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Back to Energy's Future?

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America's energy policy is an unmitigated disaster, being driven by the climate-change hoax. Instead of using nuclear energy to generate abundant, affordable, and reliable electricity, our leaders are turning to archaic resources, inadequate to meet even current needs, let alone future increased demands. A close look at these alternatives also reveals their detrimental environmental impact.

We'll start our assessment by addressing four factors that should be considered when choosing resources for generating electricity: energy density, energy conversion system efficiency, capacity factor, and environmental impact.

Why are these details important? Because they determine 1) how much of an energy resource will be needed to meet electricity demand, 2) how many other resources will be needed to convert that energy resource to electricity, and 3) how the environment will be affected. These should be the primary drivers of decisions regarding electricity generation.

We'll limit our discussion to coal, natural gas, uranium, solar, and wind, as these resources are the focus of current energy debates. Hydropower will not be addressed because there is no possibility of any significant future expansion of hydroelectric facilities in the United States.

Energy Density

The most important attribute of any resource for generating electricity is energy density. Resources of increasing energy density have enabled the evolution of human civilization as shown in **Table 1**. In ancient times, humans used slaves and animals to do work, and wood for cooking and heating. Mere survival was a daily chore. Later they harnessed water and wind to drive mills, and lighting came from oil lamps. Life expectancy was short. The energy density of resources was anemic — less than 0.001 kilowatt hour per kilogram of material.

Table 1 – Energy Resources Over Time

Era	Pre-Industrial Revolution	Industrial Revolution (roughly 1750-1840)	Post-Industrial Revolution
Energy Resource	Wood, wind, water, animals, humans	Fossil fuels	Uranium, Thorium
Energy Density (kWh/kg)	<0.001†	<15	> 20 million
Resource Benefits	Familiar	24/7 electricity generation; major industrial development; vastly improved world economies; increased lifespan	Most reliable 24/7 electricity generation; essentially inexhaustible energy resource; safe; compact
Resource Shortcomings	Intermittent availability; very localized domains of use	Environmentally damaging waste; finite resource	Moderate waste impact on environment; public fear due to misinformation, poor education

† One hour's work from 800 kg draft horse is about 0.0009 kWh/kg.
Adapted from Wade Allison, *Nature, Energy and Society — A Scientific Study of the Options Facing Civilization Today*, March 2020; wade.allison@physics.ox.ac.uk

Technology developments in the Industrial Revolution provided access to resources of greater energy density, allowing progress beyond a survival mode of existence. Energy-conversion machines such as the steam engine resulted in economic expansion and increased human lifespan. Fossil fuels powered the Industrial Revolution and continue to provide most of our electricity needs.

Without fossil fuels, our modern world would not exist. Modern medicine, communications, transportation, and reliable cooling and heating — these things are possible because the energy density of fossil fuels is about 15,000 times greater than that of resources available prior to the Industrial Revolution.

The post-Industrial Revolution era saw energy harnessed from the atomic nucleus of heavy elements such as uranium. Its energy density is more than a million times greater than that of fossil fuels and more than 20 billion times greater than that of pre-Industrial Revolution resources. Consequently, a relatively small amount of nuclear fuel can provide the electricity needs of very large populations. Nuclear's enormous energy density also means it has far less impact on the environment than other sources, especially wind and solar, as we shall see.

Energy Conversion Efficiency

Most energy forms cannot be converted completely into work, even under ideal conditions. When one form is converted to another, some energy will always be wasted as heat. The portion that can theoretically be converted into work is called available energy, whereas the portion actually converted is called useful energy. The ratio of useful to available energy is the energy conversion efficiency, which will always be less than 100 percent. The efficiency of an electricity-generating system is found by multiplying the efficiencies of the system's energy conversion devices.

Coal-fired and nuclear power plants generate electricity using a conventional steam cycle. Both fuels provide the heat that creates steam under high pressure, which drives a turbine connected to an electrical generator. The electricity-generating efficiency of these power plants is typically about 33 percent, while that of a simple gas-turbine power plant is typically around 35 percent.

