Name:

Name: Iris & Kathi

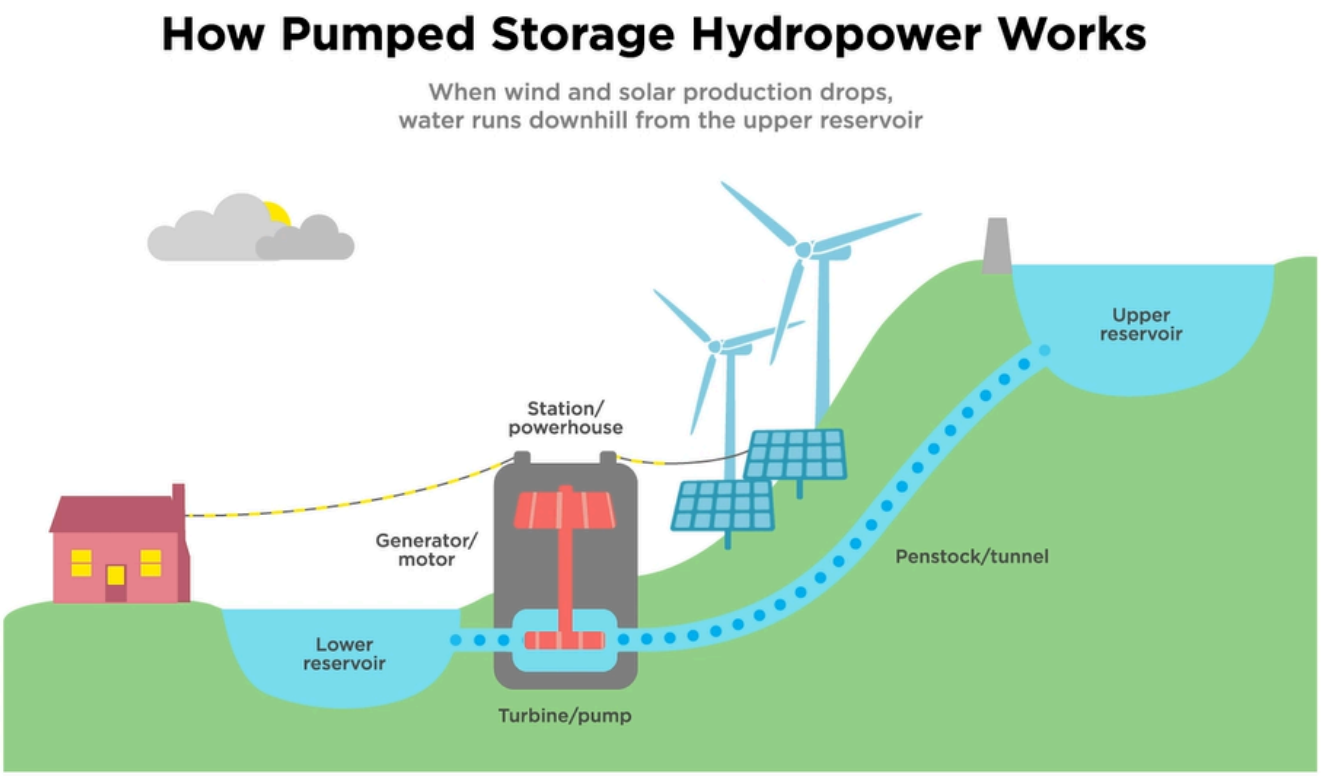
Question:How to store clean energy (excluding batteries)?

Clean energy is more difficult to store than fossil energy and is mostly used as it is produced. The energy of solar, wind, etc has to be changed into a different type of energy to be able to store.

Pumped Hydro Energy storage

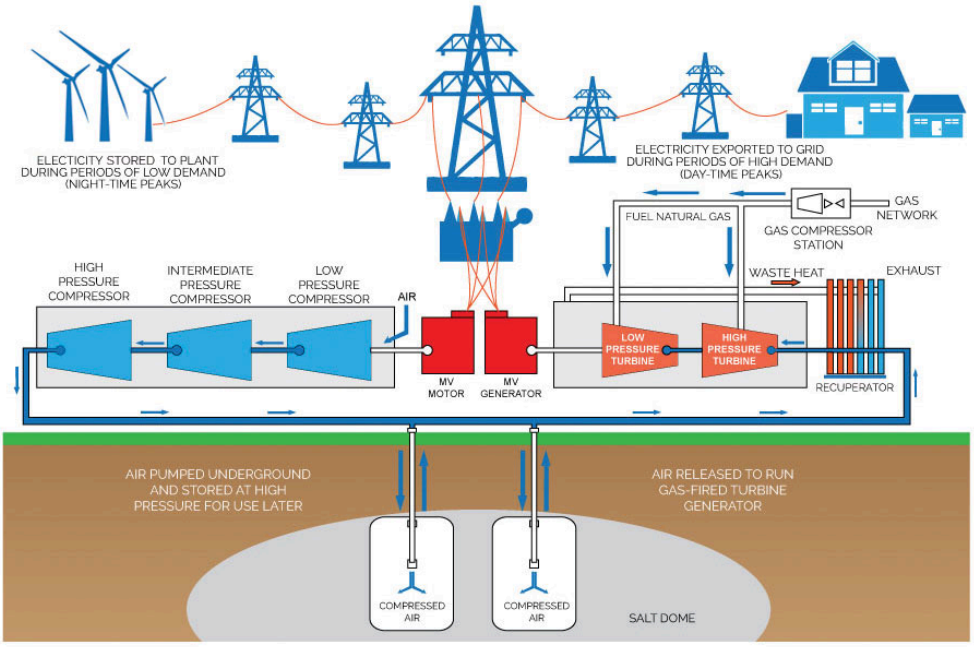
- Excess energy is used to pump water from a lower altitude to a higher
- When energy is needed the energy will be reproduced by making the water flow back down
- Turbines generate the energy
- Efficiency: 75%-85% (slight loss)
    - 10 hours of electricity (lithium-ion batteries 6 hours)
- Cost: cheapest to exist in terms of energy production
    - To produce: $106-$200 per kilowatt-hour (lithium-ion batteries $393-$581)
- Problems: Water and height difference needed as well a a lot of terrestrial space
- Countries mostly dependent on ex-import of energy. If one (Germany) produces more in solar/wind energy (Switzerland) has a lower demand for pumped hydro as it gets most energy from (France) nuclear power
- Changes needed: developing policy, market framework and maintaining environmental sustainability standards

