How Offshore Wind Drives Up Global Carbon Emissions

Emissions from mining, processing, manufacturing and transportation offset any reductions

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Executive Summary

Offshore wind facilities are enormously expensive and environmentally destructive. The primary purported justification for constructing them is to reduce "carbon" (carbon dioxide or CO_2) emissions and save the planet from "catastrophic climate change." However, this justification is not just built on a false premise, but adding offshore wind to a state's energy mix will most likely also increase global CO2 emissions. That means the net emission benefits are hugely negative, as are other net environmental and economic effects.

This study finds that carbon dioxide reductions from local (state and national, as opposed to global) wind power generation are greatly overstated. For starters, any CO2 decrease will be small at best, largely because the intermittency of necessary wind speeds forces backup gas-fired power emissions to increase when the wind isn't blowing. (Sufficient backup electricity from battery modules is also hugely expensive, heavily reliant on raw materials that are in short supply, and likely a decade or more away.)

The net result is that adding offshore wind to the existing coal, gas, and nuclear and/or hydroelectric power system, though modestly lowering emissions at first glance, does little to reduce local power emissions overall because of the gas (or coal) backup generation now needed to maintain a stable grid.

But the story gets worse.

Often overlooked are the other factors associated with wind energy that actually drive up emissions. For example, supply chain emissions from constructing offshore wind facilities to replace existing generation facilities will be very large. Supply chain emissions include those arising from all the steps required to create an offshore wind facility: mining and processing the necessary metals and minerals, manufacturing components, constructing turbines and substations on site, and operating, maintaining, replacing, and ultimately decommissioning and landfilling worn out, damaged, and obsolete equipment. They also include the myriad transportation steps along the way, via ship or truck.

These supply chain emissions are global and add to the global atmosphere. Thus, the net result of combining small local CO2 reductions with large increases in emissions via the supply chain is not a *reduction* in global atmospheric CO2, but an overall *increase* of atmospheric CO2.

In short, the "emission reduction" justification touted by proponents of building offshore wind facilities is simplistic and false.

Finally, another justification for building wind farms is that they benefit local job creation. This too is by-and-large false. One reason is that such jobs are subsidized by local electric power ratepayers who will likely see their electricity prices soar, leading to layoffs in many businesses and the closing of businesses and entire industries – making the net benefit minimal, zero, or even negative. Even worse, much of the ratepayer and taxpayer money behind offshore wind facilities will go overseas, because that is where the supply chain exists. In short, the jobs created by wind energy should be viewed as costs, not benefits.

Moreover, few local jobs will be created directly by offshore wind energy facilities, because building them is a simple assembly project, not a construction project. This is because the parts being assembled are primarily manufactured and fabricated overseas. These include the towers, turbines, blades, connecting cables, substations, and transformers. Adding insult to injury, assembling offshore turbines is typically done by highly specialized ships primarily provided by foreign nations.

Local or U.S. jobs are likely to be relatively few and even low-paying installation, maintenance, repair, decommissioning, and recycling/landfilling jobs. Factory jobs manufacturing offshore wind turbine components will likely disappear, because U.S. factories will no longer have reliable, affordable power in a wind-solar-battery-backup-gas-turbine economy, will be faced with hiring highly paid American workers, and thus will not be able to compete with Asian and other foreign competitors.

Also on the local level, once the actual overseas emission increases and local reductions are known, it is possible to calculate a cost per ton of carbon dioxide reduction. This number is likely to be very large, certainly in the thousands of dollars per ton and possibly much more. Moreover, supply chain costs will almost assuredly grow because critical raw material shortages are predicted as demand increases.

This study is only an initial examination of the complex issues surrounding the alleged justification for massive offshore wind development. For illustrative purposes, we have used a few simple examples, such as New Jersey's 11,000-MW offshore wind target and emissions created along the supply chain for installing mostly monopile turbines.

However, our findings are more general in scope and application. In brief, for all offshore wind installations:

A. Local power system emission reductions will be small.

B. Supply chain emissions will be large.

C. Global emissions will therefore increase, not decrease.

Conclusion 1: There are no carbon dioxide emission reduction benefits, and thus no manmade climate change amelioration justifications for offshore wind development.

Our secondary findings explain in greater detail why this is so.

A. Any local jobs created will be exorbitantly costly when U.S. wage scales, "clean energy" subsidies, and ratepayer increases are factored in, and thus are likely to be relatively few and low-paying.

B. Many existing local jobs will disappear, as electricity costs replace fossil fuel costs and rise steadily – resulting in layoffs in many economic sectors and reduced spending by cash-strapped families.

C. Supply chain costs are bound to go up due to rising U.S. and global demand for and looming shortages of essential metals and minerals.

Conclusion 2: Offshore wind projects and infrastructure are tremendously expensive, will provide pricey intermittent electricity, and thus will destroy numerous American jobs, while supporting few long-term jobs that offer similar wages.

Conclusion 3: Offshore wind projects and infrastructure inflict numerous other costs that thus far have not been factored into any cost-benefit analyses for the industry.

Conclusion 4: The net “carbon” (carbon dioxide) reduction effects of offshore wind development are thus hugely negative and cannot justify further investments in this industry.

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I. Introduction

Offshore wind development in America has become a stampede, with hundreds of billions of dollars being spent on construction and deployment of wind turbines and associated infrastructure, especially off America's East Coast. The primary purported justification for such widespread development is the "urgent need" to rapidly reduce "carbon" emissions to avert impending "climate catastrophes."

