for the first time also found microplastics in freshly fallen Antarctic snow. Samples were collected from 19 sites in Antarctica, including along the Ross Ice Shelf - the largest ice shelf in Antarctica - and analysis of the samples identified 13 different types of plastics and the most common was polyethylene terephthalate (PET), a common type of plastic used in making drink bottles, food packaging and fabrics. Some of the microscopic fragments of plastic found in fresh snow on Antarctica were similar to those shed by synthetic clothing, often used by researchers at Antarctic scientific bases.

We produce about one million plastic bottles every minute. In addition, every year about 6 trillion cigarette filters are manufactured. Approximately 4.5 trillion of the resulting cigarette butts are dumped into the environment and they're not made of harmless paper or cotton – they're made of a microplastic, cellulose acetate, that never completely decomposes. Another hidden but very damaging source of water pollution from plastic materials are the tiny fragments that wear off of automobile tires on roadways, then wash into streams and then into the ocean. The resulting leachate from tire wear particles contains a broad range of harmful chemicals. California's *Department of Toxic Substance Control* (DTSC) has launched a process to regulate a chemical in vehicle tires that, upon wear, transforms into a threat to water quality and is toxic to salmon populations. The state is proposing to regulate the tire preservative called "6PPD", which transforms into a highly toxic chemical ("6PPD-quinone") in the environment. The tire antidegradant 6PPD and its reaction product 6PPD-quinone are particularly toxic to aquatic organisms.

California has found that exposure to these tire compounds may cause or contribute to significant adverse impacts to aquatic organisms, including two populations of coho salmon in the state, one of which is endangered, the other threatened. 6PPD-quinone has been measured in stormwater flowing through four sites into San Francisco Bay at concentrations above those shown to kill at least half of coho salmon in laboratory experiments.

Preliminary studies suggest that a range of plastics can influence basic ecological processes. We do know that all aerosols, regardless of composition, can result in consequences to human health. This information should raise some alarms for the global community since the consequences are inescapable in the immediate future. The amount of plastic waste entering the environment is expected to double by 2030.

The Innovative "Plastics of the Future"

Plastic discarded in the environment often winds up in our ocean. The way to prevent plastic pollution in the ocean is obvious. We need to reduce plastic production and make plastic easier to recycle by standardizing its chemical composition. The use of plastics needs to be limited to applications in which the material generates an essential benefit to society and for which no other substance is workable.

In this context, plastics can then be made from simplified ingredients and formulations that are as recyclable as aluminum and glass. Changing the process by which plastics are made, thus reducing their toxicity to both humans and our environment, will not be an insurmountable technical challenge, it is problem only constrained by of our willingness to do it. It is time to re-engineer plastics to be simple, safe, and standardized. Our elected officials and decisionmakers are confronted with the opportunity to incentivize redesigning the chemistry and formulation of polymers, mixtures of polymers, and other plastics ingredients (such as additives, colorants, and adhesives). We can reformulate plastics to be recyclable by design. To do so would not be a cost, but rather an investment.

The total volume of plastic also needs to be reduced at the source, and the most efficient way to do this is to limit plastic to uses for which there is no current alternative, and to then transfer *end-of-life* costs for single-use packaging and food service ware from ratepayers to the manufacturers and producers of the plastic materials.

June of 2022 brought progress in setting limits on certain single-use plastics by governments in both Canada and India, and Governor Gavin Newsom of California signed legislation requiring that at least 30% of plastic items sold, distributed, or imported into the state must be recyclable by 2028, with this percentage rising to 65% by 2032.

Separately, in a June 2022 legal setback, the conservative majority on the U.S. Supreme Court ruled in favor of the coal industry by arbitrarily cutting back the scope of the Environmental Protection Agency's key federal rulemaking jurisdiction over planet-warming emissions from power plants. This judicial hurdle represents a codification of the carbon-based industries' ongoing lobbying strategy of climate denial. A counterintuitive step backward, this court decision means that either the U.S. Congress will now need to act to control harmful emissions from power plants, or that individual states will be compelled to take action to regulate these climate-warming pollutants on their own, since after the transportation sector, power plants are the second-largest source of greenhouse gases in the U.S. There is a very real concern that similar future actions by the present Supreme Court could further curtail EPA jurisdiction over other important climate mitigations.

The Perils of Arctic Shipping

If international shipping were a country, it would be the sixth-biggest greenhouse gas emitter. Ship engines produce vast amounts of climate changing pollutants, including black carbon and carbon dioxide.

International shipping emissions using traditional global routes are already responsible for roughly 3% of the world's greenhouse gases. It is urgent for the global community to adopt at least a 50% reduction in these emissions over 2005 levels by 2030 and to decarbonize shipping completely by 2035 to align with the Paris Agreement to keep global warming under 1.5° C.

Sea ice in the Arctic has long been a natural impediment to the establishment of international shipping routes across the top of the globe. The past persistence of seasonal sea ice has protected sensitive wildlife that makes the cold waters of the Arctic their home. As more of the Arctic sea ice continues to melt and then takes longer to refreeze, leaving more open water, an increasing commercial interest in establishing international shipping routes through remote Arctic waters will result in new kinds of safety and environmental risks, including potential impacts to the culture and food security of Arctic Indigenous Peoples.

Increasing declines in sea ice coverage in recent years have made the Northwest Passage and the Bering Strait more attractive routes for international shipping. With this prospect of increased vessel traffic comes a corresponding need for increased traffic regulation. Since 2018, the U.S. Coast Guard has been studying how vessel traffic in the region should be routed.

Accompanying the observable loss of seasonal sea ice from traditional areas, the offshore oil drilling industry is also increasingly trying to move into these fragile Arctic Ocean waters where there is simply no effective oil spill cleanup technology yet invented.

The Elusive Myth of Biofuels

The castoff byproducts of timber harvest, sugar processing, urban waste, livestock waste, crop residues, and the discards from urban gardens and tree-trimming are hypothetically suitable for use for generating electricity, space heating, or the production of fuel for internal combustion engines. Although crop-based biofuels can also be used in similar ways, the associated release of nitrous oxide, from the manufactured nitrogen fertilizer used to grow the crops, makes it difficult to approach net-zero climate emissions with such fuels. The current practice of adding ethanol made from corn or sugar waste to gasoline is itself an energy-wasting process. Fundamentally, bioenergy production is an inefficient use of land.

