Nuclear Energy in a Shifting Landscape

Paul Wilson
Midwest Rural Energy Council
February 2026

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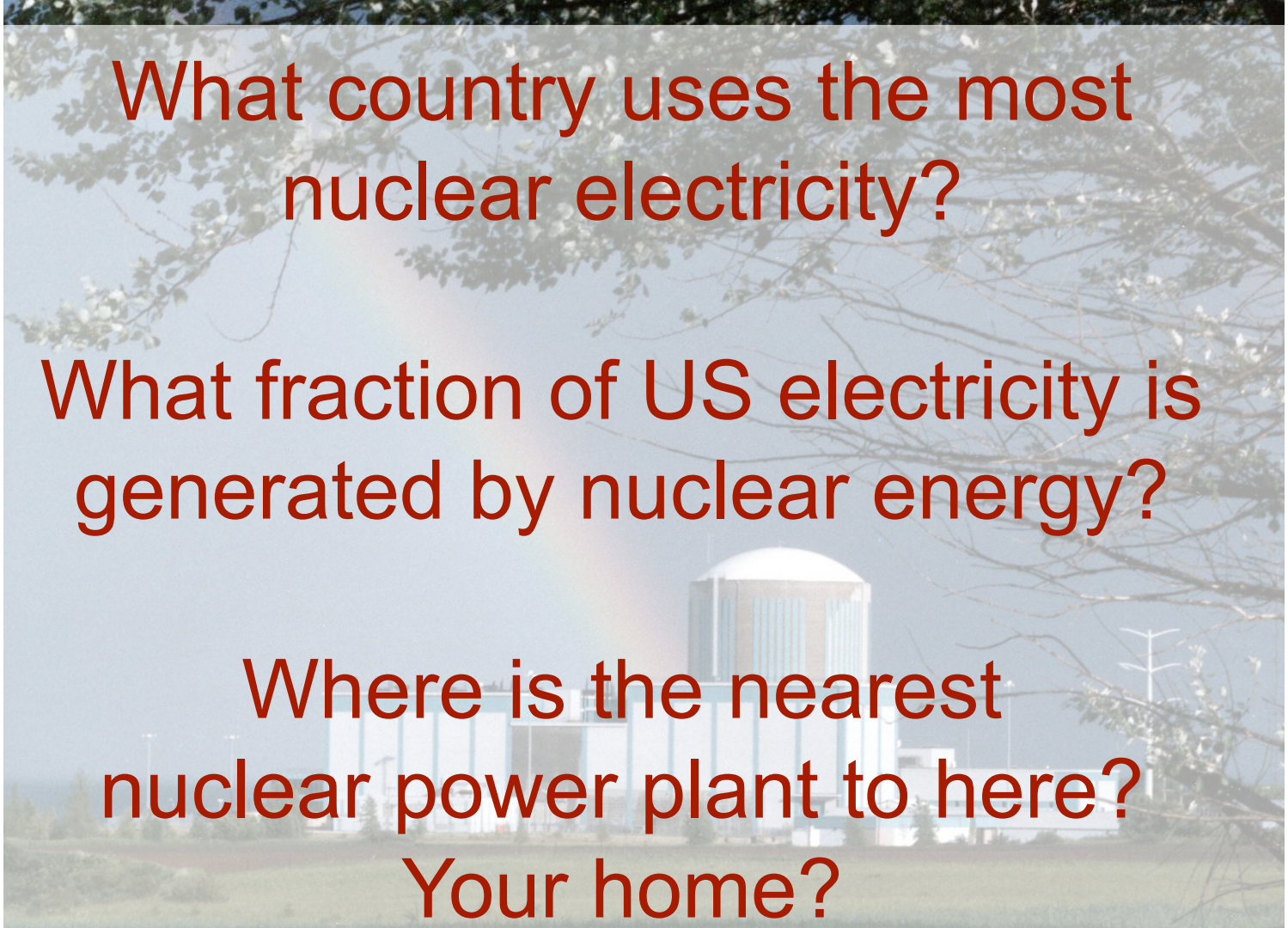
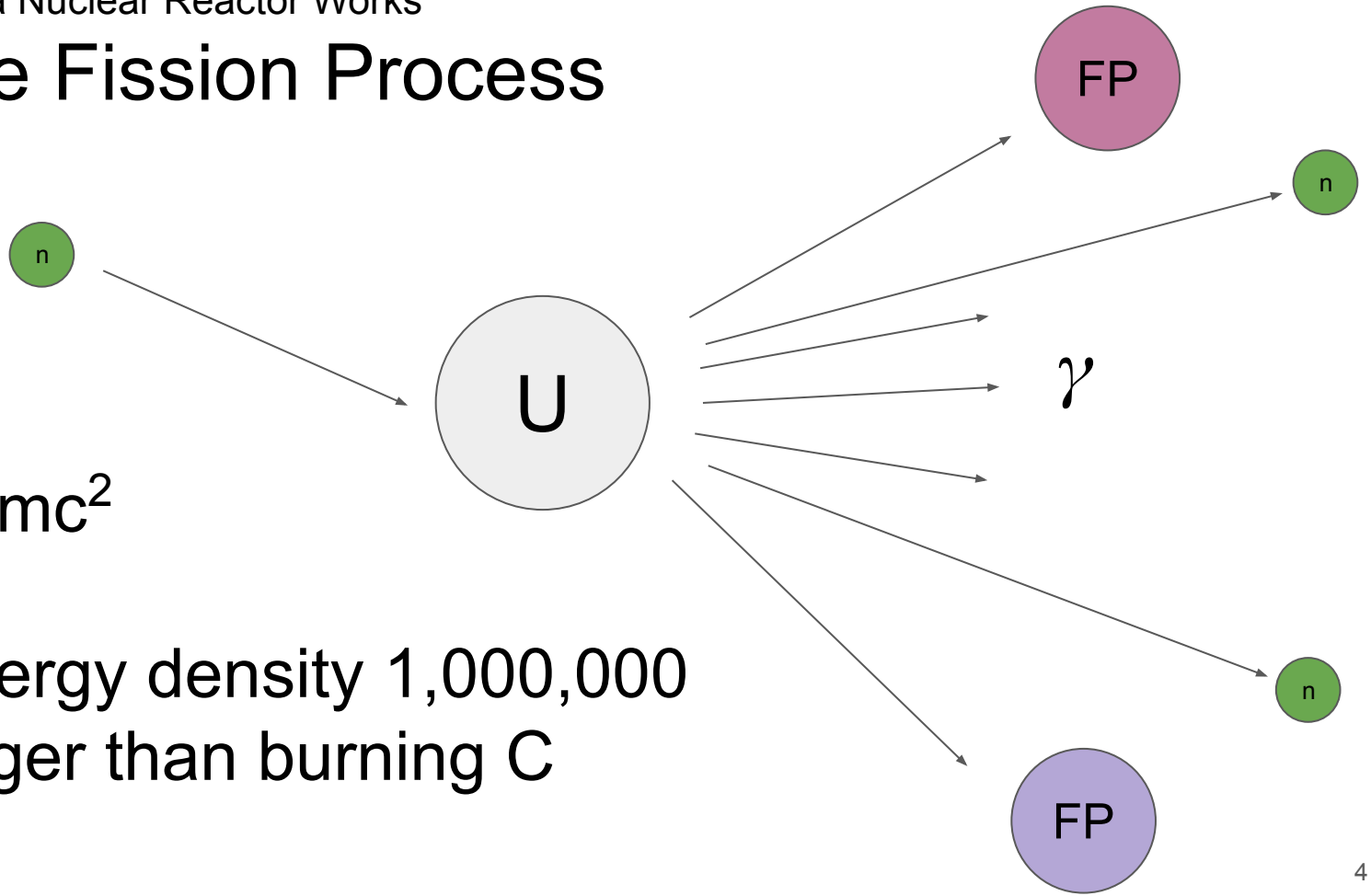
What do you know?