["Carbon" emissions actually refer to carbon dioxide or CO2, the naturally occurring gas that humans and animals exhale when they breathe, and plants require to grow and even exist. Current CO2 levels of 400 parts per million (ppm) equate to a mere 0.004% of Earth's atmosphere (417 ppm), compared to 0.280% prior to the Industrial Revolution, but the increase has spurred plant growth across the planet.]

It turns out, however, that wind power is an abysmal means to reduce CO2 emission. In fact, adding offshore wind will likely increase CO2 emissions on a global scale. Therefore, the net benefits (that is, benefits minus costs) of wind energy as a means to address "climate change" are hugely negative.

II. Offshore wind energy will reduce power generating emissions very little, if at all.

There is a common assumption that offshore wind electricity generation greatly reduces CO2 emissions. In fact, it is this presumption that provides the primary justification for accepting any heightened costs or adverse impacts brought about by the construction of offshore megaprojects and their associated offshore and onshore infrastructure. Indeed, it is typically assumed that every megawatt-hour (MWh) of wind electricity generation reduces CO2 emissions by an equal MWh's worth.

As with many green assertions, however, this turns out to be untrue in reality.

To begin with, given the way power generation actually performs, the reduction in fossil fuel emissions will not be all that great. Take New Jersey as an example.

The Garden State aspires to be a leader in offshore wind development, with a stated goal of achieving a very ambitious 11,000 MW of offshore generating capacity, and state officials claim to be willing to pay a hefty cost of around $100 billion to achieve it.

If reducing CO2 emissions is their purported reason for paying this incredible cost via ratepayers and taxpayers, one would assume there will be tremendous reductions of carbon dioxide (CO2) emissions. It turns out, however, that all this money will likely achieve very little in terms of CO2 reductions – making the project an "all pain-no gain" endeavor. Even worse, it is more likely that manufacturing and installing all these offshore wind turbines will *increase* global emissions, making the effort worse than worthless.

On the generation side, several factors must be considered. First, New Jersey has already shut down some 2,000 MW of coal fired power. That means any potential emission reductions tied to those facilities have already been accounted for, before any “wind farms” are installed. Second, half the state's current power generation is nuclear, which already has no CO2 emissions. Thus, if wind is to replace some nuclear output, there will be no CO2 reductions from that sector.

The remaining half of New Jersey’s electricity generation is provided by natural gas. This is where things get both interesting and complex.

Bear in mind, a gas-fired generator is designed to produce electricity almost instantly when people need it. Wind energy, on the other hand, is intermittent and generates power only when the wind blows. It generates most of its power when the wind blows hardest (up to wind speeds that are too high for turbines to operate safely), less so when it blows weakest, and none at all when there is no wind.

Roughly speaking, wind output increases linearly from zero power below 10 mph, to full power at 30 mph.

Over the full course of a year, offshore wind turbines typically provide electricity less than 30% of their rated capacity – in good wind locations, and perhaps 15-20% overall. As offshore wind developments proliferate, the best wind locales will be utilized and future facilities will go in less desirable locations. But even now wind energy companies balk at guaranteeing a paltry 40% capacity, and output declines every year, as turbines age and are battered by storms and saltwater spray.

Winds required for electricity generation are *sustained wind speeds*, not gusts; steady 30 mph winds for hours or days are rare. On the other hand, less than 10 mph is relatively common, meaning no power is produced or hours or even days at a time. With apologies to Samuel Taylor Coleridge, the turbines become as idle as a painted ship upon a painted ocean.

In between those relatively short periods of electricity production, the wind and power output go up and down, up and down. A 20% change in output in an hour is common. These irregular wind oscillations have a profound impact on gas-fired power plant emissions, whether from simple cycle (SC) units or combined cycle (CC) plants.

Simple cycle (SC) plants employ generators driven by combustion turbines, similar to jet engines running on natural gas. They have overall efficiencies of 30-38% depending on their age, but they can be turned on and off as needed and reach full power capacity very quickly. That’s why they are often used as emergency power at hospitals and as backup for off-and-on wind and solar facilities.

Simple cycle plants are also used to meet “peak” needs, when electricity demand spikes as large numbers of AC units or EV chargers are turned on, for example. That’s why they are often called “peakers.” Peak needs rarely coincide with strong winds, especially during heat waves and cold snaps, both of which are often marked by very low or no wind. Both weather extremes are often caused by stagnant high-pressure systems. That means wind-based electricity is often unavailable when it’s needed most.

It also means simple cycle units are forced to operate in off-and-on mode: constantly ramping power output up and down, while maintaining standby mode in between, to be ready for the next drop in wind speed. This results in very low efficiency, much higher CO2 emissions per unit of electricity generated, and much lower capacity factors for gas power plants that would have very high capacity factors if they were permitted to be operated as designed and intended. Using peakers year-round is very inefficient.

In short, adding a lot of intermittent offshore wind to the generation mix radically degrades the efficiency of any gas-fired electricity generation. The result is that CO2 emissions are not likely to be much reduced; in fact, emissions could even increase in proportion to wind turbine deployment.

Combined cycle (CC) power plants also use combustion turbines but augment that power by utilizing hot exhaust heat to boil water, to operate steam turbine generators that provide additional electricity. The combination of turbines and boilers makes CC plants much more efficient than SC units, reaching around 60% efficiency levels and nearly 90% reliability.

