SAND2017-2043C

Weighing the Benefits and Costs of Nuclear Power

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Why am I a nuclear engineer?

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Energy security and surety enables a better quality of life.

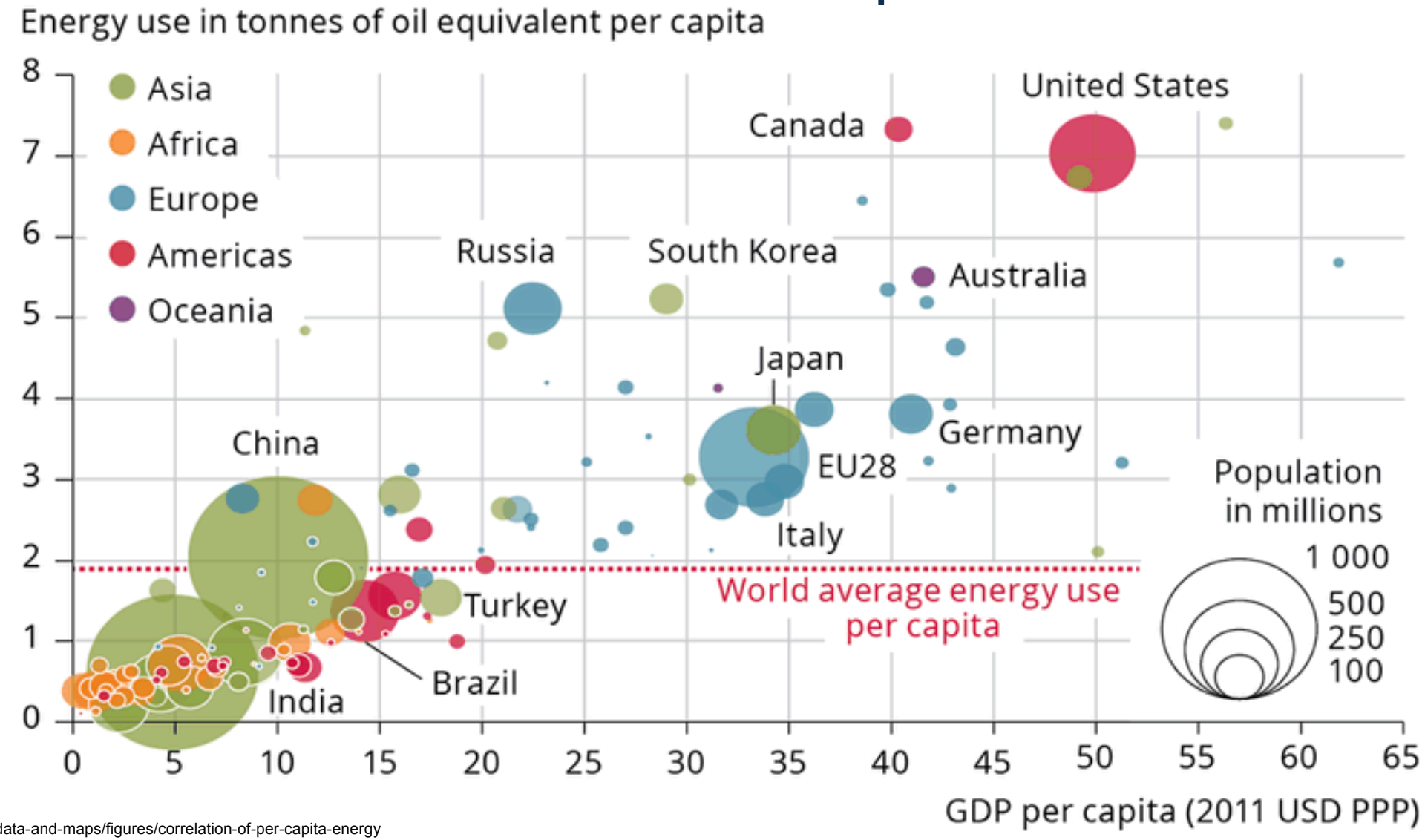
All decisions are tradeoffs:

- Nuclear power is the cleanest option that I have seen.
- All human activities have pros and cons; there is no free lunch;
- The future bears the costs of the past's decisions.

