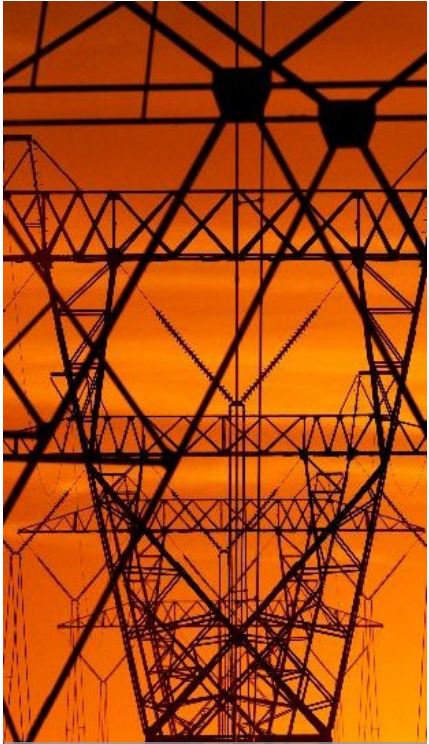


# **Social context for fusion**

Heather Jackson, ARPA-E Fusion Technology to Market Advisor

June 10, 2024

# What Problems is ARPA-E Trying to Solve?



Resilient energy infrastructure for the 21<sup>st</sup> century



Affordable, sustainable energy for all



U.S. economic development



American leadership in science and technology



Reduce energy-related emissions



# Heather Jackson, ARPA-E Technology to Market Advisor for fusion & advanced fission

- ▶ Physics
- ▶ Fusion @ LANL
- ▶ Nuclear Engineering
- ▶ Commercial nuclear power (HP, Operations, Maintenance Strategy)
- ▶ Side ventures in affordable housing, advanced manufacturing, community event space
- ▶ MBA
- ▶ water strategy, grid strategy, technology assessment, utility innovation
- ▶ Contract work for energy startups
- ▶ Full-time focus on clean energy startups
- ▶ ARPA-E technology to market advisor