How a Nuclear Reactor Works

The Fission Process

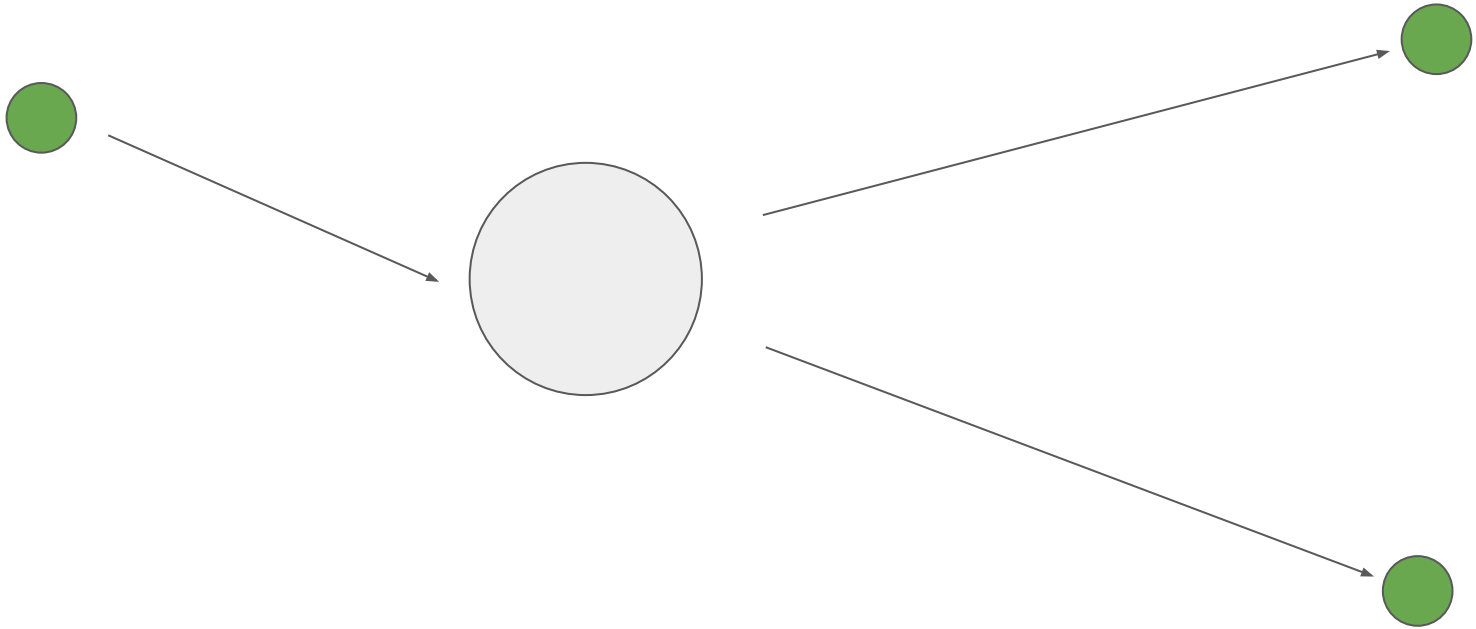


$E=mc^2$

Energy density 1,000,000 larger than burning C

How a Nuclear Reactor Works

A Chain Reaction



How a Nuclear Reactor Works

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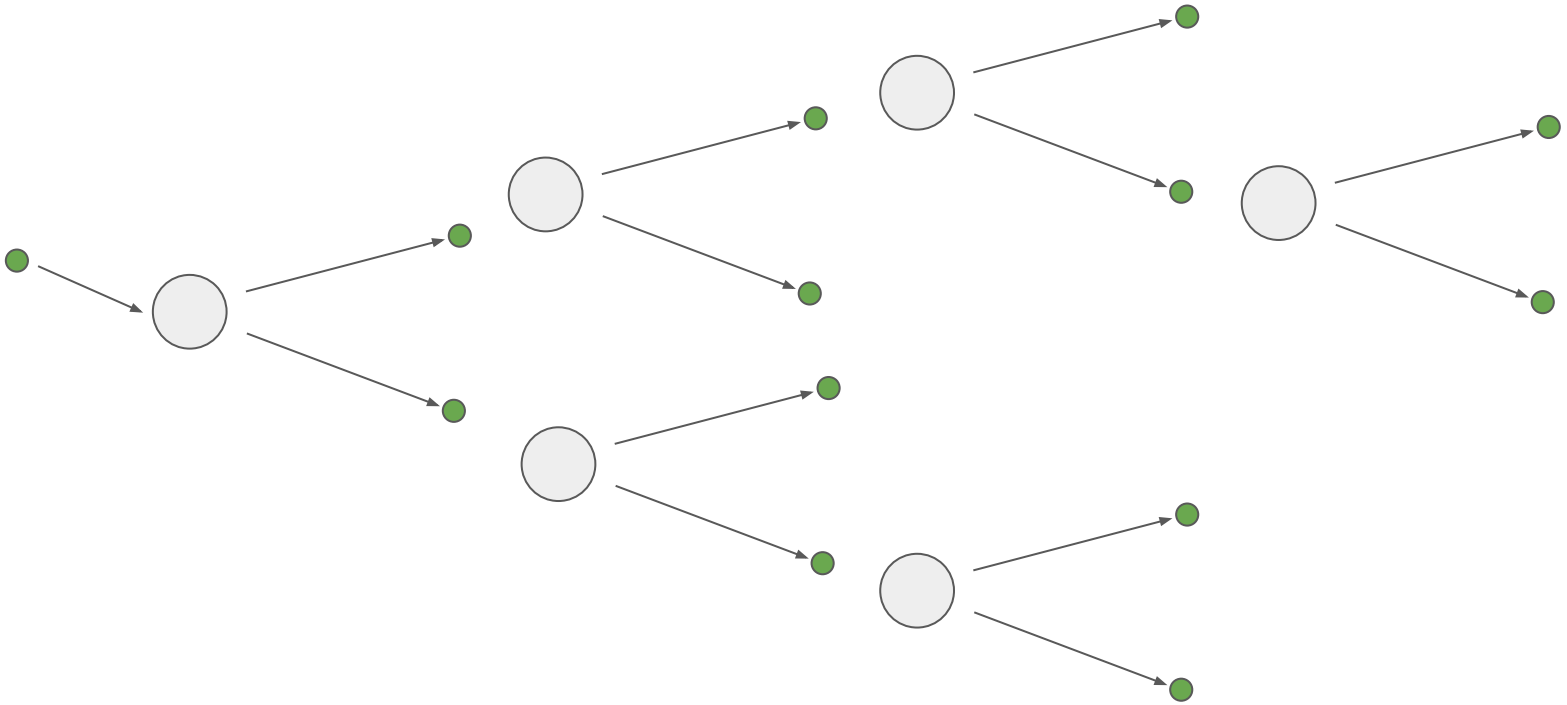
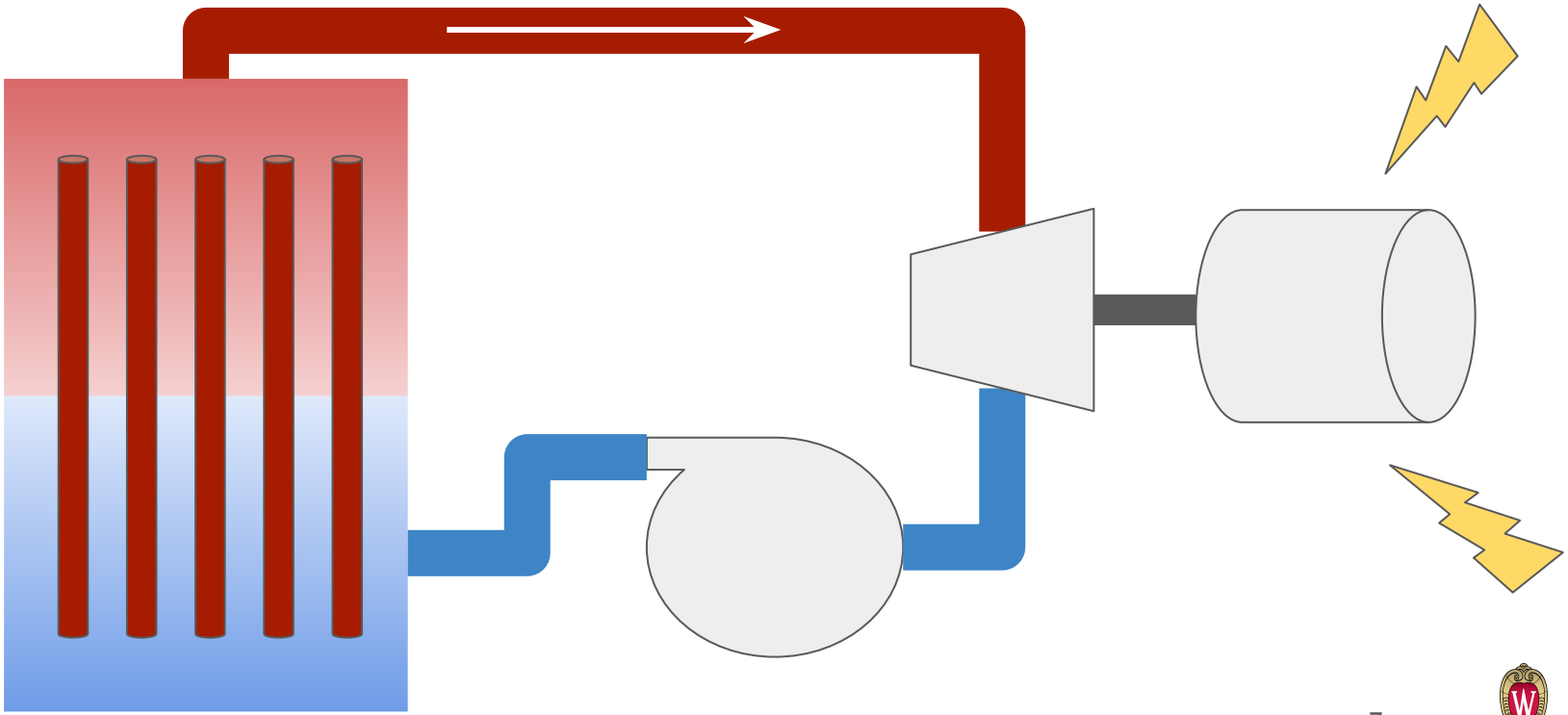
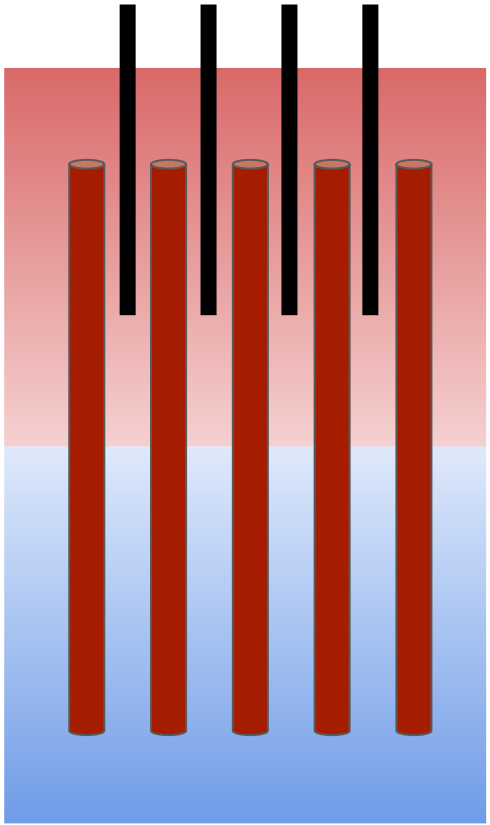


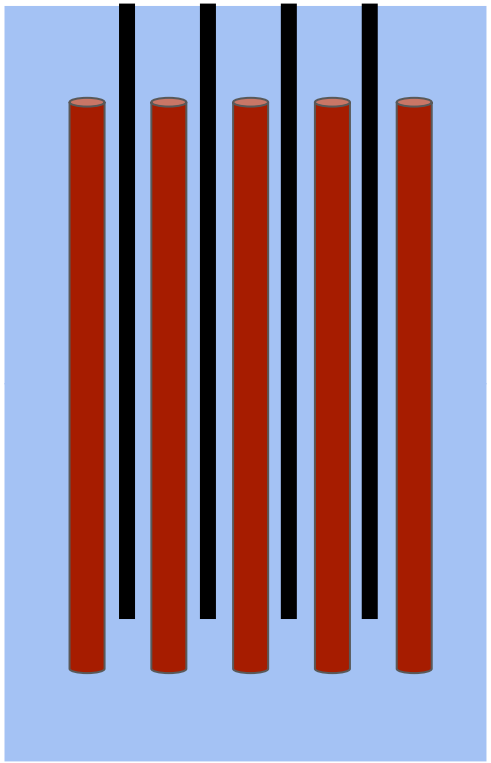
How a Nuclear Reactor Works

Producing Energy



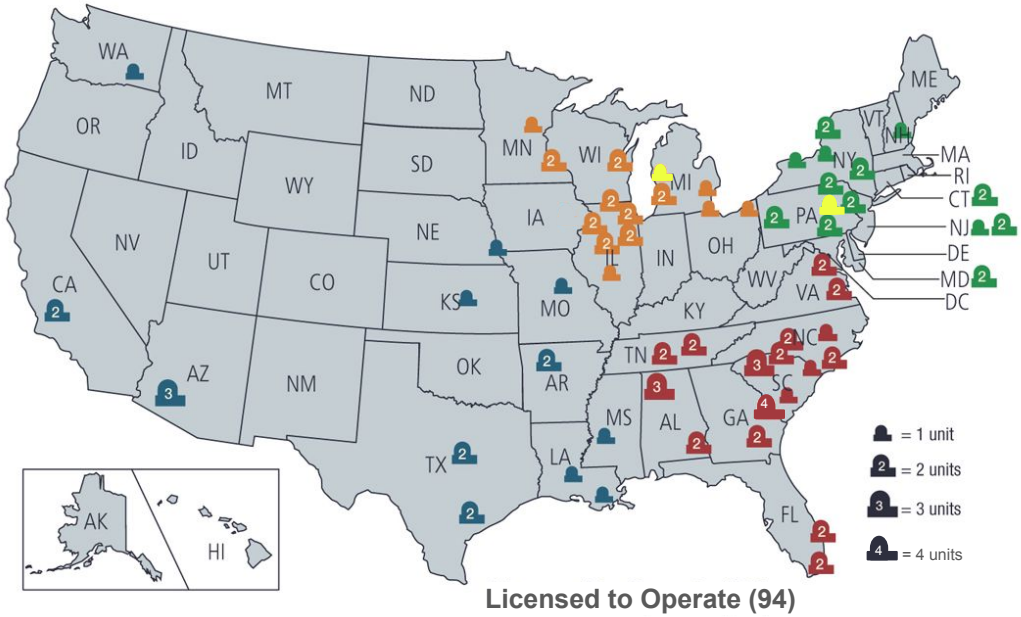
Controlling the Chain Reaction





US Commercial Nuclear Power

- First Commercial Reactor: 1957
  - 1960's: 17
  - 1970's: 114
  - 2020's: 2
- Shutdown: 33
- Restarting: 2
- Currently operating: 94
- ⅔ pressurized water reactors
  ⅓ boiling water reactors
- ~18% of US electricity



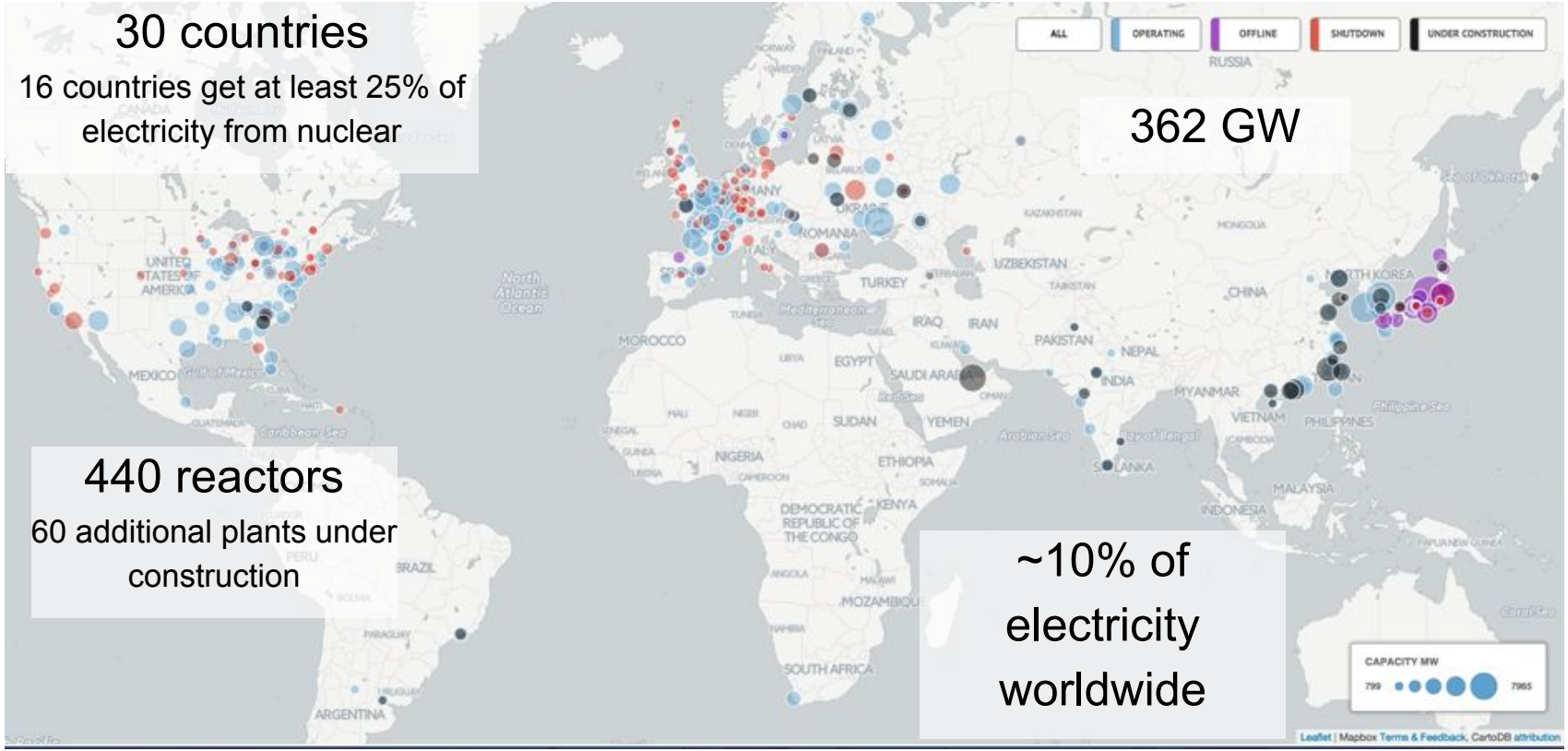
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