However, the large amounts of water in CC boilers take a long time to heat up, and once heated the combustion turbines must keep running to generate steam. That is why combined cycle systems are intended to run more or less steadily. CC is not a rapid response technology. It cannot ramp up and down in time to match winds that rapidly go down and up, and thus does little to reduce CO2 emissions.

There are two ways CC systems can supply the erratic needs created by oscillating wind output. Unfortunately, both are highly inefficient, because much more gas must be burned per unit of electricity produced, creating far more emissions.

Operators can keep steam pressure up even when wind output is high. But this requires burning a lot of gas with little or no power generation. The alternative is to shut the steam component down and run the plant as a simple cycle turbine. But this renders the expensive steam unit useless, requires extensive fuel use, and results in extensive CO2 emissions.

It would be far better economically and environmentally to rely entirely on CC systems and forget about wind turbines.

As to asserted offshore wind benefits resulting from eliminating emissions from coal-fired power plants, those plants were already being forced into retirement long before the first U.S. offshore turbines were installed. And since nuclear power plants have no emissions and cannot be ramped up and down to meet frequent peak demands, they do little to reduce “carbon” emissions.

The exact emission benefits depend on many factors, including the specifics of wind intermittency from month to month, year to year, and place to place for various offshore facilities. They present research questions that the authors have not seen addressed.

However, it is highly unlikely that offshore wind will do much to reduce peaker emissions, at least until peaking units are replaced by enormous arrays of battery modules. And that raises major issues of cost, extinguishing chemical fires when lithium-based batteries overheat and ignite, spontaneously ignite, or get damaged or water-logged and burst into flames, and raw material supply chains that involve slave and child labor and vast quantities of air, water, and soil pollution.

Simply put, if the primary justification for building enormously expensive offshore wind megaprojects is reducing CO_2 emissions, there may well be no justification.

III. Offshore wind energy will actually increase global CO_2 emissions.

Despite calling for rapid reduction in CO_2 emissions, many in the Green Movement actually champion a form of global green industrialization that would dramatically increase emissions for the foreseeable future. Thus far, however, they have failed to acknowledge this obvious absurdity.

As already explained, growing evidence demonstrates that gas-fired backup will keep renewable power generation CO_2 emissions high. There is also growing literature underscoring the enormous material requirements for building huge numbers of wind and solar power generating systems – and upgrading and expanding existing electrical grids and transmission lines. The International Energy Agency, (IEA), for example, notes that offshore wind turbines require some fourteen times more raw materials per megawatt than combined cycle power plants that are far more efficient and reliable. ("The Role of Critical Minerals in Clean Energy Transitions," IEA, May 2021, 287 pages. https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions)

These realities mean CO_2 emissions will rise, not fall, as green industrialization proceeds. Both factors are routinely ignored. However, both have enormous implications for energy, economies, living standards, the environment, and potentially Earth's climate and weather (if CO_2 indeed drives those systems).

The "green" energy transition, if examined carefully, would actually increase emissions. It is that simple.

Voluminous "supply chain emissions" accompany every stage of the process. Rebuilding the electric power and grid system, to handle all-electric U.S. and world economies, would obviously be hugely emission intensive, because unprecedented amounts of fossil-fuel-powered mining, processing, manufacturing, and construction are required, along with extensive transportation at each step, especially with materials and finished equipment moving among and across entire continents.

The huge monopile towers (masts) that hold up many offshore generating systems and blades offer an excellent but relatively simple example. Here we'll focus on New Jersey's aggressive goal of adding 11,000 MW of offshore wind, up from its current level of zero wind.

If NJ installs 12-megawatt turbines – supposedly among the best and most efficient available – it would need 917 turbines, each actually generating electricity perhaps 30-35% of its potential capacity. (The wind industry says 40% but balks when asked to guarantee that as a proviso for various subsidies.) The state would likely need twice that many turbines if it continues along its path to eliminate fossil fuel vehicles, heating, cooking, and water heating for an all-electric Net Zero economy.

The monopiles must support a nacelle (gears, generator, other equipment, and protective cover) weighing nearly 750 U.S. tons, plus three 350-foot-long blades weighing hundreds of tons more. The monopiles must also withstand storms and hurricanes – and therefore would have to be stronger than anything installed to date anywhere in the world.

Neither U.S. nor even North Sea turbines have ever faced sustained hurricane force winds, even Category 1 hurricanes (74-95 mph winds). Not only would they have to survive sustained winds of 96-110 mph (Category 2), 111-129 mph (Category 3) and even 130 to 157 mph and higher (Category 4-5), but they would also have to withstand wind shear, vertical variations in wind speeds, and sudden changes in wind direction (veer), which actually ripped onshore turbine blades right off and snapped onshore monopile towers in two during a 2017 Category 4 hurricane in Puerto Rico.

Such ferocity would be catastrophic for sprawling offshore wind installations like the 3,400 smaller turbines planned for off the New Jersey coast, or the thousands more expected in the Gulf of Mexico – to say nothing of the families, businesses, hospitals, factories, and communities dependent on electricity from turbines that would likely not be repaired or replaced for many years.

Monopile details. For simplicity, let's say a company is installing a steel cylinder 30 feet in diameter and 300 feet long, although some are already bigger, and the global race to build 15- and even 18-MW behemoths would require much larger towers. Each one weighs around 2,500 tons.