The industrial push for bioenergy extends beyond transportation fuels to the harvest of trees and other sources of biomass for electricity and heat generation. Industry-sponsored research suggests that bioenergy could meet 20% of the world's total annual energy demand by 2050. Yet doing so would require an amount of plants equal to all the world's current crop harvests, plant residues, timber, and grass consumed by livestock – thus making it impractical.

A timber industry-funded lobbying campaign aimed at pushing policies to promote increased use of biomass has made the claim that burning forests for fuel is carbon-neutral. This falsehood that burning forests for "renewable" biomass energy has been promoted as helping forest health.

In response to longer fire-seasons, persistent drought conditions in the U.S. Western states, and the resulting damaging wildfires in urban interface situations, the timber industry is pushing what it calls "thinning" as a false premise, sometimes recommending the removal of up to 80% of standing trees.

These deceptive logging proposals fail to acknowledge that carbon is lost when trees are cut down and again when they are burned. The underlying miscalculation in these bioenergy theories as a proposed fix for climate warming by transitioning from burning fossil fuels to burning trees would not only accelerate climate warming but would also threaten global biodiversity.

Among the most effective carbon sequestration strategies nature itself has designed is in our old growth forests, and these should be preserved as a topline social priority. The *Alaska Roadless Rule*, approved by then-President Trump on Oct. 29, 2020, exempted Southwest Alaska's Tongass National Forest from the 2001 Roadless Rule, which prohibited road construction, reconstruction and timber harvest in inventoried roadless areas – with limited exceptions. The Tongass, part of one of the world's last relatively intact temperate rainforests, is the only national forest where oldgrowth logging still takes place on an industrial scale. In November of 2021, the U.S. Department of Agriculture (USDA) announced it is taking steps to repeal the 2020 Alaska Roadless Rule and restore protections to more than nine million acres of inventoried roadless areas on the Tongass National Forest.

Powering cars with corn and burning wood to make electricity might seem like a way to lessen dependence on fossil fuels and help solve the climate crisis. But although some forms of bioenergy can play a helpful role, dedicating land specifically for generating bioenergy is unwise. It occupies land needed for food production and carbon storage, requires large areas to generate just a small amount of fuel, and it won't typically cut greenhouse gas emissions.

Dedicating areas to bioenergy production increases competition for land. Roughly three-quarters of the world's vegetated land is already being used to meet people's need for food and forest products, and that demand is expected to rise by 70% or more by 2050. Much of the rest contains natural ecosystems that keep climate-warming carbon out of the atmosphere, protect freshwater supplies, and preserve biodiversity.

Because land and the plants growing on it are already generating these benefits, diverting land—even degraded, under-utilized terrain—to bioenergy would require sacrificing much-needed food, timber, and carbon storage.

While photosynthesis may efficiently convert the sun's rays into food, it is an inefficient way to turn solar radiation into non-food energy that people can use. Thus, it takes a lot of land (and water) to yield a small amount of fuel from plants. In a new working paper, *The World Resources Institute* calculates that providing just 10% of the world's liquid transportation fuel in the year 2050 from biomass would require nearly 30% of all the energy in a year's worth of crops the world produces today.

Burning biomass, whether directly as wood or in the form of ethanol or biodiesel, also emits carbon dioxide just like burning conventional fossil fuels. In fact, burning biomass directly emits a bit more carbon dioxide than fossil fuels for the same amount of generated energy. But most calculations claiming that bioenergy reduces greenhouse gas emissions relative to burning fossil fuels do not include the carbon dioxide released when biomass is burned. They exclude it based on the assumption that this release of carbon dioxide is matched and implicitly offset by the carbon dioxide absorbed by the plants growing the biomass. Yet if those plants were going to grow anyway, simply diverting them to bioenergy does not remove any additional carbon from the atmosphere and therefore does not offset the emissions from burning that biomass. Furthermore, when natural forests are felled to generate bioenergy or to replace the farm fields that were diverted to growing biofuels, greenhouse gas emissions actually increase.

That said, some forms of bioenergy do not increase competition with food or land, and using them instead of fossil fuels could help reduce greenhouse gas emissions. One example is biomass grown in excess of what would have grown without the demand for bioenergy, such as winter cover crops for energy. Other examples include timber processing wastes, urban waste wood, landfill methane, and otherwise-discarded agricultural residues. Using so-called second-generation technologies to convert material such as crop residues into bioenergy has a potential role to play in climate mitigation and avoids competition for land. It would be a challenge to undertake this at scale, since most of these residues are already used for animal feed or needed for soil fertility, while others are expensive to harvest.

There are positive alternatives to bioenergy made from dedicated land. For example, solar photovoltaic cells convert sunlight directly into energy that people can use, much like bioenergy, but with greater efficiency and less water use. On three-quarters of the world's land, solar photovoltaic systems today can generate more than 100 times the usable energy per hectare as bioenergy. Because electric motors can be two to three times more efficient than internal combustion engines, solar photovoltaics can result in 200 to 300 times as much usable energy per hectare for vehicle transport compared to bioenergy.

One of the great challenges of our generation is how the world can sustainably feed a population expected to reach 9.6 billion by 2050. Using crops or land for biofuels competes with food production, making the goal of adequate food production even more difficult. The world's land is a finite resource. As Earth becomes more crowded, fertile land and the plants it supports become ever more valuable for food, timber and carbon storage— for which we don't have alternative sources.

Phasing Out Fossil Fuels in the Anthropocene Era - The Cascading Climate Bomb

During a heat wave in 2019, Greenland registered daily ice melts of 12 to 24 billion tonnes over a single five-day period—accompanied by daily meltwater runoff of 10 to 12 billion tonnes. As a result, the melting of ice on Greenland will contribute to a higher sea-level increase than previously believed.

The general public thinks of climate change as a steady upward increase in average global temperatures that will have its most alarming impact on future generations. This is because the Earth now has an average temperature of about 1° C above the period just before the Industrial Revolution. It has risen about 0.17° C per decade since 1970.

The problem is that cascading dominos of interactive feedback loops raise the concern that children born today will experience truly unlivable impacts under conditions known as "Hothouse Earth". In considering 10 different feedback loops, including permafrost thaw, loss of methane hydrates from the ocean floor, weakening land and ocean carbon sinks, bacterial respiration in the oceans, Amazon rainforest dieback, boreal forests dieback, reduction of northern hemisphere snow cover and in other places, a close examination of all these different feedback loops suggests that the Earth's biosphere can dangerously tip from just 2° C, which is what the Paris climate agreement discusses. At 2° C, the planet might slide into this Hothouse Earth state and remain in that state.