As of October 2024

Global Commercial Nuclear Power

30 countries

16 countries get at least 25% of electricity from nuclear



362 GW

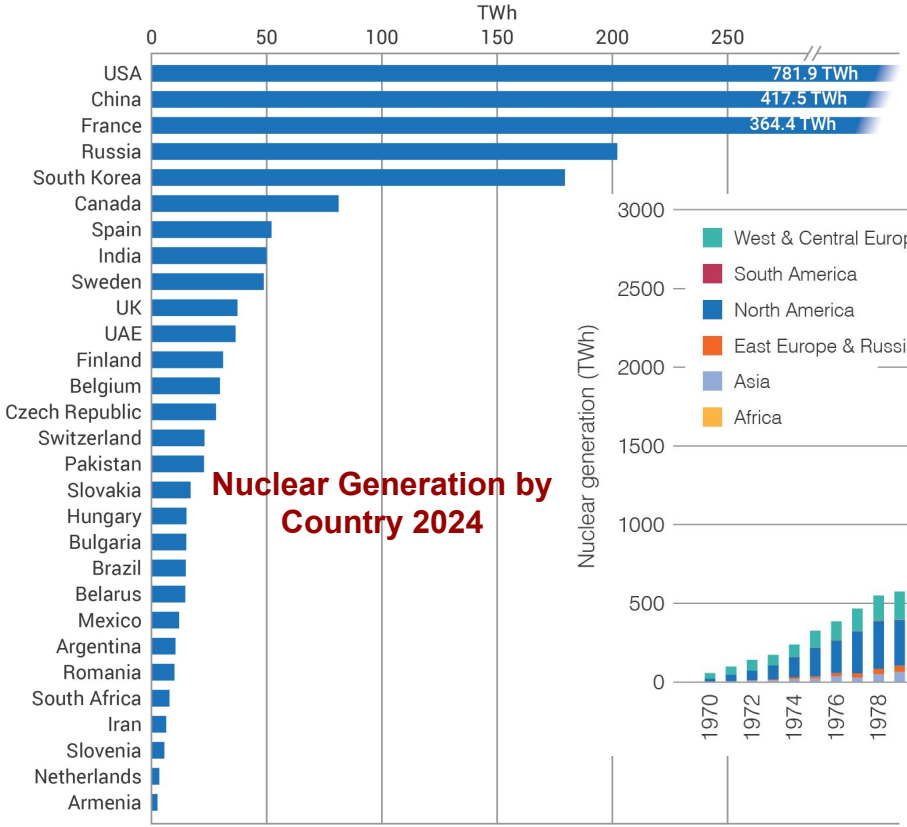
440 reactors

60 additional plants under construction

~10% of electricity worldwide

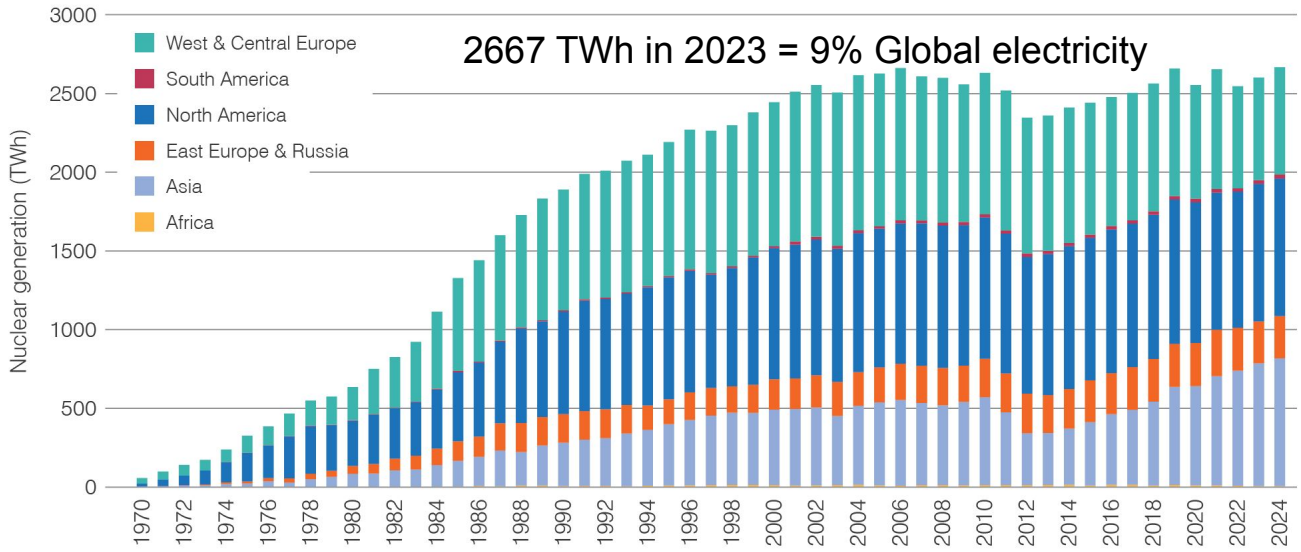
https://world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx

Global Commercial Nuclear Power



Nuclear Generation by Country 2024

Nuclear Generation by Continent through 2024



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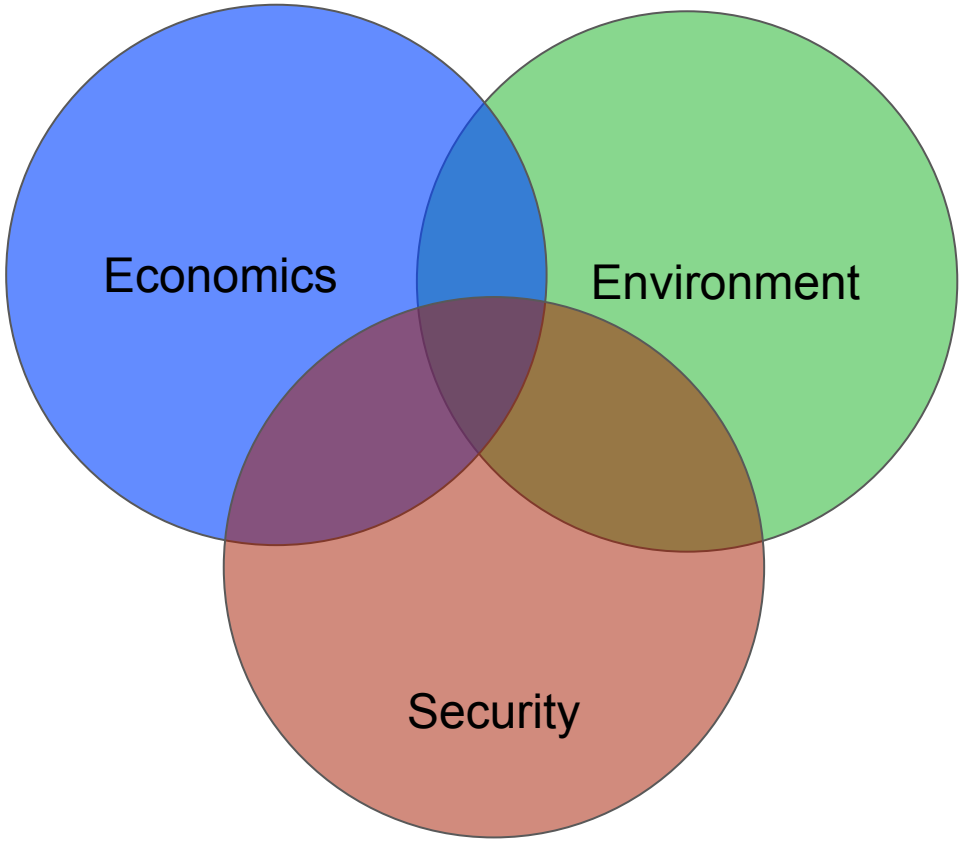
Energy Policy in a Nutshell



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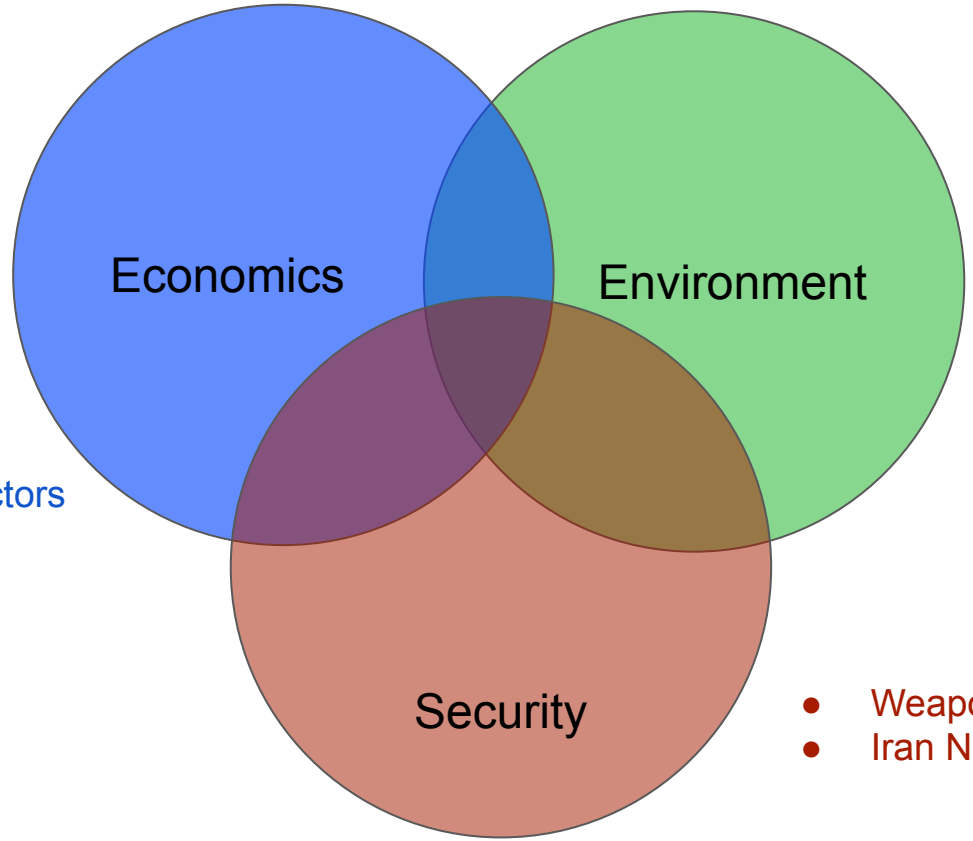
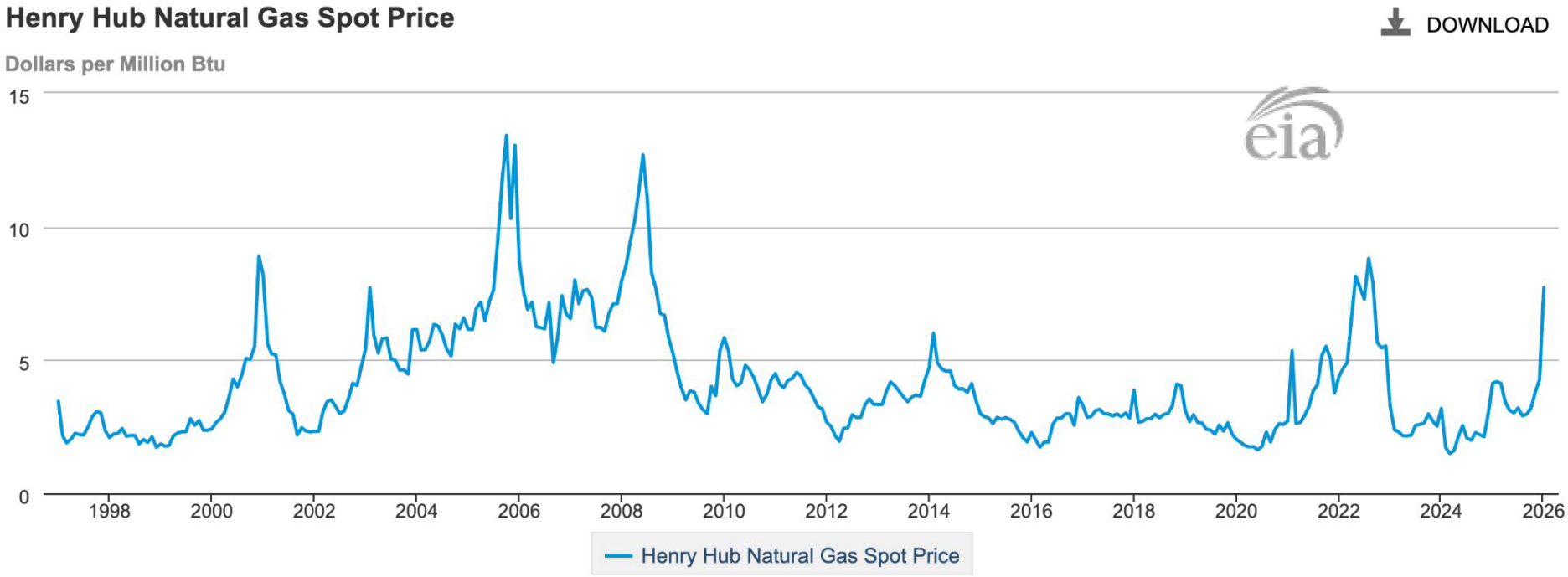