It is pile-driven into sea floor sediments or pre-drilled holes, usually to bedrock, after which sediments are removed and the cylinder is anchored with grout to the hole or to a previously installed pile or stub. In some cases, the cylinder is backfilled with concrete to create additional strength and stability. (Excellent discussions and explanations of this can be found at https://www.youtube.com/watch?v=2GiWKa3QreY, especially at 0:35:00 – 0:50:00.)

Steel and cement making both result in substantial CO_2 emissions. Steel making creates about 2 tons of CO_2 per ton of steel; producing the steel for one monopile emits about 5,000 tons of CO_2. This does not include shaping, cutting, and welding steel plates to fabricate the monopile.

Backfilling an entire monopile can involve as much as 15,000 tons of concrete and around 9,000 tons of CO_2 from the chemical reaction of curing the concrete. This is in addition to emissions associated with cooking limestone to make cement.

Altogether, simply producing the basic materials might result in about 14,000 tons of CO2 per monopile. Actual figures will depend on specific site conditions. For example, under ideal conditions much less concrete might be needed.

Assuming for simplicity that the average turbine is 11 MW and New Jersey will initially need 1,000 monopiles, this works out to a whopping 14,000,000 tons of CO2 just for the steel and concrete.

Again, this does not include the fuels and emissions associated with mining, processing, manufacturing, and other steps for the multitude of metals, minerals, and resins in turbine blades, wiring, and other components of the complex mechanical systems in offshore wind turbines and associated equipment. It does not include the copper, steel, concrete, aluminum, and other materials in undersea and onshore cables, transmission lines, substations, transformers, and other equipment needed to get electricity from far-away offshore turbines to power-hungry cities and industrial zones.

Nor does it include the numerous transportation steps along the way from mine to final erection. At present, the steel monopiles are made in Europe and shipped some 4,000 miles. Many of the giant substations, each filling a flatbed ship, come from as far away as China, Indonesia, Singapore, and Thailand. Iron ore is itself a major ocean shipping commodity. That means abundant transport emissions, especially from the thousands of ocean vessels that burn bunker fuel, the dirtiest of all fuels.

This is emission-intensive industrialization on a grand scale. The “great green energy transformation” cannot possibly reduce CO2 emissions, certainly not in the foreseeable future.

A thorough supply chain emission analysis is urgently needed.

IV. The “job creation” component of offshore wind is a societal cost, not a benefit.

Proponents of renewable energy, up and down the East Coast, are touting all the jobs that will theoretically be created by offshore wind development. While it’s true that some jobs may appear, these advocates fail to mention that: (a) any jobs created will be paid for by those who use (increasingly expensive) electricity, including low-income ratepayers; and (b) many existing jobs will be lost, as factories, businesses, and even schools and hospitals find they must cut employee costs to pay for more costly electricity, must install expensive all-electric systems, and cannot function with intermittent power and recurring blackouts when backup prove inadequate to cover growing electricity demands.

To simply label the huge offshore wind costs as “benefits,” because somebody gets money that often comes from taxpayer-financed subsidies, is misguided. In fact, jacking up electric rates is a highly regressive tax.

Electricity is a major cost in low-income household budgets, where families often pay 10-20% or more of their total incomes just for energy. The poor will get hit the hardest, paying for other people's jobs, for no good reason. Energy is likewise a major component of overall costs for hospitals, schools, factories, data centers, grocery stores, and other businesses. When their energy costs increase, they must pass those costs on to customers, via the prices they charge for goods and services – or they go out of business.

In addition, most of the good jobs associated with wind farm construction tend to be in other countries, especially Europe and Asia. America does not have a domestic offshore wind production industry per se, because it has inadequate access to raw materials, pays much higher wages, and requires compliance with much tougher environmental and workplace safety standards than many other countries do. Almost all the equipment, which is most of the overall cost, will thus come from overseas. Even the big ships needed to install enormous offshore wind turbine boats are foreign made and operated.

New Jersey is arguably the leader in poor thinking here, although there are several serious contenders.

Keep in mind that NJ already has all the power generating capacity it needs. Nevertheless, its policy makers' stated offshore wind development goal is a hefty 11,000 MW. To get an idea of what kinds of costs New Jersey might be facing, we can look to nearby Dominion Energy, which is constructing Virginia's offshore wind facility. The public information Dominion and the Commonwealth of Virginia have made available shows a current estimate of around $4 billion per thousand MW for construction.

If these costs hold roughly true with New Jersey, which is likely the case, then NJ ratepayers are looking at something like $44 billion to reach their target – and much more than that if the state seeks to meet growing electricity demand with offshore wind, as Net Zero mandates increasingly eliminate fossil fuel use with electric vehicles, heating, cooking, and "green" power generation.

Dominion points out finance charges must be also added to upfront construction costs, and they are at least equal to those costs. It's likely that NJ's green dream will cost $88 billion to build and pay for.

However, this does not include operation, maintenance, repair, and replacement costs. It was recently reported that the new giant Siemens and other turbines planned for installation in U.S. waters are having high failure rates, so this could be a very large expense.

Moreover, Virginia, New Jersey, and other states along the East Coast are subject to frequent hurricanes. If a big hurricane roars up the Atlantic coast, damaging hundreds of offshore turbines and with whiplash forces snapping some towers off as winds shift, it would likely take many years to repair or replace them and their electricity.