The melting of Arctic ice is an example of just one these feedback loops. When the excess heat is absorbed by the darker ocean rather than being reflected back into the atmosphere by the white ice, called the Albedo Effect, this can lead to more ice melting and more heat being absorbed, reinforcing the heating effect planetwide. Such feedback loops elevate the risk of "abrupt climate change" or "nonlinear climate change", which poses a threat to the existence of the human species on Earth. Science now confirms that oceans are retaining much more carbon dioxide than had been believed in the past. This means that if the oceans warm to a certain point, they will likely release more carbon dioxide into the atmosphere than was expected before, partially due to the impact of aerosols and emissions on the jet stream. The world's oceans have increased to their warmest and most acidic levels on record, as measured during 2021, according to the *World Meteorological Organization* (WMO).

Climate tipping points in Antarctica, the Arctic and the Amazon are at risk of being reached before or at the current level of global warming of 1.2° C. There is increasing scientific evidence that critical climate tipping points are already being reached in Antarctica, the Arctic, the Greenland Ice Sheet, the Amazon rainforest, and for coral reefs. Data indicates that West Antarctica's Thwaites Glacier could lose its eastern ice shelf in the next five years and has passed a tipping point for abrupt change, likely triggering a cascade of similar events in the region. The Arctic is warming at four times the planetary average and has passed a tipping point for rapid, system-level change, including on the Greenland Ice Sheet, which is now beyond a point of system stability. Land-based carbon stores, including the Amazon Rainforest, are reaching a critical point, after which their efficiency at drawing down carbon decreases. There is considerable evidence that eastern Amazonia is in the process of "tipping" and is now a net source of carbon. In addition, coral reefs are now bleaching so frequently that there is no longer sufficient natural recovery time between bleaching events, resulting in reefs having entered a death cycle without significant interventions.

Permanent alteration of the amount and location of arable land and increased food production leads to desertification, with changing precipitation patterns that are already contributing to large-scale migrations from Africa and Bangladesh. As food yield-per-acre declines—particularly in locations like the tropics—increased food prices, reduced nutrient quality, and supply chain disruptions mean that at around a 3° C planetary temperature increase, crops fail and the Amazon starts to burn down, so the forests become net carbon producers, not the carbon sinks that they have historically provided.

The frozen peatlands in the Arctic regions areas store up to 39 billion tonnes of carbon – the equivalent to twice that stored in the whole of European forests. A new study by the *University of Leeds* used the latest generation of climate models to examine possible future climates of these regions and the likely impact on their permafrost peatlands. The projections show that even with the most stringent efforts to curtail global carbon emissions, and therefore limit global warming, by 2040 the climates of Northern Europe will no longer be cold and dry enough to sustain peat permafrost. However, strong proactive measures to reduce emissions could help preserve suitable climates for permafrost peatlands in northern parts of Western Siberia, a landscape containing 13.9 billion tonnes of peat carbon.

These alarming numbers emphasize the importance of socio-economic policies aimed at reducing emissions and mitigating climate change and their role in determining the rate and extent of permafrost peatland thaw. Unless we can achieve more significant reductions in greenhouse gas emissions to divert us away from a path toward human extinction, the impending threat of climate feedback loops being triggered will loom as a profound threat to human society.

To date, the net-zero equation remains unsolved. Greenhouse gas emissions continue unabated and are not counterbalanced by removals, nor is the world prepared to complete the net-zero transition. Indeed, even if all net-zero commitments and national climate pledges were fulfilled, research suggests that warming would not be held to 1.5° C above preindustrial levels, increasing the odds of initiating the most catastrophic impacts of climate change, including the risk of biotic feedback loops. The challenge now before humanity is to find the appropriate mix of technologies, including energy conservation, that need to be deployed to achieve emissions reductions while staying within a carbon budget, limiting costs, and ensuring an orderly and socially-equitable transition.

We Need to Avoid Trading One Set of Ocean Impacts for Another

We know that life in the sea has already suffered a disproportionate share of the environmental cost of our use of carbon-based fuels, since the ocean itself has absorbed much of the excess atmospheric carbon from the industrial age. In the marine environment, climate warming impacts are driving dangerous change via super-heating, deoxygenation, and acidification, all existential threats to our ocean. As a result, fragile marine ecosystems in our coastal waters are now approaching a risky tipping point in the context of ocean acidification and warming seawater temperatures.

Compounding the present ecological pressures on our oceans due to their role as a global carbon sink by adding new and disruptive technologies for strip mining the seafloor for metal resources would be counterproductive. The emerging subsea quest for lithium, cobalt, nickel, copper, and manganese for manufacturing alternative energy devices is poised to introduce additional new cumulative adverse impacts to our oceans. Taken in conjunction with potentially-altered ocean upwelling systems and modified surface current patterns associated with extensive offshore wind turbine arrays, a resilient ocean resource policy will require, at the least, careful monitoring and the rigorous adoption of zero discharge of waste. If intensified metals recycling and renewed research efforts to find safer sources of raw materials for alternative energy technologies elsewhere can avert further damage to the ocean, then these more benign alternatives should be pursued as a safer path forward.

Creating a Wholistic Transition Without Using the Ocean as a Dumpsite

Responsible decommissioning and safe disposal of extensive spent industrial infrastructure now already installed in our oceans, including thousands of miles of disused subsea pipelines and hundreds of obsolete offshore oil drilling rigs throughout the U.S. Gulf of Mexico that still await removal, plus eliminating twenty-three spent offshore oil rigs off of the Southern California coast, now presents an inviting opportunity instead of a long-ignored challenge.

Efforts in the U.S. and elsewhere to curtail fugitive methane emissions have led decisionmakers and legislators to now refocus on shutting in and plugging orphaned oil and gas wells, both on and offshore. This societal mainstreaming of sealing and cementing abandoned legacy oil and gas wells is now widely viewed as the "low-hanging fruit" of methane emissions abatement. This represents an important public policy shift that now opens the door for large scale decommissioning of leftover on-and-offshore oil and gas wells, the required full-removal of disused offshore drilling platforms, cleanup of rusting hydrocarbon processing facilities, and recovery of abandoned terrestrial and subsea pipelines. On land, more than 2 million California residents live within 2,500 feet of an operational oil and gas well. California has more than 120,000 documented abandoned oil and gas wells, in addition to 30,000 idle and 70,000 active wells, each one presenting a public health hazard and many offering an opportunity for abatement of climate-harming emissions.