- Cheap Natural Gas
- Energy Markets
- Small Modular Reactors

- Climate Change
- Yucca Mountain
- Radiation Risk

- Weapons Proliferation
- Iran Nuclear Agreement

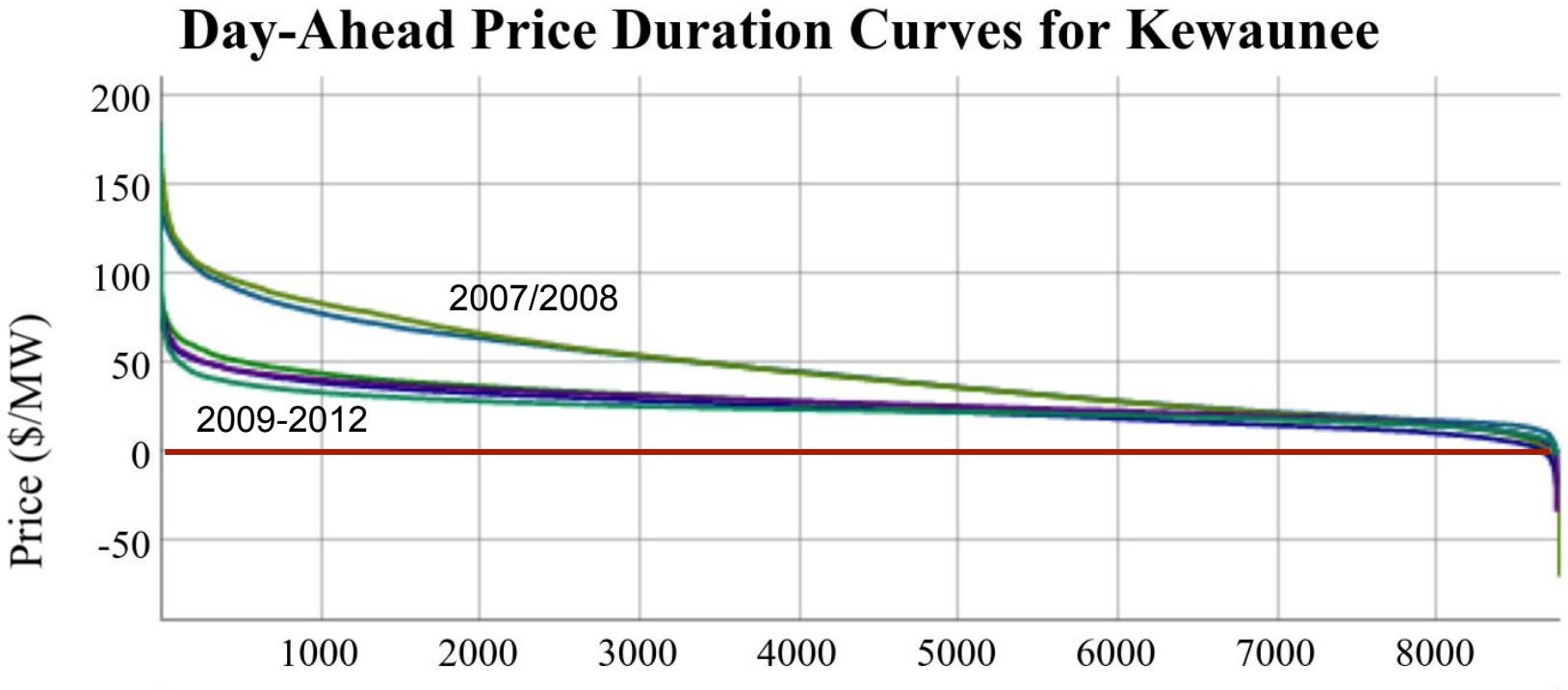
Cheap Natural Gas



https://www.eia.gov/dnav/ng/hist/rngwhhdM.htm

Cheap Natural Gas

45% revenue reduction from 2008 to 2009



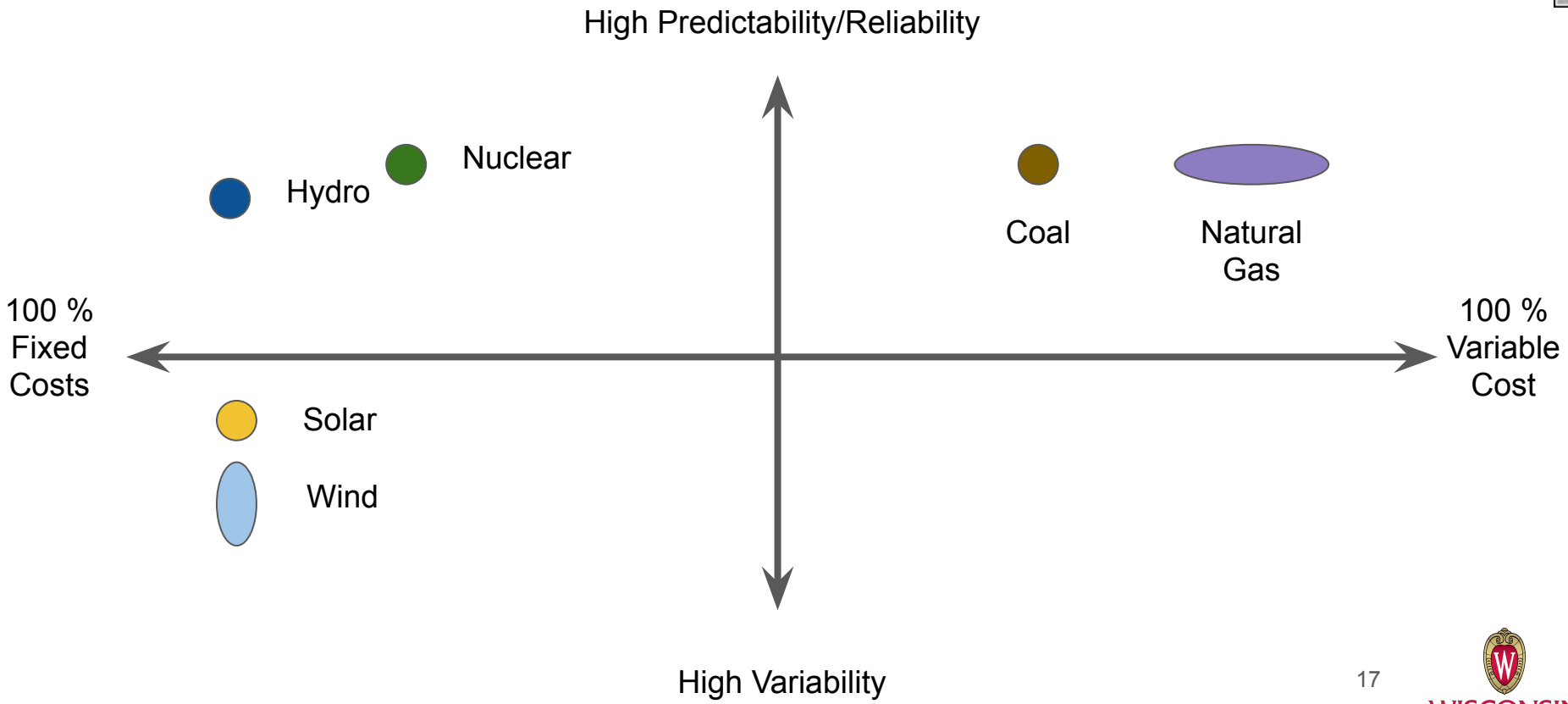
Eric Anderson, http://eja4.info/kwe.html [accessed: 09/28/15]

Cheap Natural Gas

- Riding the decline in natural gas prices
  - Rapid construction of natural gas plants allow electricity system to quickly follow

- Weathering an increase in natural gas prices
  - If vs When
  - Alternatives tend to have longer construction/lead times

Energy Market Structure



Recent Clean Energy Policies - Federal

- When nuclear power plants close, fossil fuel use increases
- Federal action
  - Civil Nuclear Credit Program (Bipartisan Infrastructure Law)
  - Public-Private Advanced Reactor Demonstrations (BIL)
  - Production Tax Credits (IRA)
- Executive Orders
  - DOE/DOD oversight of reactor licensing to support national security
  - Streamlining of federal regulation
  - DOE oversight of test reactors to support licensing of new technologies
  - Immediate support for 5 GW of uprates and start construction on 10 GW of new capacity

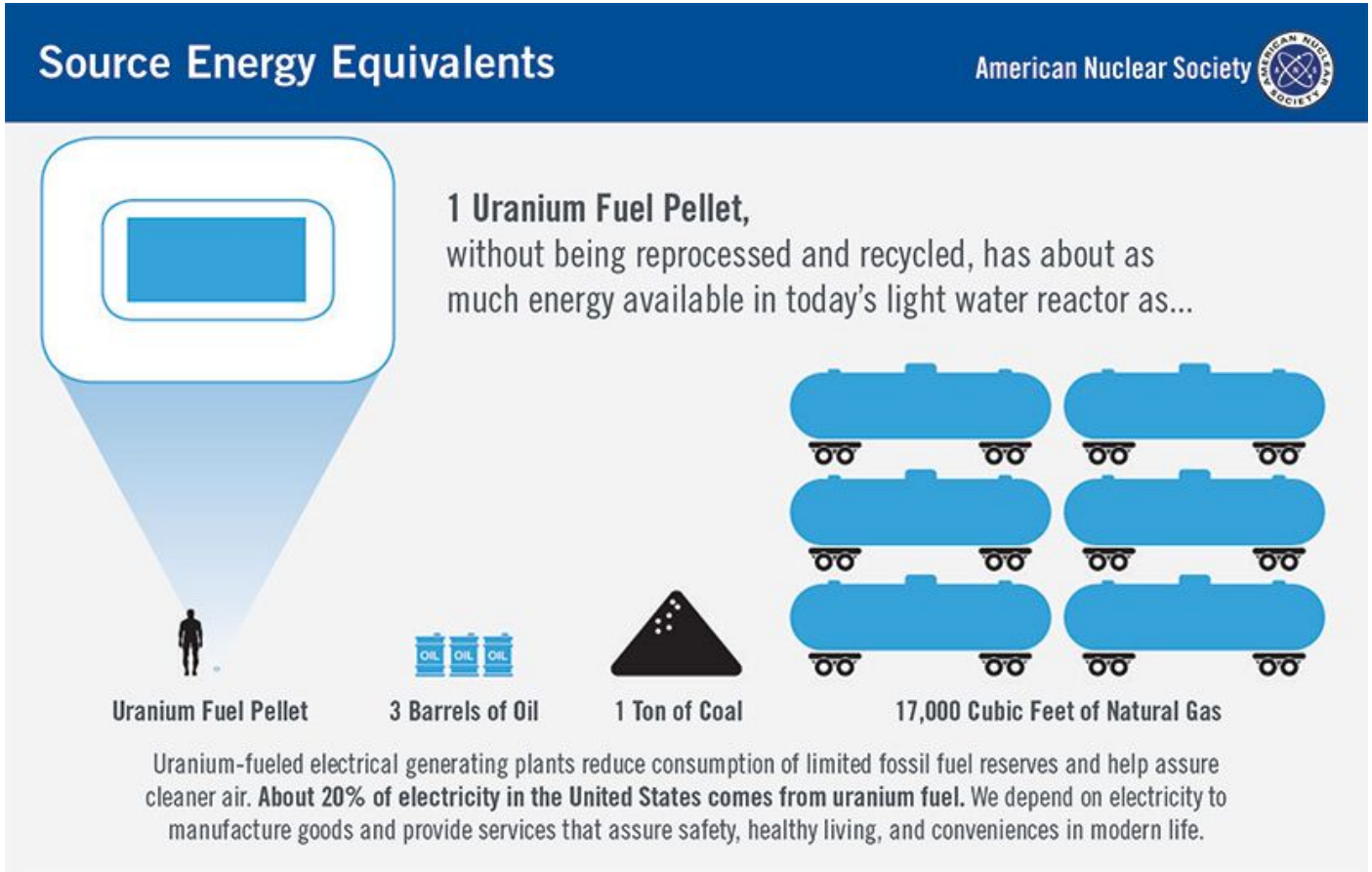
Recent Clean Energy Policies - State

- When nuclear power plants close, fossil fuel use increases
- Some states are adopting policies that favor all clean energy
  - Clean energy credits first-movers: New York, Illinois, Connecticut, California*
  - 2022: 12 states enacted policies that support existing & new nuclear out of 19 states that considered such legislation
  - 2023: 17 states had acted in favor of nuclear energy by August
  - 2025: Wisconsin siting study and global nuclear energy summit

