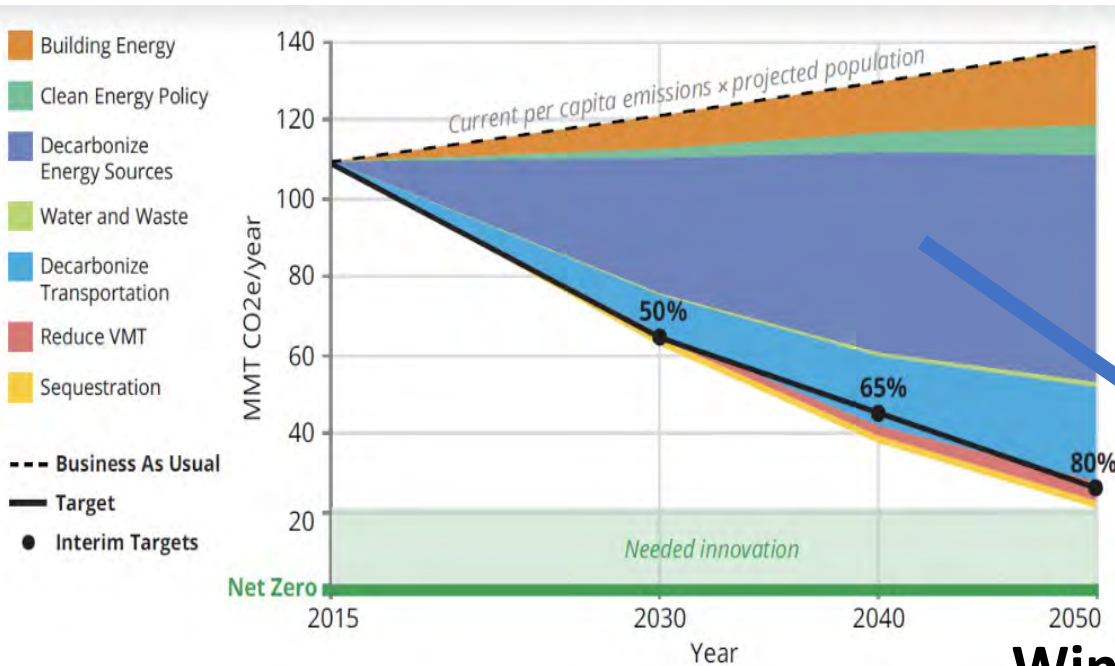


MMC Climate Action Plan adopted by Winnetka & Illinois Climate and Equitable Jobs Act & Illinois Municipal Electrical Agency (IMEA)

MMC CAP targets



CEJA mandates

- All municipal coal fired power to be 100% carbon free by 2045
45% carbon free by **2035**
- All municipal natural gas fired units to reach zero emissions by 2035

Winnetka is a member of and buys power from IMEA

Winnetka's

financial obligations for Prairie State coal power plant cease in **2035**

power plant is under contract to provide peaking power until **2035**

paid by IMEA 1.4 million dollars/yr to stand by to produce peak power

IMEA/Naperville Power Supply Resources

▶ IMEA/Naperville sources of power as of Apr 30, 2021:

Prairie State (Coal)	45%	(15.17% ownership share)
Trimble County (Coal)	23%	(12.12% ownership share)
Vistra (Coal/Market)	21%	(contract ends May 31, 2022)
Wind	10%	
Hydro and Solar	1%	

To replace Vistra, IMEA has entered into agreement for 50 MW of non-carbon emitting generation from Exelon (4 year contract) and 50 MW of solar capacity from Prairie Wolf Solar project (5 year contract).

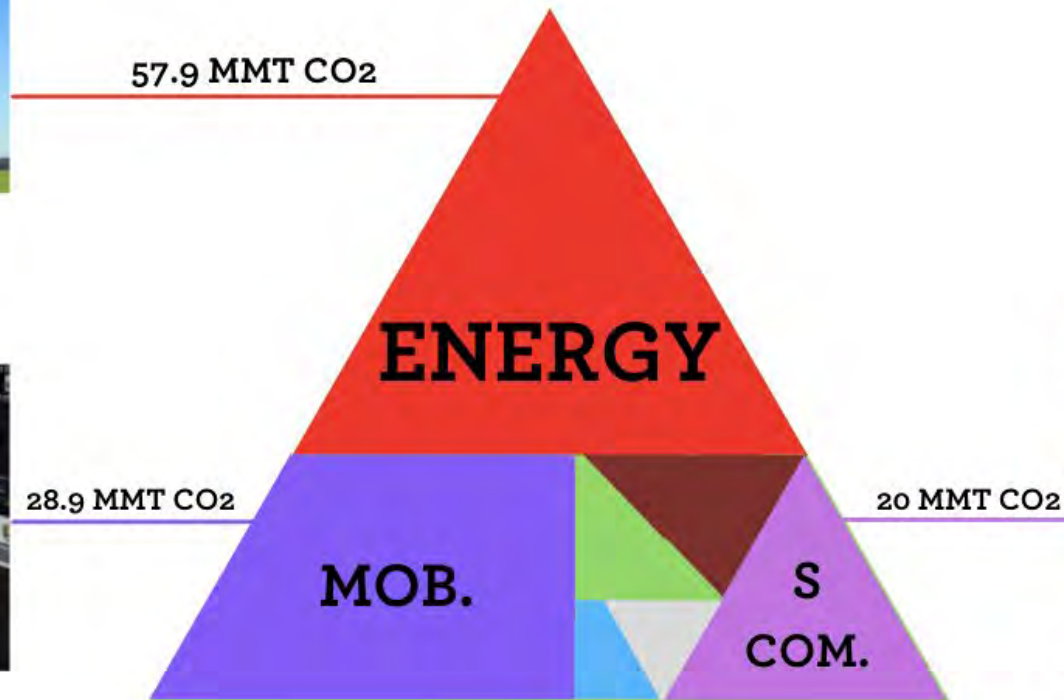
Reprioritized MMC & Winnetka's GRC2 Focus Areas



Decarbonize Energy Sources
Prairie State, Peaking Power



Decarbonize transportation
Bike Paths
Reduce Vehicular Miles Traveled



LEED Homes

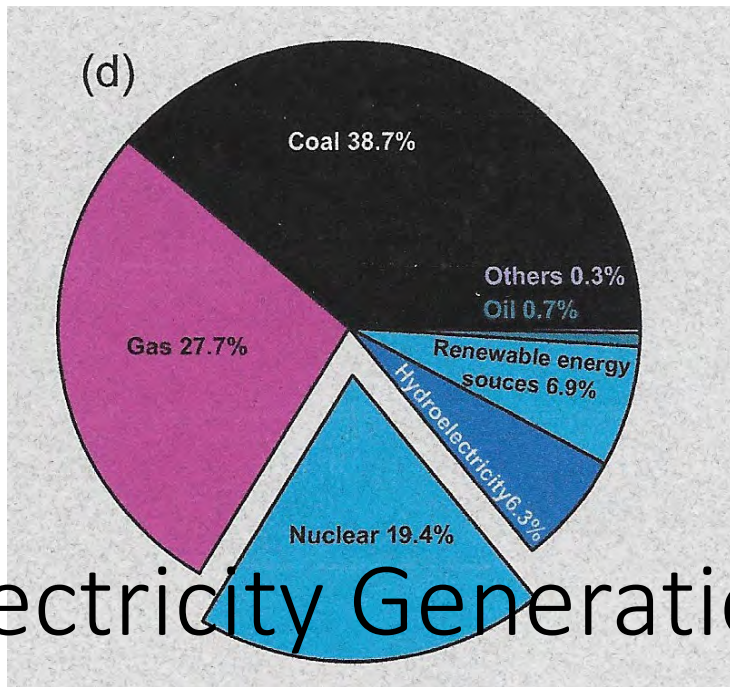


Combating Global Warming with Wind, Solar, Nuclear Energy and Batteries: Uniqueness of Winnetka and Illinois

Comparison of energy sources copied from my colleague Professor Elmer Lewis at NU;
PhD in Nuclear Engineering and author of book, How Safe is Safe