The oil companies' promotion of their longstanding public relations program for pursuing *Rigs-to-Reefs* ocean dumping of spent drilling rigs continues as their lobbyists seek a handout from the taxpayer, even as much of the U.S. Congress has come to view increased public funding for *full removal* of spent hydrocarbon infrastructure from our lands and waters in a more favorable light. Rewarding the polluters has never been a promising path to alleviating pollution.

Political support for substantial measures to curb unnecessary methane emissions has now become a part of most American political campaign platforms, since it is such an obvious and relatively low-cost method of stopping carbon emissions in order to competitively address one of the most egregious atmospheric culprits causing climate warming.

Two European energy plans have now been released that could have implications for the U.S. natural gas and offshore wind sectors. These plans are a response to the Russian invasion of Ukraine and call for measures ranging from doubling solar photovoltaic capacity in three years to a ramp up in renewable hydrogen to also advancing the EU's efforts to start importing more LNG, but those increases must be "coupled" with efforts to reduce the venting and flaring of methane. As part of these plans, the EU has pledged to cooperate with its fossil fuel supply partners to reduce methane emissions, which could put pressure on U.S. companies exporting to Europe who have thus far resisted tight restrictions on emissions, sending an added signal to gas producers in the Texas Permian to clean up their act. The U.S. energy industry ranks third in the world for methane emissions, according to the International Energy Agency.

Four European Union countries have also announced plans to speed up the continent's green transition and help wean it off Russian energy imports through a large project to build new wind farms in the North Sea. Belgium, the Netherlands and Germany are making an effort to increase their total offshore wind capacity fourfold by 2030 and tenfold by 2050. If these goals are met, the four nations could potentially deliver more than half of all offshore wind needed to reach climate neutrality in the EU.

Another part of the EU planning effort also calls for doubling the deployment of heat pumps over the next five years as part of curtailing dependence on imports of Russian gas.

Unfortunately, in spite of professed concern about the dangerous climate threats posed by additional oil and gas leasing, petroleum industry lobbyists in the U.S. are now seeking to acquire new "area-wide" offshore oil and gas leases encompassing all available unleased Outer Continental Shelf lease tracts throughout the western, central, and eastern Gulf of Mexico and elsewhere in U.S. waters. This in spite of the fact that these same companies are not yet even exploring their existing 1,500 idle undeveloped offshore leases.

The Sustainable Future Beckons

Now that climate change has emerged as an obvious crisis for humanity, our present circumstances are generating a sudden rush to quickly implement sometimes-misguided climate "solutions" that in themselves can pose more of a threat to our environment than the challenges they are supposed to resolve. Long-ignored planetary problems, including looming species extinctions, climate driven habitat shifts, the consequences of unsustainable fishing practices, widespread bleaching of corals, damaging Superstorms - and even the newfound rush to transition to innovative carbon-free energy sources - all hold an innate potential to compound our damage to the ecosystems on which human life itself depends.

Those experiencing floods, wildfires, evacuations or other distress resulting from climate-induced disasters justifiably want immediate answers. But a workable response needs to be comprised of the *right* answers, not hasty experiments that will do further environmental damage. Without slowing needed climate adaptation, opportunities for positive stewardship measures need to be incrementally verified to avoid further endangering complex ecological systems. The precautionary principle still applies to our future on this fragile planet, now more than ever.

Society is today picking the energy sources to serve humanity for the next fifty years, and if these supposedly "cleaner" sources of commercial electricity and transportation fuels turn out to instead cause unforeseen adverse impacts over the long term, we need to anticipate those hazards early and expediently adopt better alternatives. Indigenous science brings with it uncountable centuries of human experience. Native leaders tell us that there is a spiritual dimension within this crisis, that we need to see it with a broader perspective. These voices of experience remind us that while there is a social question in this crisis, it is also a transcendent question of planetary ecological survival.

There is clearly no shortage of positive pathways forward. We need only to make the societal decision to pursue those solutions that sound science, and common sense, deem the most promising.

Managed Decline of Fossil Fuels - Finding Reliably Constructive Solutions

New directions for society, accomplished in positive ways that protect the ecosystems on which all life depends, will require a discerning public evaluation at each step. The overarching goal is not to fight the needed adaptive change, but to steer it in constructive ways. Illusory "progress" that damages the baseline survival conditions of our environment is not sustainable progress at all, but instead represents a dangerous detour that could waste precious time. The amount of excess carbon already "baked in" to the Earth's atmosphere and oceans will mean that even the immediate application of constructive adjustments will take time to exhibit improved conditions.

Continuing to consume fossil fuels at current levels will inevitably result in tremendous damage from global warming. However, we also know that a sudden abandonment of our existing energy infrastructure would be an economic and ecological disaster. This means that a rapid but managed decline of fossil fuels must provide the centerpiece for transforming the global energy sector to limit the rise in global temperatures to 1.5 C. Thoughtful deployment of clean energy technologies such as solar, wind, electric vehicles and energy efficiency in the near-term can reduce and replace the use of fossil fuels, but these steps need to be undertaken in a manner that does not precipitate environmental harm.

This will be a challenging and exciting time. New skillsets will need to be adopted within the human community, and responsible innovation by society will be the rule of the day. The nuanced challenge for our leaders will be to guide and harness public support for constructive change by supporting the best possible technologies and painless societal adjustments, while educating the public about contributive research results from those competent scientists guiding society in the right direction.

For more than a decade, psychologists and psychiatrists have been raising the alarm about the coming wave of psychological distress due to the climate crisis. One manifestation of this is has come to be known as "Nature Deficit Disorder", in which urban residents crave refreshing exposure to the wilderness, to the outdoors, and to natural beauty. America's National Parks are now experiencing newfound seasonal popularity beyond anything on record. Being in nature gives us hope and a host of positive models that demonstrate adaptability to change.

Hope is the most promising antidote for the emerging institutional paralysis over climate impacts, a social reluctance based on fear and lack of understanding of the science of climate change. The path to a resilient, thriving future remains ours to determine, and transitioning to social patterns that can resolve the current dilemma that we now face lies within reach. We need only to act decisively and with all due caution, with our next steps based on paying close attention to realizing the full potential of our collective journey into the future.