Hydropower-storage.mp4 How Pumped Hydro Energy Storage Works



https://www.greentechmedia.com/articles/read/pumped-hydro-moves-to-retain-storage-market-leadership
https://www.livescience.com/renewable-energy-storage

Compressed Air Energy Storage



SINO VOLTAICS

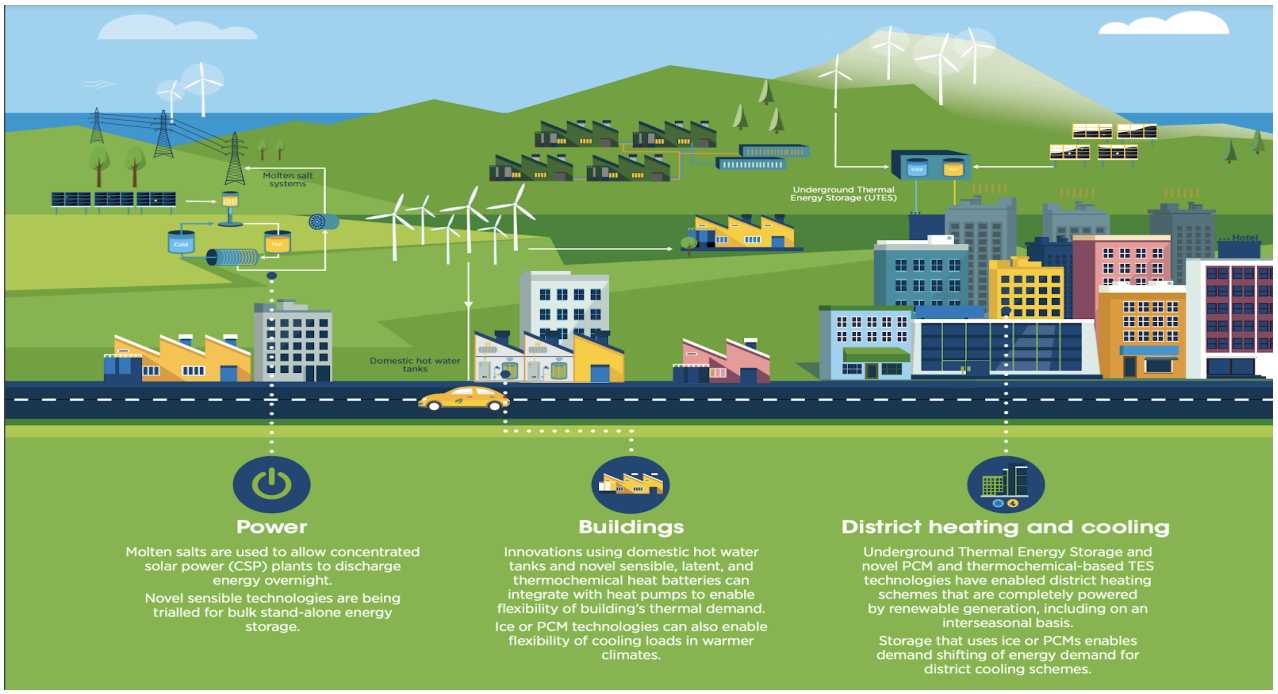
Compressed Air Energy Storage (CAES)

Thermal energy storage

Thermal energy storage is used particularly in buildings and industrial processes. It involves storing excess energy – typically surplus energy from renewable sources, or waste heat – to be used later for heating, cooling or power generation.

Liquids – such as water – or solid material - such as sand or rocks - can store thermal energy. Chemical reactions or changes in materials can also be used to store and release thermal energy.Water tanks in buildings are simple examples of thermal energy storage systems.

In its 2020 Innovation Outlook: Thermal Energy Storage update, the International Renewable Energy Agency predicts the global market for thermal energy storage could triple in size by 2030, from 234 gigawatt hours (GWh) of installed capacity in 2019 to more than 800 GWh.

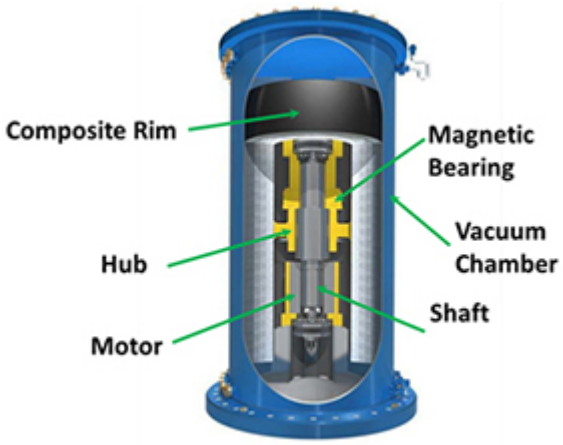


Mechanical energy storage

Mechanical energy storage harnesses motion or gravity to store electricity.

For example, **A flywheel** is a rotating mechanical device that is used to store rotational energy that can be called up instantaneously. At the most basic level, a flywheel contains a spinning mass in its center that is driven by a motor – and when energy is needed, the spinning force drives a device similar to a turbine to produce electricity, slowing the rate of rotation. A flywheel is recharged by using the motor to increase its rotational speed once again.
Flywheel technology has many beneficial properties that enable us to improve our current electric grid. A flywheel is able to capture energy from intermittent energy sources over time, and deliver a continuous supply of uninterrupted power to the grid. Flywheels also are able to respond to grid signals instantly, delivering frequency regulation and electricity quality improvements.

Flywheels are traditionally made of steel and rotate on conventional bearings; these are generally limited to a revolution rate of a few thousand RPM. More advanced flywheel designs are made of carbon fiber materials, stored in vacuums to reduce drag, and employ magnetic levitation instead of conventional bearings, enabling them to revolve at speeds up to 60,000 RPM.