<https://www.youtube.com/watch?v=lpd1x8ZnVIQ>

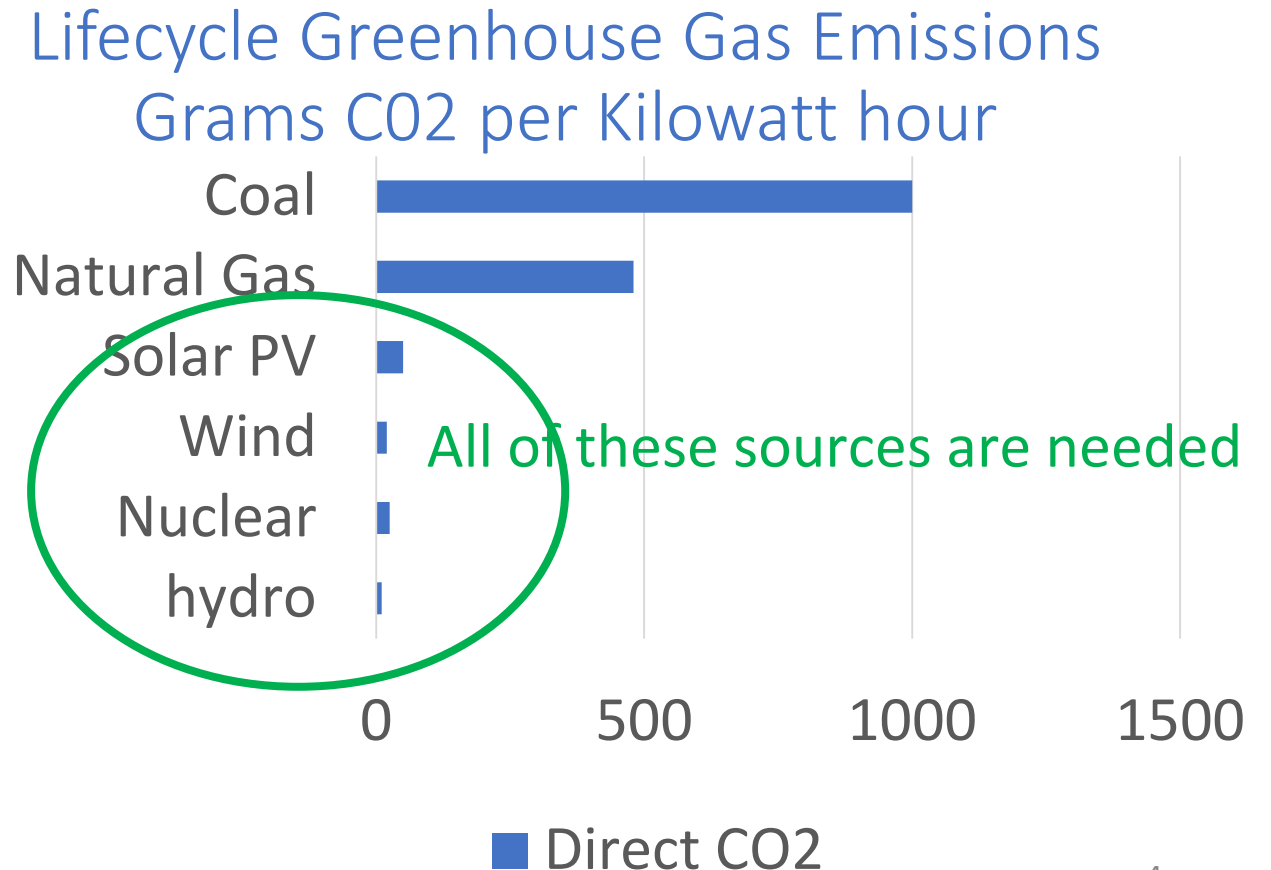
<https://www.youtube.com/watch?v=bEuIQosyQBo>



Electricity Generation

Leaders in carbon free electrical power generation

Nuclear:	France	75%
Hydroelectric:	Norway	95%
Nuclear & Hydro:	Sweden	100%



Watts are a measure of power. (amps x volts = watts).

150 watt light bulb

Watts are a measurement of the amount (or more specifically the rate) of energy or power released or used.

Kilo = thousand = 1,000

Mega = million = 1,000,000

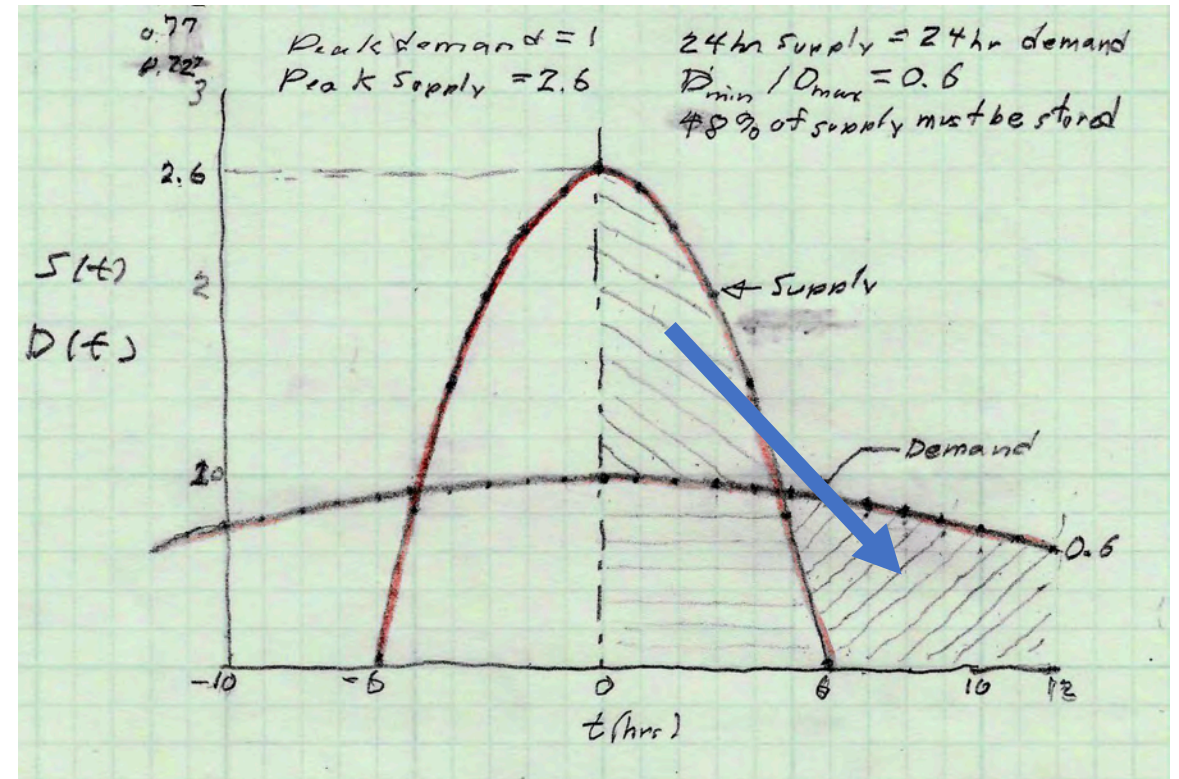
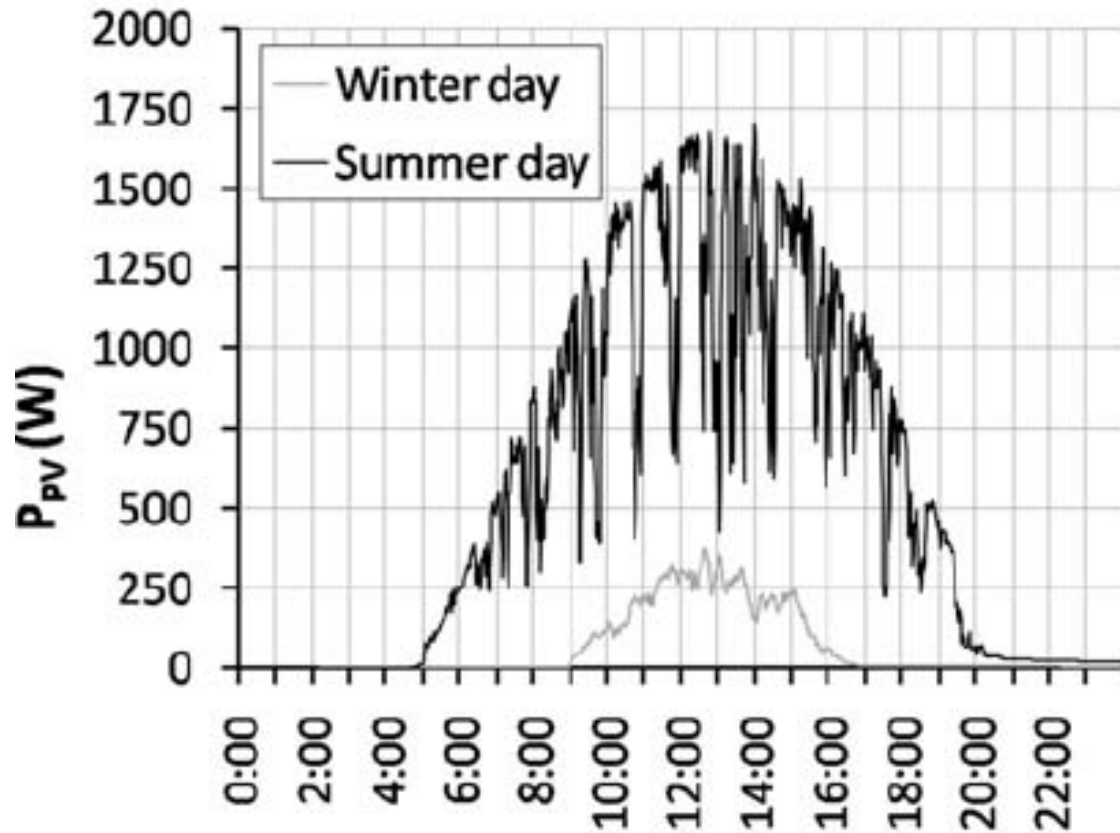
Giga = billion = 1,000,000,000