Definitions of Terms and Abbreviations Used

Watt – The "Watt" is a unit of power or radiant flux defined in the International System of Units as a derived unit of 1 $kg \cdot m^2 \cdot s^{-3}$ or, equivalently in physics, 1 joule per second. The term watt is used to quantify the rate of energy transfer.

Kilowatt – A Kilowatt (kW) is a measure of 1,000 watts of electrical power. A kilowatt hour (kWh) indicates how much energy is being used per hour, whilst a kW is a measure of power. A commercial electricity provider charges by how much electricity a consumer uses per kilowatt hour (kWh).

Megawatt – One Megawatt (MW) is equal to 1,000,000 watts.

Gigawatt – A Gigawatt (GW) is equal to one billion watts. For reference, light bulbs in our homes are typically between 60 and 100 watts, so 1.21 gigawatts would power more than 10 million light bulbs.

Gigawatt-Hour – A Gigawatt-Hour, abbreviated as GWh, is a unit of energy representing one billion (1,000,000,000) watt-hours and is equivalent to one million kilowatt-hours. Gigawatt-hours are often used as a measure of the output of large electrical power stations. One gigawatt is enough energy to power about 750,000 homes.

Barrel of Oil – One barrel of oil equals 42 gallons.

Degrees Celsius – The degree Celsius is a unit of temperature on the Celsius scale, a temperature scale originally known as the centigrade scale. To convert temperatures in degrees Celsius to Fahrenheit, multiply by 1.8 (or 9/5) and add 32.

Anthropocene – The current geological age, viewed as the period during which human activity has been the dominant influence on climate and the environment.

Anthropogenic – Anthropogenic effects, processes, objects, or materials are those that are derived from human activities, as opposed to those occurring in natural environments without human influences.

Intergovernmental Panel on Climate Change (IPCC) – The United Nations body for assessing and reporting on the science related to climate change.

United Nations Climate Conference of the Parties – The Conference of Parties (COP) is the apex decision-making body of the United Nations Climate Change Framework Convention (UNFCCC). The UNFCCC was formed in 1994 to stabilize the greenhouse gas emissions and to protect the earth from the threat of climate change.

Paris Agreement (UNFCC) – The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP 21 in Paris on 12 December 2015 and entered into force on 4 November 2016. Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. To achieve this long-term temperature goal, countries aim to reach global peaking of greenhouse gas emissions as soon as possible to achieve a climate neutral world by mid-century.

United Nations Environment Program (UNEP) – The global authority for the environment with program elements focused on climate, nature, pollution, sustainable development and more.

Nationally Determined Contributions (NDC's) – A Nationally Determined Contribution is a climate action plan to cut emissions and adapt to climate impacts. Each Party to the Paris Agreement is required to establish an NDC and update it every five years.

Net-Zero emissions – Carbon neutrality is a state of net-zero carbon dioxide emissions. This can be achieved by balancing emissions of carbon dioxide with its removal, or by eliminating emissions from society.

Carbon offsets – A carbon offset is a reduction or removal of emissions of carbon dioxide or other greenhouse gases made in order to compensate for emissions made elsewhere. Offsets are measured in tonnes of carbon dioxide-equivalent (CO_2e).

Post-carbon society – The term post-carbon emphasizes the process of transformation, or a shift in paradigm, which is necessary to respond to the multiple challenges of climate change, ecosystem degradation, social equity, and economic pressures.

International Energy Agency (IEA) – The IEA is at the heart of global dialogue on energy, providing authoritative analysis, data, policy recommendations, and real-world solutions to help countries provide secure and sustainable energy for all. The IEA was created in 1974 to help co-ordinate a collective response to major disruptions in the supply of oil.

European Commission – The European Commission is the executive of the European Union. It operates as a cabinet government, with 27 members of the Commission headed by a President.

World Meteorological Organization (WMO) – The World Meteorological Organization is a specialized agency of the United Nations responsible for promoting international cooperation on atmospheric science, climatology, hydrology and geophysics.

Carbon Capture and Storage (CCS) – An industrial process that involves capturing carbon dioxide emissions from power plants and heavy industry and then injecting them into deep underground storage facilities or using them to induce enhanced petroleum production from oil wells.

Carbon Capture and Storage Experiment – a proposed project in Louisiana to capture carbon from the state's large concentration of carbon dioxide-emitting industrial plants.

Cancer Alley – A region of Louisiana where marginalized communities are exposed to toxic chemical discharges and air emissions and where elevated rates of various cancers and other illnesses have been documented to be one result.

Global CCS Institute – The Global CCS Institute is an international think tank whose mission is to accelerate the commercialization and deployment of carbon capture and storage.

Direct Air Carbon Capture and Storage (DACCS) – Direct air capture and storage is a carbon removal solution: it captures CO_2 directly from the air, which is then permanently stored.

Carbon Capture Utilization and Storage (CCUS) – Carbon capture and storage, or carbon capture and sequestration, is the process of capturing carbon dioxide before it enters the atmosphere, transporting it, and storing it for centuries or millennia.

Enhanced Oil Recovery (EOR) – The use of captured carbon dioxide, hot water, steam, or other injected substances to increase the flow of oil from an oil well.

Greenhouse Gas – Earth's greenhouse gases trap heat in the atmosphere and warm the planet. The main gases responsible for the greenhouse effect include carbon dioxide, methane, nitrous oxide, and water vapor (which all occur naturally), and fluorinated gases (which are synthetic).

"Hydrogen Industrial Hub" – Hydrogen Hubs are regions where various producers, users, and potential exporters of hydrogen across industrial, transport, export, and energy markets are co-located.

Low-carbon beef – The U.S. Department of Agriculture has approved a program that will open a path for beef producers to market their meat as low-carbon. Livestock producers who can prove that their cattle are raised in a way that emits 10% less greenhouse gases than an industry baseline can qualify for the certification scheme, which is run by a private company called Low Carbon Beef.

Superfund site – Superfund is the common name given to the law called the "Comprehensive Environmental Response, Compensation and Liability Act of 1980", or CERCLA. Superfund is also the trust fund set up by Congress to handle emergency and hazardous waste sites needing long-term cleanup.

All-Appropriate Inquiry Rule – "All appropriate inquiries" is a process of evaluating a property's environmental conditions and assessing potential liability for any contamination.