A photovoltaic (PV) facility generates electricity by converting sunlight into direct current, which is then converted to alternating current by a DC-to-AC inverter. Solar-cell efficiency is a measure of how much of the electromagnetic radiation (photons) incident on the cell is converted to electrical current. Photons above a certain energy level will create an electrical current in a PV panel, while photons of less energy will deposit thermal energy in the panel that is ultimately lost to the environment. The physics boundary for silicon PV cells, the Shockley-Queisser Limit, is a maximum conversion of 33 percent of photons into electrons. Most PV panels are between 15 and 20 percent efficient; high-quality panels rarely exceed 22 percent. A typical DC-to-AC inverter has an efficiency of greater than 94 percent. Therefore, a PV facility has a maximum efficiency of about 20 percent.

A wind turbine generates electricity by converting wind energy into mechanical energy via a rotating shaft. A gearbox increases the shaft speed to drive a permanent magnet generator. Typically, wind turbines have a maximum efficiency around 40 percent. If a maximum gearbox efficiency of 95 percent is assumed, together with a maximum permanent magnet generator efficiency of 95 percent, then the system would have a maximum efficiency of about 36 percent.

These efficiencies would be expected for electricity-generating systems at the beginning of life. Equipment performance generally degrades over time, so system efficiencies would also be expected to decline.

While battery storage systems have been proposed to compensate for the intermittency of solar and wind, they are inefficient. The efficiency of storing and recovering wind and solar energy is 60 to 70 percent for lead-acid storage batteries and 87 to 94 percent for lithium-ion batteries. Assuming an average of 90 percent for the latter, round-trip efficiencies for generating and storing electricity are about 18 percent for solar and 32 percent for wind.

Electricity-generating Facility Capacity Factor

The capacity factor of an electricity-generating system is the ratio of actual electrical energy output over a given time period to the maximum possible electrical energy output over that period. The primary influences on a system’s capacity factor are equipment failures, routine maintenance, electricity demand (for load-following systems), “fuel” availability, and environmental regulations.

Solar and wind facilities are subject to “fuel” availability constraints since the sun doesn’t shine 24 hours a day and wind speed can vary significantly. Wind turbines don’t produce rated power until a sustained wind speed of 12 meters per second (26 miles per hour) is achieved, and such conditions are uncommon across most of the United States.

Furthermore, wind turbines become consumers of electricity at wind speeds that yield less than 20 percent of capacity rating because the electricity for the various pumps and accessories (which amounts to about 12 to 13 percent of capacity rating) cannot be drawn from the reduced wind turbine-generated electricity without compromising safety. Therefore, the electricity for this equipment must be supplied from the grid.

Finally, some coal-fired power plants are required to operate at less than 100-percent power to comply with environmental air-quality regulations.

According to 2020 data from the Energy Information Administration, listed in **Table 2**, nuclear is the clear leader and should lead the pack in electricity generation. Note that the significance of solar's 25-percent capacity factor is that obtaining a year-round average of 100 megawatts of electricity requires a facility with an installed capacity of 400 megawatts.

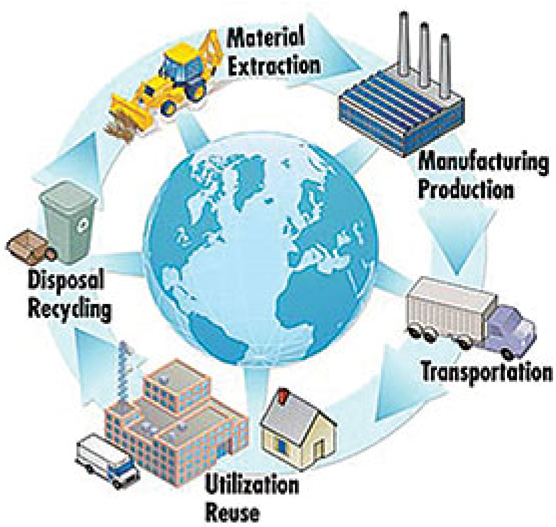
Table 2 – Energy Resource Comparisons

Electricity-Generating System	Resource Energy Density (kWh/kg)	System Energy Conversion Efficiency	System Average Capacity Factor	Equivalent Full-power Days per Year
Nuclear	> 20 million	33%	92%	336
Natural Gas	< 15	35%	56%	204
Coal	< 15	33%	40%	146
Wind Turbine	< 0.001	36%	35%	128
Photovoltaic	< 0.001	20%	25%	91

The Energy Resource Lifecycle & Environmental Impact

The environmental impact of generating electricity must be considered across the energy resource's entire lifecycle, not just the electricity-generating phase. This includes the manufacturing of machines and devices needed to convert the resource to electricity, transmitting electricity to the grid, and dispositioning of all lifecycle wastes.

