wind speed, so when the speed doubles, the energy output increases by a factor of eight. The largest individual onshore wind turbines now exceed 5 MW capacity and reach a quarter kilometer high at their tips.[761] The wind blows faster at higher elevations, creating an incentive to make the turbines as big as practicable in these areas. ~~,~~

Wind energy has experienced substantial cost reduction and robust growth over the past few decades. W~~Indeed, w~~ind scientists and engineers believe that with continued optimization and integration it could ultimately provide as much as half of the world's electricity needs.[762] This underlines the central importance of energy storage technologies. Like solar power, wind energy is not dispatchable and has a low capacity factor (Tables 1 and 2).

Some wind development happens ~~is~~ on a small scale, involving a single unit that provides energy to a farm or other facility, b~~. B~~ut most new wind power for the electricity grid will ~~continue to~~ be developed at large facilities called wind farms. The largest US wind farm, the Alta Wind Energy Center in California, has 600 units spread over 3,200 acres, with a total capacity of 1.55 GW. ~~However~~Unfortunately, most~~uch~~ of the US wind resource is concentrated in the central part of the country (Figure 5), namely ~~,~~ Texas, Iowa, ~~and~~ Oklahoma, and ~~all lead~~ California ~~in total wind power capacity~~.[763]

The major concerns about wind power are its effects on wildlife—especially bats and birds—and its land-use impacts, including aesthetics. To address these issues, new wind farms can be ~~located~~ built away from key migration routes, and the turbines can be colored and otherwise designed to minimize interference.[764] New wind farms can also be set up as dual-use land that is compatible with grazing, crop agriculture, and ~~some~~ recreation. A wind farm with turbines reaching eighty meters high, for example, must space individual units at least a third of a mile apart.

Leasing land for wind farms can provide supplemental income for rural landowners, and their operation offers new employment opportunities for ~~the~~ local communities. Effective governance of wind farms is gaining ~~in~~ importance as the industry expands, with a central issue being the balance of decision-making power between local and state authorities.[765]

Wind farms can also be located offshore, where turbines ~~can~~ either float or are~~be~~ anchored to the

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[761] Shaun Campbell, *Clash of the T~~t~~itans – T~~t~~op 5 B~~b~~iggest O~~o~~nshore T~~t~~urbines*, Wind Power Monthly, 2 August 2019, https://www.windpowermonthly.com/article/1592000/clash-titans-top-5-biggest-onshore-turbines

[762] P. Veers et al., *Grand C~~c~~hallenges in the S~~s~~cience of W~~w~~ind E~~e~~nergy*, Science 10.1126/science.aau2027 (2019), https://science.sciencemag.org/content/sci/early/2019/10/09/science.aau2027.full.pdf

[763] National Renewable Energy Laboratory, https://www.nrel.gov/gis/wind.html

[764] Russelll McClendon, *6 W~~w~~ays to P~~p~~rotect B~~b~~ats and B~~b~~irds from W~~w~~ind T~~t~~urbines*, Mother Nature Network, October 22, 2019, https://www.mnn.com/earth-matters/energy/blogs/6-ways-to-protect-bats-and-birds-from-wind-turbines

[765] Jeffrey Tomich, *End of Iowa's W~~w~~ind B~~b~~oom? Renewable R~~r~~ules S~~s~~park F~~f~~ears*. E&E News, July 8, 2020, https://www.eenews.net/stories/1063523833

Rachel Howe
I would consider switching these sentences. Start with "Like solar power..." and follow it with "This underlines..."

Rachel Howe
I'm not sure if this statement really contributes much to the conversation. It seems very out of place and unrelated to the conversation at hand. I would consider deleting it.

feasibility, and ~~probably~~ substantial public subsidies are required to ~~get operations going.~~start operations. The fracking ~~part~~ aspect of EGS also carries the same hazards inherent to ~~in~~ oil and gas, including the possibility of induc~~ing~~ed earthquakes and contaminating~~ion of~~ groundwater. Despite these challenges, the technology is worth exploring because, if it is successful, it could provide a reliable, carbon-free complement to solar and wind power, ultimately decreasing the need for both energy storage and the dedication of large amounts of land.[786]

The N~~n~~uclear O~~o~~ption

The nuclear power industry relies on *nuclear fission*, in which a radioactive form of uranium, U-235, is bombarded by a subatomic particle called a neutron. The nucleus of the uranium atom splits into smaller pieces, generating more neutrons to create a chain reaction; t~~.~~ ~~T~~his releases a great deal of energy that can be used to make steam for electricity generation. The chain reaction is kept in check with control rods made of materials that capture neutrons, and the whole reactor core is bathed in water, which moderates the reaction and carries away excess heat. These are the most important components of *pressurized light water reactors*, which make up two-thirds of the ~~95~~ ninety-five nuclear reactors currently operating ~~today~~ in the US. The remaining third of the US nuclear fleet consists of *boiling water reactors*, which differ in how ~~how~~ the subsystems for making steam are designed.[787]

Nuclear power is carbon-free, but it is not renewable because it relies on mining finite stores of uranium ore. The US reserves for uranium ore are small, so about 90 percent is imported from ~~Australia, Canada, Kazakhstan, Russia, and~~ other countries like Australia, Canada, Kazakhstan, and Russia.[788] At the 2018 rate of consumption, the world uranium resource would run out in about 115 years—but, like fossil fuels, more is always being discovered.[789] After it is mined, uranium ore is milled into a more concentrated form ~~,~~and then processed into a gas called uranium hexafluoride. At this point, it is modestly enriched to a level of 3–5 percent into the fissionable U-235 isotope.[790] ~~because most naturally occurring uranium does not undergo fission. Finally, the~~The enriched uranium

Rachel Howe
Can you be more specific with what you are referring to here?