# Framing fusion under the energy trilemma



## EQUITY



12,000 kWh/person  
332 million



808 kWh/person  
1.41 billion



122 kWh/person  
202 million



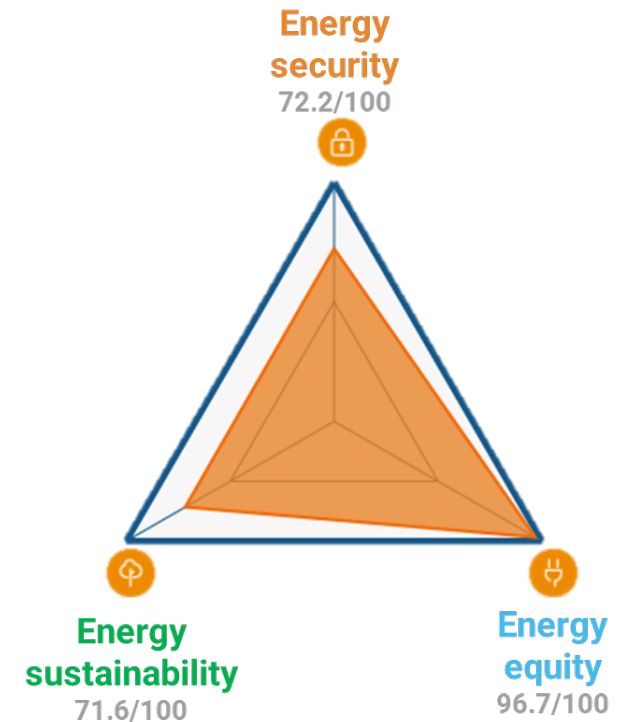
## SECURITY

- Grand Ethiopian Renaissance Dam
- 24 February 2022
- Island nations

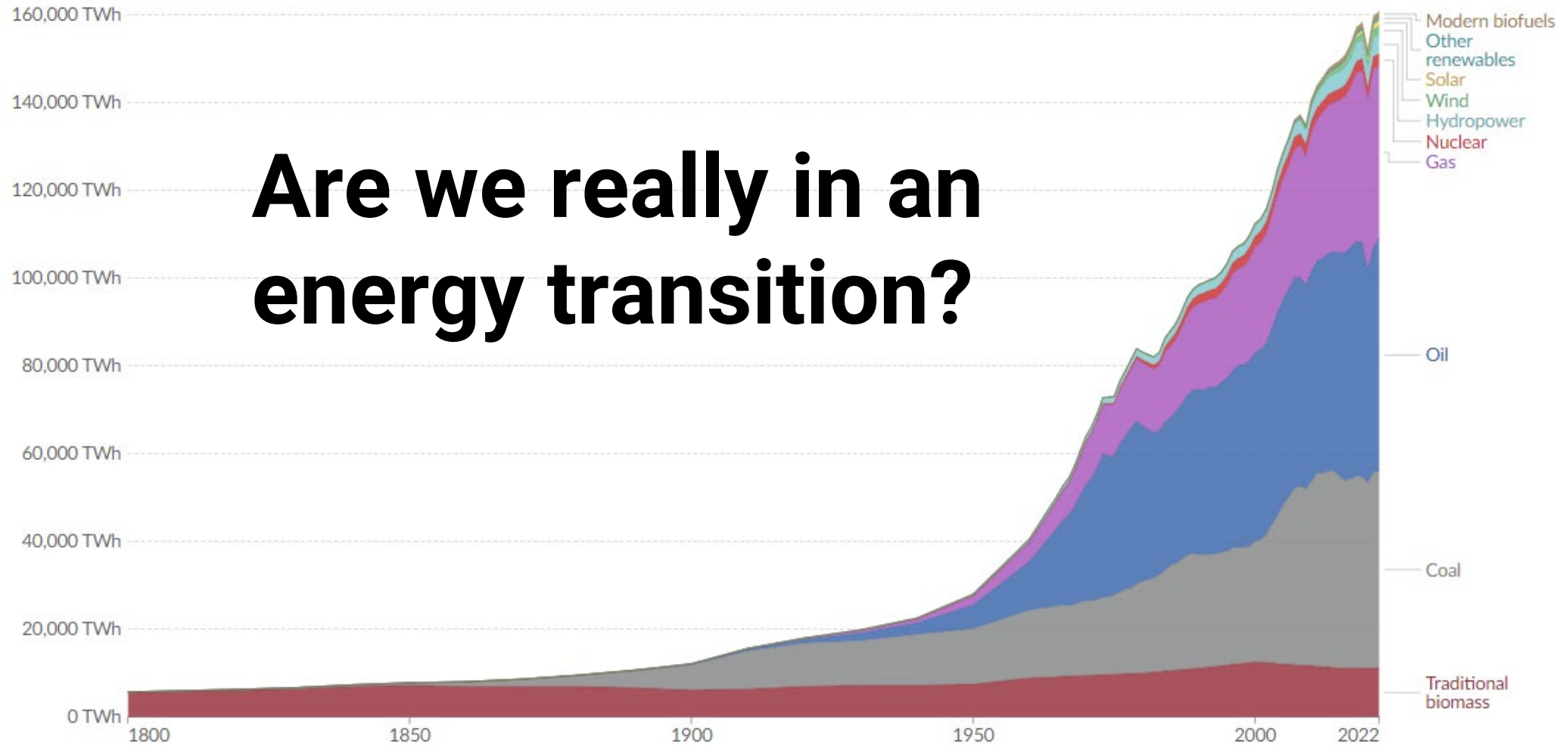


## SUSTAINABILITY

- COP26
- Cleantech



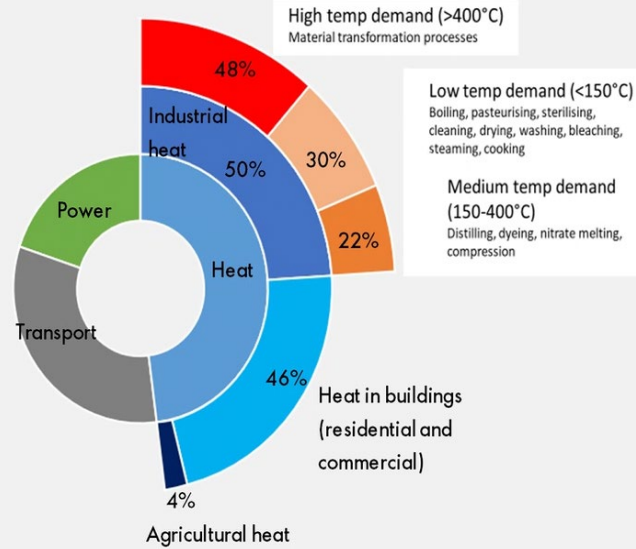
# Global direct primary energy consumption through 2022



[Global direct primary energy consumption \(ourworldindata.org\)](https://ourworldindata.org)

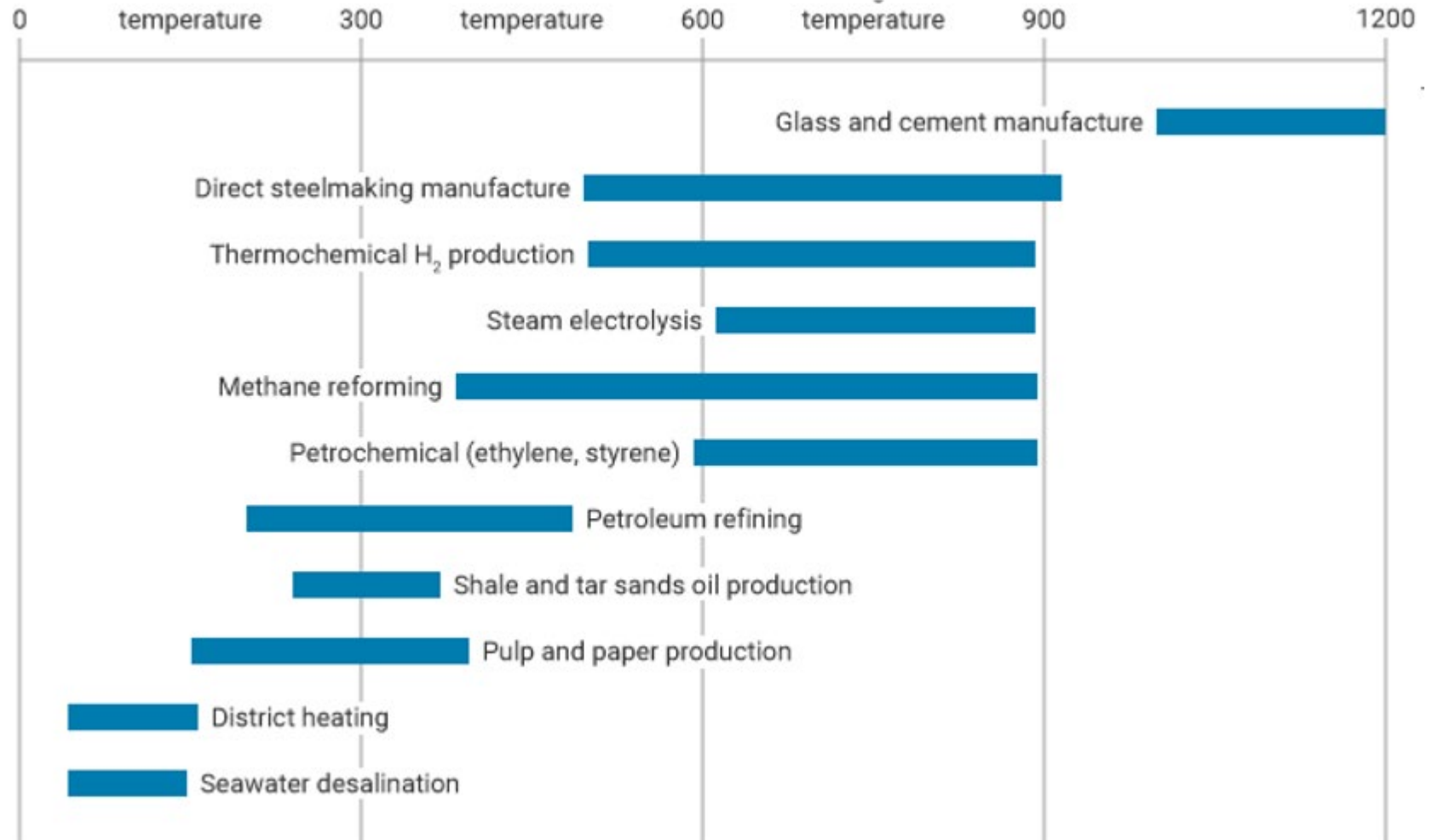
# Industrial decarbonization provides new opportunities

## Heat Demand World



\*Data sources: IEA (Fuel Report, 2018) and Solar Payback (2017, IEA&IRENA)