Another big cost number is the grid upgrades required to handle all this new juice. The New England ISO estimates that around 4,500 miles of transmission lines will have to be rebuilt or newly built to handle the proposed offshore wind energy, which is a much more modest plan than New Jersey's. In addition, neighborhood and individual home electrical systems would have to be upgraded substantially to handle increased demands, especially for heating homes and fast-charging EVs.

All things considered, an estimate of around $100 billion is a good working number for New Jersey's proposed offshore wind. Electric bills would have to go way up to pay it – and most of that money will be leaving the state and country, and heading to foreign shores.

As a side note, the majority owner of the biggest offshore wind developer (Ørsted) is the Government of Denmark. That means the people of New Jersey will be sending big bucks to Queen Margrethe, who probably has a much better job and home than they do.

The bottom line is simple and eye-opening. Offshore wind energy imposes enormous costs to produce expensive, intermittent, weather-dependent electricity that will create some jobs locally, after killing many other local jobs, but above all will accrue to the benefit of overseas investors and corporations.

In fact, the enormous steel substations and transformers might well be made in Singapore or Indonesia, with mining and manufacturing emissions, and brought to U.S. shores with huge shipping emissions. The Empire Wind project off New York just ordered substations from both places, making the Empire State another strong contender in the offshore stupidity contest.

Put bluntly, the offshore wind stampede will cost New Jersey families and businesses a Midas fortune, for no real benefits. Creating a few local jobs will be nice, but they should be viewed as a cost, not a benefit.

V. Offshore wind costs will likely escalate significantly over time.

If reducing CO2 emissions is the justification for industrializing the ocean with offshore wind, then we need to know what the cost is per ton of CO2 reduction. This number is likely to be ridiculously large, on the order of thousands of dollars a ton.

As shown above, the reductions are likely to be relatively small per MW of wind generating capacity. On the cost side, offshore wind is already very expensive but is bound to rocket much higher. The global stampede to build huge numbers of industrial wind generating facilities is widely predicted to seriously strain the supply chain. The inevitable result will be soaring demand, shortages, and price spikes.

The growing technical literature on supply chain shortages so far seems to focus mostly on the material and facility shortages that are likely to occur, not on the specific cost increases that are bound to follow.

A good recent example is "Future material requirements for global sustainable offshore wind energy development," Li et al., Renewable and Sustainable Energy Reviews, August 2022. https://www.sciencedirect.com/science/article/pii/S1364032122004993

Here is a telling paragraph from their abstract:

"We show that the exploitation of OWE [offshore wind energy] will require large quantities of raw materials from 2020 to 2040: 129–235 million [metric] tonnes (Mt) of steel, 8.2–14.6 Mt of iron, 3.8–25.9 Mt of concrete, 0.5–1.0 Mt of copper and 0.3–0.5 Mt of aluminium. Substantial amounts of rare earth elements will be required towards 2040, with up to 16, 13, 31 and 20-fold expansions in the current Neodymium (Nd), Dysprosium (Dy), Praseodymium (Pr) and Terbium (Tb) demand, respectively."

Porphyry copper deposits today average around 0.44% copper per ton of ore. That means obtaining 110,000 tons of copper (roughly the amount needed for wind turbines to meet President Biden's goal of 30,000 MW of offshore wind energy by 2030) would require mining 25,000,000 tons of copper ore – after removing some 40,000,000 tons of overlying rock (overburden). Mining for other metals will also involve relatively similar amounts of ore and overburden, followed by processing with a host of chemicals.

This raises important questions that are almost never mentioned, much less addressed.

How many new mines will be needed? By when? Where will they be located? Under what wage, workplace safety, air, and water pollution control, child and slave labor and other human rights, wildlife and habitat protection, and mined-land reclamation laws will they be operated? What costs will be attributed to all these negative consequences in calculating net ecological and other supposed benefits of offshore wind?

How many of these mines and processing plants will be located in the United States? How much will the USA instead rely on foreign sources – and have the negative impacts occur out of sight and mind?

Given that this is a vast new category of raw material requirements, on top of today's, shortages are clearly possible, even likely. The rare earth numbers are particularly interesting. Total production of each must increase by 13 times today's levels, perhaps even an incredible 31 times. Is this even possible?

(Readers wishing to explore these issues in greater depth can begin with the cited article and then employ the Advanced Search function at https://scholar.google.com/, under the triple bars in the upper left. Enter "Future material requirements" in the "Exact Phrase" box and hit "Search." It should be one of the first hits, and one need not go to the article. That will find every article that cites this one. A powerful "Related Articles" button returns about 100 closely related articles, taking researchers deeply into the literature. The IEA document cited earlier is also extremely helpful and detailed; it is not specifically about offshore wind, but it discusses the prospect of shortages and price spikes in both wind and solar development.)

Nor are the foreseeable shortages confined to basic materials. An enormous amount of specialized equipment must also be made, often in factories that do not now exist and will require large, reliable, affordable supplies of electricity, which the United States will likely not be able to provide because of its growing focus on weather-dependent wind and solar power. Here too price spikes are likely inevitable.

For example, an industry analyst recently reported the near-term need for an additional 200 specialized offshore wind turbine construction ships. These are projected to cost an estimated twenty billion dollars, but could cost much more if the estimate is based on today's prices, which are bound to go up.