Some details of the energy resource lifecycle are rarely addressed, especially regarding "renewables." Solar and wind are touted as both "free and clean," a claim that is only true about their initial states (i.e., photons and kinetic energy of air molecules). They cease to be free and clean when converted to any other form of energy.



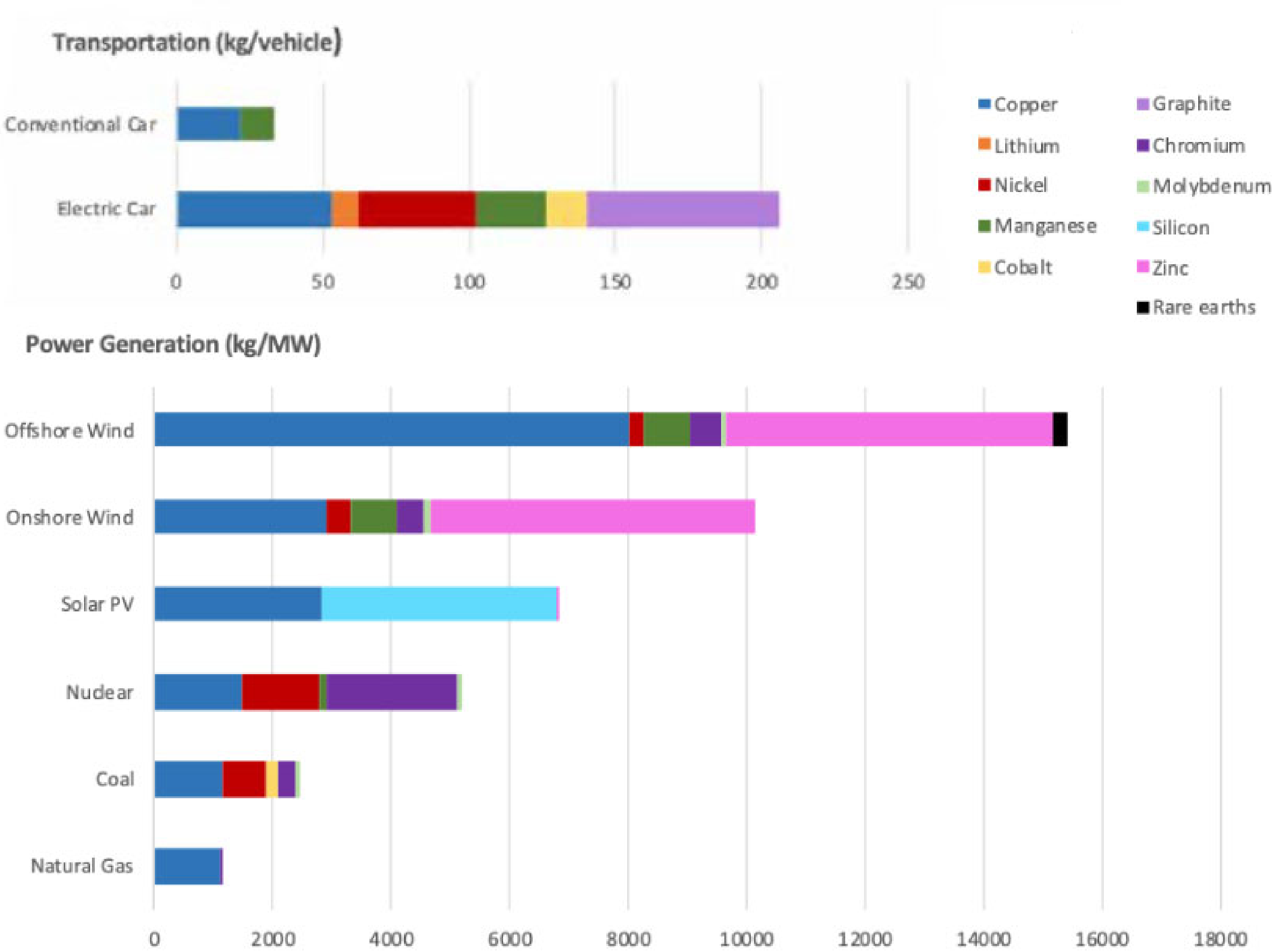
(The National Institute of Standards and Technology)

An exhaustive list of all material, processing, transportation, and transmission requirements of each energy resource is beyond the scope of this article, but solar and wind are far more demanding than their hydrocarbon counterparts. Realizing net-zero carbon dreams "would require the biggest expansion in mining the world has seen and would produce huge quantities of waste," relates The International Chronicles in its 2019 article, "The Destructive Myth of Green Energy: If You Want 'Renewable Energy' Get Ready to Destroy the Environment."