Fukushima did not change my view of nuclear power.

- Current designs still provide compelling benefits.
- New technologies are quite exciting!

The link between energy and economic development



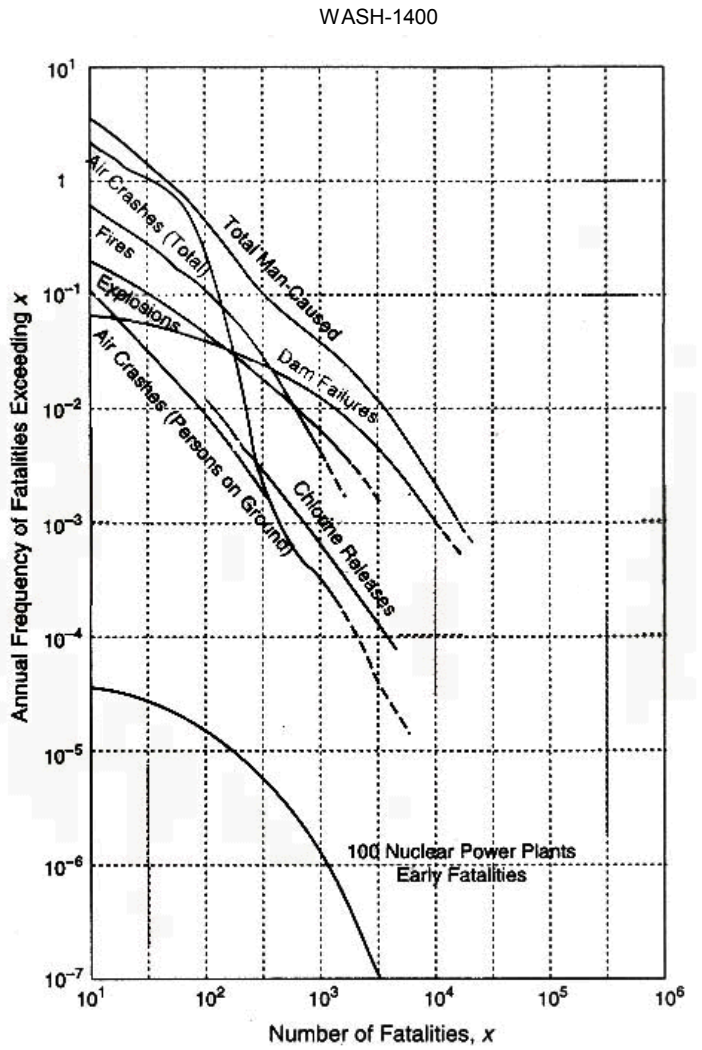
http://www.eea.europa.eu/data-and-maps/figures/correlation-of-per-capita-energy

Risk analysis for nuclear power

The costs of nuclear power are quantified because nuclear accidents happen so rarely:

- What can go wrong?
- How likely is it to go wrong?
- What are the consequences if it goes wrong?

The Nuclear Regulatory Commission (NRC) quantitative safety goal states that an individual's risk from nuclear power should be less than 0.1% of the total background risk.



But how do we actually judge risks?

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Perception of Risk is key

- Experience: Dread rare events more than common events
- Control: Dread risks that we think we can influence
  - No one asked you what power plant would be built in your town before you were born
- Size: Dread large consequences more than small consequences

Rates are useful comparisons but remember the denominator

TABLE 6-3 INDIVIDUAL RISK OF EARLY FATALITY BY VARIOUS CAUSES
(U.S. Population Average 1969)