(See "US$20bn of spend is needed to build 200 new vessels," OffshoreWind.biz, March 30, 2023, https://www.offshorewind.biz/2023/03/30/us20bn-of-spend-is-needed-to-build-200-new-vessels/?utm_source=offshorewind&utm_medium=email&utm_campaign=newsletter_2023-06-14)

The point is that multiple studies are finding looming shortages, the cost impact of which is not being estimated and considered. Given that offshore wind development has become an industrial stampede of monster proportions, this is not at all surprising.

As the cost of offshore wind development goes up, the cost per ton of CO2 emissions avoided goes up with it. So does the cost of electricity. It is crucial to determine what those future costs look like.

In a zero-fossil-fuels economy, power generation, vehicles, and home heating, water heating, and cooking will all have to be run off wind and solar power – and grid-stabilizing and backup power batteries will all have to be charged almost constantly by those same wind turbines and solar panels.

That means, whatever electricity generation is needed today to run America's modern industrialized economy will have to be tripled or even quadrupled to meet Net Zero requirements. Battery requirements will likewise skyrocket.

To cite one example, California recently installed the world's largest grid battery system, rated at 1,200 megawatt-hours (MWh) of storage capacity. However, California peak demands are an enormous 42,000 megawatts: 1,008,000 MWh per day. If that enormous demand occurs on a hot, low wind night (no wind or solar power), even this "huge" battery system would keep the Golden State's lights on for just 1.7 minutes – 103 seconds!

Even more troubling, the U.S. Energy Information Administration reports that grid-scale battery systems cost an average of around $1.5 million per MWh. At that price, this trivial amount of storage will cost nearly $2 billion. At 103 seconds of peak storage, that is about $18 million per second.

Again, this is for California's existing economy and energy system before it goes Net Zero and triples or quadruples its electricity and battery storage needs. The mining, processing, and manufacturing requirements, emissions, and ecological impacts would be astronomical. For batteries to back up total United States electricity requirements, the planetary impacts would be catastrophic.

All of this means that any CO2 analysis conducted today will have to be revised sharply upward to recognize these realities.

VI. Offshore wind is an ineffective way to reduce local or global CO_2 emissions.

The sole justification offered for the offshore wind stampede is that we need to reduce CO2 emissions from electric power generation. A quick look at the numbers shows that this is a truly terrible idea in terms of cost-benefit analysis. This very simple review illustrates the likely costs and supposed benefits.

We first present a “fantasy” cost-benefit analysis for offshore wind emission reductions. It is a fantasy because it simplistically assumes that (1) every MWh of wind generation eliminates a MWh of gas fired power, and (2) there are no environmental costs associated with manufacturing and installing turbines and other equipment, and no wind project cost increases. This is the rosiest possible case.

This analysis also employs the so-called Social Cost of Carbon (SCC) to calculate the supposed benefits from the CO2 reduction. This SCC is also a highly inflated fantasy that counts all U.S. fossil fuel emissions toward alleged costs of global climate changes, but ignores nearly all the costs enumerated in this report. But that is another issue.

Once again, we will use New Jersey’s proposed target of 11,000 MW of offshore wind capacity as our example, since these analyses are quite general.

The simplified, fantasy cost-benefit calculation assumes a constant 40% capacity factor and a generator life of 20 years, both of which are commonly used (but quite generous). There are 8,760 hours in a year, so 40% of 20 years is roughly 70,000 hours.

11,000 MW thus generates around 770,000,000 MWh over its lifetime. The standard gas-fired emission factor is roughly 0.5 tons of CO2 per MWh. (This combines peakers and combined cycle plants, which have very different emission factors, so it is sensitive to the local generation mix, which we ignore here.)

This yields a fantasy total of 385,000,000 tons of CO2 emissions avoided. Given our previously estimated direct cost of $100,000,000,000 – this yields a cost for avoided emissions of about $260 per ton.

The official Biden Administration SCC is just $51, making the offshore wind cost over five times the benefits for the fantasy case. Note that this SCC includes mythical damages *across the entire world*. Damages just in America give a SCC of a mere $7/ton, in which case the costs are 37 times the benefits.

Therefore, even in the fantasy case, the costs are at least four times the benefits, making offshore wind a very poor way to reduce emissions.

Let us now consider a somewhat more realistic case that nonetheless still ignores the environmental damage caused by wind power and the cost increases that are bound to occur. Let's simply take into account the fact that the CO2 reduction will be nowhere near as big as the fantasy case assumes.

As explained above, the intermittency of wind power greatly reduces the efficiency of gas-fired backup generators. That means far more gas must be burned to generate the same amount of electricity – and produce far more CO2 emissions. That means wind power will not reduce emissions by very much.

It would be far better to rely entirely on combined cycle gas turbines and nuclear power – and never build the wind turbines, solar panels, grid-scale backup batteries, and massively expanded transmission lines and substations that a Net Zero future would require. Taking that approach would also eliminate the need to expand global mining, processing, and manufacturing to levels never before seen in human history.

Assume the CO2 reduction is only 20% of the fantasy case. This gives a cost per ton of $1,300 – roughly 26 times the global SCC benefits of $51/ton and a whopping 186 times the US benefits of $7/ton.

Thus, assuming SCC is real, offshore wind is a terrible way to reduce CO2 emissions. The cost of offshore wind will be enormously greater than the benefits. A more complex analysis could, and should, be done, even though it would likely make these bad numbers worse.