PFAS – PFAS (Per- and polyfluorinated alkyl substances), also known as the *Forever Chemicals*, are a large chemical family of over 9,000 highly persistent chemicals. Human exposure to PFAS increases the risk of cancer, harms the development of the fetus, and reduces the effectiveness of vaccines. Biomonitoring studies by the federal Centers for Disease Control and Prevention show that the blood of nearly all Americans is contaminated with PFAS.

Forever Chemicals – "Forever Chemicals" is a term used for PFAS substances.

Global Warming Potential (GWP) – The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO_2).

"45Q" tax credits – A U.S. federal government incentive program made available in 2008 to enable manufacturing facilities built by 2026 to earn around $30 per metric ton of carbon dioxide that they can sequester each year, increasing to $50 per metric ton by 2026.

U.S. Department of Interior (DOI) – The U.S. Department of the Interior is a Cabinet-level agency that manages America's natural and cultural resources.

U.S. Fish and Wildlife Service (USFWS) – A U.S. federal government agency whose primary responsibility is to manage fish and wildlife resources.

U.S. Bureau of Ocean Energy Management (BOEM) – The mission of the Bureau of Ocean Energy Management is to manage development of U.S. Outer Continental Shelf subsea energy and mineral resources.

U.S. Department of Agriculture – The U.S. Department of Agriculture is the federal executive department responsible for developing and executing federal laws related to farming, forestry, rural economic development, and food.

National Oceanic and Atmospheric Administration (NOAA) - A scientific and regulatory agency within the U.S. Department of Commerce that forecasts weather, monitors oceanic and atmospheric conditions, charts the seas, conducts deep sea exploration, and manages fishing and protection of marine mammals.

U.S. National Marine Sanctuary System – A part of the U.S. Department of Commerce, the Office of National Marine Sanctuaries serves as the trustee for a network of underwater parks encompassing more than 620,000 square miles of marine and Great Lakes waters, including a network of 15 national marine sanctuaries and Papahanamokuakea and Rose Atoll marine national monuments.

White House Office of Management and Budget (OMB) – The Office of Management and Budget oversees the implementation of the U.S. President's vision across the Executive Branch.

U.S. Energy Information Administration (USEIA) – A principal agency of the U.S. Federal Statistical System responsible for collecting, analyzing, and disseminating energy information.

National Renewable Energy Laboratory (NREL) – The National Renewable Energy Laboratory in the U.S. specializes in the research and development of renewable energy, energy efficiency, energy systems integration, and sustainable transportation. NREL is a federally-funded research and development center sponsored by the Department of Energy and operated by the Alliance for Sustainable Energy, a joint venture between MRIGlobal and Battelle. Located in Golden, Colorado, NREL is home to the National Center for Photovoltaics, the National Bioenergy Center, and the National Wind Technology Center.

U.S. Department of Energy (DOE) – The Department of Energy is an executive department of the U.S. federal government that oversees national energy policy and manages the research and development of nuclear power and nuclear weapons in the United States.

Nuclear Regulatory Commission (NRC) – The Nuclear Regulatory Commission is an independent agency of the U.S. government tasked with protecting public health and safety related to nuclear energy.

Oak Ridge National Laboratory – Oak Ridge National Laboratory is a U.S. multiprogram science and technology national laboratory administered, managed, and operated by UT–Battelle as a federally funded research and development center under a contract with the U.S. Department of Energy.

Environmental Protection Agency (EPA) – The Environmental Protection Agency is an independent executive agency of the United States federal government tasked with environmental protection matters.

Office of Land and Emergency Management – The Office of Land and Emergency Management provides policy, guidance and direction for the Environmental Protection Agency's emergency response and waste programs.

South Atlantic Fishery Management Council (SAFMC) – The South Atlantic Fishery Management Council, headquartered in Charleston, South Carolina, is responsible for the conservation and management of fish stocks within the federal 200-mile limit of the Atlantic off the coasts of North Carolina, South Carolina, Georgia and east Florida to Key West.

California Coastal Commission – The California Coastal Commission is a state agency within the California Natural Resources Agency with quasi-judicial control of land and public access along the state's 1,100 miles of coastline.

California Air Resources Board (CARB) – The California Air Resources Board is the "clean air agency" of the government of California.

California State Energy Commission (CEC) – The California Energy Commission, formally the Energy Resources Conservation and Development Commission, is the primary energy policy and planning agency for California.

California Ocean Protection Council (OPC) – The Ocean Protection Council is charged with ensuring that California maintains healthy, resilient, and productive ocean and coastal ecosystems for the benefit of current and future generations.

California Public Utilities Commission (CPUC) – The California Public Utilities Commission is a regulatory agency that oversees privately owned public utilities in the state of California, including electric power, telecommunications, natural gas, and water companies.

California Department of Toxic Substances Control (DTSC) – DTSC is charged with taking a multi-pronged approach to regulating more than 100,000 entities to prevent the release of hazardous waste, clean up contamination, and ensure hazardous waste is handled safely by conducting inspections and taking enforcement actions to ensure compliance.

Net metering (NEM) – Net metering theoretically allows a utility customer to earn credits for any excess solar electricity sent to the power grid when the user's private solar panel system generates more electricity than needed by the customer.

Outer Continental Shelf Lands Act (OCSLAA) – A federal law which enables leasing of U.S. subsea lands for the purpose of offshore oil and gas, seabed minerals mining, and offshore wind energy extraction.

U.S. Safe Drinking Water Act – The Safe Drinking Water Act is the principal federal law in the United States intended to ensure safe drinking water for the public.

U.S. Clean Water Act – The 1972 Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters.

Toxic Substances Control Act (TSCA) – The 1976 Toxic Substances Control Act is a U.S. law administered by the United States Environmental Protection Agency that regulates the introduction of new or already existing chemicals.

Significant New-Use Rules – Once the U.S. EPA determines that a use of a chemical substance is a significant new use, TSCA section 5(a) requires persons to submit a significant new use notice (SNUN) to EPA at least 90 days before they manufacture (including import), or process the chemical substance for that use.

Roadless Rule – Roadless area conservation is a conservation policy limiting road construction and the resulting environmental impact on designated areas of public land. In the United States, roadless area conservation has centered on U.S. Forest Service areas known as inventoried roadless areas.