Eliminating fossil fuels and nuclear power in favor of solar and wind energy systems would require a massive worldwide increase in mining for lithium, cobalt, copper, iron, aluminum, and numerous other raw materials. According to 2020 research published by The Manhattan Institute, building wind turbines and solar panels to generate electricity, as well as batteries to fuel electric vehicles, requires on average more than 10 times the quantity of materials compared with building machines for hydrocarbons to deliver the same amount of energy.

In addition to the mineral requirements shown in **Figure 1**, an onshore wind turbine requires hundreds of tons of concrete to anchor the base and hundreds of tons of steel, made from hundreds of tons of iron using hundreds of tons of coking coal, as detailed by CFACT senior science analyst Jay Lehr in his 2021 article "Wind Does Not Meaningfully Add Power, but Imposes Huge Costs on Ratepayers and the Environment."

Figure 1: Quantity of minerals required for various transportation and power-generation technologies. Based on IEA 2019 data from *The Role of Critical Minerals in Clean Energy Transitions.*



Additionally, much of the material in renewable-energy devices cannot be recycled when they reach end of life. Even technology for their disposal has yet to be developed. Since wind turbines have only a 20-year lifespan, scientists at America's National Renewable Energy Laboratory in Lakewood, Colorado, warn that in the next few decades, the world faces a tidal wave of used, non-recyclable turbine blades. With an average lifespan of 25 years, solar panels pose similar challenges.

Battery storage systems to back up wind and solar also pack a punch when it comes to environmental impact, from production through end of life. Currently, there is no market for recycling industrial batteries.

The International Energy Agency (IEA) predicts that the demand for lithium used to produce lithium-ion batteries will increase 100-fold by 2050, followed by soaring new demand for graphite, cobalt, manganese, nickel, and copper.

Additionally, most equipment needed to mine and transport "green" energy materials must run on diesel fuel made from oil because it's too big and heavy to be powered efficiently by batteries. In addition, hydrocarbons are needed to produce the concrete, steel, plastics, and purified minerals used to build "green" machines.

Another factor prominently missing from most renewable-energy discussions, but featured in the 2017 book *Roadmap to Nowhere: The Myth of Powering the Nation with Renewable Energy* by Mike Conley and Tim Maloney, is the $500 billion (or more) cost associated with at least 500,000 miles of new transmission lines required to connect 50,000-plus wind and solar facilities for an all-renewables grid. A 2021 Princeton University study entitled "Net-Zero America" reveals that achieving net-zero emissions by mid-century through renewables alone would require a tripling of electricity-transmission systems to move energy generated in far-flung solar and wind farms to population centers.

Then there is transportation. Electric vehicles require many more metals and minerals than internal combustion engine-powered vehicles. Most importantly, mining and processing infrastructure capacities don't yet exist to meet the demand for essentially every category of mineral necessary for these power-generation and transportation transition paths.

Worse yet, a 2021 report from the Geological Survey of Finland, *Assessment of the Extra Capacity Required of Alternative Energy Electrical Power Systems to Completely Replace Fossil Fuels*, considered the mineral implications of a "green" future and concluded that the demand for nearly every necessary mineral, including copper, nickel, graphite, and lithium, would exceed not just existing and planned global production capabilities, but also known global reserves.

Foreign Reliance

The United States is, unfortunately, dependent on foreign nations for the mining and processing of many raw materials needed for renewable energy, as illustrated in **Figures 2 and 3**. In 1954, the United States was 100-percent dependent on imports for eight minerals listed in the Strategic Minerals Act of 1939. Today that list has grown to 17 strategic minerals, and we also depend on imports for more than half of 28 other widely used minerals.