Of course, SCC is itself a suspect claim. There is weak evidence that U.S. emissions are causing a global climate crisis, or that reducing U.S. emissions would make any detectable difference, with China, India, and other rapidly modernizing countries collectively emitting many times more carbon dioxide than the United States. By contrast, there is growing evidence that global temperatures, floods, droughts, hurricanes, tornadoes, other extreme weather events, and rising sea levels are much in accord with what occurred during previous millennia – and have not become more frequent or intense in recent decades.

That suggests that offshore wind energy is all costs and no benefits, and that there is no justification for ecologically and economically destructive offshore wind development.

VII. Other important costs must also be addressed and incorporated into decision-making.

Carbon dioxide and employment considerations are critically important, but must not be viewed in isolation. Significant additional costs that likewise offset alleged benefits must also be examined and incorporated into any analysis. Unfortunately, most have been ignored in government, wind industry and environmental activist studies, proclamations, press releases and policy prescriptions.

They need to be examined carefully and dollar costs attributed to them. Those costs and damages include the following.

Subsidies. Offshore wind subsidies – paid by taxpayers, ratepayers, and future generations – continue to grow. Twenty years ago, the subsidies were justified on the ground that offshore wind was an immature, unproven industry, yet today the subsidies continue unabated and in fact increase every year.

Some are direct and obvious payments to wind companies to cover portions of project costs; others are more covert – such as “congestion” or “curtailment” fees paid to wind companies for turning off turbines when their electricity isn’t needed. When it becomes obvious that costs will greatly exceed low-balled project estimates that were offered to secure contracts, households and businesses are expected to cover those costs, as well.

Safety. As offshore wind proliferates along U.S. coastlines, the 600- to 850-feet-tall turbines will increasingly endanger civilian and military radar operations and aircraft. Forests of towers anchored to the seafloor will also pose collision dangers for surface and subsurface vessels. Subsea infrastructure will also threaten submarines, and noise from generators and tower vibrations will impact Navy sonar.

Marine environments. Seafloor mapping involves seismic surveys that can impair whale and porpoise communication and navigation, disorient them and cause them to run aground. Nearly constant subsonic noise from turbine operations and tower vibrations travels many miles and can have the same harmful effects. Turbine foundations and towers can impact marine habitats and interfere with fisheries.

Human rights and climate justice. Toxic pollution associated with mining and processing the voluminous metals and minerals required for offshore wind turbines, infrastructure, and backup power has poisoned land, air, and water in Africa, Asia, and Latin America; destroyed valuable agricultural areas; used enormous amounts of water in arid regions; and caused blood, skin, lung, and heart diseases and cancer. Frequent accidents kill many miners and other workers, and have left others maimed or paralyzed.

Tens of thousands of children as young as six work in cobalt mines in the Democratic Republic of Congo, generally for just a dollar or two per day, exposing them to the same illnesses and accidents. Adults working in mines, processing plants, and factories often receive little better than slave wages. These human rights abuses violate even generous definitions of climate or environmental “justice.”

Transmission. Especially in an increasingly electricity-reliant economy, supply and demand must be carefully balanced for sudden and dramatic hourly, daily, weekly, and monthly fluctuations in the availability and intensity of wind (and sunshine) and the power generated. When there is no wind or sunshine – for hours, days, or even weeks at a time – sufficient, substantial backup electricity from gas turbines or batteries is essential. Electrical grids and neighborhood/household transmission systems must be expanded and modernized to accommodate all of this.

Those costs are all borne by taxpayer subsidies and customer payments. Electricity prices thus inevitably and unavoidably increase many times over, as they already have in Europe. However, families, hospitals, businesses, factories, and economies cannot survive with electricity that is too costly for them to afford, or is available only when nature cooperates, regardless of outside temperatures or other factors.

Congestion charges. At other times wind and/or solar systems generate far more electricity than is needed or than the grid can accommodate. One “solution” is to turn off wind and solar generators – and compensate wind and solar companies for this “wasted” electricity via “congestion” or “curtailment” charges, which ratepayers or taxpayers are likewise expected to pay.

Those costs can run into tens of billions of dollars per year nationally, an exorbitant and unfair charge to families, businesses, schools, hospitals, and other power users – who thus face a triple whammy.

They pay more for electricity at all times, to cover wind and solar systems and expanded transmission systems plus backup systems that are not needed for pure coal, gas, nuclear, and hydroelectric generation. They often suffer from repeated blackouts when renewable energy systems cannot provide electricity during peak demand periods, blizzards, and other events. And they must pay congestion/curtailment fees when wind or solar facilities generate more electricity than needed.

But the costs are cleverly hidden in incomprehensible acronyms and electricity bills, or in business investments that were never made and jobs that were never created because of rising prices for unreliable electricity. Calculating them is thus extremely difficult.

Bluntly put, the costs are *regressive taxes* that most severely impact poor families, who must pay the highest portions of their incomes for energy. In many cases, families on low or fixed incomes fall into “energy poverty” and cannot afford to heat and cool homes properly. Many elderly and ill people die during cold weather from hypothermia and illnesses that would likely survive if they weren’t so cold.

Regressive taxes also hit poor families and small businesses in the form of higher costs per dollar of income for the products and services they provide or require, because other businesses are in the same situation regarding sharply higher electricity costs. This too is a perverse form of “climate justice.”