Rig decommissioning – Rig decommissioning is the process of ending offshore oil and gas operations at an offshore platform and returning the ocean and seafloor to their pre-lease conditions.

"Rigs-to-Reefs" – Petroleum operators facing the required end-of-life full decommissioning of their spent offshore oil drilling platforms often hope to be able to instead abandon their steel platforms by either cutting them off in place below a level that threatens maritime navigation, while dumping the rest of the rig on the seafloor nearby, or by transporting the spent rig to a nearby seafloor dumping ground. Adopting this shortcut approach can save a petroleum company approximately 50% of the cost of full decommissioning, while usually transferring liability for any subsequent seafloor oil leaks or other resulting economic damage to a nearby state or to U.S. taxpayers.

Second-generation anticoagulants (SGARS) – A controversial formulation of blood-thinner rodenticide that is designed to be a "one-feeding" poison that works by causing slow internal bleeding of animals that consume the poison, while spreading throughout the entire food chain.

Gasoline – A liquid fuel refined from crude oil.

LNG – Liquified natural gas.

Fracking – Hydraulic fracturing of gas-bearing geological formations using high-pressure chemicals to break open fissures in the rock through which methane can be extracted.

NORMS – Naturally occurring radioactive wastes resulting from fracking and other hydrocarbon drilling projects, usually based on radon and other radium-related minerals.

Trans-Alaska Pipeline (TAPS) – an oil 800-mile pipeline completed in 1975 from Alaska's North Slope oil fields to load oil into supertankers at the Valdez Oil Terminal in Prince William Sound.

Deepwater Horizon Blowout – The 2010 fire and explosion aboard a floating offshore drilling rig in the Gulf of Mexico called *Macondo* resulting in 11 deaths and the largest human-caused offshore oil spill in U.S. history.

Taylor Energy oil spill – An ongoing oil spill caused by damage to offshore drilling facilities off of Louisiana caused by Hurricane Ivan in 2004. The hurricane caused an underwater mudslide which toppled the oil platform, damaging the connections to as many as 28 oil wells on the seafloor below, which continue leaking.

Long Beach oil spill – A significant 2021 coastal oil spill resulting from the rupture of a subsea oil pipeline from an offshore drilling rig to shore off of Long Beach, California.

COREXIT chemical dispersant – Corexit (often styled COREXIT) is a controversial product line of oil dispersants sometimes used during spill response operations. Although approved by the EPA, formulations of Corexit 9500 and 9527 were banned from use in the United Kingdom in 1998 because laboratory tests found them harmful to marine life that inhabits rocky shores.

Tar sands – The Athabasca oil sands, also known as the Athabasca tar sands, are comprised of large deposits of bitumen or extremely heavy crude oil, located in northeastern Alberta, Canada.

Bitumen-in-place – Bitumen is a tar-like form of very heavy crude oil, and when found as oil sands near the earth's surface it can be mined and sent to a bitumen processing plant. For deposits that are deep below the surface, bitumen is extracted in-situ (or in place).

EV's – Modern highway vehicles using electric motors powered by large banks of rechargeable batteries.

Hydrogen Airport Refueling Ecosystem (HARE) – A proprietary experimental hydrogen aviation refueling system for smaller commercial aircraft.

Paley Commission – A commission established by former President Dwight D. Eisenhower in 1952 to develop and commercialize solar energy and other alternative energy sources.

Solar thermal energy – The capture and use of the direct heat from the sun to warm living spaces, provide hot water, or for manufacturing purposes.

Hydropower – Energy harvested from dams to run electrical power generators.

Hydrokinetic energy – Energy obtained by harnessing the force of ocean waves and converting it into rotary motion to operate a generator to obtain electricity.

Geothermal power – Energy from the earth's heat, usually captured by drilling geothermal wells to bring steam or very hot brine to the surface to run a turbine to power an electrical generator or to provide process heat for space heating, greenhouses, or manufacturing.

Geothermal brine – Naturally-occurring chemical-laden hot water from deep in the earth, harvested from drilling geothermal wells or found as artesian hot springs.

Biosphere – The regions of the surface, atmosphere, and hydrosphere of the Earth (or analogous parts of other planets) occupied by living organisms.

Biofuel – A fuel derived directly from living matter.

Biomass fuels – Organic matter used as a fuel, especially in a power station for the generation of electricity.

"Hothouse Earth" – An entirely new climate system, characterized by natural feedback loops that could bolster global warming, despite emissions reductions and entirely outside of human control. A "Hothouse Earth" climate will in the long term stabilize at a global average of 4–5°C higher than pre-industrial temperatures with sea level 10–60 meters higher than today.

Megadrought – A megadrought (or mega-drought) is a prolonged drought lasting two decades or longer.

Photovoltaics – Photovoltaics is the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the *photoelectric effect* that causes them to absorb photons of light and release electrons.

Rooftop solar thermal – Collection of heat directly from the sun through the use of a device with a darkened surface placed on the roof of a building, often to heat a domestic water supply, or by allowing the sun to shine on a wall of the building that serves as a heat sink and stores heat and releases it gradually.

Green buildings – A "green building" is a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts.

LEED – LEED (Leadership in Energy and Environmental Design) is an ecology-oriented building certification program run under the auspices of the U.S. Green Building Council (USGBC).

Circularity – Circularity is a simple concept. It means that a product is created with its own end-of-life taken into account. In a circular economy, once the user is finished with the product, it goes back into the supply chain instead of the landfill. The motto of the circularity movement, in a nutshell: Waste not, want not.

Blue Carbon accounting – Blue Carbon (BC) is the term for carbon captured by the world's ocean and coastal ecosystems, and Blue Carbon accounting is used to quantify the inputs and outputs of this system. Blue Carbon strategy refers to the approaches that mitigate and adapt to climate change through the conservation and restoration of seagrass, saltmarsh and mangrove ecosystems.

Blue Finance – Blue Finance is an emerging area in Climate Finance that is now gathering increased participation from investors, financial institutions, and insurers globally. Blue Finance helps address pressing climate-related challenges by contributing to economic growth, improved livelihoods, and the health of marine ecosystems.

Microgrids – A microgrid is a small network of electricity users with a local source of supply that is usually attached to a centralized national grid but is able to function independently.

Lithium-ion battery – A rechargeable battery that uses lithium ions as the primary component of its electrolyte A lithium-ion battery or Li-ion battery is composed of cells in which lithium ions move from the negative electrode through an electrolyte to the positive electrode during discharge and back when charging. Li-ion batteries have a high energy density, no memory effect, and low self-discharge.