Source: Beacon Power, LLC

flywheel_1.jpg
https://energystorage.org/why-energy-storage/technologies/mechanical-energy-storage/

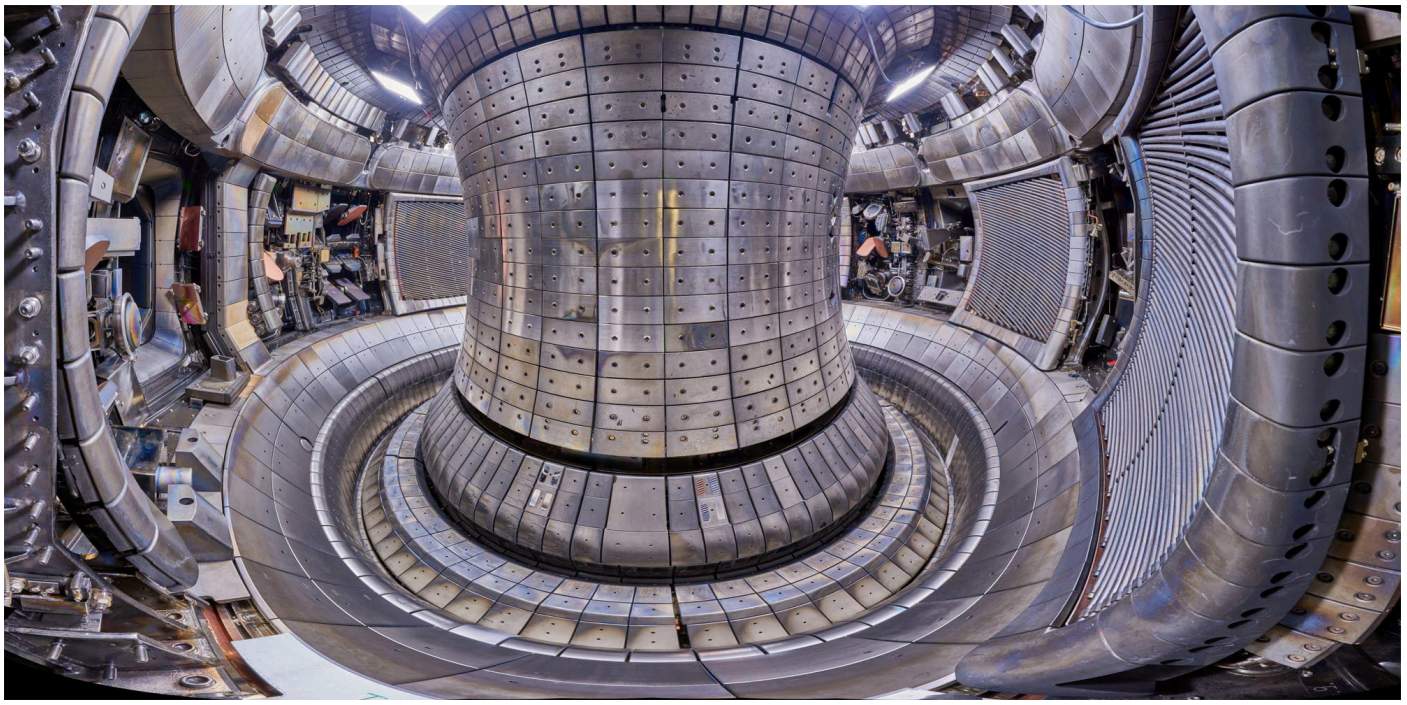
https://www.weforum.org/agenda/2021/04/renewable-energy-storage-pumped-batteries-thermal-mechanical/ **How can we store renewable energy?**

Name: Youngjun Jeong, Zach

UK selects site for prototype fusion energy plant, says it will replace coal-fired facility

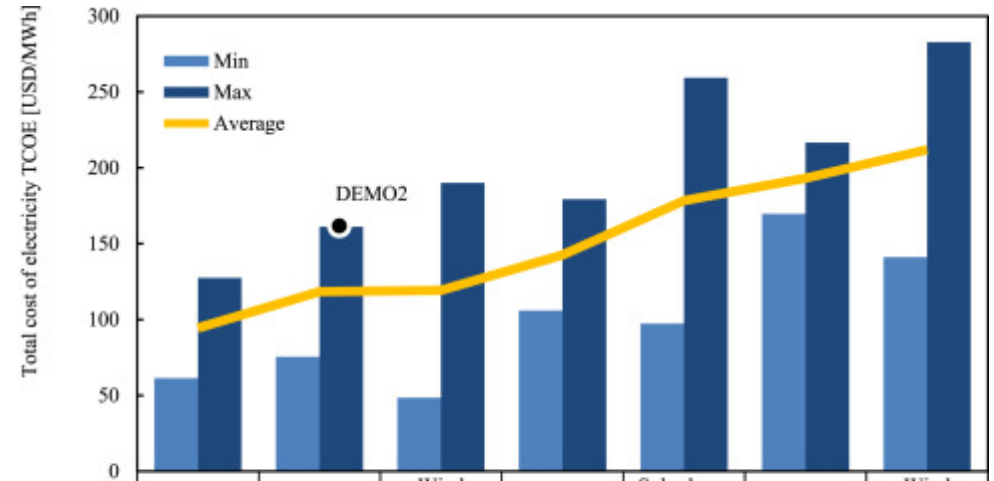
How long is it possible to maintain operation nowadays?

How long will it take to achieve successful fusion energy?
https://www.bbc.com/news/science-environment-60312633 ‘
https://www.ief.org/news/how-close-are-we-to-unlocking-the-limitless-energy-of-nuclear-fusion
https://www.sandiegouniontribune.com/business/story/2022-11-04/san-diego-based-general-atomics-plans-to-roll-out-a-nuclear-fusion-pilot-plant



Safety issue of fusion energy
https://www.euro-fusion.org/faq/top-twenty-faq/since-plasma-is-a-super-heated-substance-will-it-cause-the-burning-of-the-reactor/

Cost
https://world-nuclear.org/information-library/current-and-future-generation/nuclear-fusion-power.aspx
2017 - 20 billion $, 2021 - 6 billion $
https://energydigital.com/renewable-energy/fusion-energy-four-times-cheaper-nuclear



	Nuclear	Fusion	Wind onshore	Natural gas	Solar large PV	Coal	Wind offshore
Min	61	76	49	106	97	170	141
Max	127	161	190	179	259	217	283
Average	94	118	119	143	178	193	212

If it’s successfully developed, would it be the utopia or dystopia humanity will face?