Mining and materials imports. Even as U.S. and global demand for metals and minerals rises exponentially to build offshore wind turbines, related infrastructure and other “clean” energy systems, U.S. state and federal governments are restricting access to more mineral deposits or denying permits to develop them. This results in steadily increasing dependence on foreign supplies, most of which are now controlled by China.

That situation makes the United States dangerously reliant on less-than-friendly suppliers for what some intend to make the entire energy foundation of the nation's economic, defense, transportation, medical, manufacturing, and communication system. The dollar and other costs of that have never been estimated, and certainly have never been included in any offshore wind cost-benefit analysis.

VIII. Offshore wind development cannot be justified for CO2 reduction or other reasons.

Offshore wind energy development is an expensive, environmentally damaging proposition that cannot be justified on any basis as an alternative to fossil fuels electricity generation.

Conclusion 1: There are no carbon dioxide emission reduction benefits, and thus no manmade climate change amelioration justifications for offshore wind development.

A. Local (within the United States) power system CO2 emission reductions will be small. The endless intermittency of wind power dramatically increases the inefficiency of the gas-fired backup power. Gas turbines are constantly going from standby to power-up to power-down to standby mode, burning fuel at every stage, but never operating efficiently and constantly as designed. They therefore burn more gas and emit more CO2 (and water vapor, a much more important greenhouse gas than carbon dioxide) than if wind power were not the purportedly primary energy source, to produce the same amount of electricity.

B. Global supply chain CO2 emissions will be large and will increase steadily as wind (and solar) installations increase. The supply chain is global, is powered primarily by fossil fuels at every step, and will require enormous increases in mining and processing ores, manufacturing components for wind turbines and other infrastructure equipment, and transportation at every step.

Not only do "clean, green, renewable" energy technologies require far more raw materials per megawatt than fossil fuel or nuclear power, but they also involve far more transmission lines, substations, and transformers, and far more fossil-fuel transportation throughout the process.

C. Batteries may eventually replace gas turbines for backup electricity, if cost, battery life, and fire hazard issues can be resolved. However, batteries also require enormous amounts of raw materials, and thus extensive mining, processing, manufacturing, transportation, fossil fuel use, air, and water pollution, and carbon dioxide emissions.

Conclusion 2: Offshore wind projects and infrastructure are tremendously expensive, will provide pricey intermittent electricity, and thus will destroy numerous American jobs while supporting few long-term jobs that offer similar wages.

A. Local/U..S jobs are likely to be relatively few, and primarily in the construction/assembly, maintenance, repair, and demolition/landfilling sectors. Those jobs will be paid by local electricity ratepayers, so there are no net economic benefits. Mining, manufacturing, shipbuilding, and other high-skill jobs will likely be overseas, currently centered in Europe but moving rapidly to Asia, especially China, where energy costs, wages, workplace safety rules, and environmental protection standards are much lower than in the USA.

Substantial U.S. job losses in fossil fuels, petrochemicals, and manufacturing in an expensive, unreliable, Net Zero energy economy (which also opposes oil and gas production for petrochemical feed stocks) will not be replaced by the jobs most likely to be found in a wind/solar economy. Adverse impacts from intermittent, more expensive electricity will also be felt in numerous other sectors – including healthcare, research, transportation, and communications – all of which require enormous energy. Those costs and losses must also be accounted for in an honest, thorough assessment of costs and benefits.

B. Supply chain costs are bound to go up due to looming shortages in a world where mining, processing, and manufacturing will be unable to keep up with soaring demand, especially with intense opposition to mining in the United States. There is a large and growing literature warning of the serious material shortages implicit in the global rush to massively expand offshore wind development.

Conclusion 3: Offshore wind projects and infrastructure inflict numerous other costs that thus far have not been factored into any cost-benefit analyses for the industry.

Tens of billions of dollars in myriad subsidies still have not enabled the offshore wind industry to function on its own, and probably never will because of the multiple problems noted in this report.

The proliferation of offshore turbines creates increasing safety risks for military, commercial, and private aircraft; fishing and private recreational boats, naval ships, freighters, and cruise liners; and submarines. The danger of fatal collisions and impacts on marine environments will reach unacceptable levels if thousands of turbines are installed off U.S. coasts to meet Net Zero targets.

Adverse impacts on whales, porpoises, and other marine life will also reach unacceptable levels due to constant noise from wind turbine machinery and vibrations send down monopile and other towers in ocean waters.

Human rights and climate justice violations include child labor, near-slave wages, widespread air and water pollution, serious injuries and diseases, and deaths and permanent maiming from mining and other operations conducted in support of the offshore wind industry.

Rising electricity prices, congestion charges, and higher prices for goods and services of every kind impose regressive taxes on minority and other poor families. Meanwhile, increasing reliance on China and other foreign suppliers for the overwhelming majority of metals and minerals required to build offshore turbines and infrastructure severely impairs United States national security.

All these costs and risks raise serious liability, insurance, and political problems for the industry. And yet virtually none of them have been quantified or addressed in studies, legislative, and regulatory hearings, news stories, or other efforts to promote and develop offshore wind energy.

Conclusion 4: The net "carbon" (carbon dioxide) reduction effects of offshore wind development are thus hugely negative and cannot justify further investments in this industry.

There will almost certainly be no CO2 reduction benefits at all. In fact, offshore wind costs will greatly exceed the benefits, for carbon dioxide and every other parameter used to justify offshore wind.

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