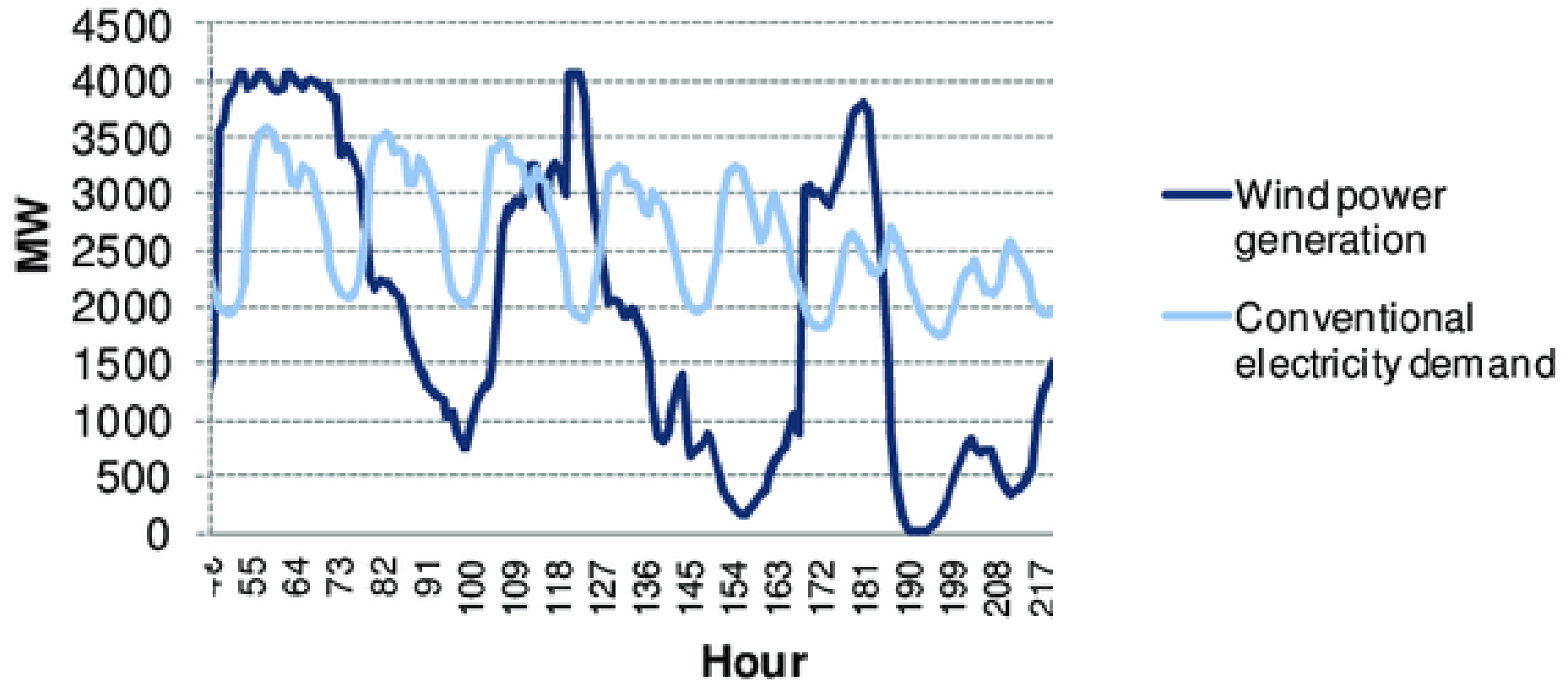
Watt*hour = Wh = energy = 1 Wh => consume 1 watt for 1 hour



Solar supply does not match the demand in time.

In US Night time demand is supplied mainly by hydrocarbon fuels





Matching demand with wind supply is even more challenging



Production of 1.0 GW of Power

	Wind	Solar -PV	Nuclear
Power	250 4 MW turbines	1.4 million $\frac{3}{4}$ kW panels	1 reactor
Design life yrs.	25	25	40-80
Sq. miles 1.0 GW capacity	100	40	1.0
Capacity Factor	35%	25%	93%
Sq. miles 1.0 GW Average	286	160	1.1

GW = thousand MW = million KW = billion W



Power Plant Economics

LCOE = Levelized Cost of Energy

Capital Costs

Construction, Financing
+ Fixed Operating Costs
personnel, maintenance
+ Variable Operating Costs
fuel, maintenance

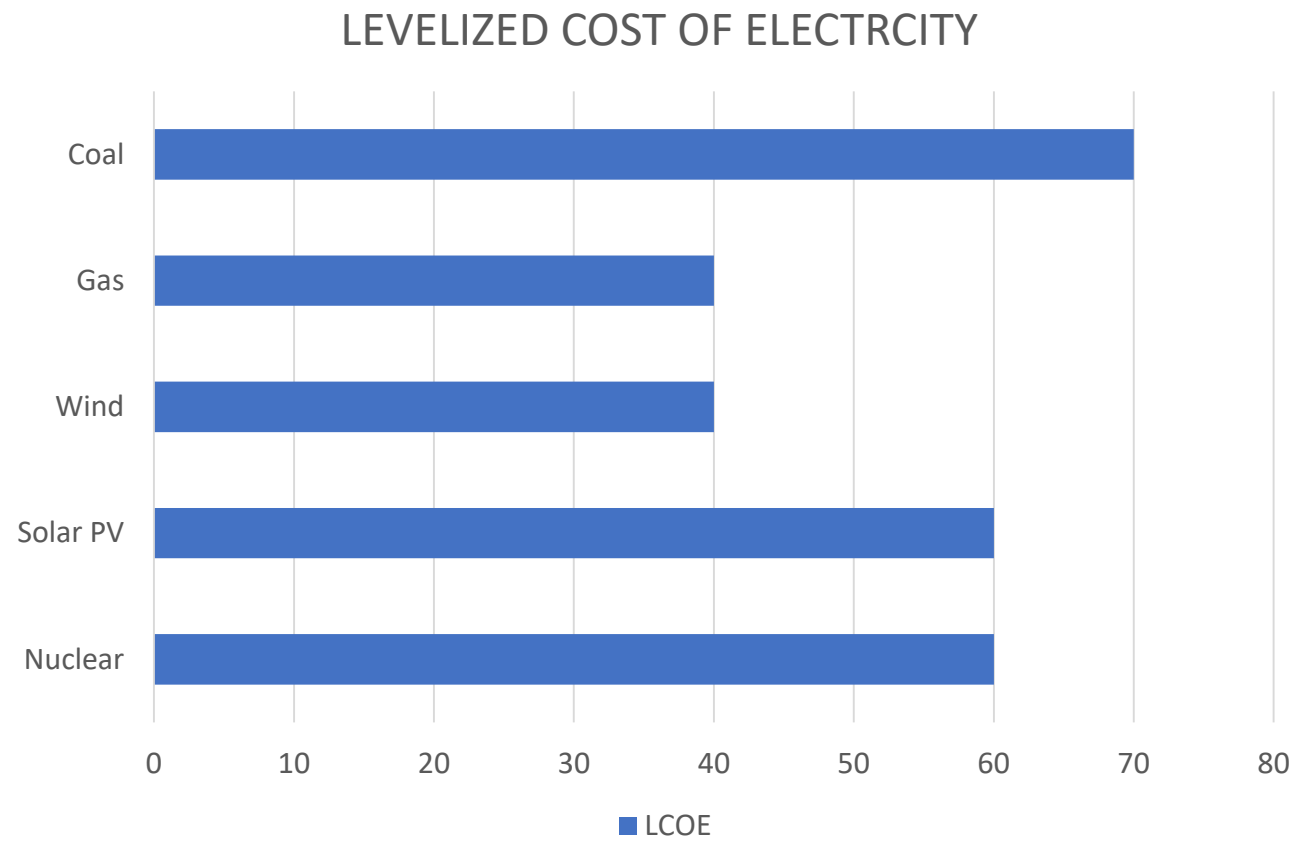
System Costs of VRE

Transmission from remote locations

Increased Storage Capacity

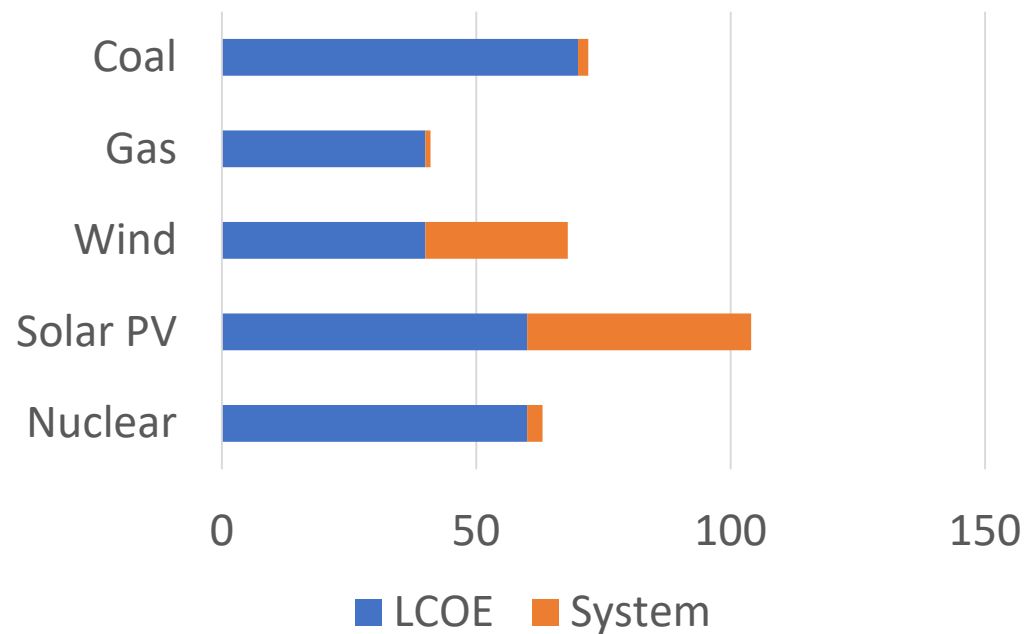
Demands on Dispatchables;
nuclear, hydro & fossil