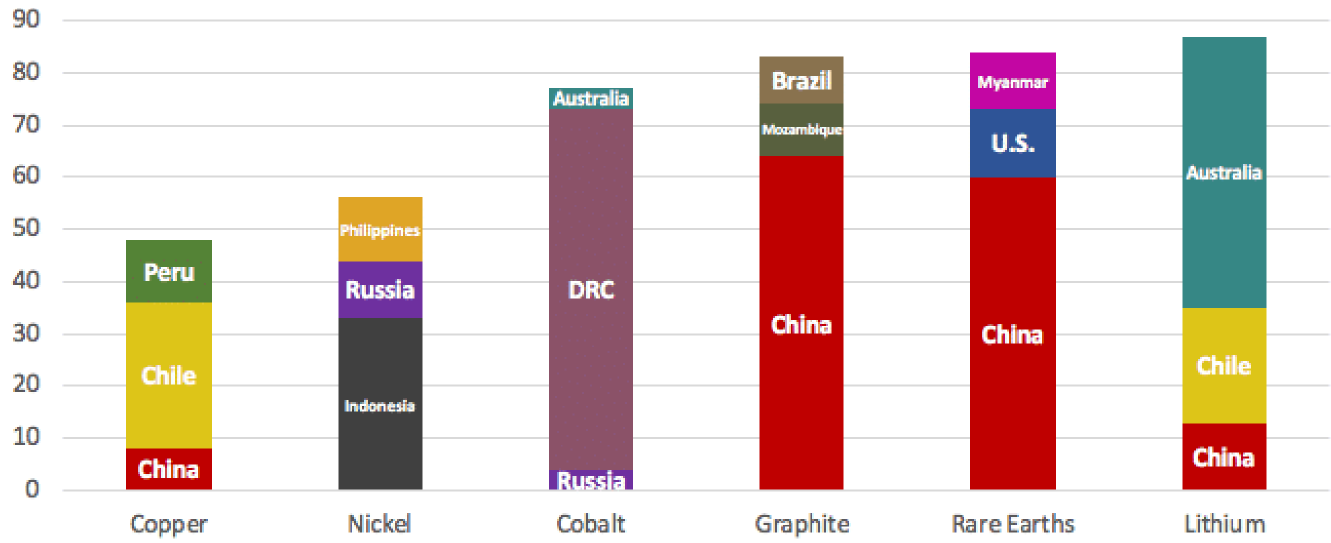
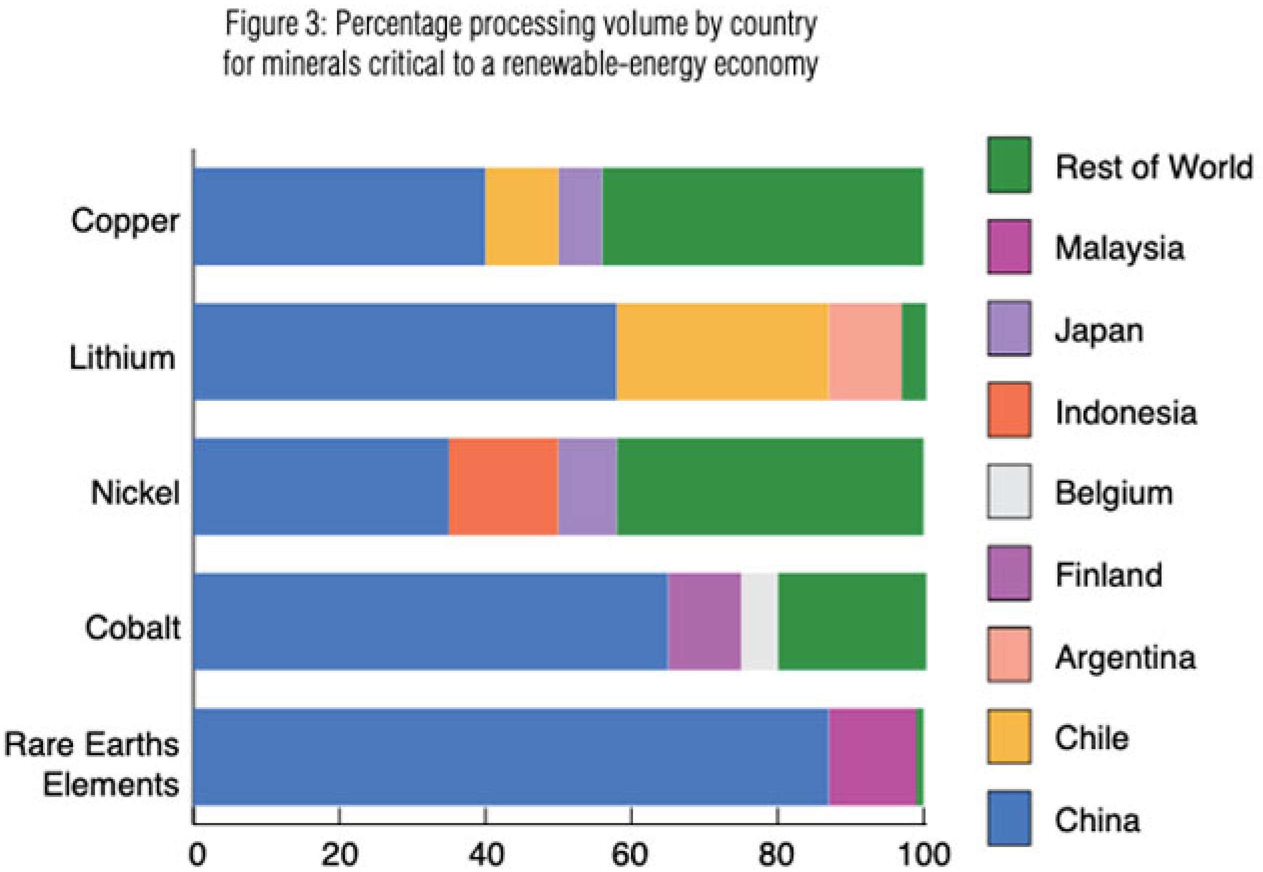