Accident Type	Total Number for 1969	Approximate Individual Risk Early Fatality Probability/yr[a]
Motor Vehicle	55,791	3×10^{-4}
Falls	17,827	9×10^{-5}
Fires and Hot Substance	7,451	4×10^{-5}
Drowning	6,181	3×10^{-5}
Poison	4,516	2×10^{-5}
Firearms	2,309	1×10^{-5}
Machinery (1968)	2,054	1×10^{-5}
Water Transport	1,743	9×10^{-6}
Air Travel	1,778	9×10^{-6}
Falling Objects	1,271	6×10^{-6}
Electrocution	1,148	6×10^{-6}
Railway	884	4×10^{-6}
Lightning	160	5×10^{-7}
Tornadoes	118[b]	4×10^{-7}
Hurricanes	90[c]	4×10^{-7}
All Others	8,695	4×10^{-5}
All Accidents (from Table 6-1)	115,000	6×10^{-4}
Nuclear Accidents (100 reactors)	—	2×10^{-10}[d]

(a) Based on total U.S. population, except as noted.
(b) (1953-1971 avg.)
(c) (1901-1972 avg.)
(d) Based on a population at risk of 15×10^6.

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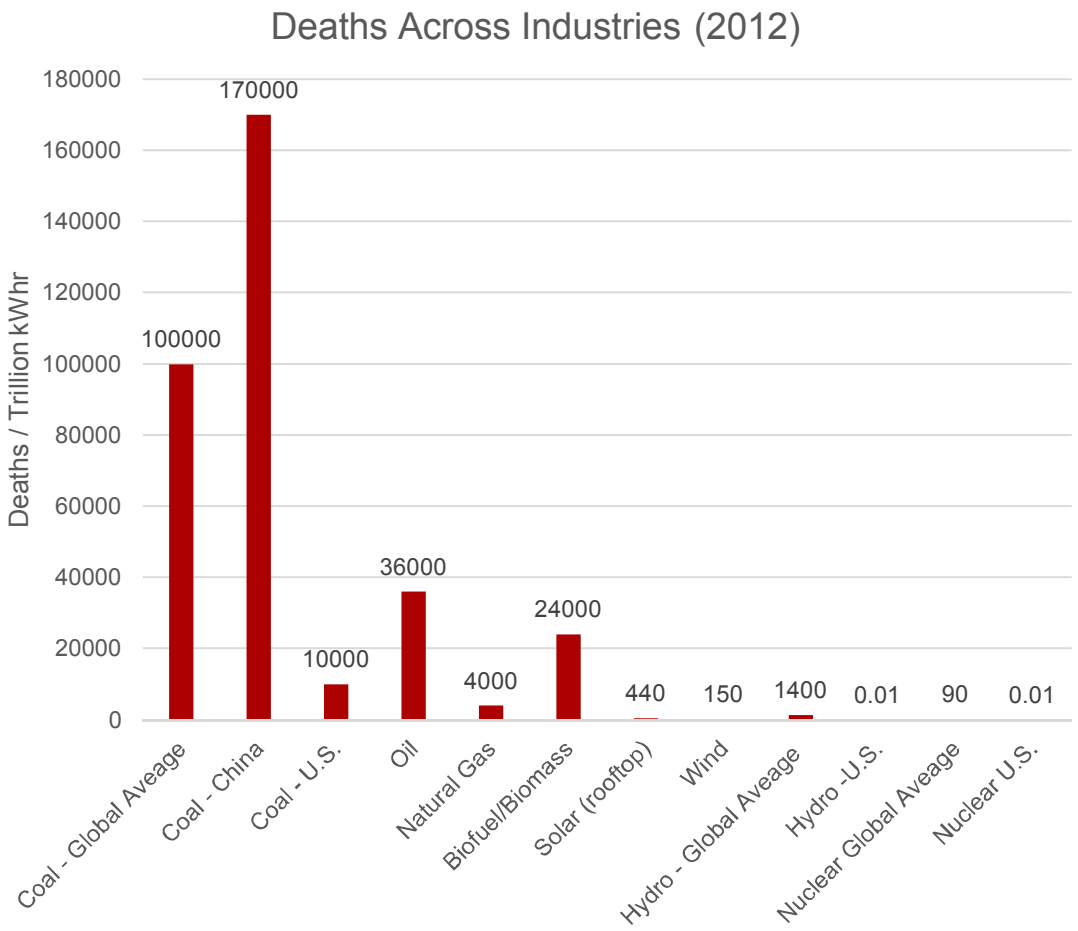
How deadly is nuclear compared to other sources of electricity



What other metrics may be important?