- Meet maximum demand w/out VRE
- High ramp rates
- Reduced capacity factors

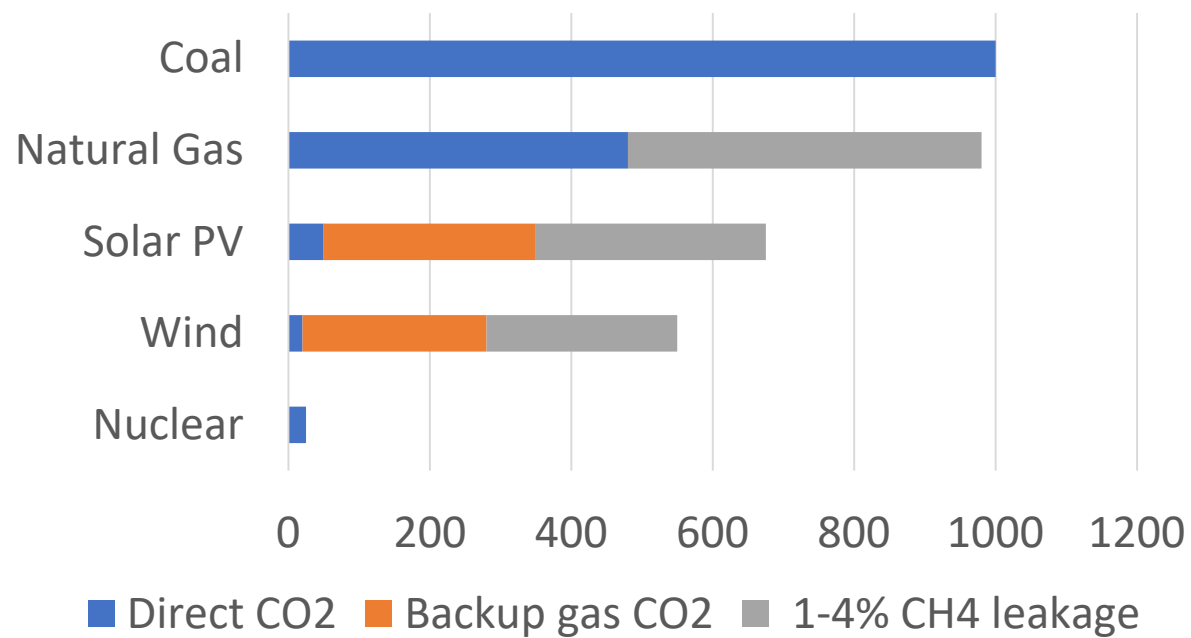




TOTAL COST
\$/MWh

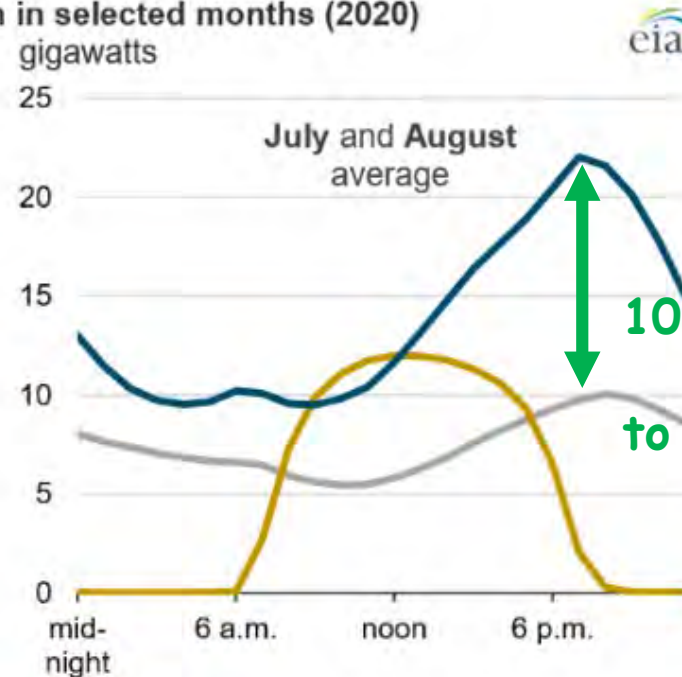
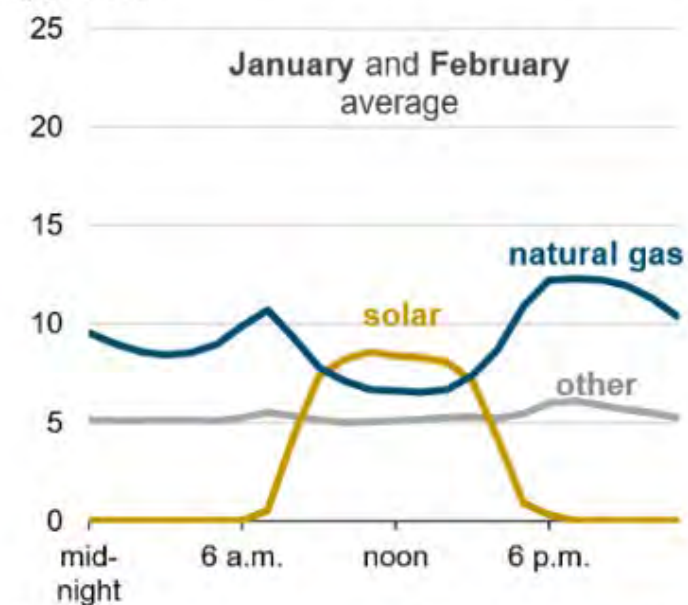


GREENHOUSE GAS
Kg CO₂/MWh



Cost of batteries for California -a sunny state - when the sun is setting and the AC is needed

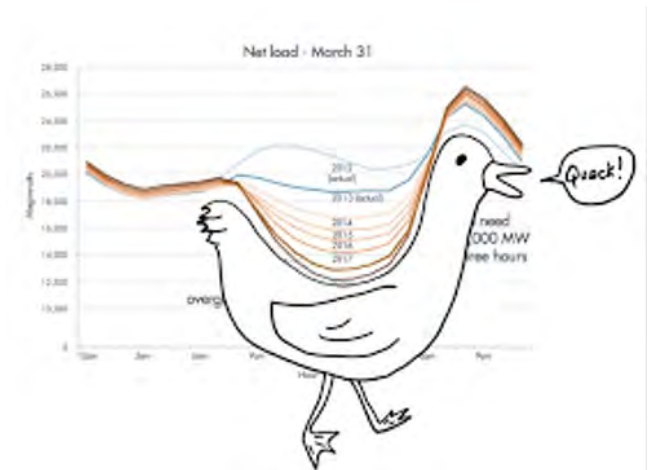
California average hourly electricity generation in selected months (2020)
gigawatts



10 Gigawatts needed for 4 hours or
~40 Gigawatt hours
to reduce excessive burning of natural gas

Source: U.S. Energy Information Administration, [Hourly Electric Grid Monitor](#)

Note: Data are for the [California](#) region, which includes electric power markets regulated by the California Independent System Operator (CAISO) and other balancing authorities operating largely in California.



Ludington pumped storage battery



Can store 19,550 MWh or ~18 GWh according to Wikipedia

Cost: Built between 1969 and 73 for \$ 327 million, which is around \$ 3 Billion today

<https://www.hydropower.org/factsheets/pumped-storage> (map of projects in USA)

How about Tesla power walls and e cars



Cost \$11,500 for Power Wall; up from \$8,000 2 or 3 years ago

Storage capacity 13 kWh

Max rate of provision of power 6 kW and say runs for 4 hrs at 3 kW

Cost per kWh $11,500/13 = \$900/\text{kWh}$

US EIA (US Energy Information Agency) indicates utility scale costs are same

How many Californians are needed to volunteer to spend \$11,500 and store electrons in an organized, altruistic fashion to give/sell them to those who aren't wealthy in order to run the irrigation pumps, streetlights, 911 call centers, cell phone towers, heat refuge facilities, etc during the duck curve hours. 40 GWh needed divided by 3kWx4hrs supplied by each Powerwall = $40,000,000,000/(3,000 \times 4) = 3.3$ million Californians at a total cost of $3,300,000 \times 11,500 = \sim 38$ billion dollars.