Figure 2: World Producers of Selected Minerals



The Democratic Republic of the Congo (DRC) mines 68 percent of the world's cobalt. As of 2020, Chinese companies own or invest in 15 of 19 Congolese mines, and China supplies about 60 percent of rare-earth elements for the world. Nearly 87 percent of cobalt ore leaving the Congo is refined in China. In addition to providing cobalt for wind-turbine permanent magnets, China also provides almost 90 percent of the cobalt used in manufacturing lithium-ion batteries. Australia, the top miner of lithium, exports most of it to China, which accounts for about 60 percent of the world's lithium refining capacity.

Several of the 35 mineral commodities listed as critical by the Department of the Interior play an important role in the production of solar panels and backup energy storage batteries. The U.S. Geological Survey reports that in 2018 the United States was reliant on foreign sources for 100 percent of the arsenic, gallium, and indium, 75 percent of the tellurium, and half of the germanium used in manufacturing solar panels. Similarly, the United States relies on foreign sources for 61 percent of the cobalt, 50 percent of the lithium, and 100 percent of the graphite used in manufacturing batteries for backup energy storage.

China runs the show in manufacturing, too. Nine of the world's top 10 solar panel manufacturers are Chinese-owned or operated. Our strongest adversary owns the vast majority of the world's solar panel supply chain, controlling about 80 percent of every single key stage of solar photovoltaic panel manufacturing and processing. As of 2020, seven of the world's top 10 wind-turbine manufacturers are Chinese-owned or operated, as well.

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Wind Turbine Issues

There are significant environmental costs associated with mining and refining rare earth elements for wind turbines. Writing for MIT News, D.L. Chandler explains in "Clean Energy Could Lead to Scarce Materials" that approximately one ton of neodymium magnets is needed for each five-megawatt wind turbine.

But that's just the tip of the iceberg. Generating all of America's power currently provided by fossil fuels and nuclear (> 8 billion megawatt hours) with wind energy would require 2.12 million turbines on 500,682 square miles of farm, wildlife habitat, and scenic lands. This area is equivalent to the states of Arizona, California, Nevada, Oregon, and West Virginia combined, according to *Protecting the Environment from the Green New Deal* published in 2019 by The Heartland Institute.

Preparation of land for many wind farms often does extensive environmental damage, including removing trees and bulldozing hills and valleys. Since 2015, from Maine to Hawaii, there have been more than 300 rejections or restrictions of wind projects, wrote Robert Bryce for *Forbes* last year.

Many wind-turbine projects invariably encounter the NIMBY response (not in my backyard) from potential neighbors. Wind turbines generate both audible and inaudible low-frequency noise, which can cause problems such as sleep disturbance and headaches. Wind projects are invariably targeted for low-income counties where opponents don't have as much money to fight back.