- Energy security?
- Diverse energy portfolio?
- Raw material extraction impacts?
- Impact to the surrounding land?

Data Source: Forbes
https://www.forbes.com/sites/jamesconca/2012/06/10/energys-deathprint-a-price-always-paid/#53dee65f709b

Because accidents are rare…

https://www.youtube.com/watch?v=CZ8uvQk1H9I

The Tsunami that Crippled the Fukushima Plants

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Impacted Zones

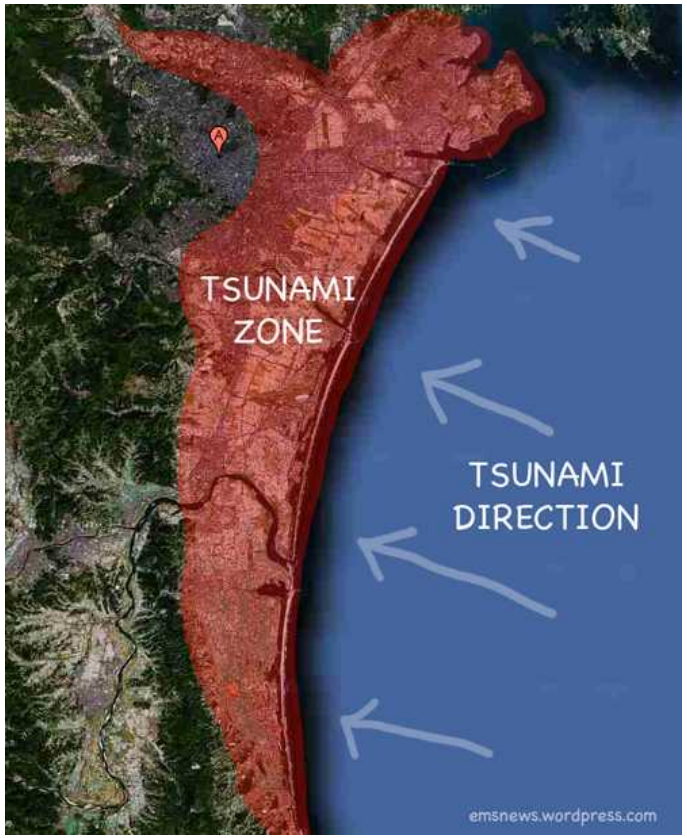

Image During the Flood

https://cdn.theatlantic.com/assets/media/img/photo/2016/03/5-years-since-the-2011-great-east-j/q07_RTR2JR49/main_900.jpg?1457636351