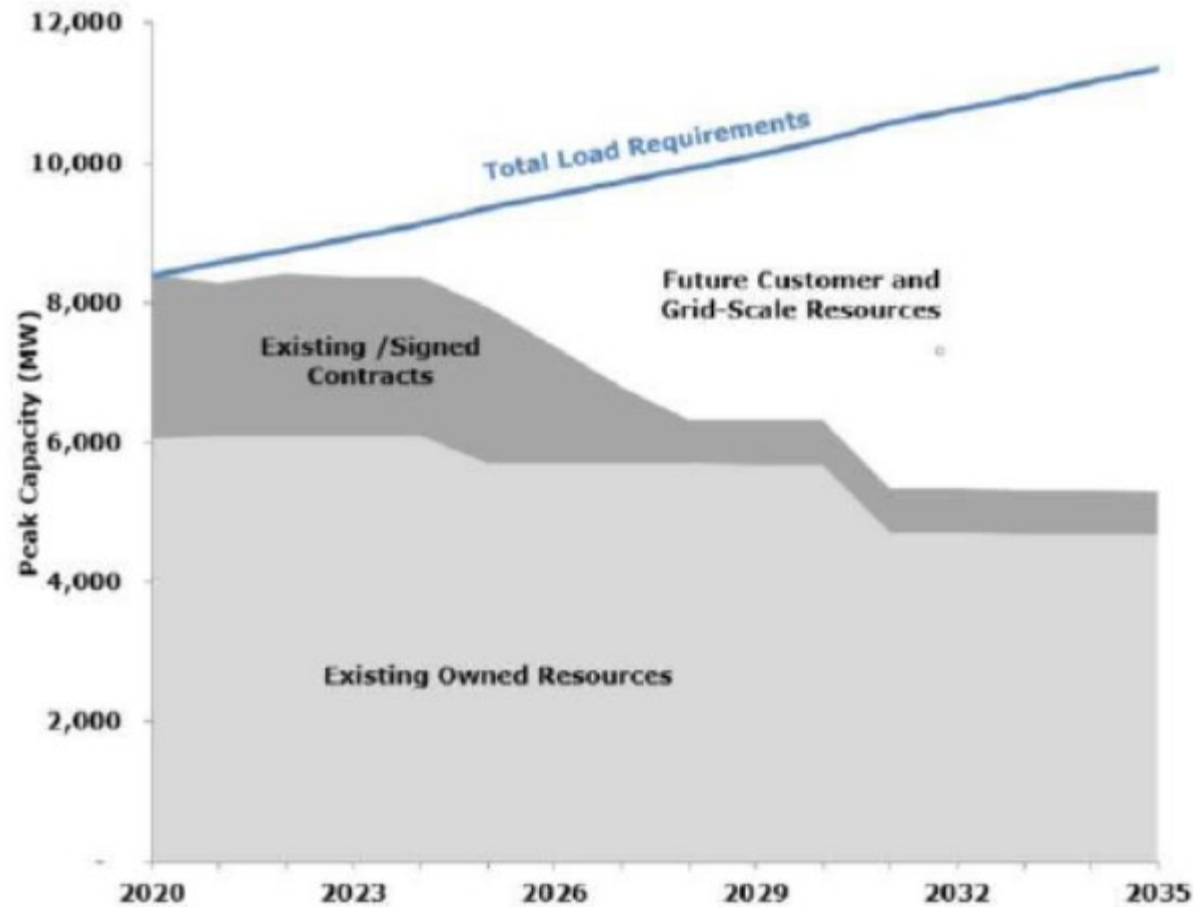
Heat application processes



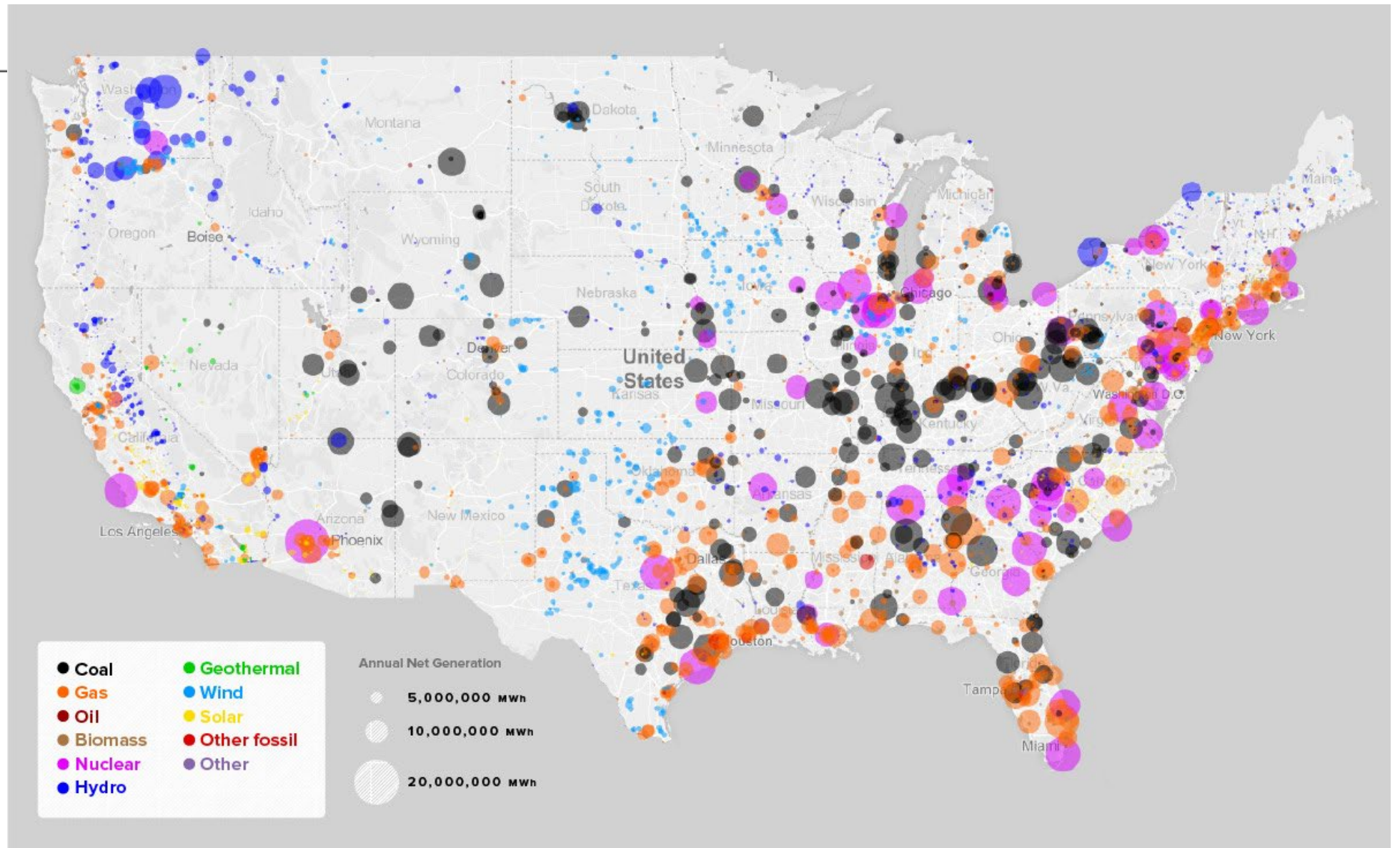


# Projected power generation capacity needs at a utility that produces 0.5% of US electricity

**FIGURE ES-1. APS SUPPLY-DEMAND GAP (IN MW)**



# United States Power Plants by size & type





## 500 MW natural gas plant

- 10 pack of 50 MW combined cycle gas turbines
- Airplane engines that spin generators
- Gas-water heat exchangers that make steam from waste heat in exhaust
- Thousands of these units across the country
- Transformer yard / interconnection permits are hard and slow to start from zero on