Name: Seok Jun, Jane, and Jin Beom

Question:

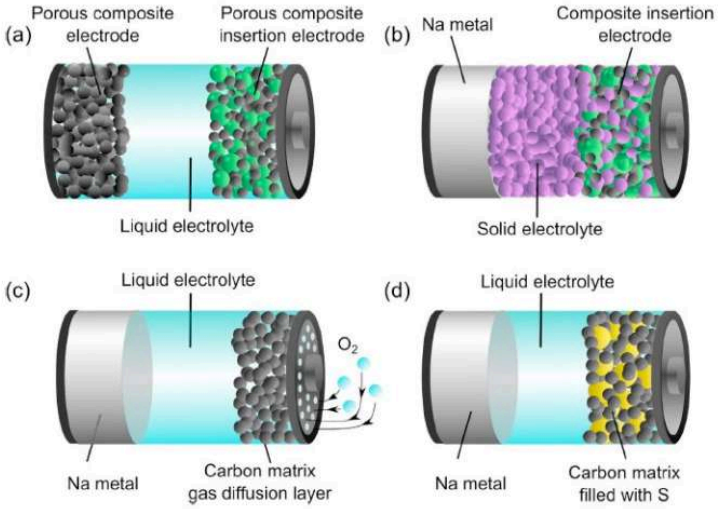
1. How can salt be an alternative to lithium-cobalt batteries? (Alternatives to current commercialized batteries)

Notes:

https://electrek.co/2022/07/14/sodium-ion-battery-breakthrough/

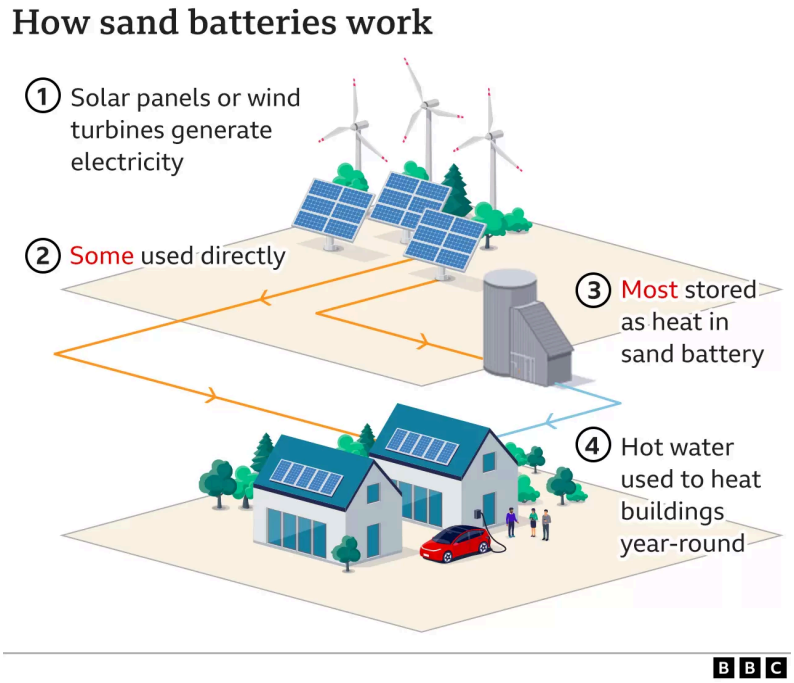
- They’re energy dense, nonflammable, and operate well in colder temperatures, and sodium is cheap and abundant. Plus, sodium-based batteries will be more environmentally friendly and even less expensive than lithium-ion batteries are becoming now. Sodium-ion battery performance has been limited because of poor durability, but this is about to change for the better.
- Lithium is a limited resource that is currently running out. On the other hand, sodium is currently abundant.

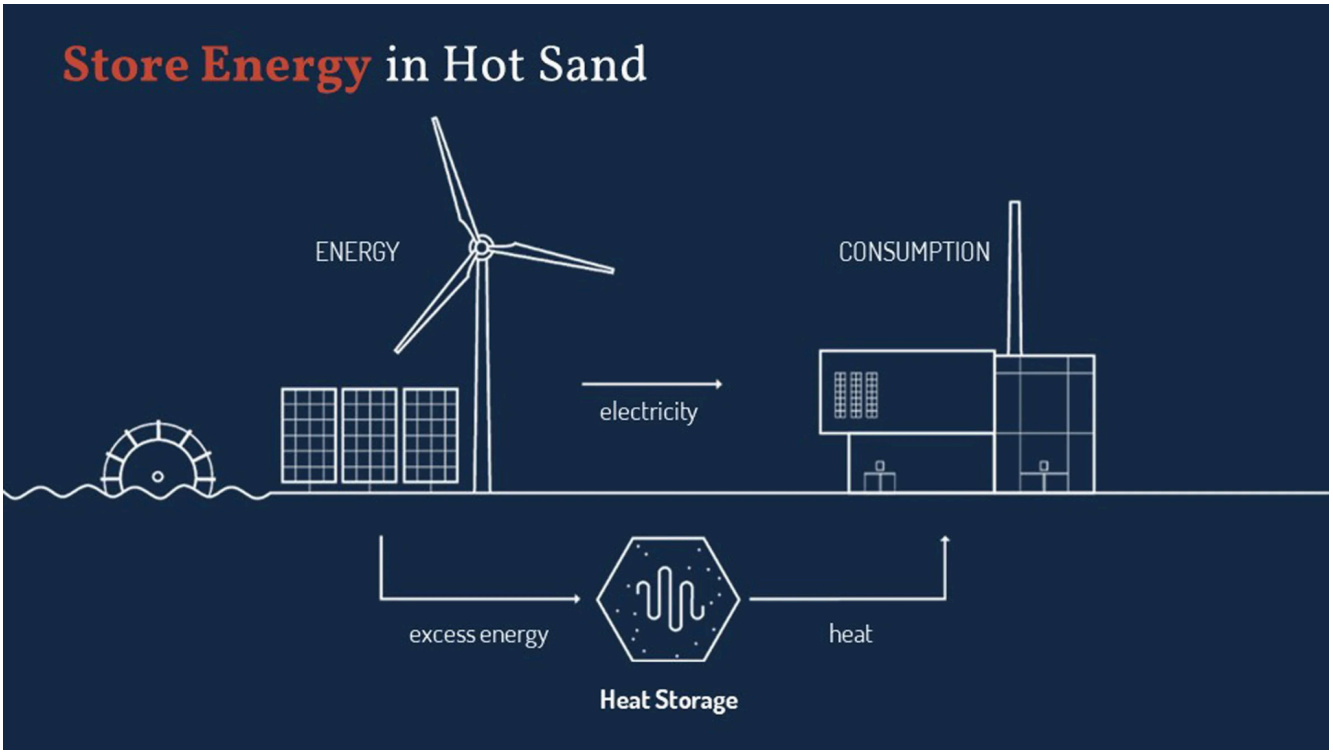
https://techxplore.com/news/2020-09-sodium-ion-batteries-valid-alternative-lithium-ion.html