Advanced Reactor Designs – *Advanced nuclear reactors* are being designed to more quickly adjust their electricity output to match demand, which proponents claim could help them stabilize the power grid in areas with a high volume of intermittent renewables. Advanced reactors are being planned that would use a variety of coolants including water, molten salt, high temperature gas and liquid metal.

Strategic minerals – Strategic minerals are critical commodities considered essential to national defense for which the supply during war is wholly, or in part, dependent upon sources outside the boundaries of the U.S.

RFID chip or RFID tag – RFID tags are a type of tracking system that uses radio frequency to search, identify, track, and communicate with items and people. Essentially, RFID tags are smart labels that can store a range of information from serial numbers, to a short product description, and even pages of data.

QR code – A machine-readable printed graphic code consisting of an array of black and white squares, typically used for storing URLs or other information for reading by the camera on a smartphone.

End-of-Life (EOL) recycling – An end-of-life product (EOL product) is a product at the end of the product lifecycle which prevents users from receiving updates, indicating that the product is at the end of its useful life (from the vendor's point of view). For the consumer using the product, EOL concerns include disposing of the existing product responsibly, smoothly transitioning to a different product, and ensuring that disruption and waste will be minimal.

Microplastics – Extremely small pieces of plastic debris in the environment resulting from the disposal and breakdown of plastic consumer products and industrial waste.

Fugitive methane emissions – Fugitive gas emissions are emissions of gas (typically natural gas, which contains methane) to the Earth's atmosphere or to groundwater which result from oil and gas or coal mining activity or from leaking pipelines or appliances.

"Least Harm" – An emerging term signifying a planning process for industrial projects that causes the least possible harm to natural systems.

Ocean upwelling centers – Coastal upwelling is the process by which strong winds blow down the coasts of continents and, in conjunction with the earth's rotation, cause the surface waters to be pushed offshore. Water from the ocean depths is then pulled up - or upwelled - to the surface to take its place.

"Wind Energy Area" – A term developed by the U.S. Department of Interior to delineate parts of the ocean targeted for the installation of commercial offshore wind turbine arrays.

Lidar – A detection system which works on the principle of radar, but uses light from a laser.

Pore Space – In geology, the empty space between grains of rock, fractures, and voids.

Build Back Better Act – Federal legislation proposed the Biden Administration and passed by the U.S. House of Representatives in 2021 to rebuild the American economy after the worst of the COVID-19 pandemic had receded. This bill would provide funding, establish programs, and modify provisions relating to a broad array of areas, including education, labor, child care, health care, taxes, immigration, and the environment. Not passed by the U.S. Senate as of June 2022.

Richard Charter spent much of his early childhood among the tidepools of the Northern California coast. He currently directs the Coastal Coordination Program, a project of The Ocean Foundation, continuing four decades of professional dedication to protecting fragile marine ecosystems. Richard engaged with four Administrations in Washington and multiple Members of Congress to maintain the bipartisan 27-year annual renewal of the offshore drilling moratorium that has long protected the U.S. Atlantic and Pacific coasts while securing a separate law setting aside Florida's Gulf Coast and Panhandle from expanded offshore oil and gas leasing. Richard coordinated the local government support leading to the designation of California's Greater Farallones, Cordell Bank, Channel Islands, and Monterey Bay National Marine Sanctuaries and helped secure the Obama White House declaration of permanent protection from offshore drilling for Alaska's fishery-rich Bristol Bay in 2015. Richard is currently working to advance the proposed Chumash Heritage National Marine Sanctuary off of Central California, to address the emerging global threat posed by seabed mining, and to ensure full protection for Florida's iconic Biscayne Bay Coral Reef Reserve.

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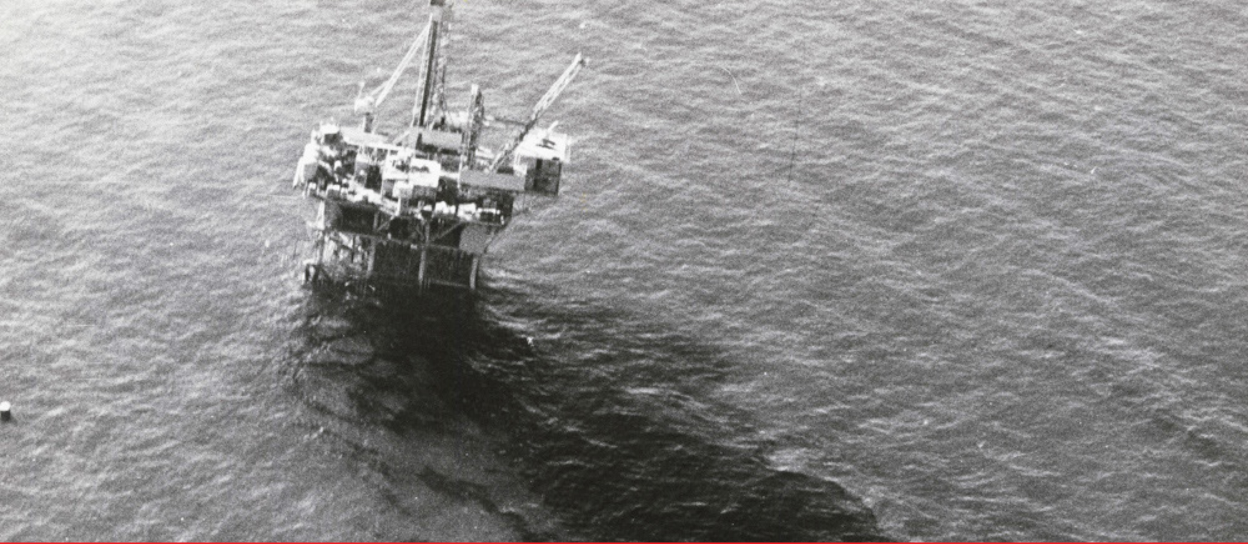

The Current Climate

This true story of how climate change became a crisis and what is possible—and now necessary—is based on a wide-ranging compilation of facts that add up to both a serious challenge and a compelling promise. We are exploring not only the scope and scale of our present climate threats, but also revealing the broad range of options from which we can choose our future actions. We know the path forward. We know that we need to tread carefully, and we can be certain that there is no time to waste.

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