- Turn on like a pickup truck
- Only technology commercially available at scale which can keep grid stable with high variable renewable energy penetration





# 1540 MW coal-fired power plant



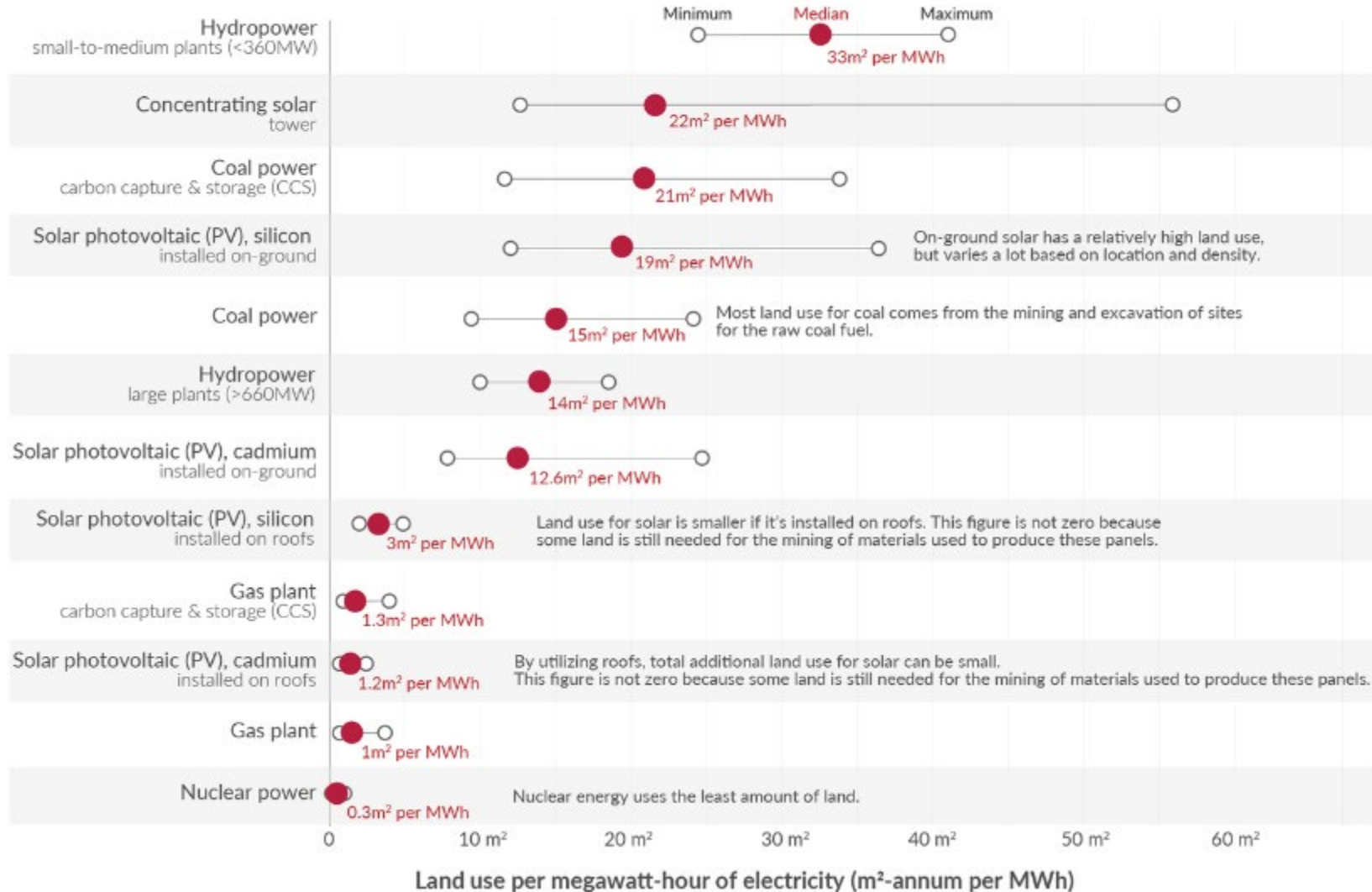
# 1,700 MW, two-unit Nuclear Power Plant





# Land use of energy sources per unit of electricity

Land use is based on life-cycle assessment; this means it does not only account for the land of the energy plant itself but also land used for the mining of materials used for its construction, fuel inputs, decommissioning, and the handling of waste.



# Relative capital costs of power generation technologies

FUTURE GENERATION RESOURCE OPTIONS	CAPITAL COSTS (\$/KW)
<b>NUCLEAR</b>	
AP1000 Hybrid	\$6,830
Small Modular Reactor (SMR)	\$5,605
<b>NATURAL GAS (Hydrogen Capable)</b>	
Large-Frame Combustion Turbine	\$652
Aeroderivative Gas Turbine	\$1,512
Combined Cycle	\$994
<b>MICROGRID</b>	
Gensets	\$946
<b>GRID-SCALE SOLAR</b>	
Thin Film Solar PV - Single Axis Utility	\$1,160
Thin Film Solar PV - Fixed Utility	\$1,084
Solar PV + Battery Energy Storage System (PVS)	\$2,385
Solar Thermal Tower with Storage	\$7,107
<b>ROOFTOP SOLAR</b>	
Thin Film Solar PV - Fixed Commercial	\$1,260
Thin Film Solar PV - Fixed Residential	\$2,687
<b>ENERGY STORAGE</b>	
Battery Energy Storage System (Li-ion)	\$1,225
Compressed Air Energy Storage (CAES)	\$3,878
Pumped Storage Hydro	\$3,546
Flow Battery	\$1,570
<b>OTHER RENEWABLE ENERGY SOURCES</b>	
Arizona / New Mexico Wind	\$1,343
Geothermal	\$3,034
Biomass	\$4,666

- ▶ Consider the value of always-on power generation
- ▶ Solar and wind are intermittent
- ▶ Batteries cost a lot and don't last very long (\$100 to store \$20 of wholesale energy 1 time)
- ▶ What equipment would a grid operator need to buy to replace a nuclear power plant? What equipment would a grid operator be able to avoid buying if a reliable fusion power plant were available?

# Utility de-risking & cost standards

---

- ▶ Been built before
- ▶ At at least 10% of the proposed scale
- ▶ somewhere in North America
- ▶ Operated successfully for a year
- ▶ Cost-competitive with other alternatives on a time horizon set by weighted average cost of capital





# Business model innovation for faster deployment

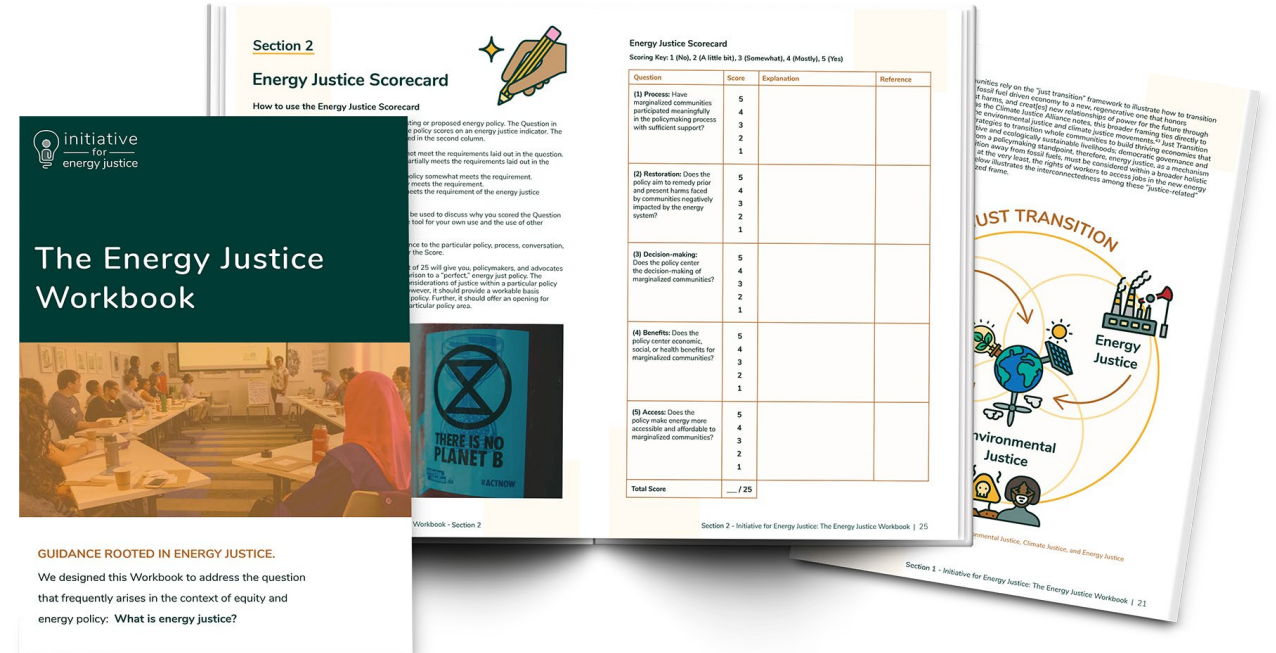
- ▶ Sharing risk differently
  - People who are betting on the success of a team might be more willing to own / underwrite the risk than a utility
- ▶ Who owns the power plant?
- ▶ Who operates the power plant?
- ▶ Who buys the energy, and on what terms and timeline?
- ▶ Who underwrites the project risk?



# What is energy justice?

**Energy justice** refers to the goal of achieving **equity** in both the **social** and **economic** participation in the energy system, while also **remediating** social, economic, and health **burdens** on those historically harmed by the energy system (“frontline communities”).

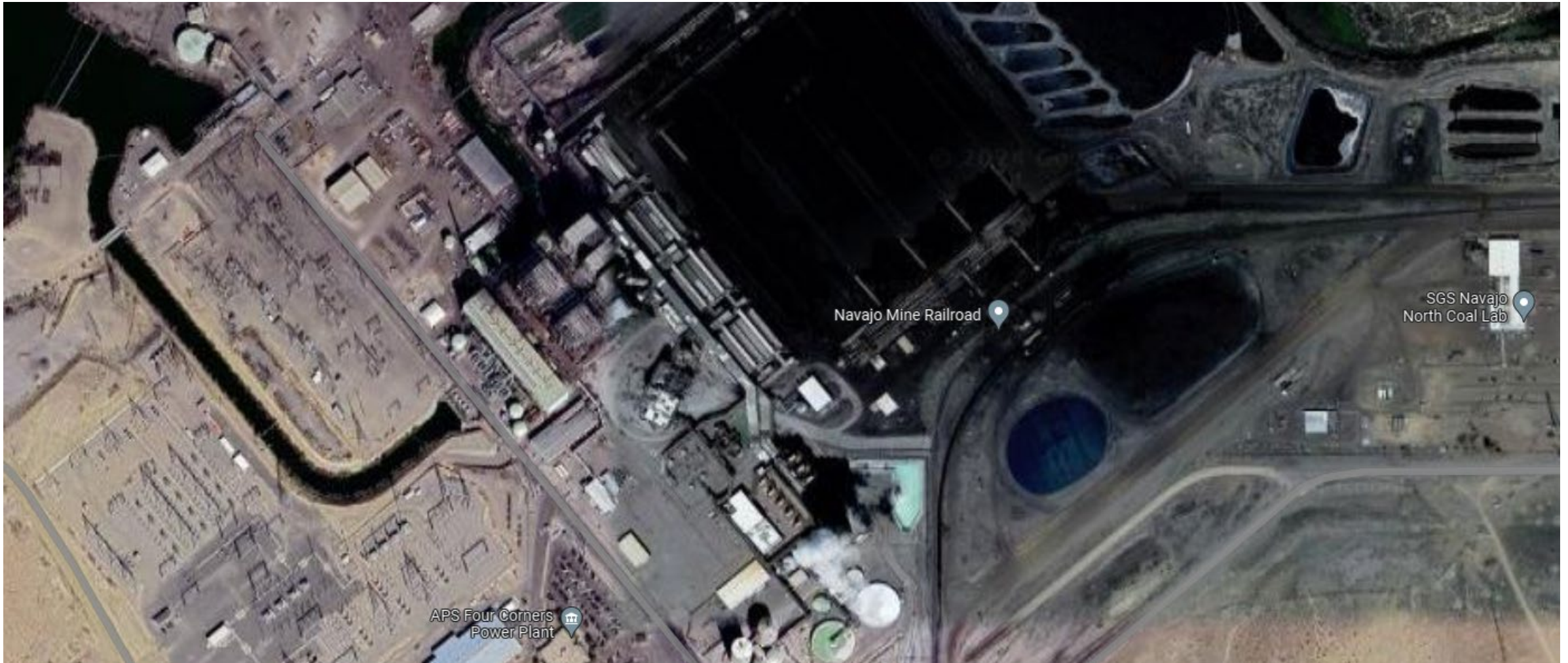
Energy justice explicitly **centers** the concerns of frontline communities and aims to make energy more accessible, affordable, clean, and democratically managed for all communities.