- NIB (Na-ion batteries) have great potential to represent in the next generation due to the low cost and eco-friendly characteristics.
- As LIB (Lithium-ion batteries) are currently mass produced, there are environmental and social challenges that are associated.
- As Li-based systems, Na-based batteries come in different forms, such as Na-ion(A), Na-all-solid-state-batteries (B), NaO2 (C) and Na/S (D). While the last ones are seen as disruptive future technologies, the Na-ion technology represent an attractive technology almost ready to challenge the Li-ion batteries in specific applications.

https://www.bbc.com/news/science-environment-61996520





- Solar and wind energy can be stored for a long term source of energy.
- The sand stores the heat at around 500 degree C which can then warm homes in the winter when energy is more expensive.
- Current batteries are mostly made out of Lithium based which are expensive and with limited excess power. However, sand batteries are low cost and eco-friendly.
- This technology was invented by scientists in Finland since most of their fuel comes from Russia. However, the war led to a lack of fuel for the economy which made it harder for them to go through this year's cold winter.

https://www.euronews.com/green/2022/02/10/batteries-made-from-trees-could-help-transform-the-future-of-electric-travel

- Finnish scientists designed a way to turn trees into batteries.
- lignin is nature's second most common macromolecule after cellulose, deposited in the cell wall of plants to make their structure firm and woody to prevent them from rotting. It makes up around a third of all **wood's total composition**
- Lignin is separated from wood during the production of cellulose fibers from its pulp. It's then refined into a lightweight carbon powder which is made into electrode sheets and combined with other **battery components** in order to replace graphite which is a major anode for lithium based batteries.

https://insideclimatenews.org/news/16012018/csp-concentrated-solar-molten-salt-storage-24-hour-renewable-energy-crescent-dunes-nevada/

- Sunlight heats salt to 1,050 degrees Fahrenheit, then the salt gets stored in the giant insulated tank. It will create steam to run turbine.
-

What batteries are available now?

https://dragonflyenergy.com/types-of-lithium-batteries-guide/

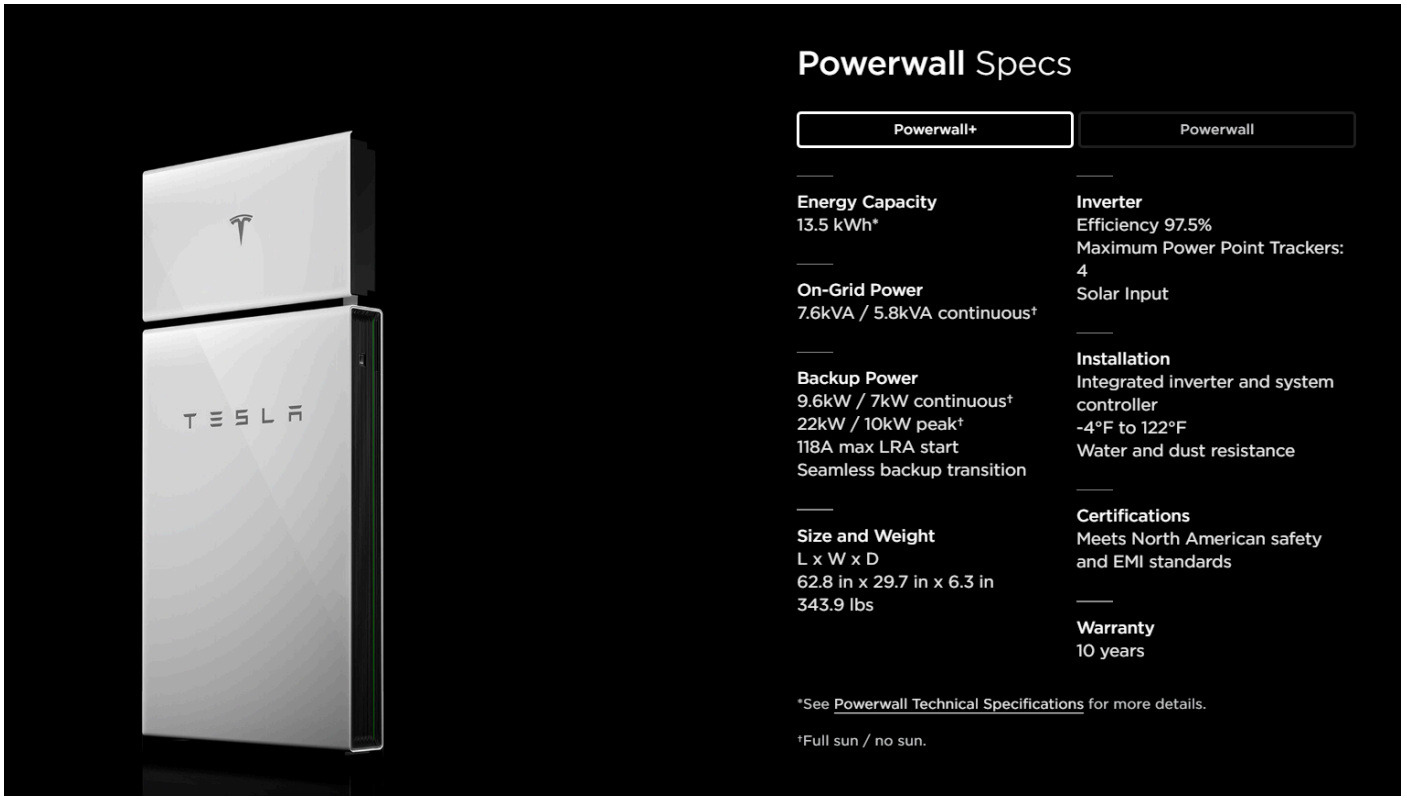
- Lithium batteries are commonly used in electronics such as cell phones, laptops, computers and electric vehicles. Lithium batteries use lithium ions to store energy by creating potential difference between the negative and positive poles of the battery. But not all of the devices use the same type of lithium batteries. To be more specific, there are six types of lithium batteries.
- 1. Lithium Iron Phosphate: Have long life cycle and good thermal stability.
- 2. Lithium Cobalt Oxide: Common is small electronic devices such as laptops, phones, tablets. Can deliver power over a long period of time.
- 3. Lithium Manganese Oxide: creates 3D structure that improves flow, lowers internal resistance. Used in medical instruments,
- 4. Lithium Nickel Manganese Cobalt Oxide: Nickel on its own has high specific energy but is not stable. Manganese is stable but has low specific energy. Combination of these two can produce stable energy with high specific energy. They are used for power plant in e-bike, electric vehicles, and scooters.
- 5. Lithium Nickel Cobalt Aluminium Oxide: Can deliver high energy for a long period. Popular in the electric vehicle market. Tesla uses it.
- 6. Lithium Titanate: Safe battery with long lifespan that can be charged faster. Used in electric vehicles, wind energy storage, aerospace and military equipment.