Rachel Howe
@Emma I couldn't get a definitive answer on percentages for CMOS, so I left them as is.

Rachel Howe
I feel like this statement doesn't really fit in with what we are talking about in the paragraph. I would consider deleting it.

Rachel Howe
@Emma I couldn't get a definitive answer on percentages for CMOS, so I left them as is.

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[786] For an optimistic take on the technology, see David Roberts, *Geothermal E~~e~~nergy I~~i~~s P~~p~~oised for a B~~b~~ig B~~b~~reakout*, Vox, Oct. 21, 2020, https://www.vox.com/energy-and-environment/2020/10/21/21515461/renewable-energy-geothermal-egs-ags-supercritical

[787] For basic information on nuclear fission, see World Nuclear Association, *How D~~d~~oes A~~a~~ N~~n~~uclear R~~r~~eactor W~~w~~ork?* https://www.world-nuclear.org/nuclear-essentials/how-does-a-nuclear-reactor-work.aspx
For information on types of nuclear reactors, see World Nuclear Association, *Nuclear Power Reactors*, April, 2020, https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/nuclear-power-reactors.aspx

[788] US Energy Information Administration, Nuclear explained, *Where O~~o~~ur U~~u~~ranium C~~e~~omes F~~f~~rom*, https://www.eia.gov/energyexplained/nuclear/where-our-uranium-comes-from.php

[789] World Nuclear Association, *Supply of U~~u~~ranium*, May 2020, https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/uranium-resources/supply-of-uranium.aspx

[790] For a brief description of isotopes, see Box 1 in Chapter 3.

to the release of methane as well as carbon dioxide ~~release~~. ~~Attention to reducing~~Reducing the inflows~~s~~ of nutrients that promote microbial growth can help limit this.[776]

The Department of Energy (DOE) has a vision to increase US hydropower capacity by 50 percent from its current level.[777] While some of this could come from adding new generation at non-powered dams, it is more ~~is~~ likely to come from *pumped storage*. In this technology, water stored in a lower reservoir is pumped to the top of the dam where it is held and then released to generate electricity according to demand (Figure 6).[778] This makes *pumped hydro* a fully dispatchable resource, while the main generation is subject to seasonal variations in river flow that can limit the ability to provide power on demand. Because it takes electrical energy to pump the water uphill, pumped hydro decreases the net power output of~~at~~ an electricity-generating dam,[779] but the gain in storage capacity makes this worthwhile.

P~~New p~~umped hydro facilities can also be constructed at locations without dams; t~~. T~~hese are called closed-loop systems.[780] Because there is no on-site electricity generation to pump water to the elevated reservoir, the idea is that this ~~such~~ pumping would be done ~~when~~ at times of low demand that coincide with an excess of renewable power. As the grid becomes more carbon-free, concerns about using fossil fuel generation to create pumped hydro storage capacity will diminish.

Geothermal P~~p~~ower

Geothermal power relies on heat that emanates from Earth's molten core and from naturally occurring radioactive elements like uranium, thorium, and potassium, which are present in rocks at low abundance. This underground heat visibly breaks through to the surface at hot springs, geysers, and volcanoes, but is present everywhere.

The temperature of the underground geothermal resource determines what it can be used for. Lower-temperature resources below 150ºC are widespread ~~in~~ throughout the US and are suitable for heating and some industrial applications like steam generation. Heating is often accomplished with geothermal heat pumps. In these ~~system~~systems, which are ~~s~~—often used in smaller settings like home~~s~~, school~~s~~, ~~or~~ and commercial- environments, ~~settings~~—a closed loop extends underground and

Rachel Howe
@Emma I couldn't get a definitive answer on percentages for CMOS, so I left them as is.

Rachel Howe
What is meant by this term? Are you referring to the current method of hydropower?

Rachel Howe
Are you referring to heating things like homes and buildings, or heating devices? I would be specific here, if possible.

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[776] Energy Education, *Water Q~~q~~uality D~~d~~egradation from H~~h~~ydropower*, https://energyeducation.ca/encyclopedia/Water_quality_degradation_from_hydropower

[777] US Department of Energy, *Hydropower Vision*, Executive Summary, https://www.energy.gov/eere/water/articles/hydropower-vision-new-chapter-america-s-1st-renewable-electricity-source

[778] University of Calgary, Energy Education, *Pumped -S~~s~~torage*, https://energyeducation.ca/encyclopedia/Pumped_storage

[779] US Energy Information Administration, *Hydropower E~~e~~xplained*, https://www.eia.gov/energyexplained/hydropower/where-hydropower-is-generated.php

[780] National Hydropower Association, *2018 P~~p~~umped -S~~s~~torage R~~r~~eport*, https://www.hydro.org/wp-content/uploads/2018/04/2018-NHA-Pumped-Storage-Report.pdf