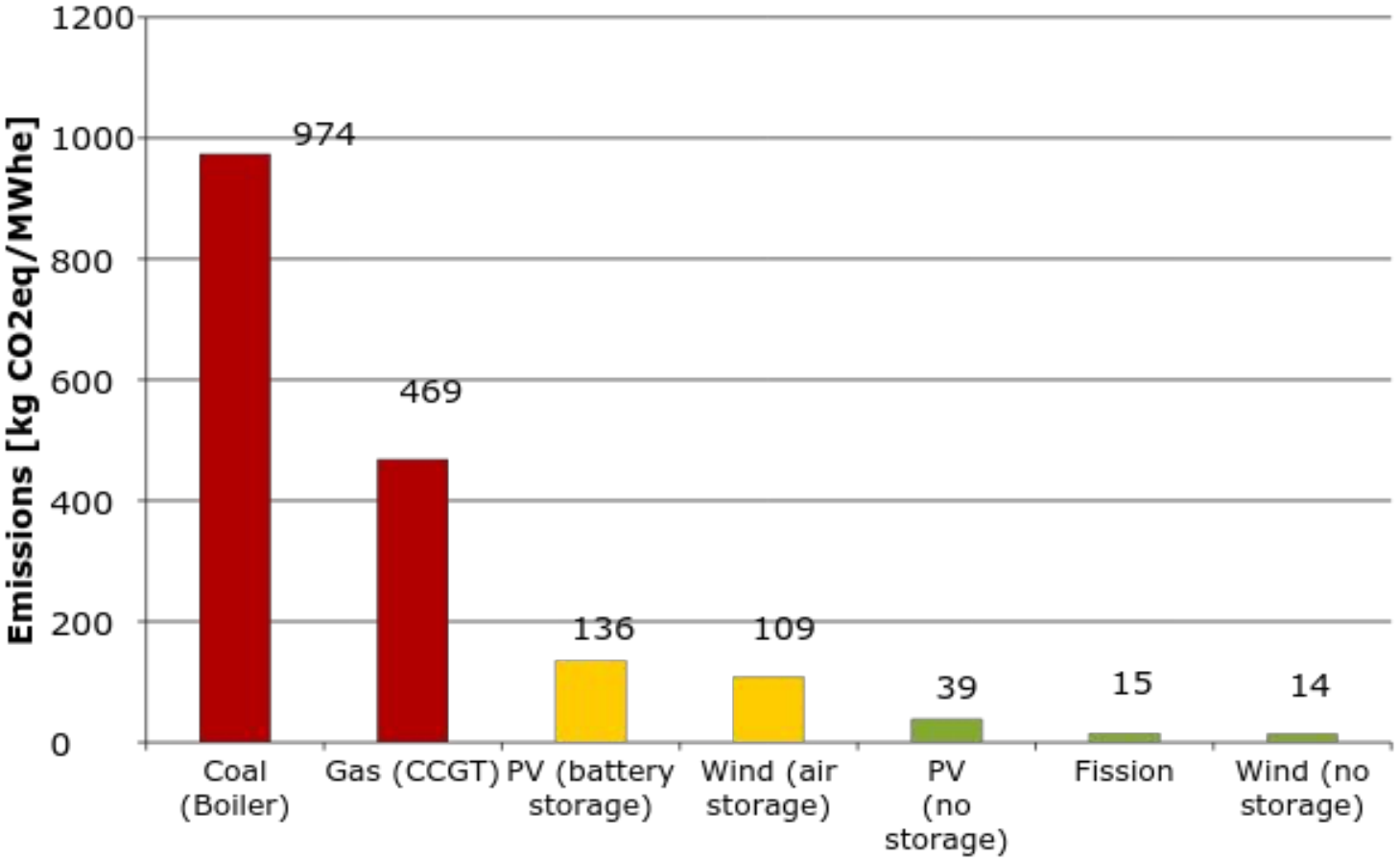
Recent Reversals

- Diablo Canyon - California
  - 2016 - Scheduled for 2024/2025 shutdown by PG&E
  - 2021 - Recognized energy shortage risk & clean energy benefit
- Palisades - Michigan
  - May 2022 - Closed for decommissioning by Entergy
  - Sept 2024 - Holtec announced reopening with State support
  - July 2025 - First ever conversion of decommissioning license to operating license
- Three Mile Island - Pennsylvania
  - 2019 - Closed for decommissioning by Exelon
  - 2024 - Constellation Energy announced reopening with Microsoft support
- Duane Arnold - Iowa
- Kewaunee - Wisconsin

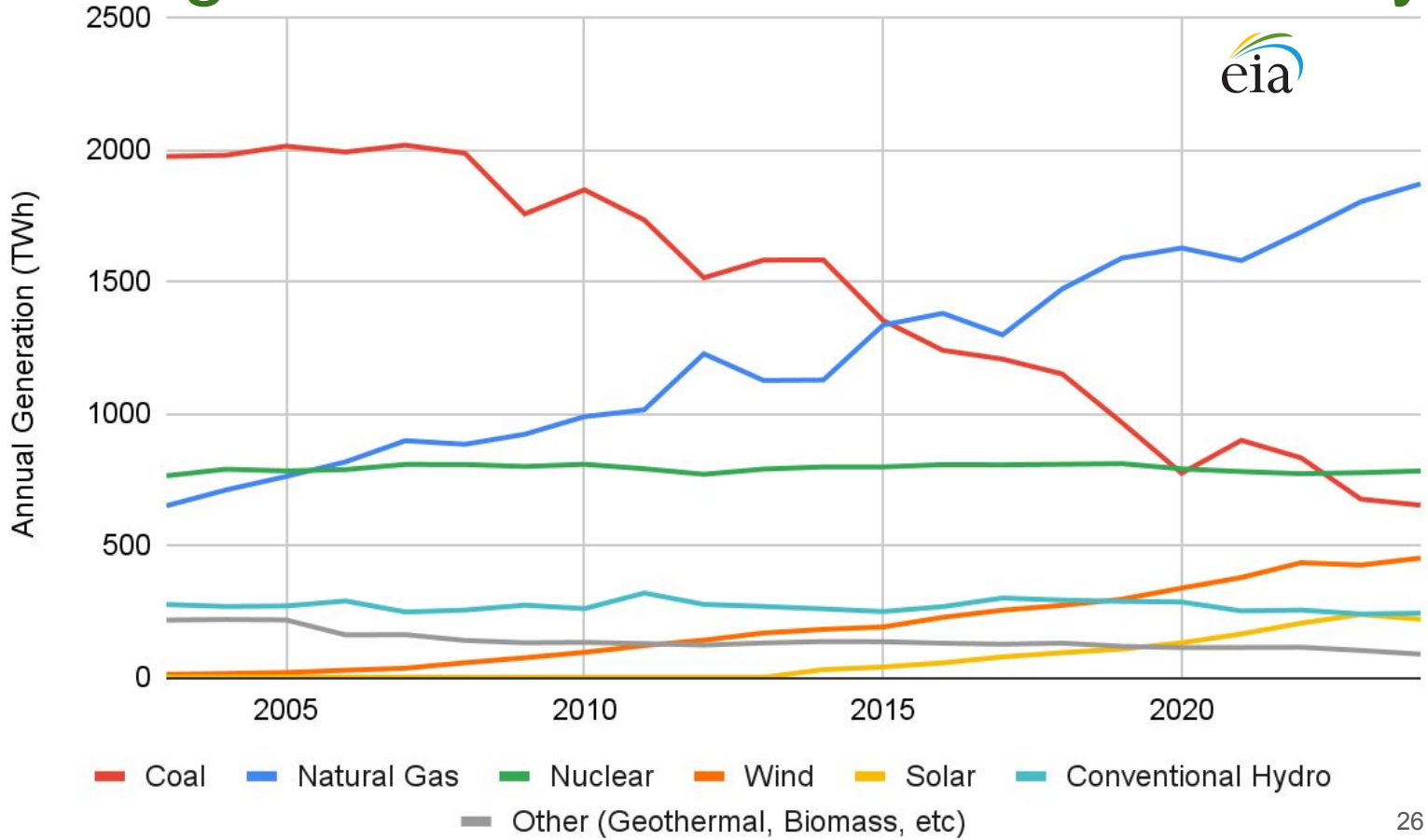
Resource Consumption



Life-Cycle Greenhouse Gas Emissions

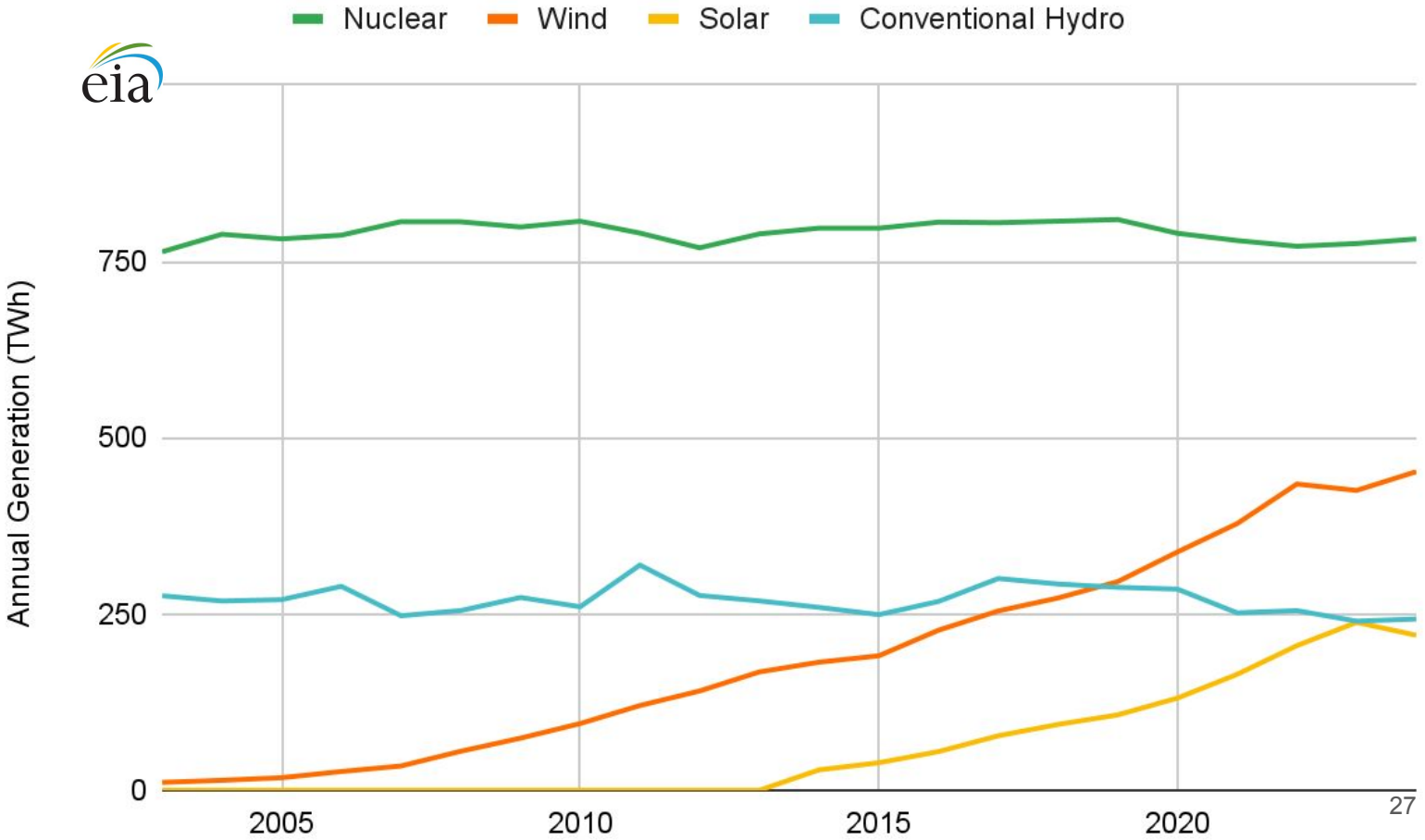


Growing Share of Low-Emission Electricity

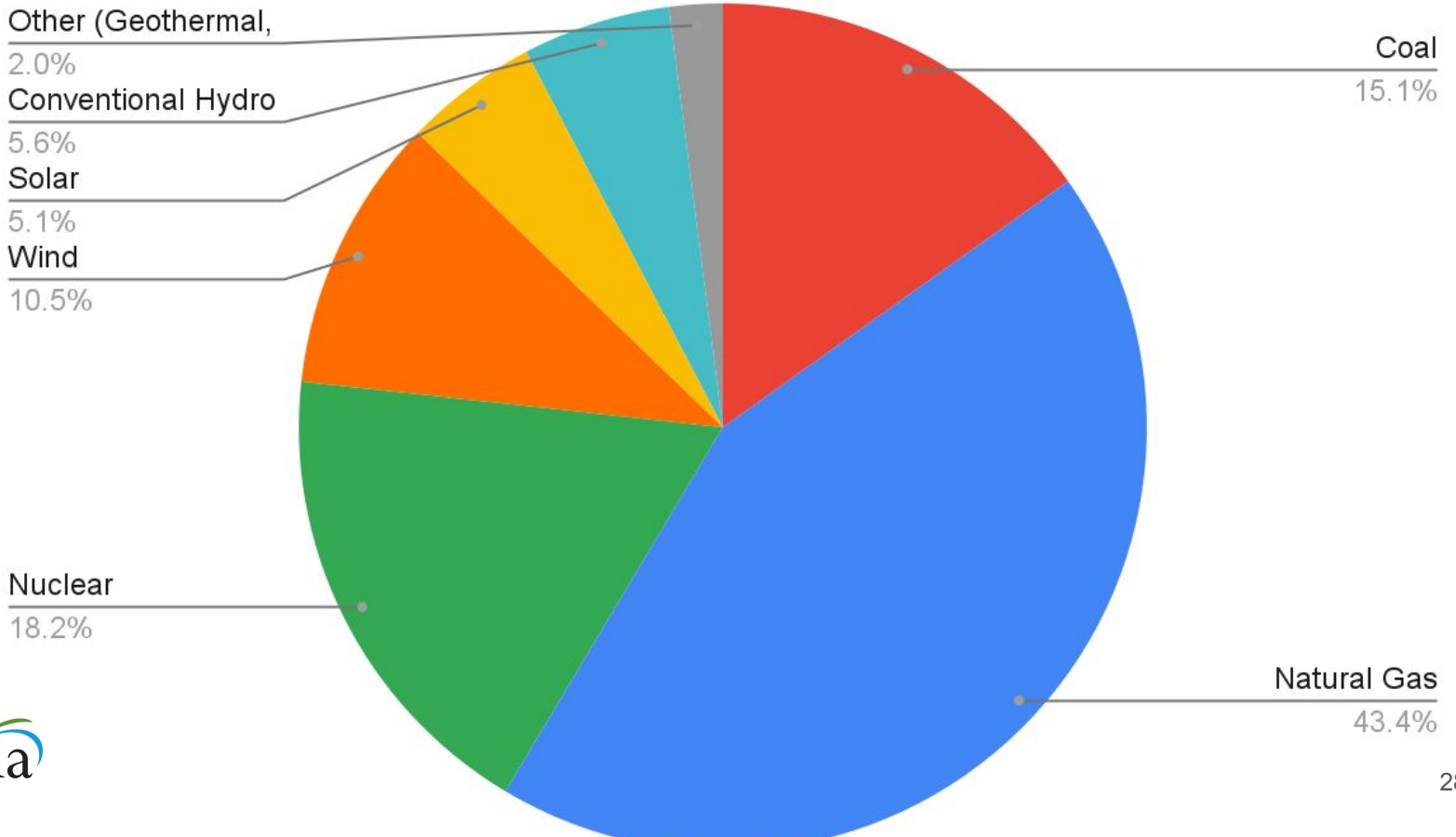


https://www.eia.gov/electricity/data/browser/#/topic/0?agg=2,0,1&fuel=vtvv&geo=g&sec=g&linechart=~ELEC.GEN.COW-US-99.A~ELEC.GEN.NG-US-99.A~ELEC.GEN.NUC-US-99.A~ELEC.GEN.HYC-US-99.A~ELEC.GEN.WND-US-99.A~ELEC.GEN.TSN-US-99.A&columnchart=ELEC.GEN.ALL-US-99.A~ELEC.GEN.COW-US-99.A~ELEC.GEN.NG-US-99.A~ELEC.GEN.NUC-US-99.A~ELEC.GEN.HYC-US-99.A~ELEC.GEN.WND-US-99.A&map=ELEC.GEN.ALL-US-99.A&freq=A&start=2003&end=2023&ctype=linechart&ltype=pin&rtype=s&maptype=0&rse=0&pin=

Growing Share of Low-Emission Electricity



Share of 2023 US Electricity Generation



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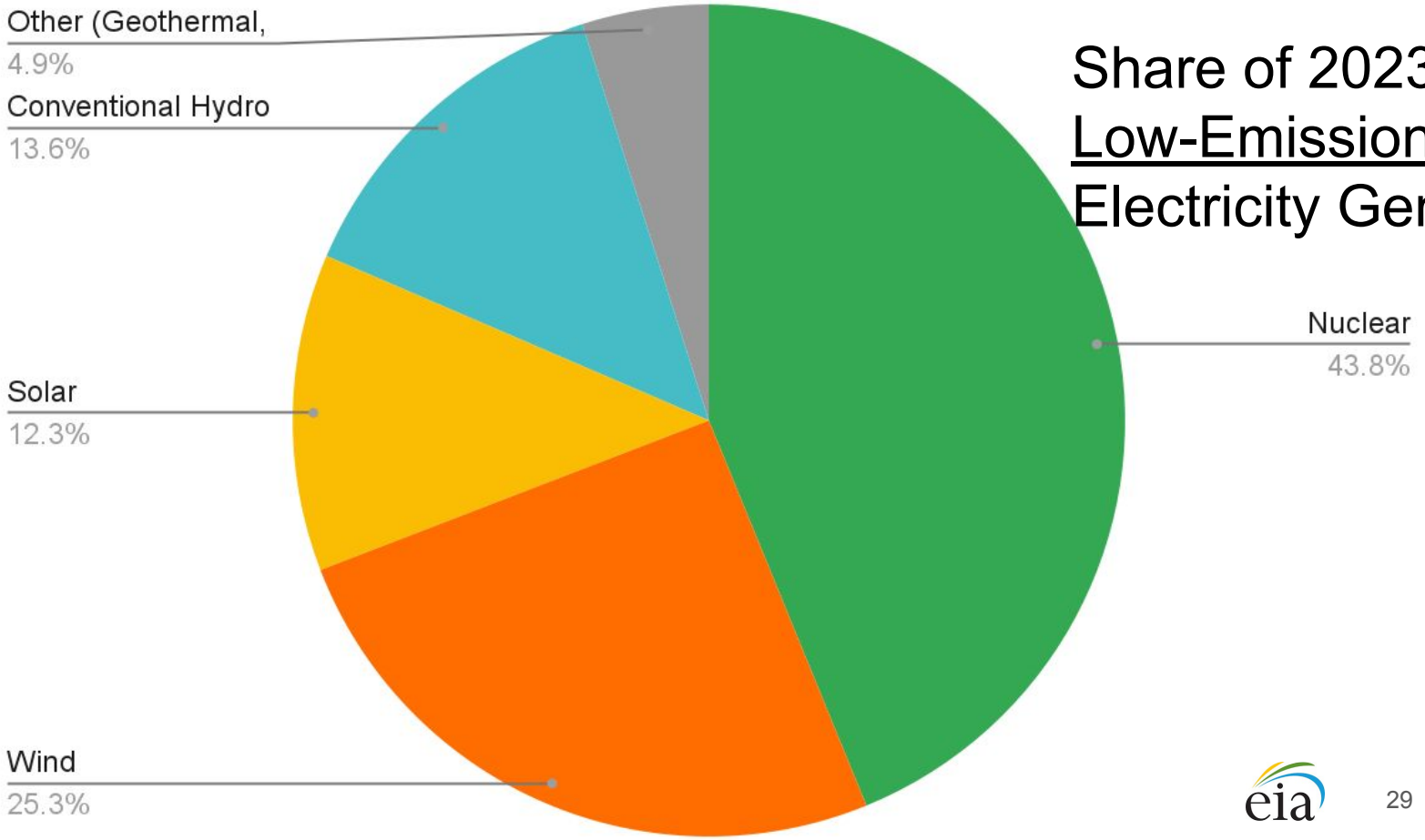
Nuclear Energy is Important Low Emission Source



Share of 2023 US
Low-Emission
Electricity Generation

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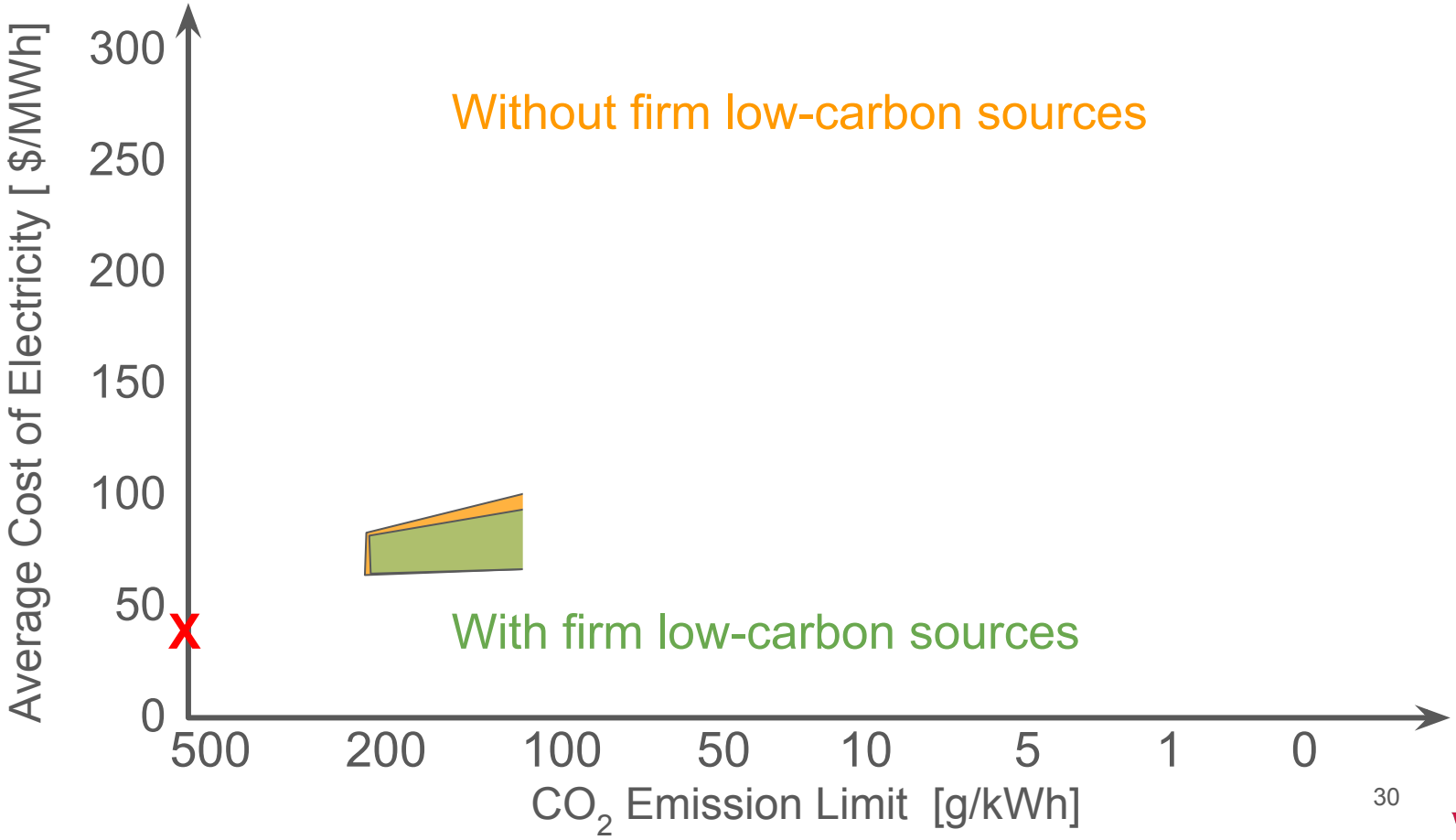
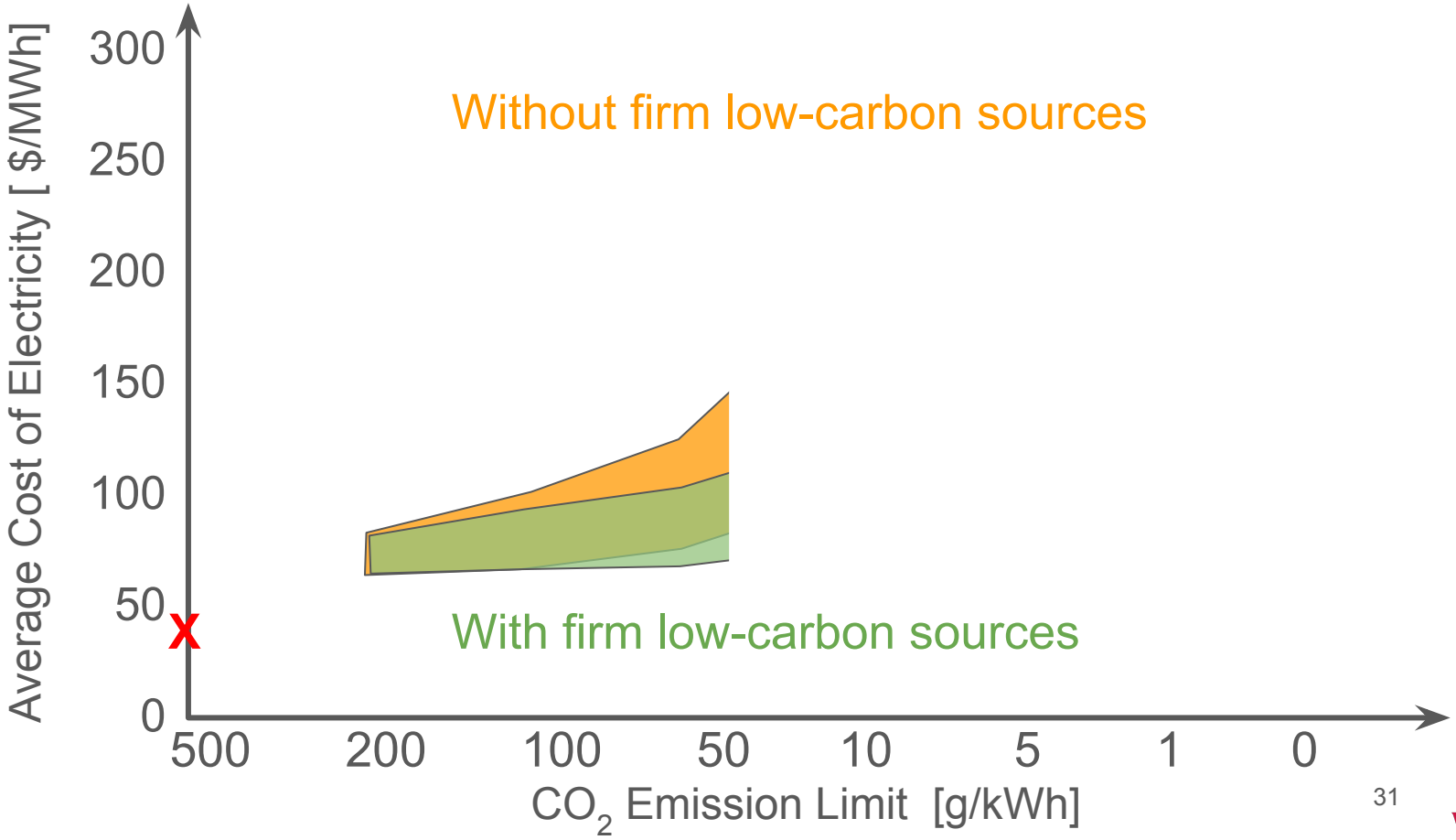
Challenge of Deep Decarbonization



Adapted from Sepulveda, *et al.*
https://doi.org/10.1016/j.joule.2018.08.006

Challenge of Deep Decarbonization



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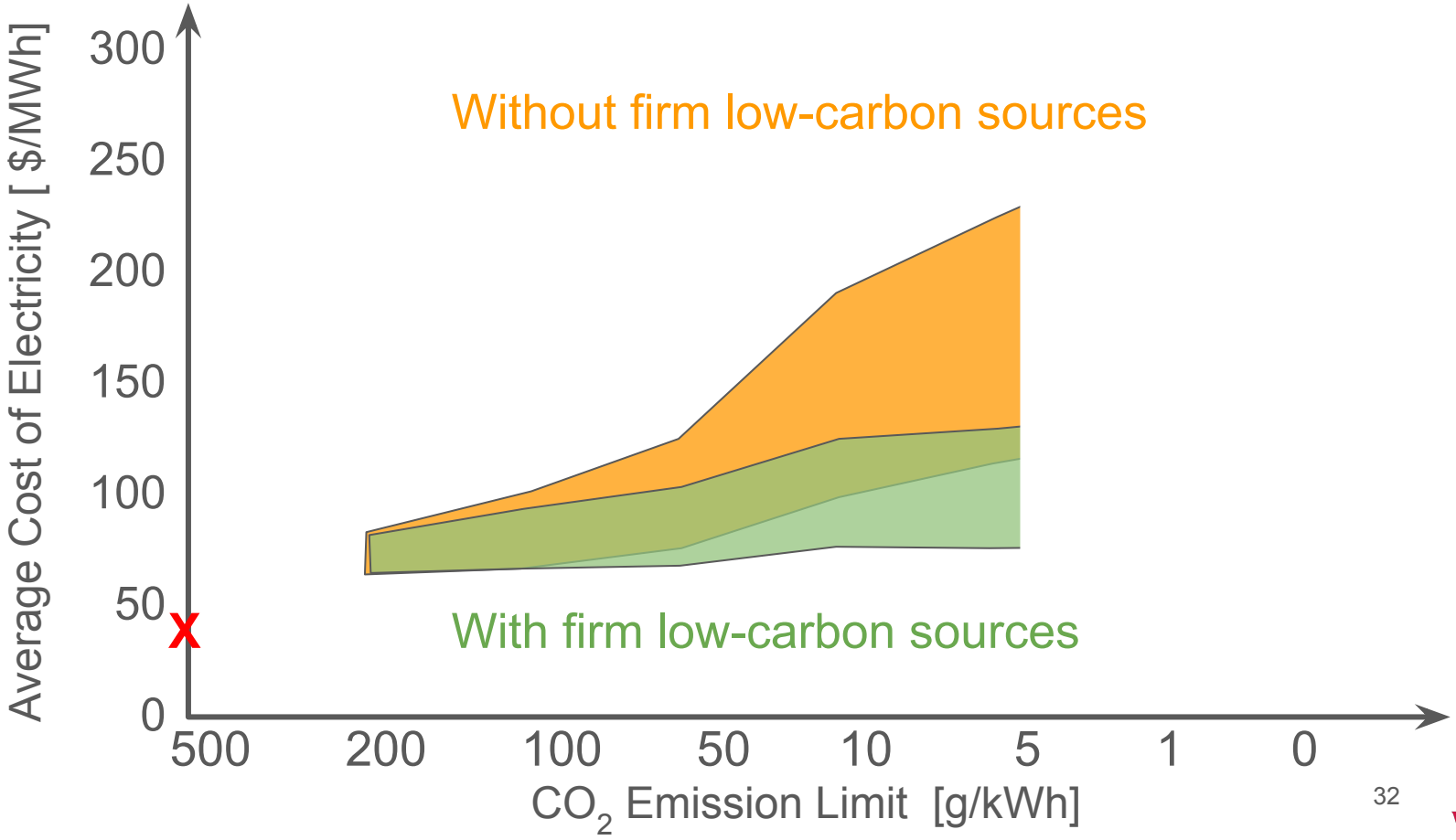

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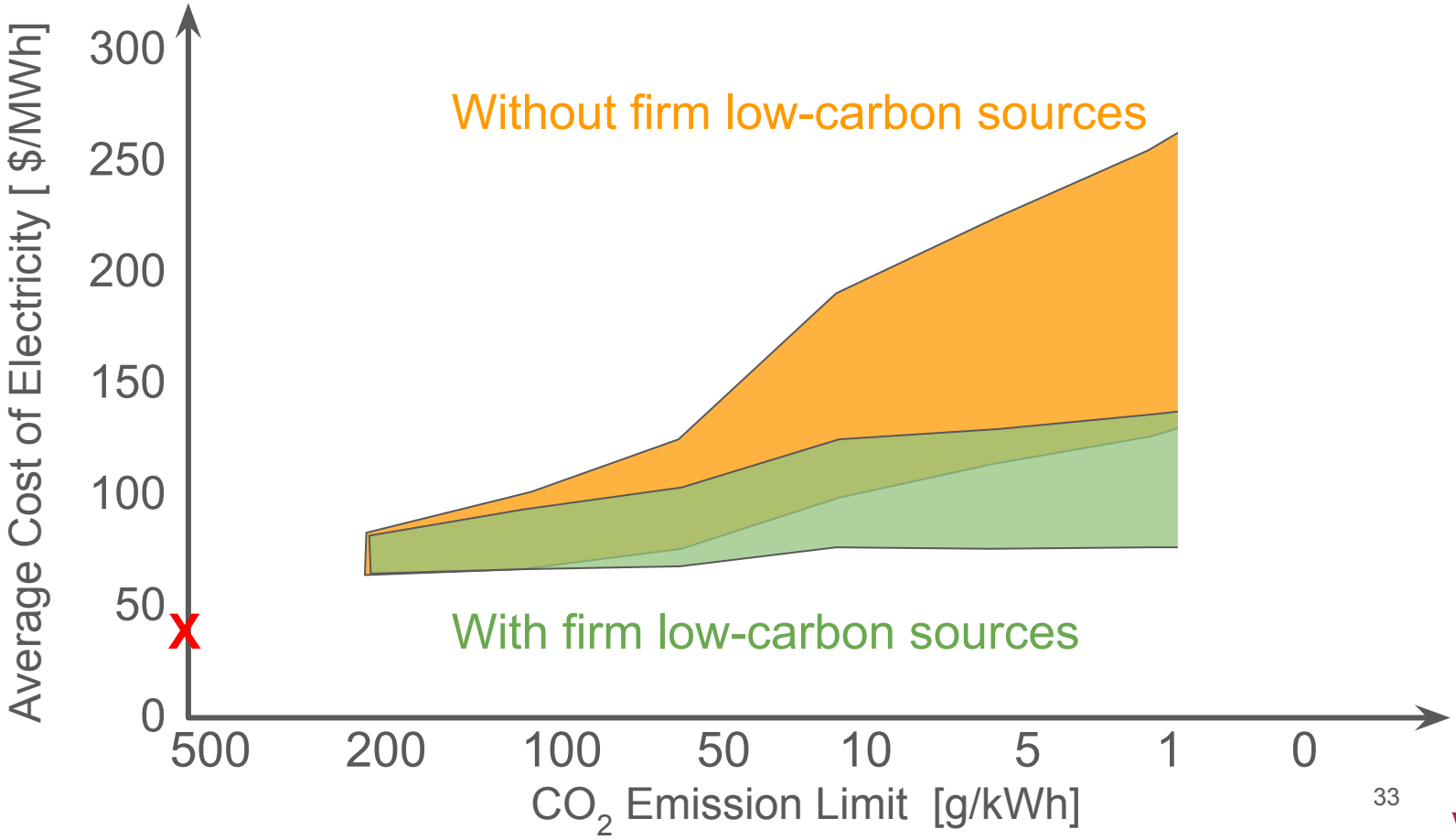

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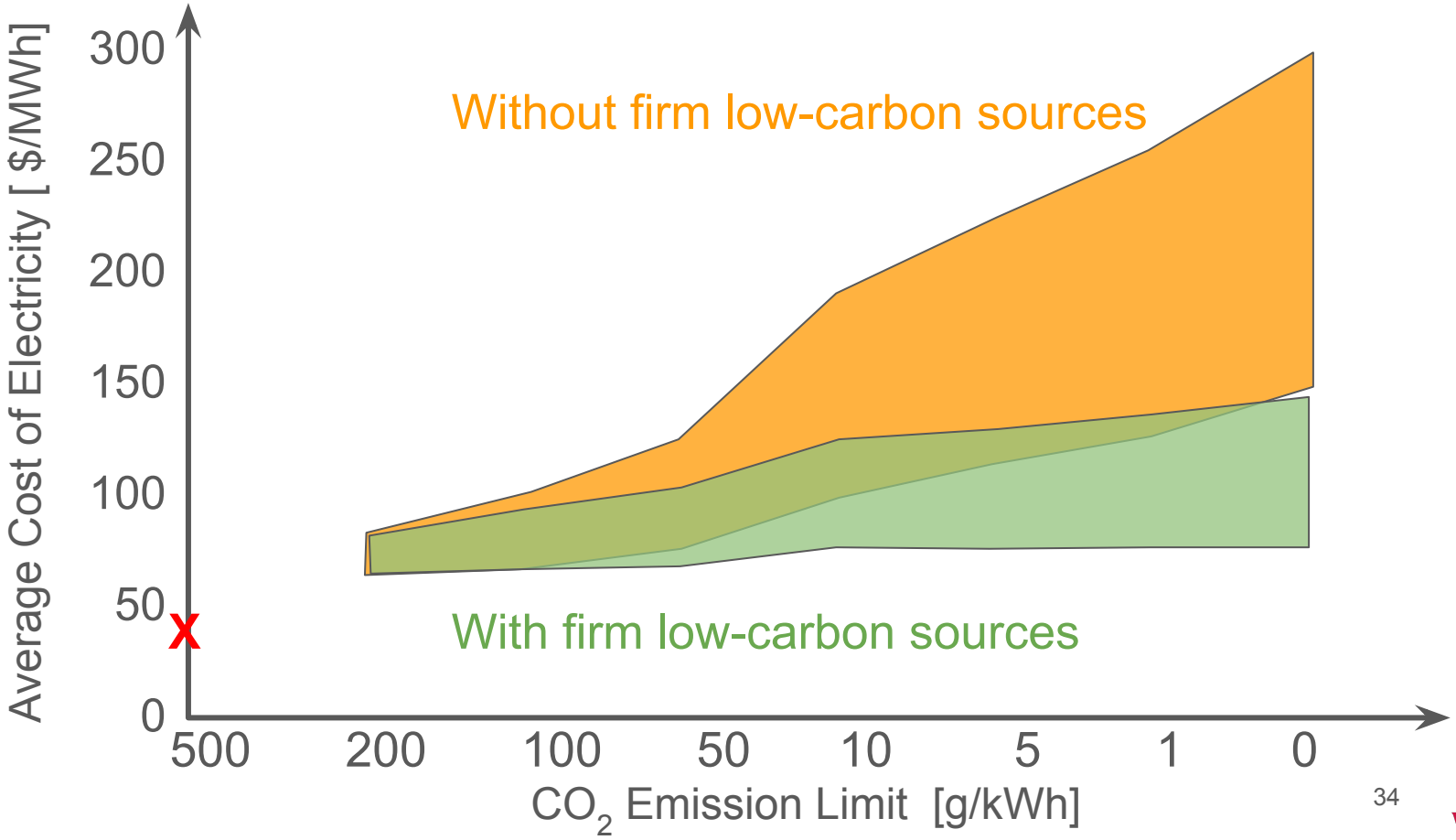

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Three C's of Used Nuclear Fuel

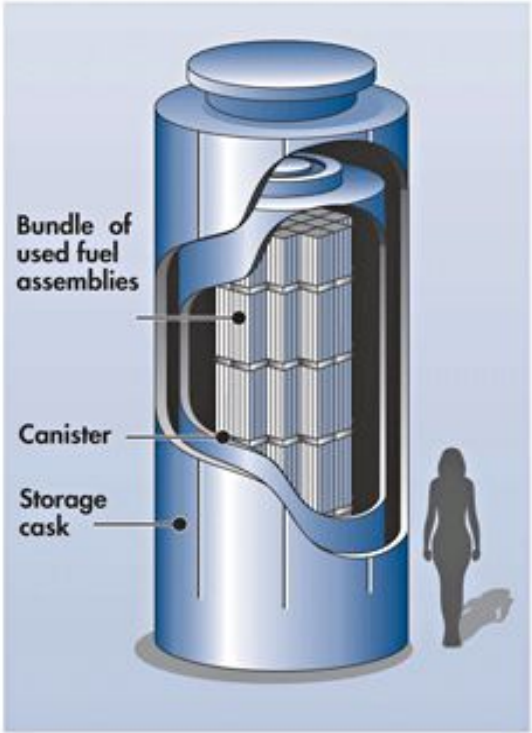
- **Compact**, Contained, Curated

- Imagine all your electricity for an entire lifetime was generated by nuclear energy
  - About 1 million kWh (2006 EIA)
- About 1 soda-can of used nuclear fuel

Three C's of Used Nuclear Fuel

- Compact, **Contained**, Curated

- Fuel itself is solid
- Wrapped in metal
- Stored in pool/cask



Three C's of Used Nuclear Fuel

- Compact, Contained, **Curated**

- Carefully tracked
- Decades of experience in safe handling
- Easy to detect and monitor
- Paid for in Nuclear Waste Fee

Future of Nuclear Energy

Rethinking Large Nuclear Reactors

- Construction of new large reactors has challenges
  - Large single investment
  - Long construction time lines prior to revenue generation
  - Deregulated markets mean no guaranteed rate of return
- Vogtle 3 & 4 were over budget & delayed
  - First new reactors built in US since 1970s
  - Should we build on the lessons we learned or abandon large reactors?
- AI Data Centers
  - Need reliable baseload power
  - Growing interest in clean power

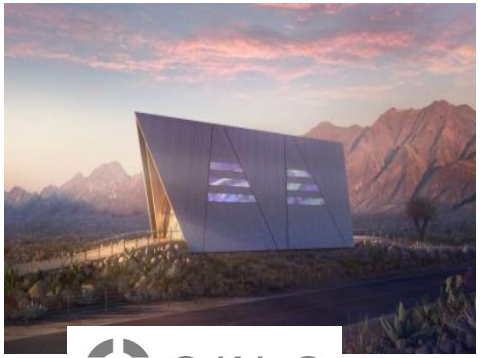
Small Modular Reactors

- Construction of new large reactors has challenges
  - Large single investment
  - Long construction time lines prior to revenue generation
  - Deregulated markets mean no guaranteed rate of return
- Small modular reactors
  - Reduce size of initial investment
  - Shorten construction time line with factory manufacturing
- Economy of scale
  - Traditionally: make reactors **as large as possible**
  - SMR: make **as many reactors as possible**

Microreactors (1-50 MW)

- “Nuclear Battery”
  - Manufactured in factory
  - Delivered as plug-and-play systems
  - Removed at end of life and replaced
- Neighborhood sized
  - Enables different scope of energy decision making
  - Suitable for campuses, individual (large) businesses
- Challenges for adoption
  - Reduce staffing requirements to nearly 0
  - Automatic/remote control
- Process/industrial heat

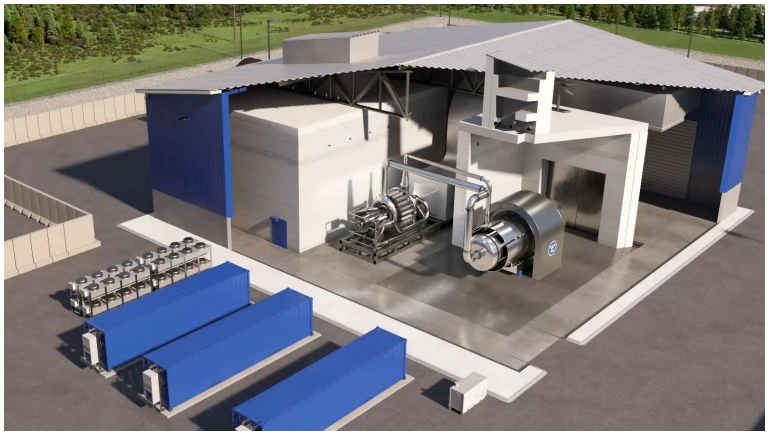
Microreactors (1-50 MW)



OKLO

Westinghouse

NANO Nuclear Energy Inc.



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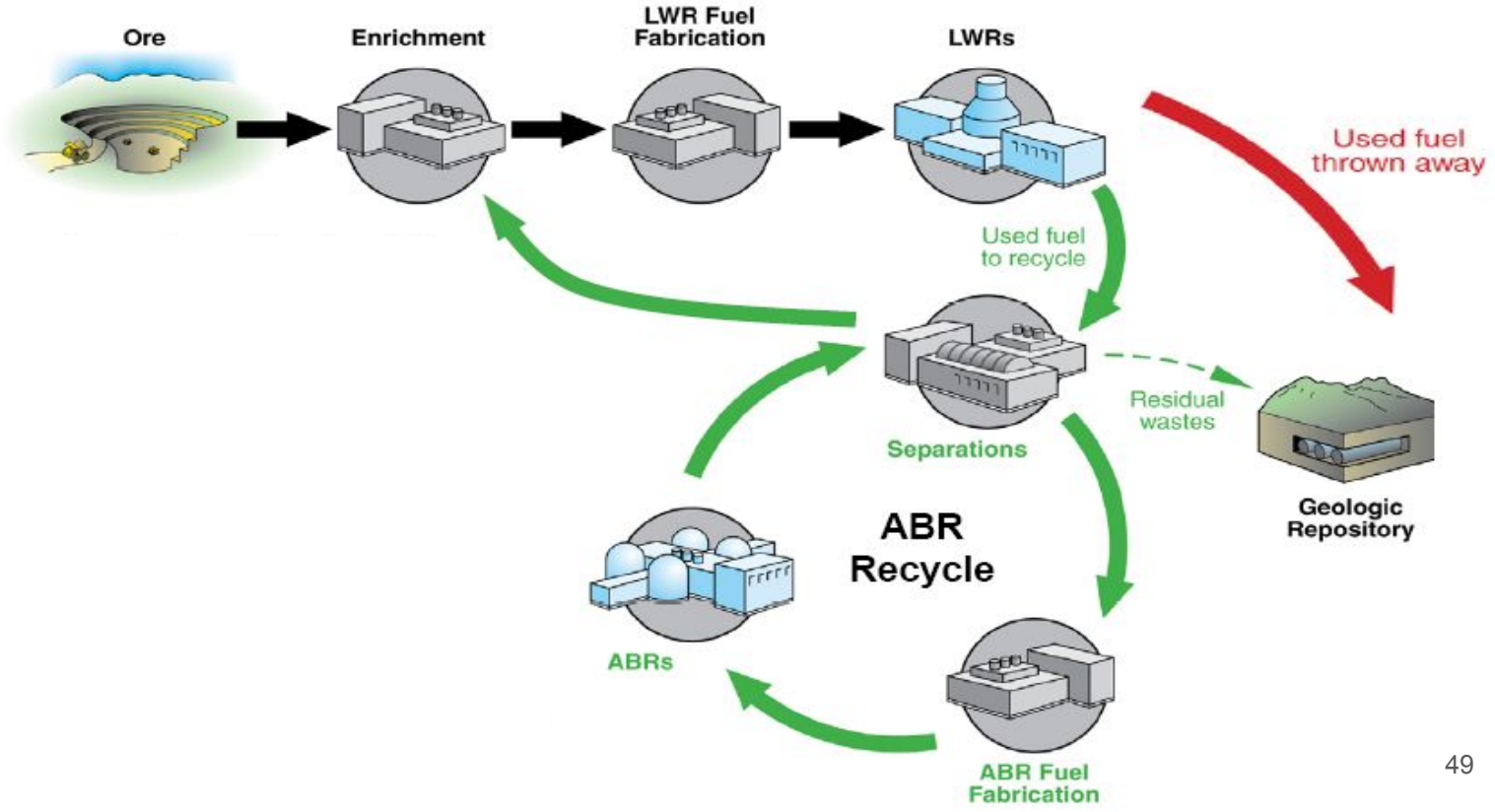
Advanced Reactor Demonstrations

- Public-private partnerships in Bipartisan Infrastructure Law
- TerraPower - Kemmerer, WY
  - Sodium cooled fast reactor
  - Integrated thermal storage for load following
  - Funded by Bill Gates
- X-Energy - Seadrift, TX
  - High-temperature gas reactor
  - Combined heat and power at Dow Chemical chemical plant
  - Dow committed to more reactors upon success

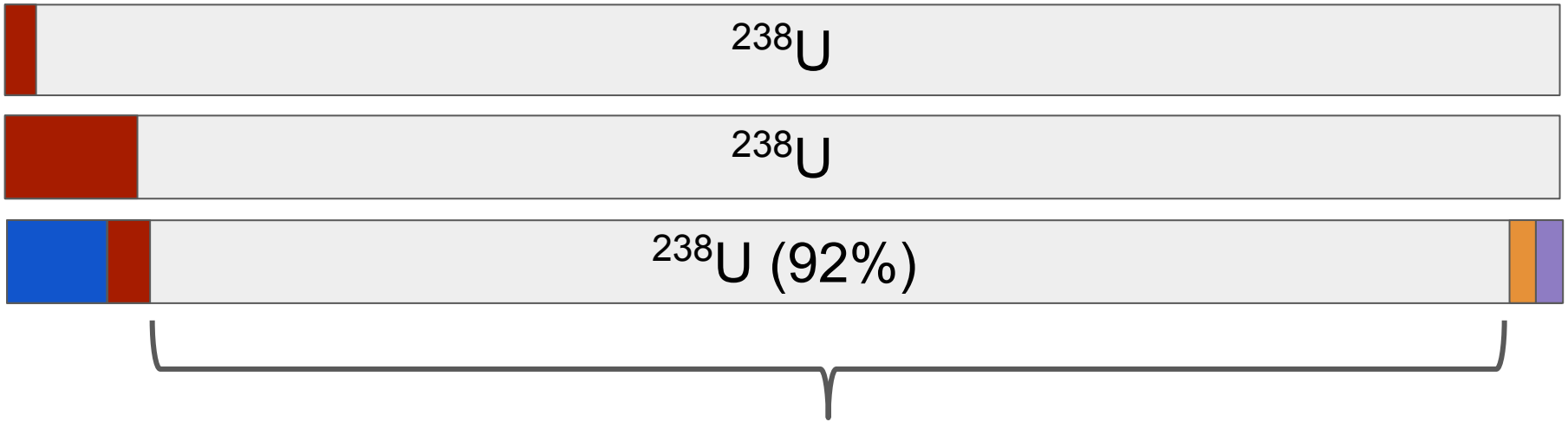
If Not Now…. Then When?

- Various estimates, predictions and expectations of new nuclear capacity
  - NEI Members: additional 90 GW (almost 2x current capacity)
  - DOE Lift-off report: additional 200 GW by 2050 (3x current capacity!)
- First-mover anxiety
  - Risk sharing between all parties involved in construction
- Regulatory costs & uncertainty
- Underdeveloped supply chain

Advanced Nuclear Fuel Cycles



Uranium Utilization



- What if we could use this too?
  - 14x more resource - 1000s of years
  - 100s of years of above-ground resource in existing depleted uranium stocks

Debate about Advanced Fuel Cycles

- Cost
  - Nuclear Waste Fee establishes the cost threshold
  - Reprocessing expected to be more expensive, BUT
  - Is waste fee set at the right level?
- Intergenerational ethics
  - This generation should resolve their own waste management solution, BUT
  - Should they bury a valuable fuel resource away from future generations?
- Proliferation
  - Used fuel renders plutonium largely inaccessible, BUT
  - Increased nuclear demand means increased demand for U, enrichment & possibly reprocessing
  - Where is the best place for that technology to be deployed?

Summary

- Nuclear energy is energy dense with small impact
  - Low emissions
  - Small land use
- Capital-intensive, complex construction projects in heavily-regulated industry
  - Economic challenge of low natural gas prices
  - Poorly matched to intermittent sources
- Variety of technologies in development for a different nuclear future
  - SMRs & advanced reactors can change part of the economic equation
  - Advanced fuel cycles have long term impact on sustainability