https://futurism.com/ikea-launches-solar-panels-and-home-battery-packs-in-the-uk

- Ikea is developing home battery packs in the UK for energy storage through solar panels.

https://www.tesla.com/powerwall

- Charge your Powerwall during the day through solar panels and then use it at any time of the day. Eve through a black out or power shortage. Manage power usage through an app. You can “stack” Powerwalls to use more than one at a time for a each house.



https://www.saftbatteries.com/media-resources/our-stories/three-battery-technologies-could-power-future

Name: Wesley & Khanh

Question: how to reduce costs in solar panel production/ where are we at now

Solar panel cost - https://www.nerdwallet.com/article/finance/solar-panel-cost

- On average, solar panel installation and the system together can run from $15,000 to $25,000, according to tfhe latest information from the Center for Sustainable Energy

Reducing solar energy costs - https://www.materialstoday.com/energy/articles/s1369702114003769/

- $0.135/watt -> 20% cost reduction
- Black silicon
    - Alternative to silicon but more efficient properties
    - Fabricated by metal assisted chemical etching (mace)
        - Many methods to fabricate but this method is most exist efficient

Producing solar panels - https://www.greenmatch.co.uk/blog/2014/12/how-are-solar-panels-made

Silicon from sands -> purify, melt and form into ingots -> slice into thin disks called wafer -> solar cells -> solar panels

The cells are expensive to produce because it takes a great deal of energy to purify the silicon.

Making solar panels without silicon wafers - https://www.fastcompany.com/90689702/this-startup-says-it-has-found-a-way-to-cut-the-cost-of-making-solar-cells-in-half

- silicon wafer: expensive to produce, energy intensive, create waste
- the price of silicon jumped from less than $10 per kilogram to $30 per kilogram
- go straight from silicon to finished solar cells -> solar panels -> reduce the cost

korea household average cost is $0.088/watt
https://www.globalpetrolprices.com/South-Korea/j/

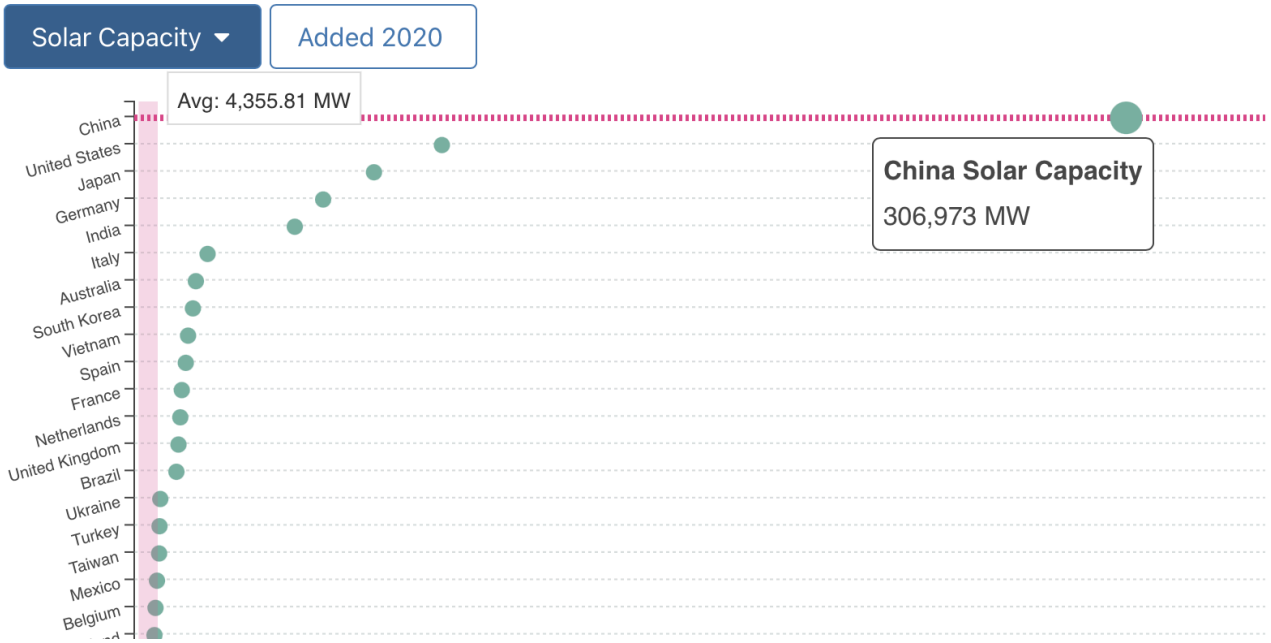
https://www.reuters.com/business/energy/china-solar-installations-more-than-double-first-half-assn-2022-07-21/