Initiative for Energy Justice (2019).



# 1540 MW coal-fired power plant: local per capita income is \$23,653





# Environmental justice

---

## Environmental Justice is good

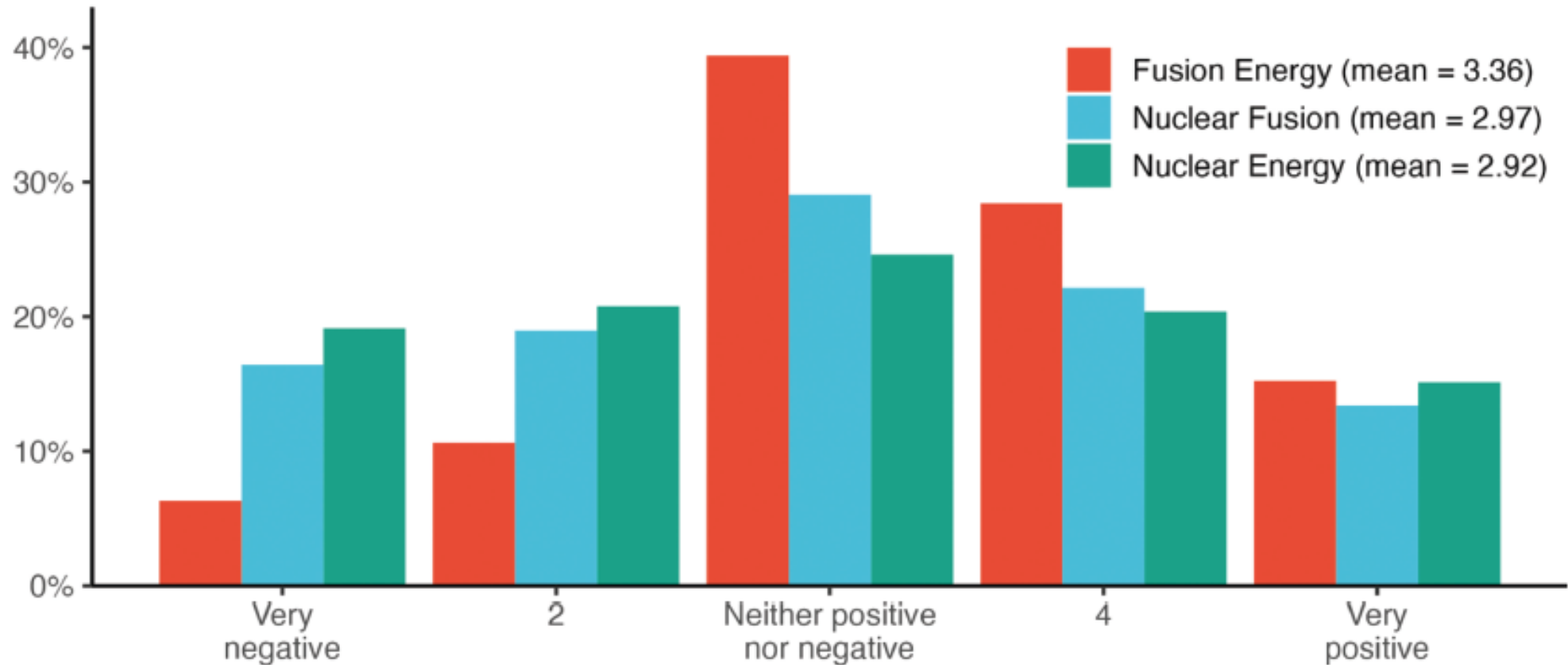
- ▶ It isn't fair to build something that disproportionately harms our most economically vulnerable community members
- ▶ We need to think about how we are allocating the benefits and the harms

## Environmental Justice is good for business

- ▶ The business costs of building something people don't want, or don't want to be around are great
  - Slow & expensive permitting
  - Burdensome regulatory regime
  - Public mistrust & resistance
  - High-operational cost

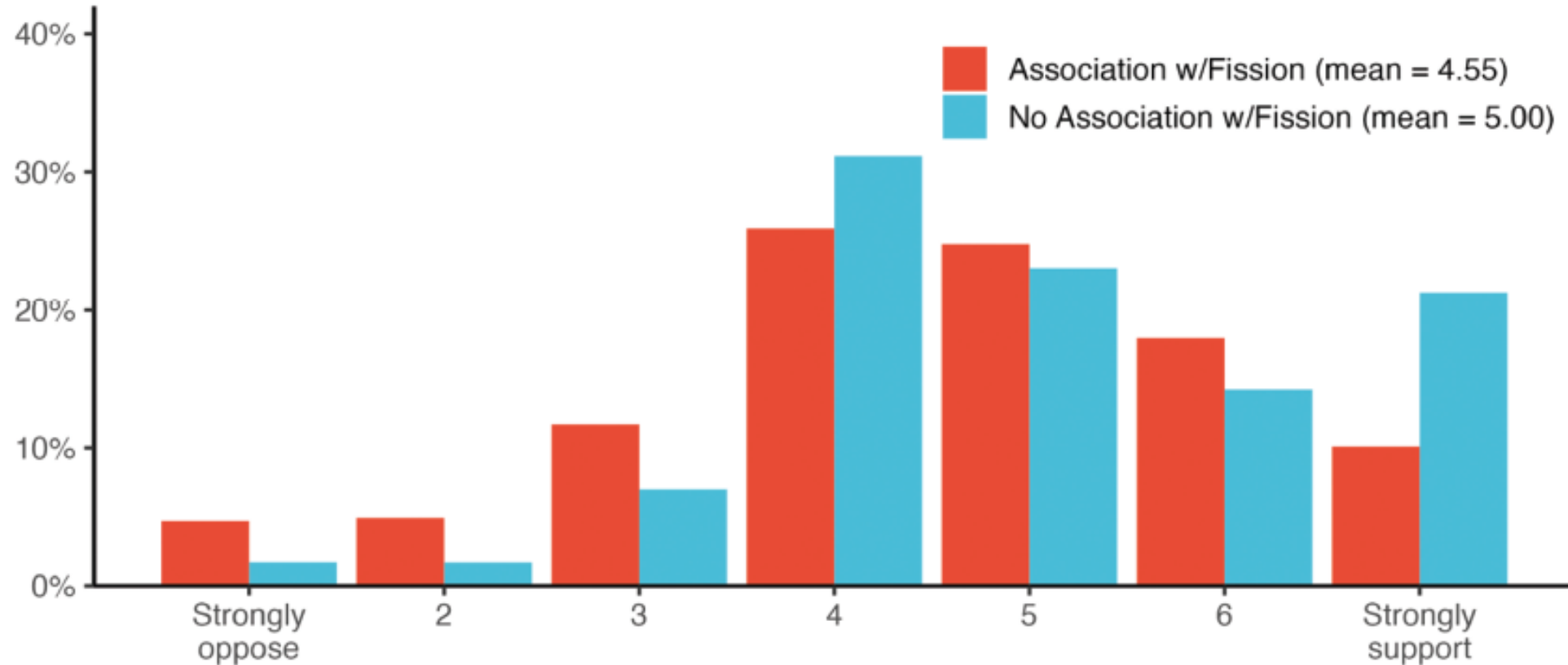
# How we talk about fusion matters

GUPTA et al. • AMERICANS' VIEWS OF FUSION ENERGY: IMPLICATIONS FOR PUBLIC SUPPORT



# Stronger support for fusion if it's not associated with fission

GUPTA et al. · AMERICANS' VIEWS OF FUSION ENERGY: IMPLICATIONS FOR PUBLIC SUPPORT





# RECRUITING

# What Makes an ARPA-E Project?

---



## IMPACT

- ▶ High impact on ARPA-E mission areas
- ▶ Credible path to market
- ▶ Large commercial application



## TRANSFORM

- ▶ Challenges what is possible
- ▶ Disrupts existing learning curves
- ▶ Leaps beyond today's technologies



## BRIDGE

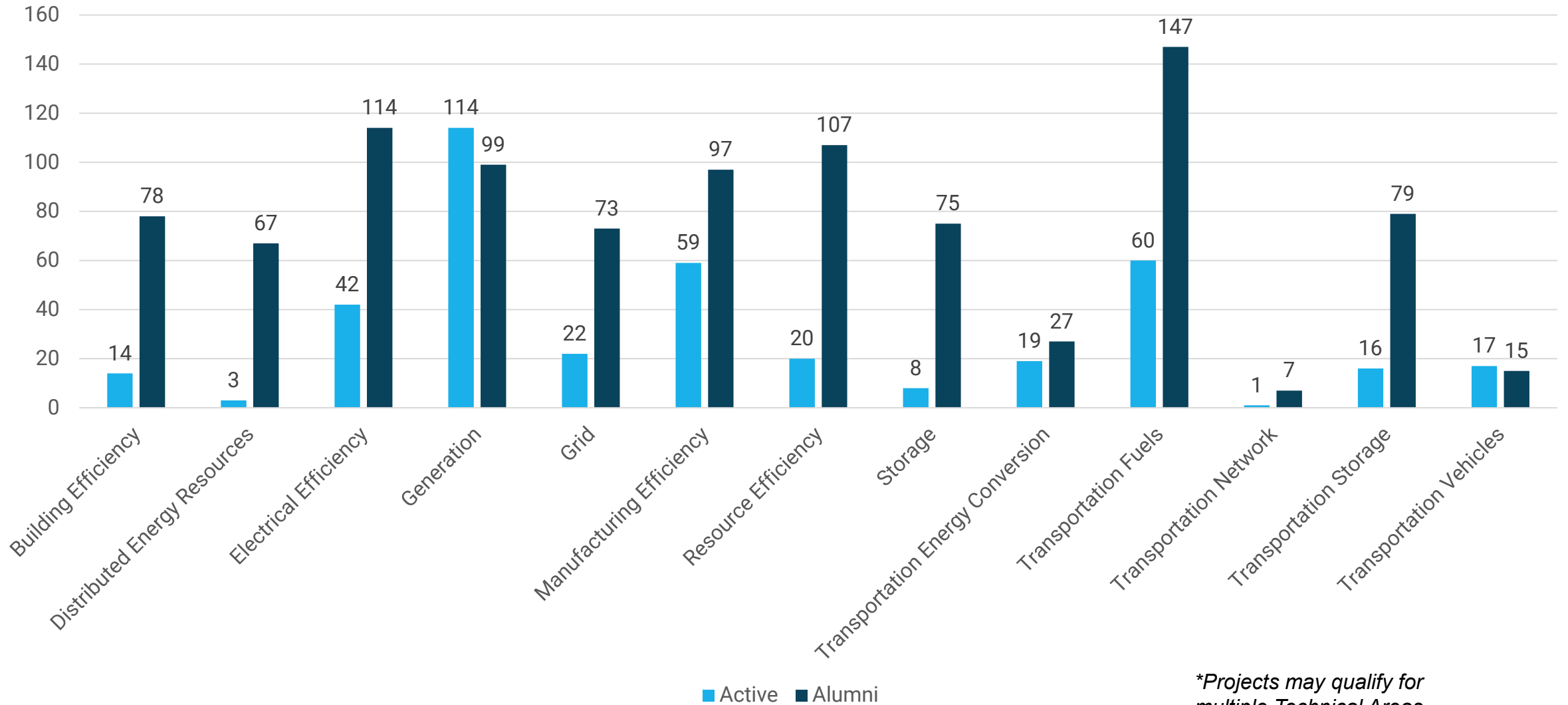
- ▶ Translates science into breakthrough technology
- ▶ Not researched or funded elsewhere
- ▶ Catalyzes new interest and investment