Pumped Storage is 3/30 or 1/10th the cost of battery farms

Illinois Microreactor Demonstration Project

Grainger Engineering | March 22, 2023



Caleb Brooks

<https://grainger.illinois.edu/news/webinars/microreactor>



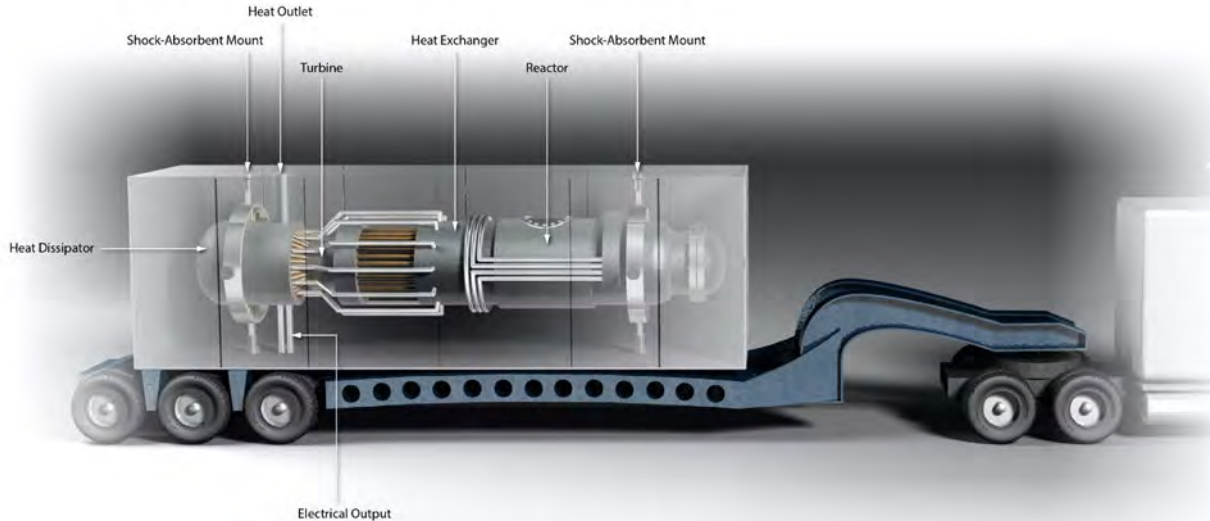
Key Milestones



Technology Provider

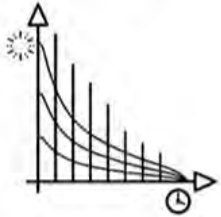


ULTRA SAFE NUCLEAR



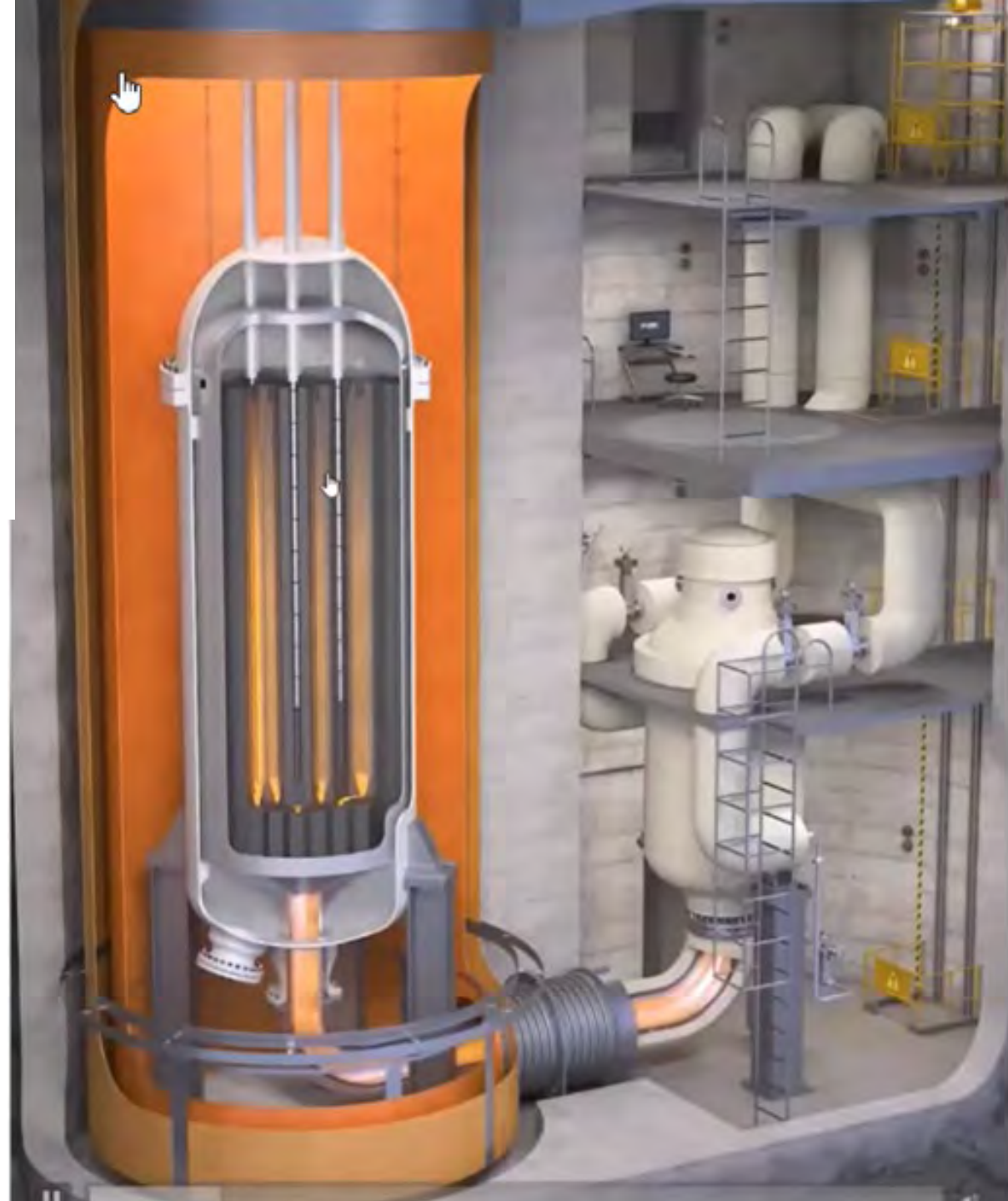
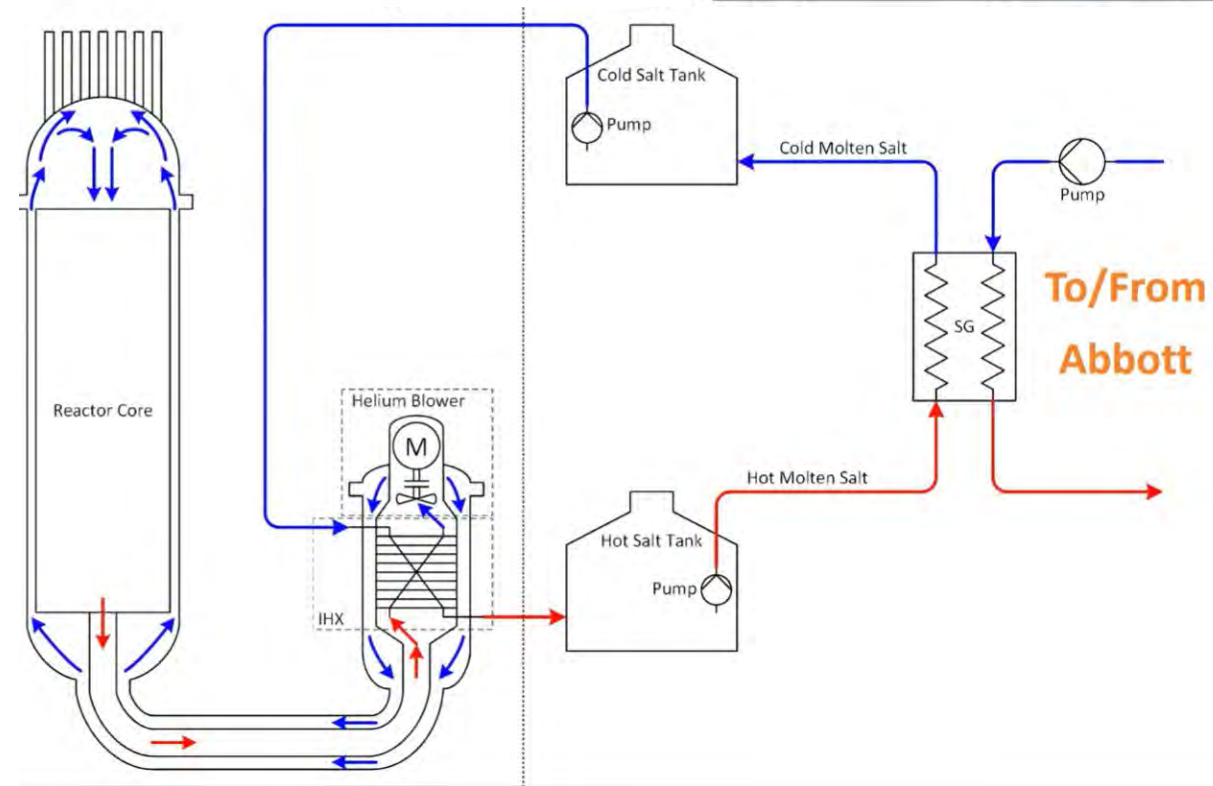
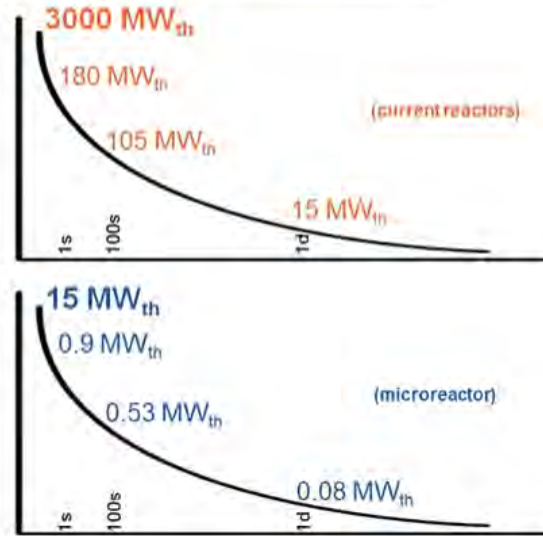
Safety in size

Conventional nuclear systems must be actively cooled after shutdown to remove residual power.



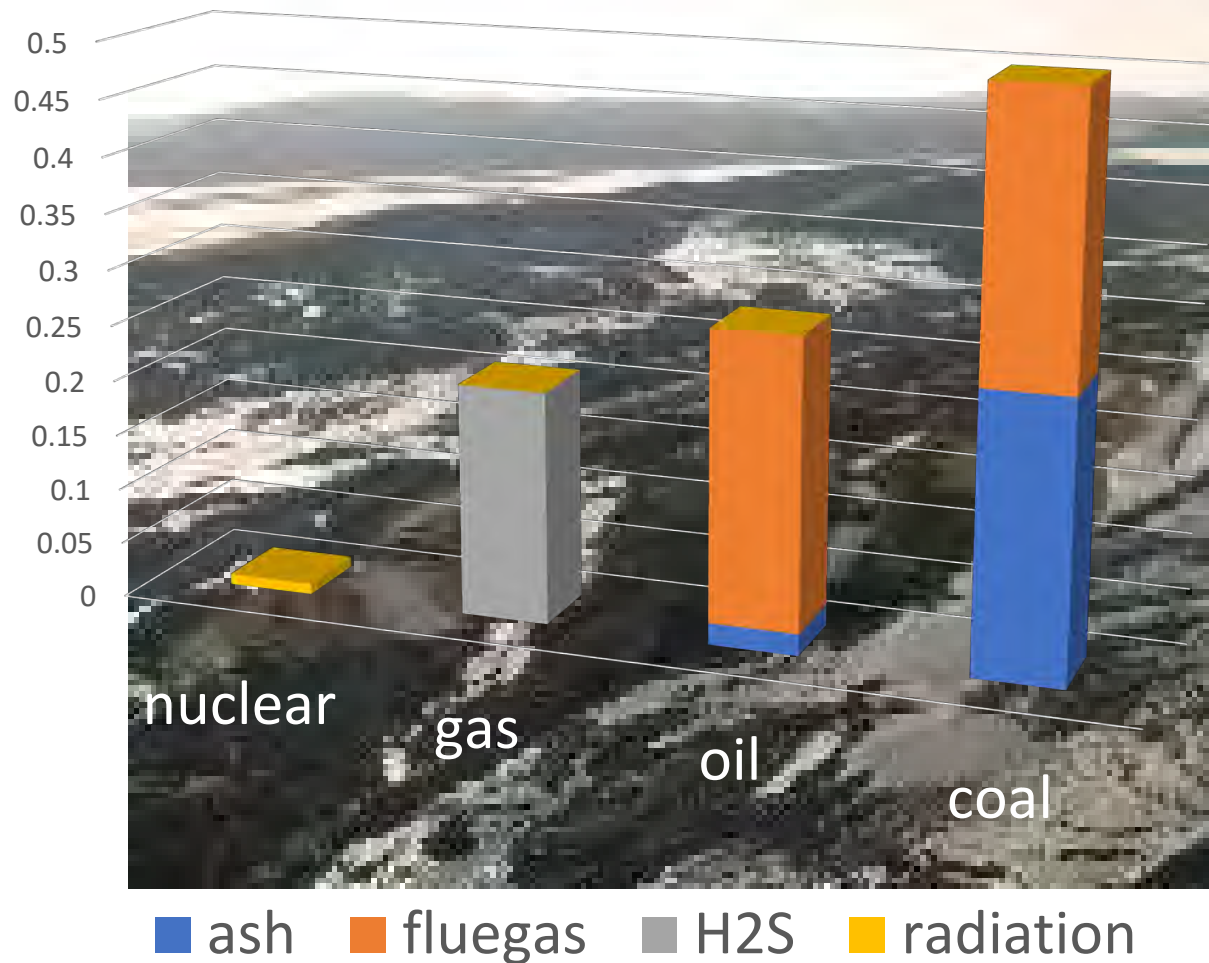
Micro-reactors are so small, they cool naturally, with all heat dissipating passively into the surrounding structures.

200x lower power means 200x less residual power after shutdown.





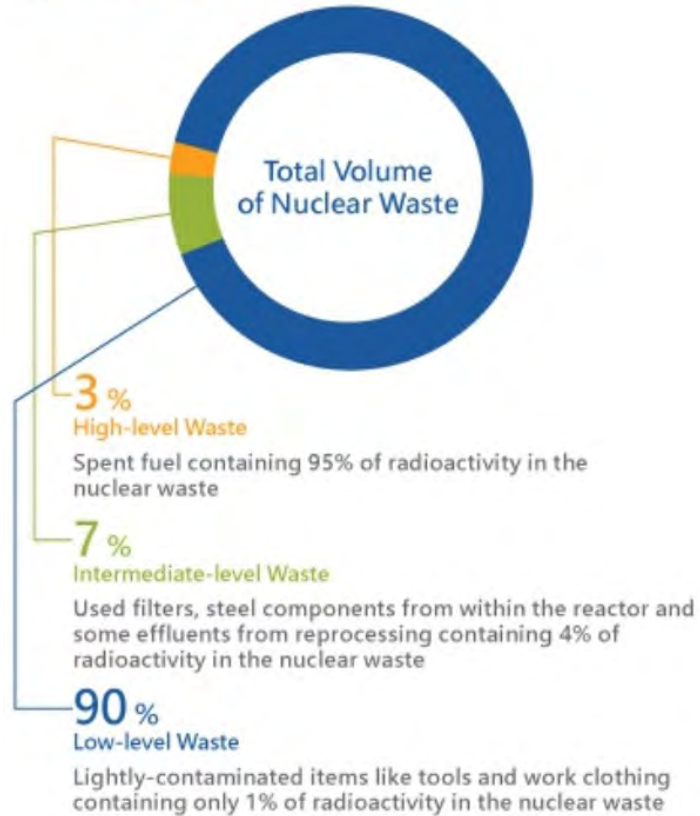
Waste, Million Tons per GW yr



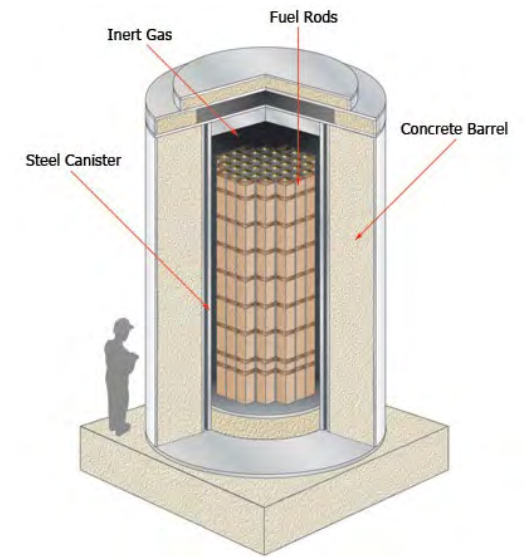
1 GW Reactor 20-30 tons spent fuel/yr
& most not really waste
uranium and plutonium

1 GW coal plant
100 railroad cars/day. $\Rightarrow$ ~15 of ash.
(coal car holds > 100 tones)
 $\Rightarrow$ 0.5 million tons of ash/yr
 $\Rightarrow$ Thus 20×10^3 as much as spent fuel

Types of Nuclear Waste



1 spent fuel cask holds ½ years worth of spent fuel (orange sliver of left circle) for a 1 GW plant



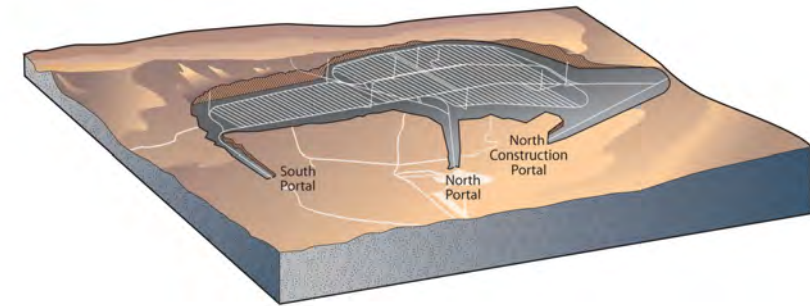
One person's waste for a year's worth of electricity would be about **1/1000 of a cubic inch** of this 14 ft high cask.

If whole blue circle were compressed into one volume, one person's volume for one year would be the size of a brick

<https://world-nuclear.org/nuclear-essentials/what-is-nuclear-waste-and-what-do-we-do-with-it.aspx#:~:text=Little%20waste%20is%20generated&text=As%20a%20result%2C%20a%20correspondingly,as%20a%20sheet%20of%20paper.>



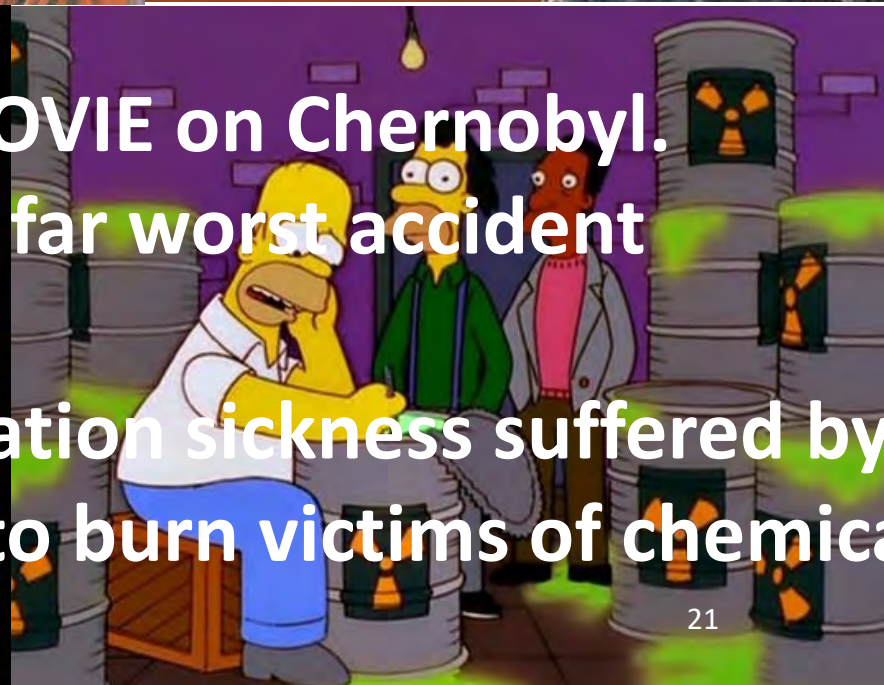
FEDERAL LANDS IN SOUTHERN NEVADA



The nuclear waste repository at Yucca Mountain will sit inside a long ridge, approximately 1,000 feet beneath the surface and 1,000 feet above the water table. Consisting of 40 miles of tunnels, the repository will accommodate an estimated 77,000 tons of nuclear waste. <http://www.lanl.gov/1663/img/Item/664/20lg.jpg>



Fear of radiation: Dr. Strangelove
Homer Simpson
On the Beach

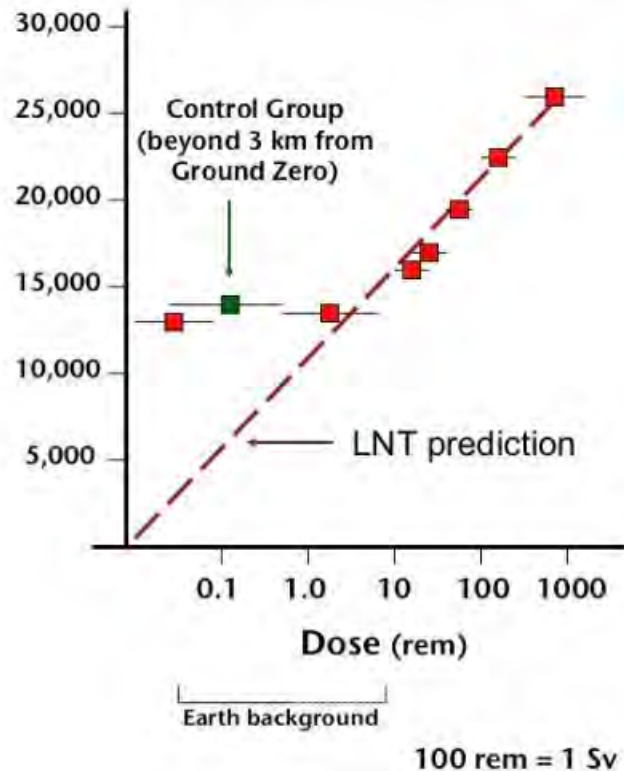


Most recently MOVIE on Chernobyl.
By far worst accident

Emphasis on radiation sickness suffered by
Suffering similar to burn victims of chemical

Japanese Atomic Bomb Survivors

<i>normalized per 100,000</i>	<i>Number of Solid Cancers over 40 years (per 100,000 population)</i>	<i>dose range</i>
13,748		> 3 km from Grd0
12,806		< 0.1 rem
13,494		0.5-10 rem
15,476		10-20 rem
16,752		20-50 rem
19,094		50-100 rem
23,949		100-200 rem
26,808		> 200 rem



Solid Cancers per 100,000 population in the Japanese Atomic Bomb Survivor Cohort of 79,901 subjects.... [+]

However, below 10 rem (0.1 Sv = 100 mSv), any effects completely disappear in the noise - the noise of all the other environmental and genetic effects that cause cancer and death. In the 1950s, to be simplistic, the world governing bodies decided to just draw in that line anyway, all the way down to zero. It made it easy to use and easy to make regulations.

World-Wide Risk From Radiation Very Small
Forbes Jun 24, 2016,06:00am
James Conca



Chernobyl - population surrounding reactor

Exposure to Iodine & Cesium

IODINE 8 day half life.

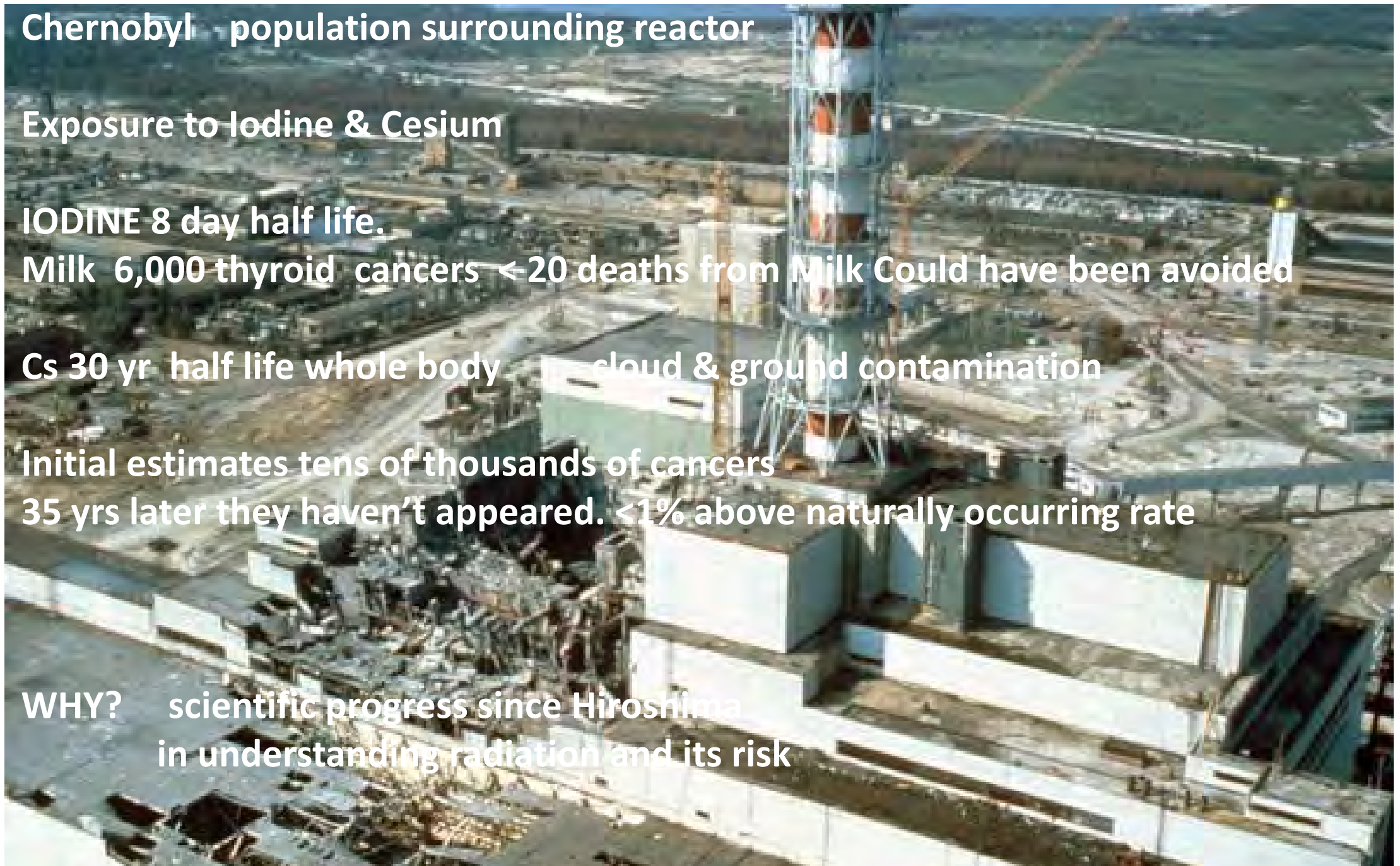
Milk 6,000 thyroid cancers $\leftarrow$ 20 deaths from Milk Could have been avoided

Cs 30 yr half life whole body - cloud & ground contamination

Initial estimates tens of thousands of cancers

35 yrs later they haven't appeared. $<1\%$ above naturally occurring rate

WHY? scientific progress since Hiroshima
in understanding radiation and its risk



10 members of the public

>10 mSv. = CAT scan

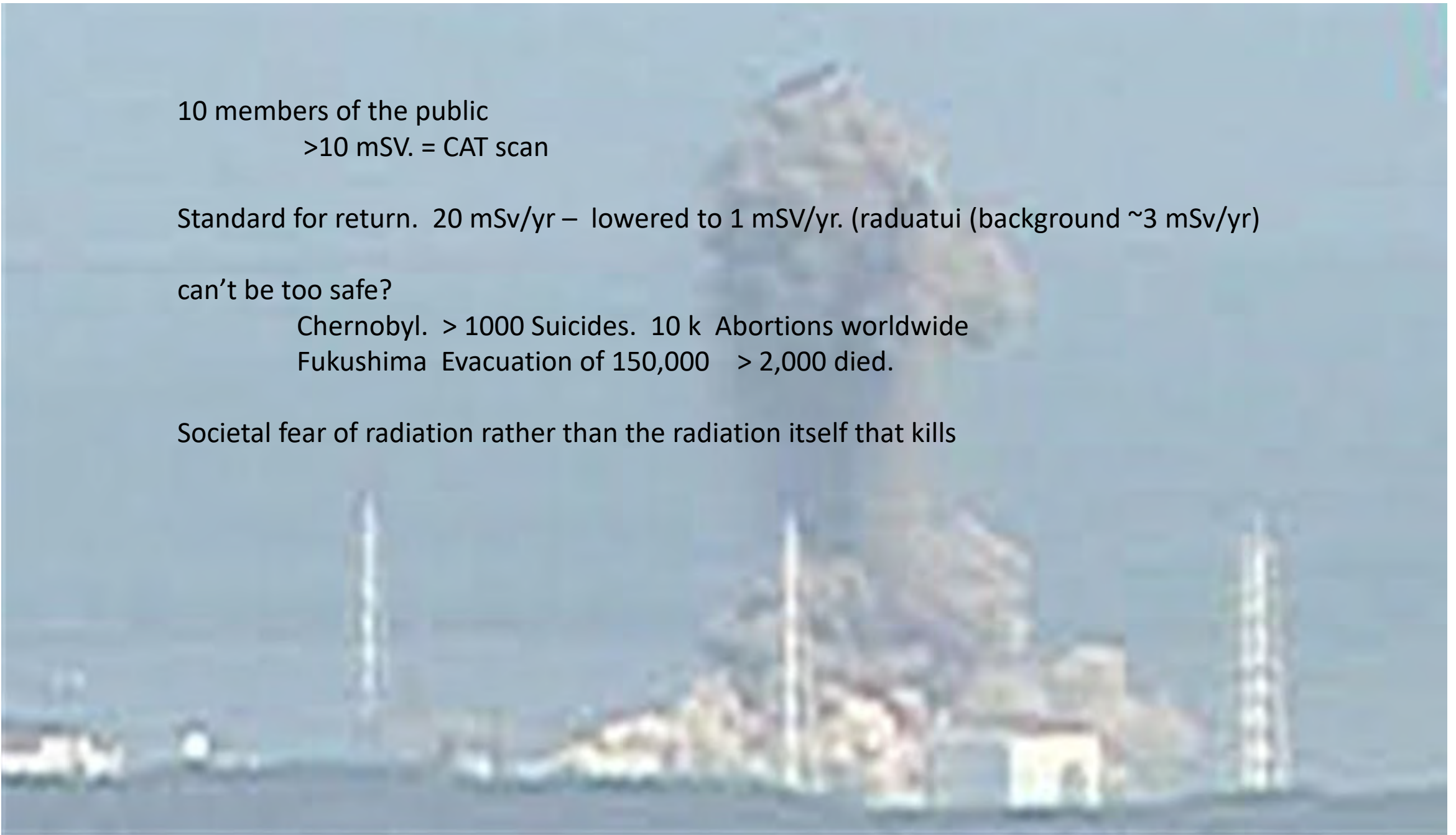
Standard for return. 20 mSv/yr – lowered to 1 mSv/yr. (background ~3 mSv/yr)

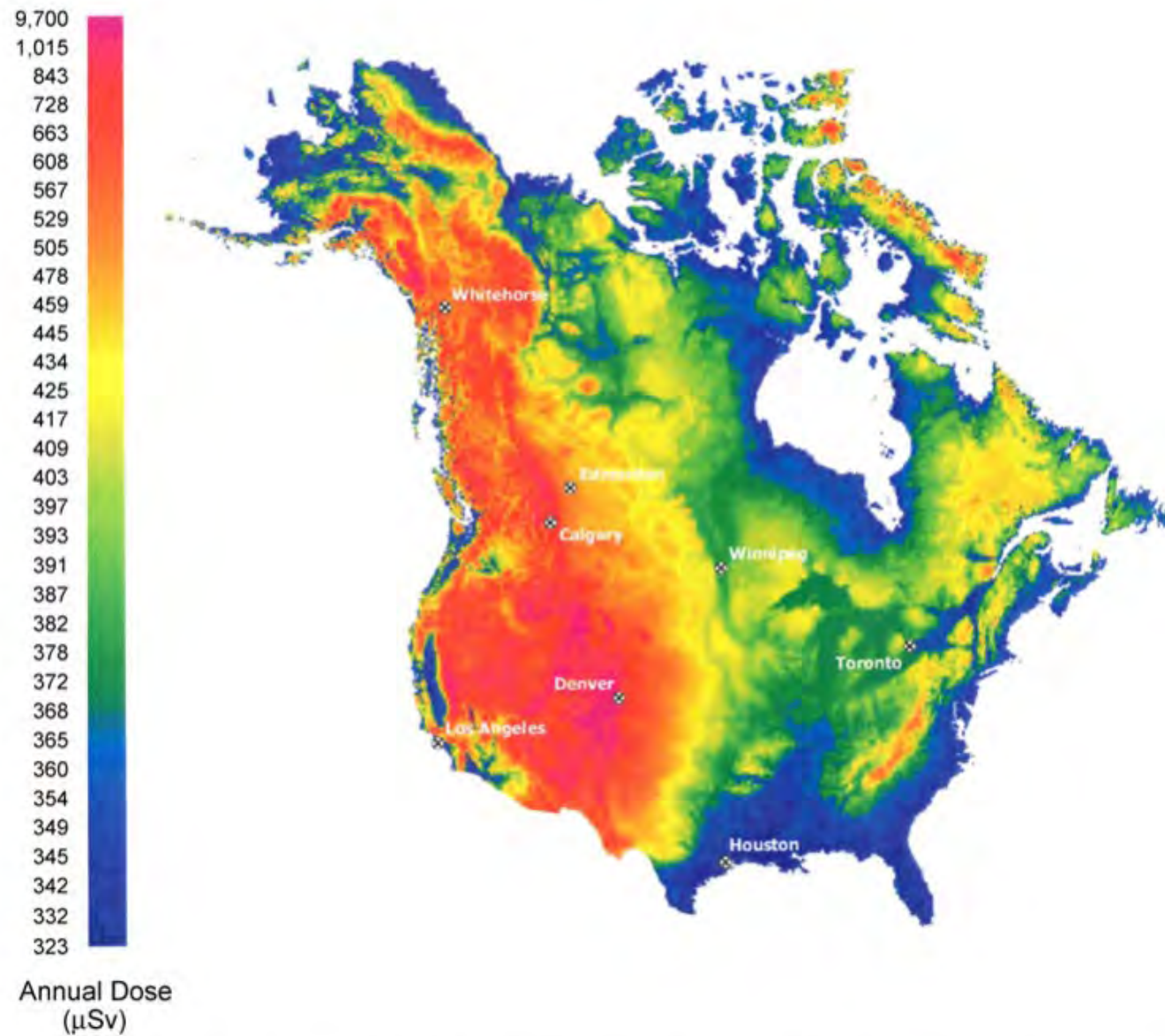
can't be too safe?

Chernobyl. > 1000 Suicides. 10 k Abortions worldwide

Fukushima Evacuation of 150,000 > 2,000 died.

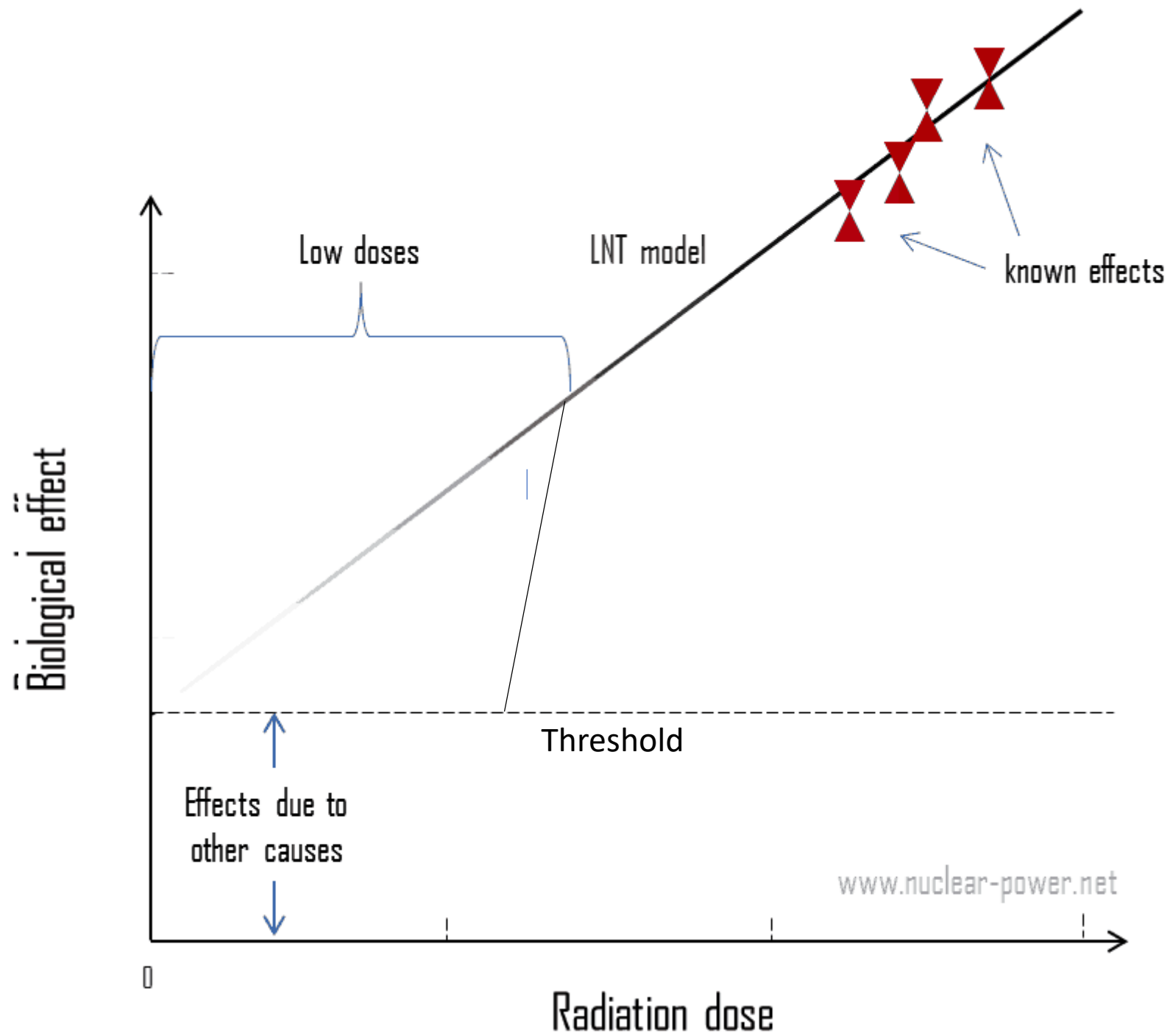
Societal fear of radiation rather than the radiation itself that kills





$$1000 \mu\text{Sv/y} = 1 \text{ mSv/y}$$

Figure 2: False-color map of calculations of annual doses ($\mu\text{Sv y}^{-1}$) in North America due to space radiation showing variability (Grasty and LaMarre, 2004) (Figure 3.4 from NCRP 160); reprinted with permission of the National Council on Radiation Protection



In the SI system, a millisievert (mSv) is defined as "the average accumulated background radiation dose to an individual for 1 year, exclusive of radon, in the United States." 1 mSv is the dose produced by exposure to 1 milligray (mG) of radiation. In the historical system of dosimetry, exposure to 1 roentgen (R) of X-rays results in absorption of 1 rad [radiation-absorbed dose], which had the effect of 1 rem [roentgen-equivalent (in) man]. The unit equivalences between the systems are given in the following table: note that SI units are 1% of historical units.

SI units	Historical dosimetry
1 Gray	100 R
1 Sievert	100 rad => 100 rem
10 mGy	1 Roentgen
10 mSv	1 rad => 1 rem

The whole-body exposure threshold for acute hematopoietic syndrome or "radiation sickness" is 500 mGy. A dose of ~3,000 mGy produces an acute gastrointestinal syndrome that can be fatal without major medical intervention, and a dose of ~ 5,000 mGy is considered the human LD 50 / 30, that is, the lethal dose for 50% of the population in 30 days, even with treatment. These are acute thresholds: the same dose fractionated over a series of exposures or over a longer time may produce less injury, as the body has a chance to repair damage between exposures.

Figure 2. Large-scale battery storage installations by region (2019)