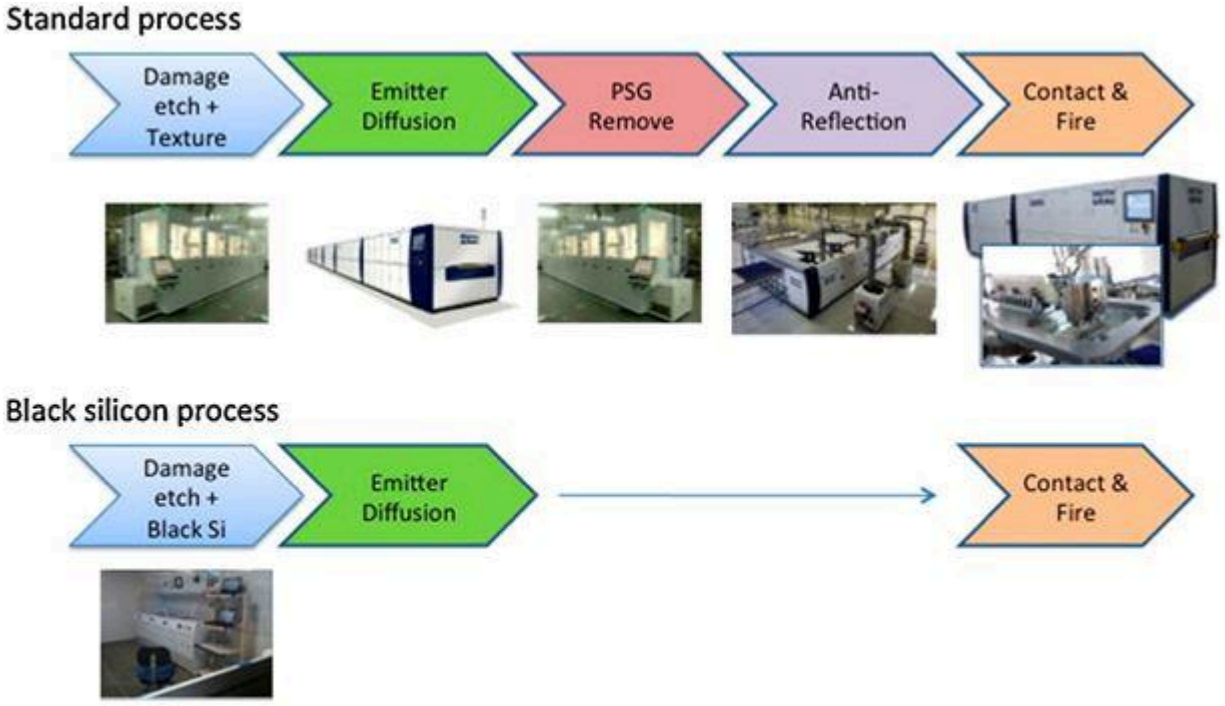
Solar farms set up by private solar developers in china

Leading countries in solar energy - https://worldpopulationreview.com/country-rankings/solar-power-by-country
megawatts

1. China - 306,973
2. United States - 95,209
3. Japan - 74,191
4. Germany - 58,461
5. India - 49,684
6. Italy - 22,698
7. Australia - 19,076
8. South Korea - 18,161
9. Vietnam - 16,660
10. Spain - 15,952

Solar Power by Country 2022





Schematic of the process flow for a traditional SiNx based AR coated Si cell and a b-Si equivalent.

-

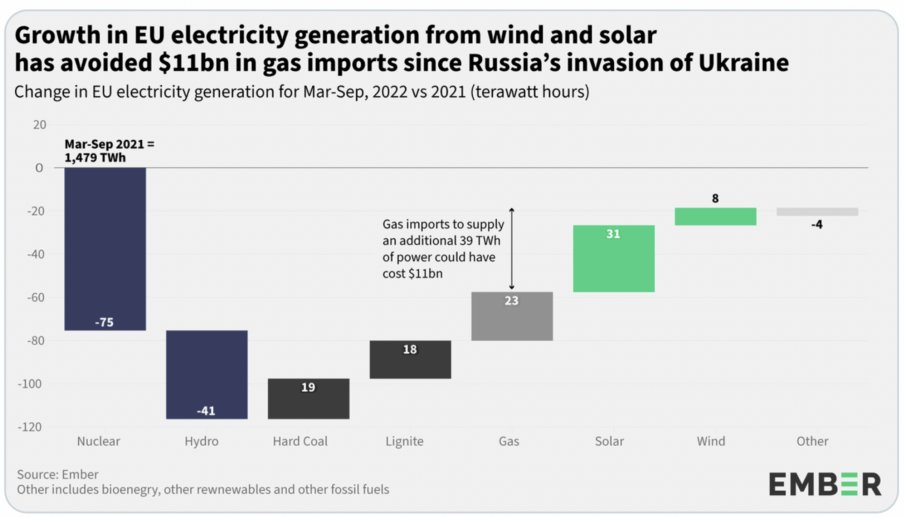
Name: Ye Won & YeEun

Question: How utilizing wind energy would possibly break European country's heavy reliance on gas?

Wind Energy is used by 14% per year.

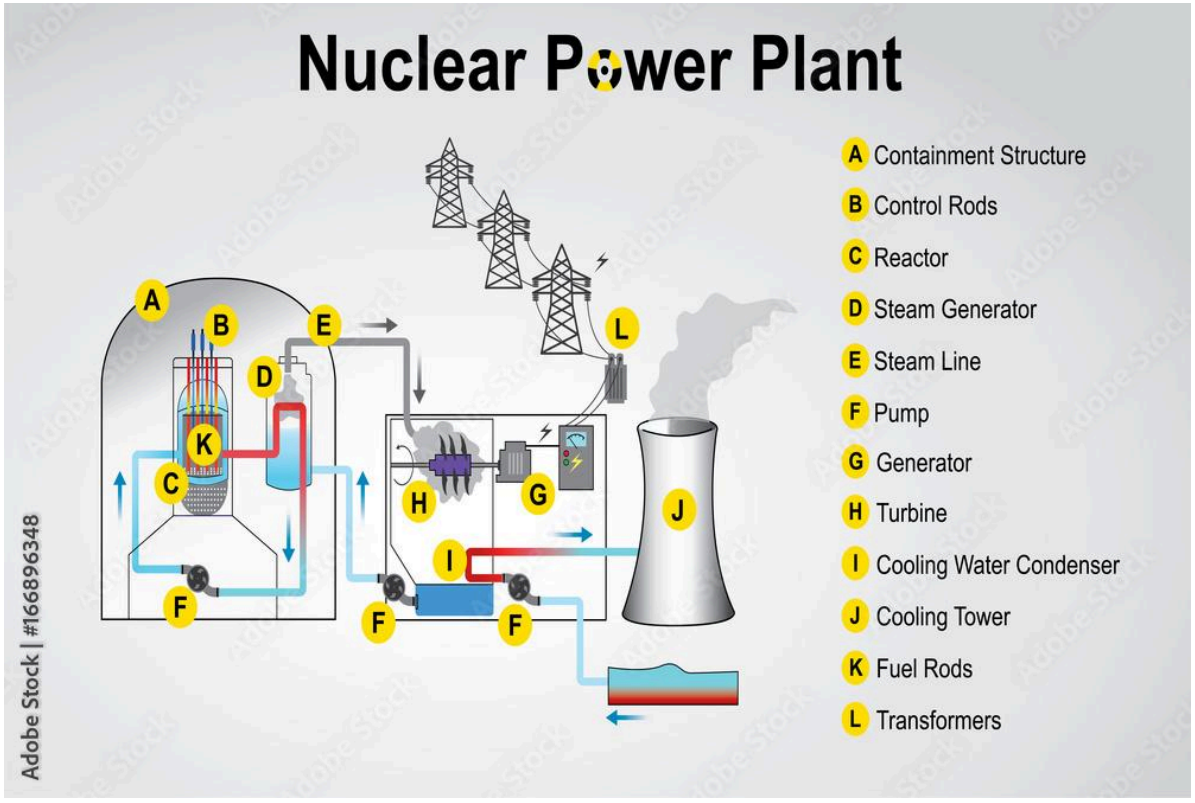
Wind farms in Europe
https://www.euronews.com/green/2022/10/18/ukraine-war-pivot-to-wind-and-solar-power-saved-the-eu-11bn-new-research-shows