## TEAM

- ▶ Comprises best-in-class people
- ▶ Cross-disciplinary skill sets
- ▶ Translation oriented

# ARPA-E Projects by Technical Area\*

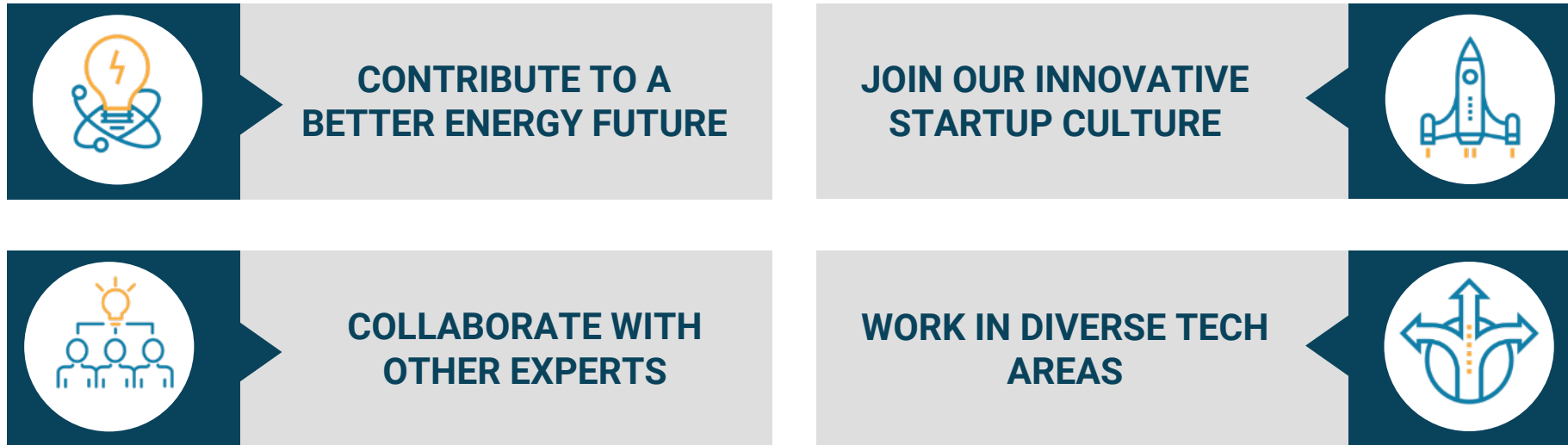


*\*Projects may qualify for multiple Technical Areas*



# ARPA-E is Looking for Thought Leaders

---



Learn more and apply: [www.arpa-e.energy.gov/jobs](http://www.arpa-e.energy.gov/jobs) or [arpa-e-jobs@hq.doe.gov](mailto:arpa-e-jobs@hq.doe.gov).



# FELLOWS ARE EARLY-CAREER INNOVATORS



**“The only problem with this job is figuring out a next step that can possibly measure up to it.”**

- Dr. Ashwin Salvi, Former Fellow

**PROJECT SUPPORT**

**PROGRAM DEVELOPMENT**

**BUSINESS DEVELOPMENT**

# WHAT MAKES AN IDEAL FELLOW?

## Program Director Support

- Helps develop future programs through technical analysis, discussions, debate and workshops
- Supports programs through technical and economic analyses and on-site project visits



## Independent Energy Technology Development

- Collaborates with experts in a variety of fields
- Publishes original research papers and reviews



## Organizational Support

- Contributes to the strategic direction and vision of the agency
- Reviews proposals and funding opportunities



## Qualifications

- Has Ph.D. in science or engineering, strong analytical, research and communication skills, drive to change the world through energy technology, U.S. citizenship.

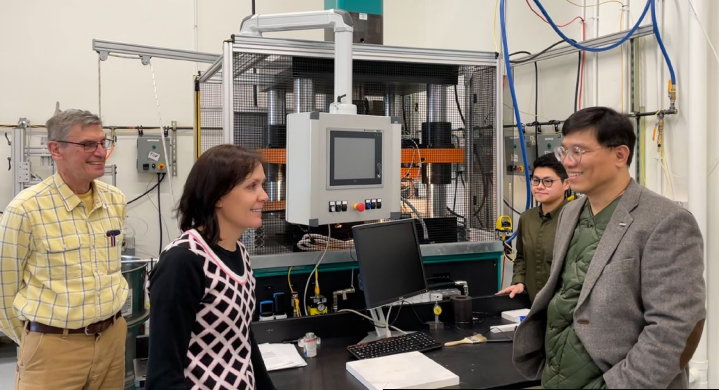


***ARPA-E is hiring.***

To apply or learn more, please contact an ARPA-E Program Director or email

**[arpa-e-jobs@hq.doe.gov](mailto:arpa-e-jobs@hq.doe.gov)**





# PROGRAM DIRECTORS DRIVE TECHNICAL INNOVATION



“The CEO of my company asked if he hadn’t given me a big enough sandbox to play in. I told him ARPA-E offered me a beach.”

—Joe Cornelius, Former Program Director

PROGRAM DEVELOPMENT

THOUGHT LEADERSHIP

HANDS ON MANAGEMENT

COMMUNITY BUILDING

# WHAT MAKES AN IDEAL PROGRAM DIRECTOR

## Thought Leadership

- Represents ARPA-E as a thought leader in the program area



## Program Development

- Dives into a topic, solicits input from stakeholders in R&D
- Presents and defends program concept in climate of constructive criticism



## Active Project Management

- Actively manages portfolio projects from merit reviews through project completion
- Work with expert colleagues and data-driven decision-making to support the full lifecycle of management



## Qualifications

- Has broad R&D experience, intellectual integrity and flexibility, commitment to energy, communication skills, leadership and management



***ARPA-E is hiring.***

To apply or learn more, please contact an ARPA-E Program Director or email

**[arpa-e-jobs@hq.doe.gov](mailto:arpa-e-jobs@hq.doe.gov)**



**If it works...**

***will it matter?***



# QUESTIONS?



U.S. DEPARTMENT OF  
**ENERGY**

<https://arpa-e.energy.gov>

[Heather.Jackson@hq.doe.gov](mailto:Heather.Jackson@hq.doe.gov)