New designs verse existing designs

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1960s

http://auto.howstuffworks.com/1962-1970-ford-xl10.htm

2010s

http://usnews.rankingsandreviews.com/cars-trucks/ford/fusion/2010

New designs verse existing designs

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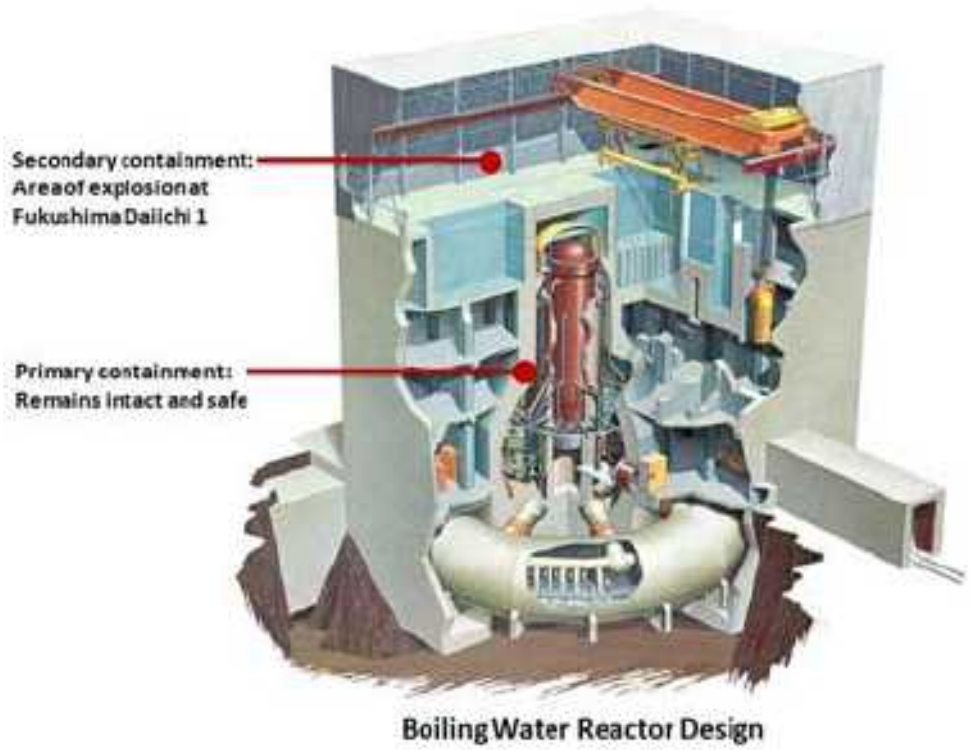
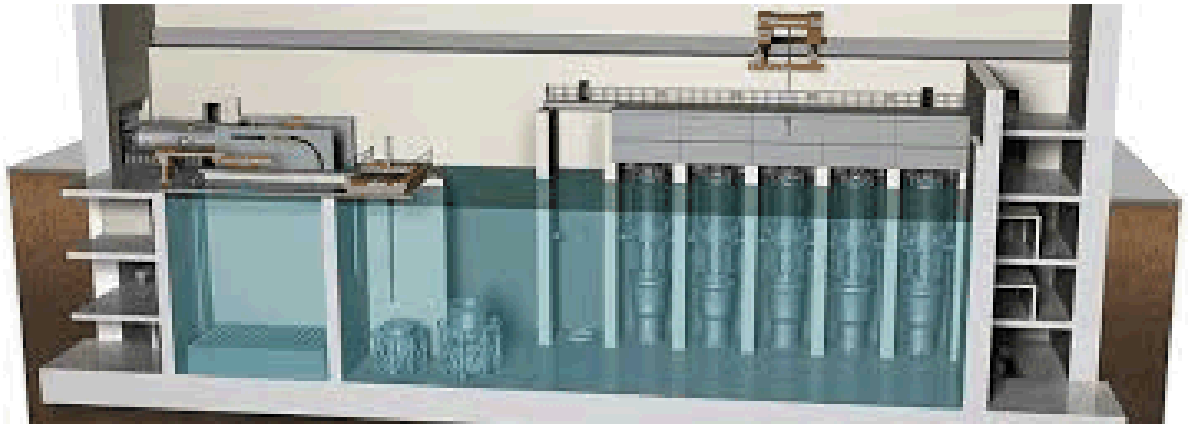
1960s



Boiling Water Reactor Design

2010s



http://www.fluor.com/projects/nuscale-power-small-modular-reactor-nuclear

There is to much to explain
Let me sum up

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▪Nuclear power is one of the safest sources of electricity production	• Nuclear accidents rarely happen • Humans are rarely harmful levels of radiation • **<u>An outsized effort is expended to understand how nuclear power can fail and potentially harm people</u>**
Nuclear power is one of the most dreaded forms of electricity	• Nuclear power and nuclear weapons rely on the same physics but fundamentally different engineering
Electricity is beneficial to humanity	• The developing world will build a massive amount power plants • What do you want them to build?