A quarter of the EU's electricity was generated by **wind** and **solar** from March to September - its highest-ever level, according to the report. But the bloc still spent an estimated €82 billion on **fossil** gas during this period, which supplied 20% of its electricity.
Wind energy lessened the impact of the Ukraine war by reducing Europe's dependency on high cost gas imports currently fuelling inflation.
Skyrocketing gas prices have fuelled record-breaking inflation this year, sparking a cost of living crisis across Europe and pushing other parts of the world to the brink of **famine**.



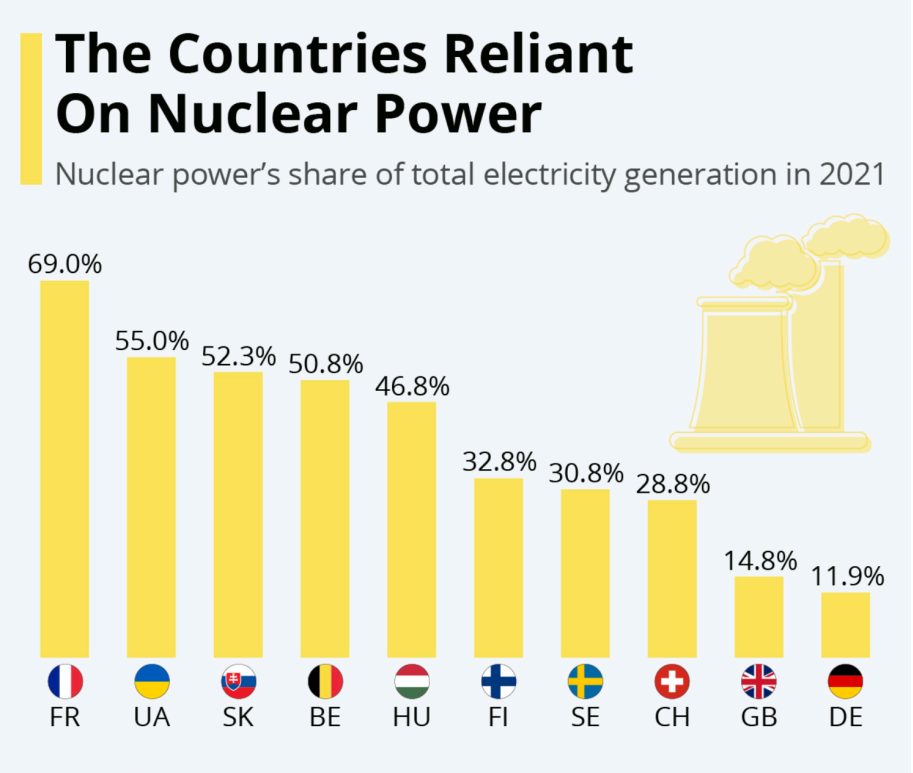
European people agrees in using wind energy
https://www.reuters.com/business/energy/group-eu-countries-agree-boost-offshore-wind-power-capacity-2022-08-30/

Name: Arina & Bia



Which countries are using nuclear energy?

COUNTRY	PERCENT OF TOTAL ELECTRICITY GENERATED BY NUCLEAR IN 2021
France	69.0
Ukraine	55.0
Slovakia	52.3
Belgium	50.8
Hungary	46.8
Slovenia	36.9



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Advantage and disadvantage of using nuclear energy

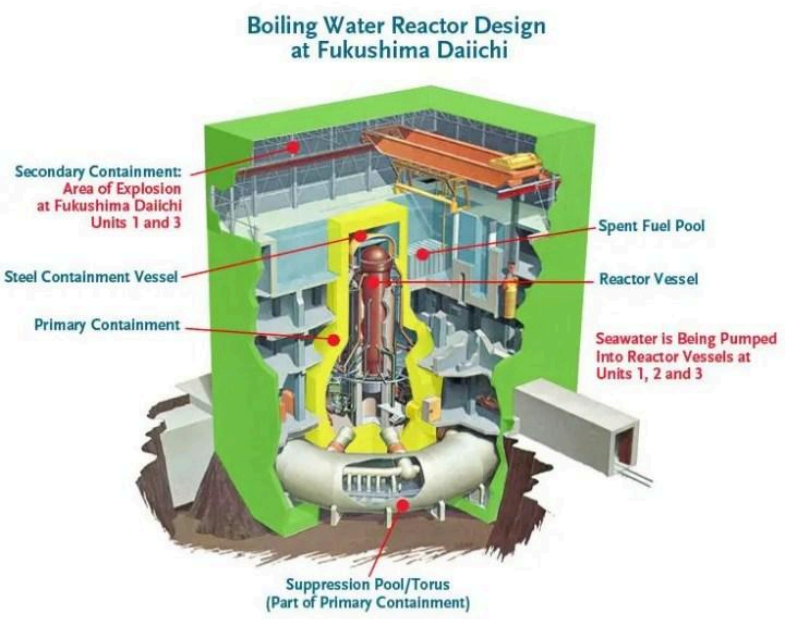
What are the most contentious issues surrounding nuclear energy?

Advantage:

Dangers of nuclear power plant:

Real life accidents

Fukushima:



Cherinobyl: