ARPA-E Workshop

Nuclear Heat for Industrial Applications

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Nuclear Heat Team

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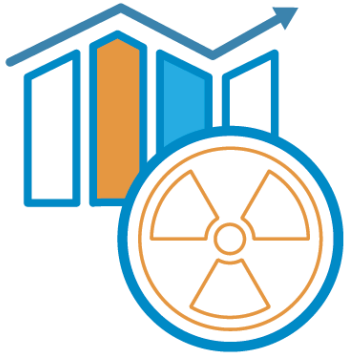
CHANGING WHAT'S POSSIBLE

REDUCE
imports

REDUCE
emissions

IMPROVE
efficiency



IMPROVE
radioactive waste management

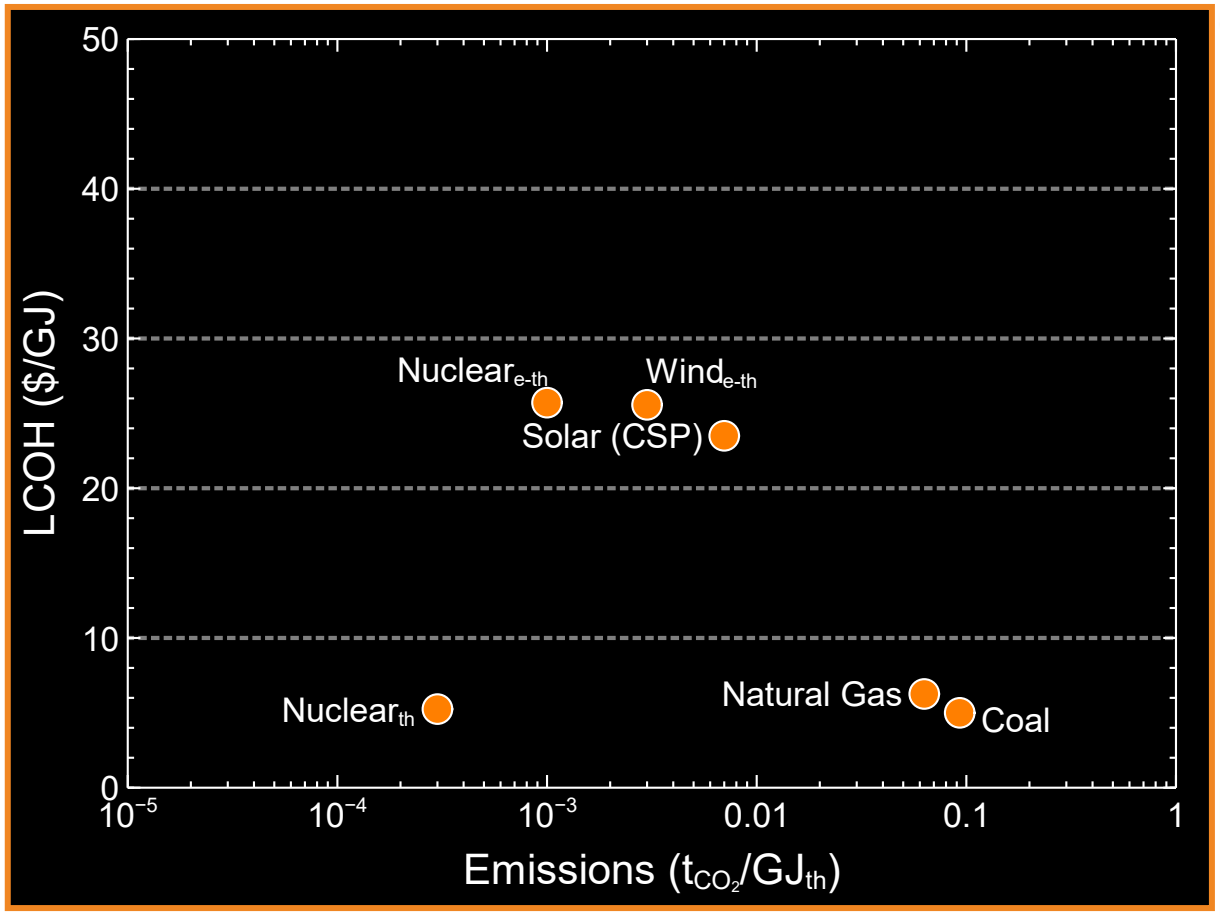
IMPROVE
energy infrastructure resilience

Executive Summary

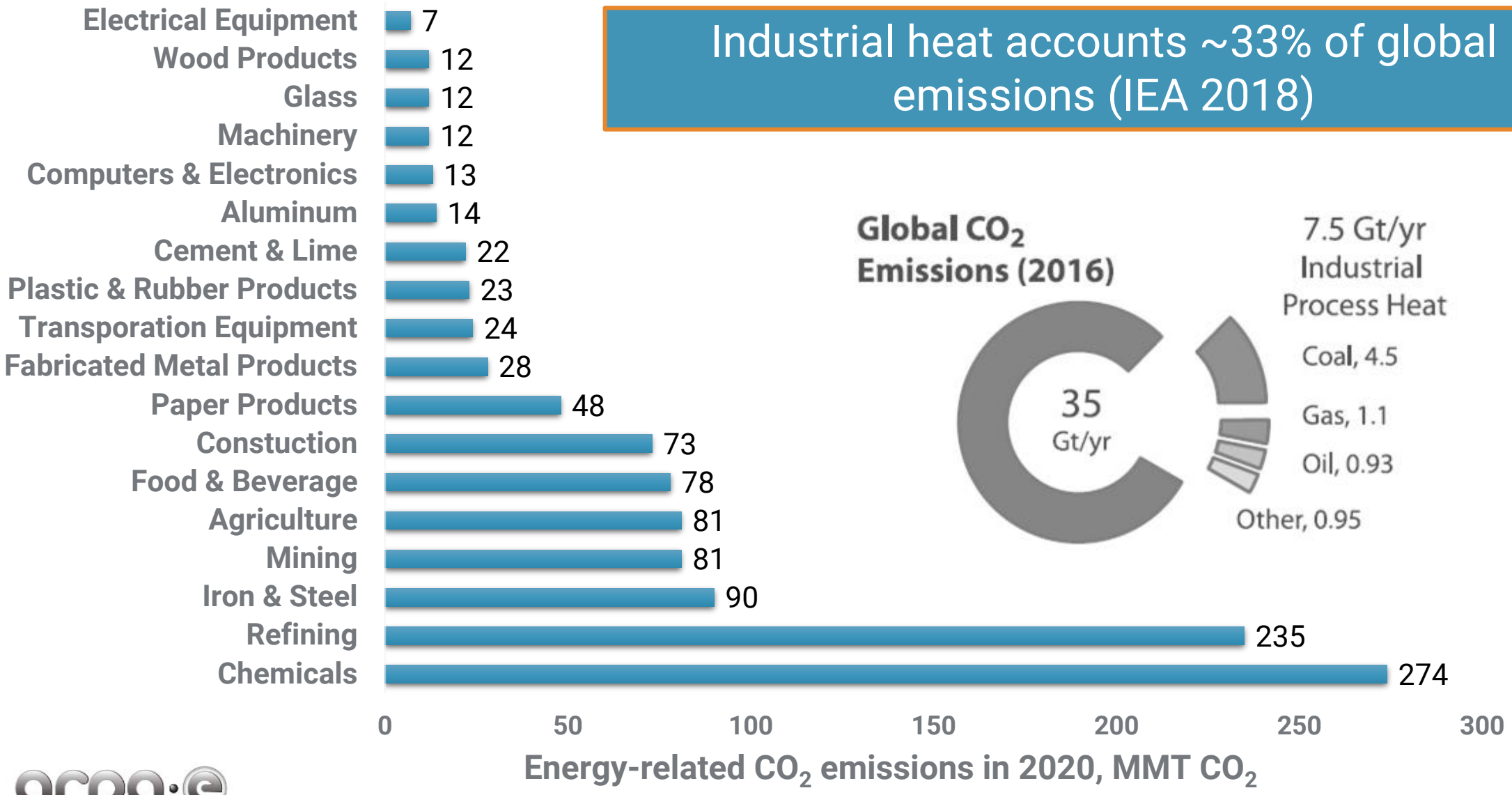
Industrials need low carbon heat and nuclear offers this

Challenges exist in deploying nuclear at speed and scale

We need your help in identifying technical R&D to solve this challenge!



Intersection of Heat & Decarbonization



Industrial heat accounts ~33% of global emissions (IEA 2018)

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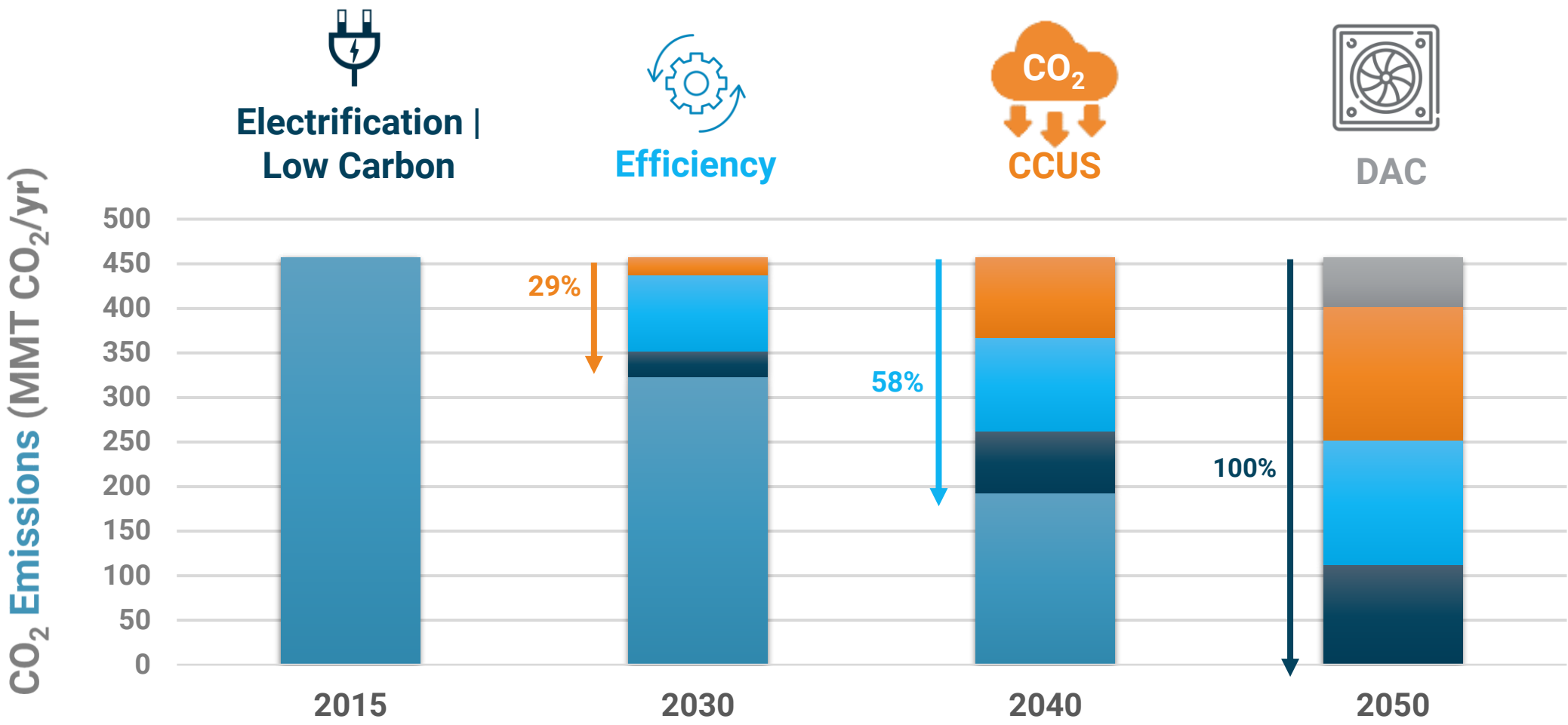
To decarbonize industry, we must decarbonize heat (cell.com) DOE Industrial Decarbonization Roadmap | Department of Energy

Roadmap Projections



Nuclear can support electrification/low carbon efforts

The Role of Nuclear Heat

Nuclear reactors provide clean firm **heat** & **power**

Maximize constant use of nuclear by hybridizing

Heat
Power
Heat + Power

with industrial consumer needs

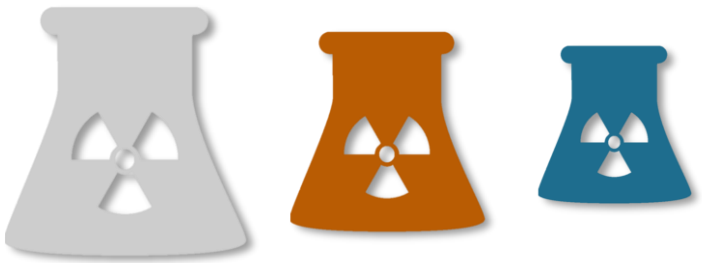
Nuclear Reactor Primer

Reactor sizes

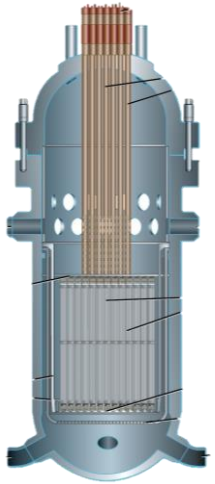
Current Fleet
1 GW_e | 3 GW_t

Small Modular Reactor
50-300 MW_e | 120-900 MW_t

Microreactor
1-50 MW_e | 3-150 MW_t



Light Water

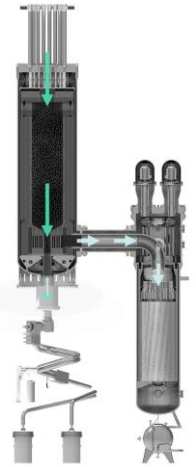


Light Water Reactor

Fuel: U Oxide

Coolant: Water

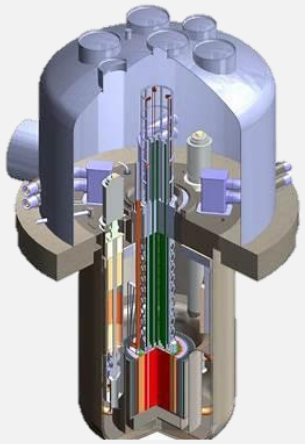
Advanced Reactors



High Temp Gas Reactor

Fuel: TRISO

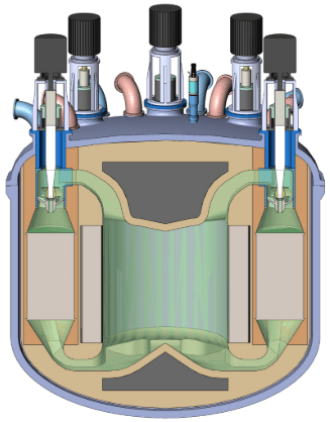
Coolant: Gas



Metal Fast Reactor

Fuel: U Metal

Coolant: Liquid Metal



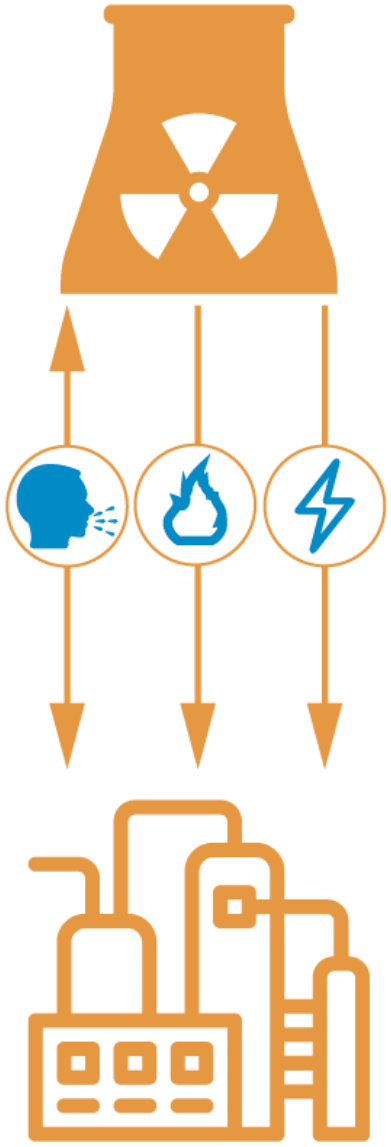
Molten Salt Reactor

Fuel: U Cl

Coolant: Cl Molten Salt

Fuel: TRISO

Coolant: F MS



Gas Cooled Reactors
Molten Salt Reactors
Supercritical Water-Cooled Reactors
Sodium Cooled Fast Reactors
Liquid Metal Cooled Reactors
Water Cooled Reactors

Anticipated heat availability from nuclear

100 200 300 400 500 600 700 800 900 1000 1100 1200 (°C)

District Heating
Seawater Desalination
Pulp & Paper Manufacturing
Methanol Production
Heavy Oil Sulfurization
Petroleum Refining
Hydrogen Electrolysis
Methane Reforming Hydrogen Production
Thermochemical Hydrogen Production
Coal Gasification
Blast Furnace Steel Making

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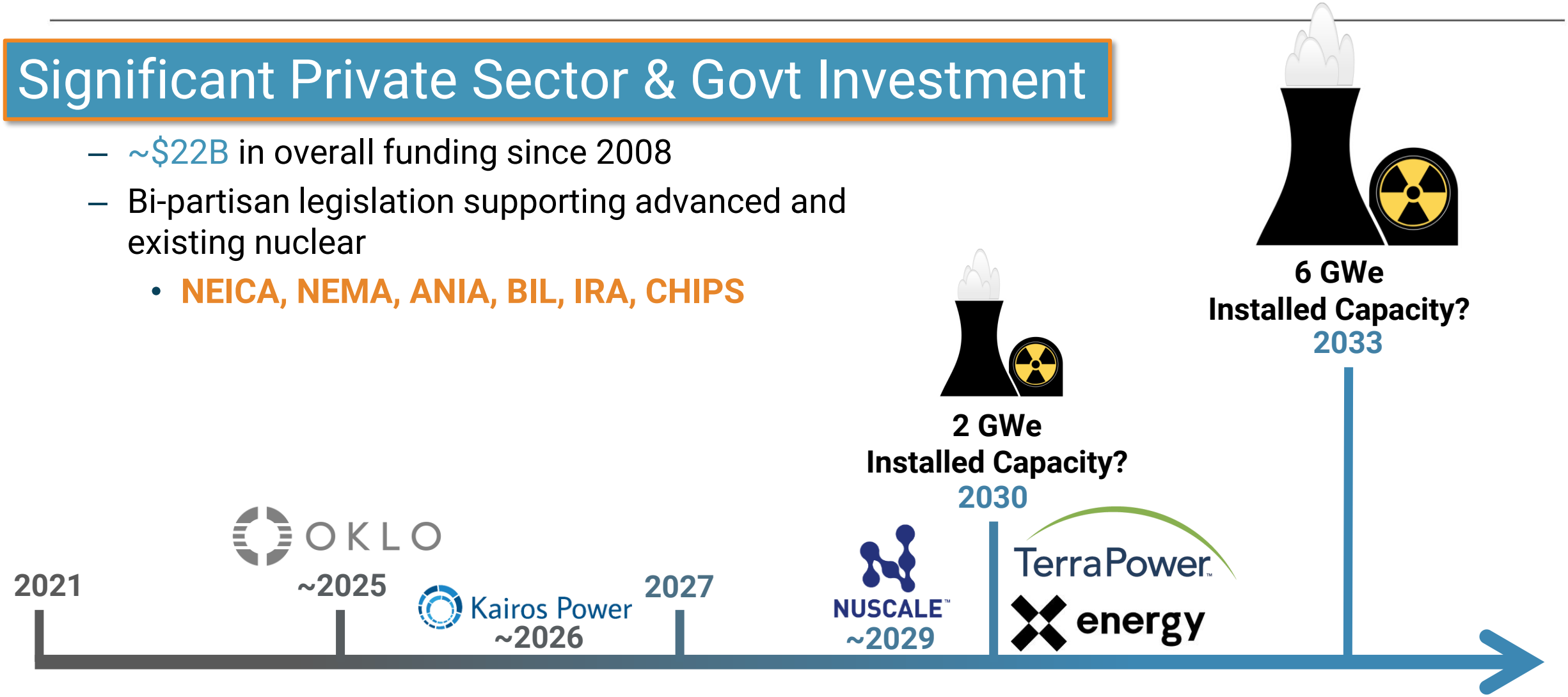
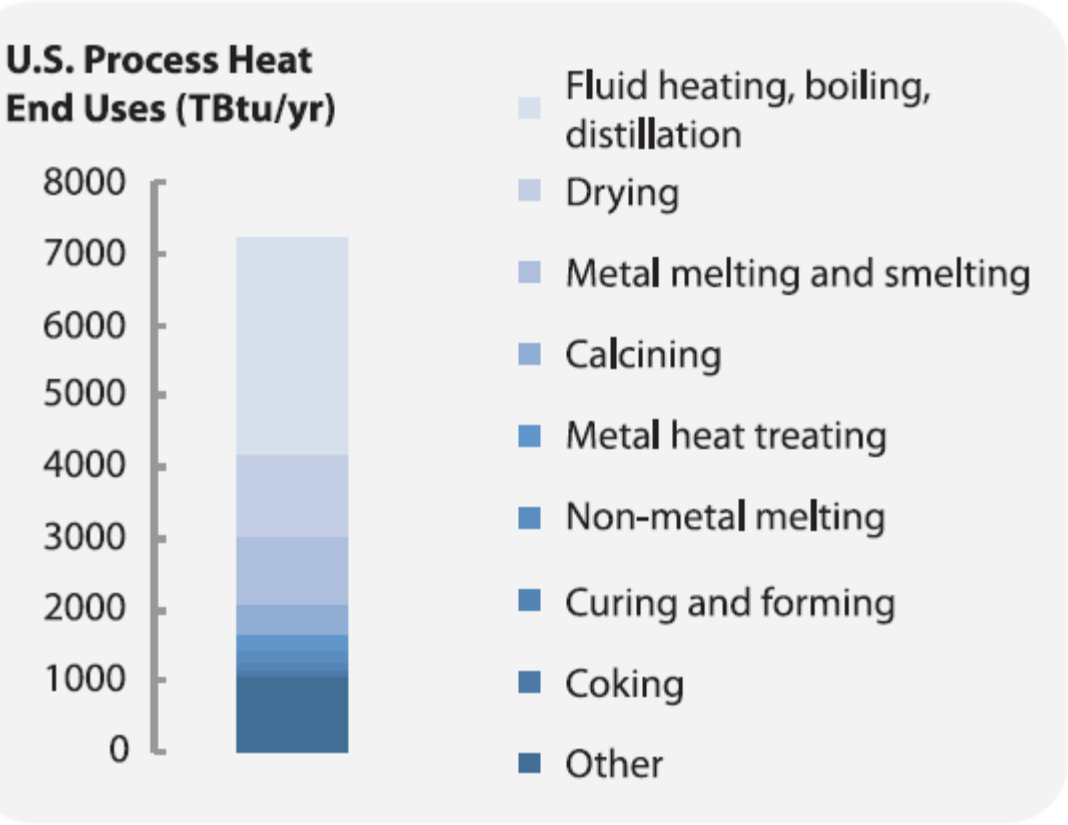
Advanced Reactors are Coming

Significant Private Sector & Govt Investment

- ~$22B in overall funding since 2008
- Bi-partisan legislation supporting advanced and existing nuclear
  - **NEICA, NEMA, ANIA, BIL, IRA, CHIPS**

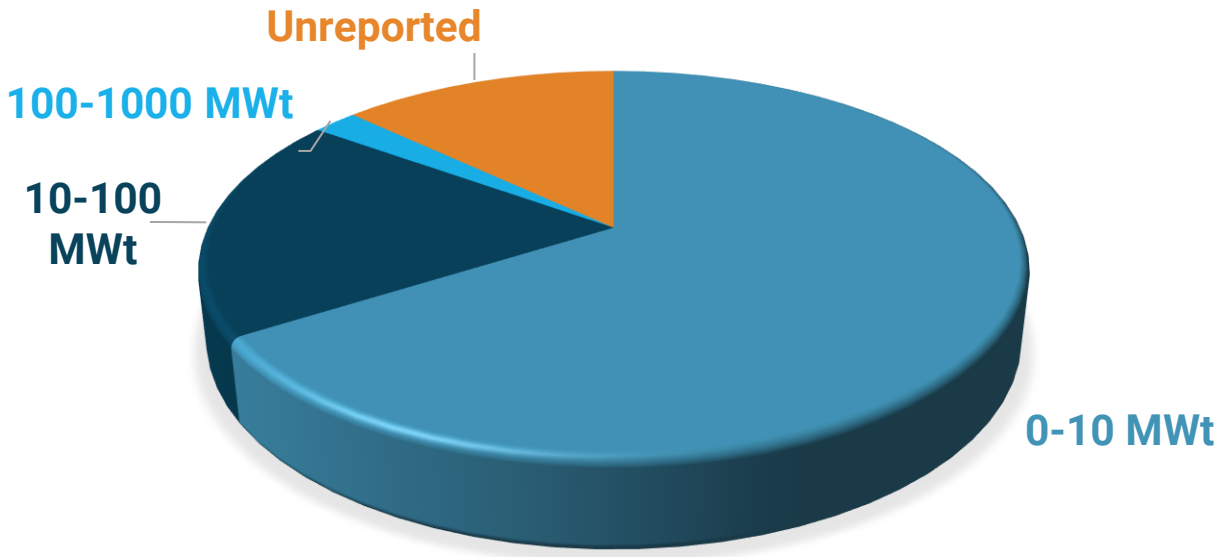


Back of the envelope



TerraPower energy

	AP1000	Natrium	Xe-100
Reactors / year	1.4	6	25
Heat Output (MWt)	3500	825	200



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Deploying nuclear *fast* will be needed

Introduction to Metrics and Our Initial Thoughts

Metric Topic Area	Metric	State-of-the-Art	Program Target
Cost	**Cost of Heat**	$2 / MWh_t	$3 / MWh_t

Others?

Potential Program Pillars

Digital Technologies

Construction Engineering

Process Design & Optimization

VR/XR Technology Development

Physical Interfaces

Heat Exchangers

Valves

Sensors

Controls

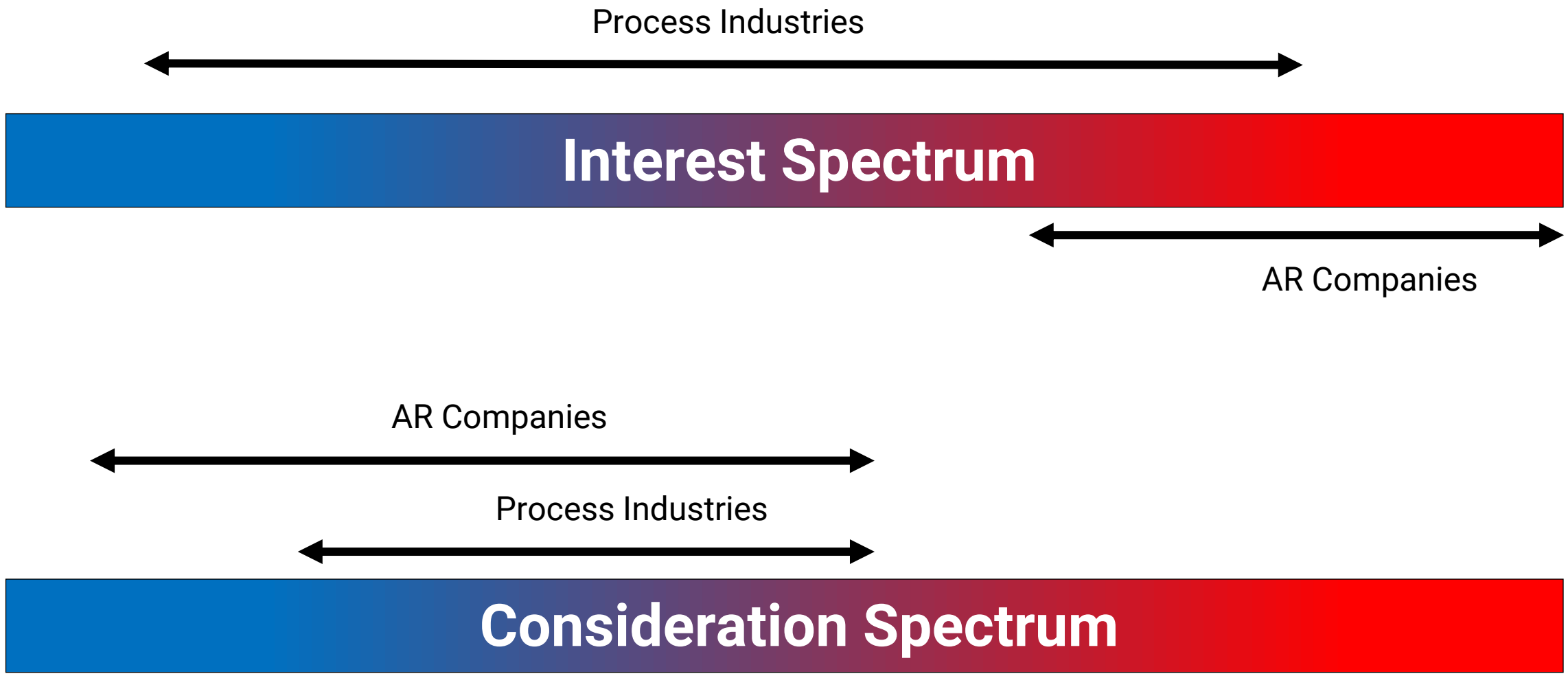
Non-nuke modifications

Heat amplification solutions

Process modification

New chemistries

Outreach lessons so far…



Agenda

- Presentations
  - Jeremy Shook – EPRI
  - Shannon Bragg-Sitton – INL
  - James Shaeffer – Guggenheim
  - Lucas Mir - OECD
- Panels
  - Advanced Reactor Panel
    - Everyone who asked
  - Industrial Partners Panel
    - Dow, Exxon, Shell
  - Digital Technologies
    - Ansys, PowerN, Terra Praxis, VTT

Breakouts

Day 1

1. Reliability
2. Process Co-Optimization
3. Minimum Viable Product
4. High Temp Augmentation

Day 2

1. Modeling & Simulation Tools
2. System & Component Needs
3. Retrofit vs. Greenfield
4. Risk Identification

General Rules of the Road

ADVISE: No one should say “we can’t do that because”:

“It has never been done”

“We tried that and it didn’t work (technology has evolved!)”

“It is not covered by existing regulations”

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