Actual electricity output is rarely as advertised, often hitting 20 percent or lower depending on location, according to the Centre for Sustainable Energy — and failing completely on the hottest and coldest days when electricity is most urgently needed. Electricity output declines by 16 percent per decade of operation — and worse than that offshore, because of storms and salt spray — warns the Renewable Energy Foundation. Whereas onshore turbines last roughly 20 years, their offshore cousins can only survive about 10 years, states *Environment & Climate News*.

Solar-panel Issues

A future with solar is even less bright. Replacing our energy needs with solar would require 18.7 billion PV panels on 57,024 square miles of land, equivalent to the states of New York and Vermont combined, explains The Heartland Institute.

Writing for *Sciencing*, David Nguyen explains that solar panels and their manufacturing processes necessitate many toxic chemicals, including lead, cadmium telluride, copper indium selenide, cadmium gallium (di)selenide, copper indium gallium (di)selenide, hexafluoroethane, and polyvinyl fluoride. These processes generate 300 times more toxic waste per unit of energy than nuclear power plants, according to Jemin Desai and Mark Nelson in their 2017 article "Are We Headed for a Solar Waste Crisis?" in *Environmental Progress News*.

Robert Monroe of the University of California at San Diego pointed out in "Potent Greenhouse Gas More Prevalent in Atmosphere than Previously Assumed" that the United Nations' Intergovernmental Panel on Climate Change (IPCC) deems toxic nitrogen trifluoride (NF3), used in some solar panel construction, more than 17,000 times more potent than carbon dioxide as a greenhouse gas.

Solar panels last about 25 years, according to the *Journal of Energy Research and Reviews*, but high temperatures can accelerate the aging process for solar cells. Snow, dust, and other natural events can cause material fatigue on the surface and in internal electric circuits, gradually reducing a panel's power output.

The International Renewable Energy Agency estimates that by 2050, up to 78 million tons of solar panels will have reached the end of their life and the world will create another six million tons of photovoltaic waste every year. Disposal of solar panels in landfills is not appropriate, as they contain toxic materials, and the cost of recycled materials is significantly more than raw material cost. Currently, U.S. solar-panel manufacturers are not even required to, and do not, collect and dispose of solar-panel manufacturing toxic waste.

Battery Issues

Battery energy storage issues have yet to be seriously addressed. There is an almost complete disconnect between current efforts of small research grants and pilot programs to investigate which of various new energy-storage technologies might work in a 100-percent renewables scenario. Furthermore, technology is not yet invented, let alone demonstrated at scale, to accomplish the multi-hundred-trillion-dollar total transformation of the entire energy economy that will supposedly be accomplished by 2035, reads a 2022 "Report on the Status of the U.S. Energy Storage Project" by Francis Menton.

Backup batteries are generally proposed as the solution to the intermittency problem of solar and wind energy. Batteries are not electricity generators, they must be recharged constantly, and the mechanism for charging them is the very solar and wind generators whose intermittency causes the energy deficiency in the first place. The off-grid system must be designed to provide a charge current capable of recharging batteries quickly and efficiently, and within the window of time the on-grid system is generating peak power. Battery energy storage systems generally can't sustain output for more than several hours, at best.

Backup battery storage requirements for the electricity demands of the entire United States would be absolutely staggering. Issues currently ignored by net-zero proponents include:

• How many batteries would be required to provide adequate backup electricity to the "green" grid when parts of the United States experience extended wind and sun deficits?

• Do sufficient raw materials exist?

• How would we dispose of huge amounts of toxic waste from battery manufacturing?

Lithium batteries contain both oxidizers and fuel within the enclosed battery space, and therefore carry risk of fire and explosion in case of overcharging, over-discharging, excess current, or short circuits. Currently there is no single standard or parameter for assessing battery safety and no fire-prevention system design standards or test criteria for battery energy storage systems.

The February 2020 issue of *Environment & Climate News* reports that, at the scale necessary to supplement on-demand "renewable" generated electricity, the cost of backup battery storage systems makes anything even close to 100-percent renewables economically impossible.

The obvious rational conclusion is that solar, wind, and energy-storage technologies cannot fulfill net-zero hopes of a rapid and wholesale replacement of fossil fuels. The idea ignores the underlying physics, engineering, and economics. The only serious discussion with respect to replacing fossil fuels is nuclear energy. A 100-percent renewables economy is not even remotely possible.