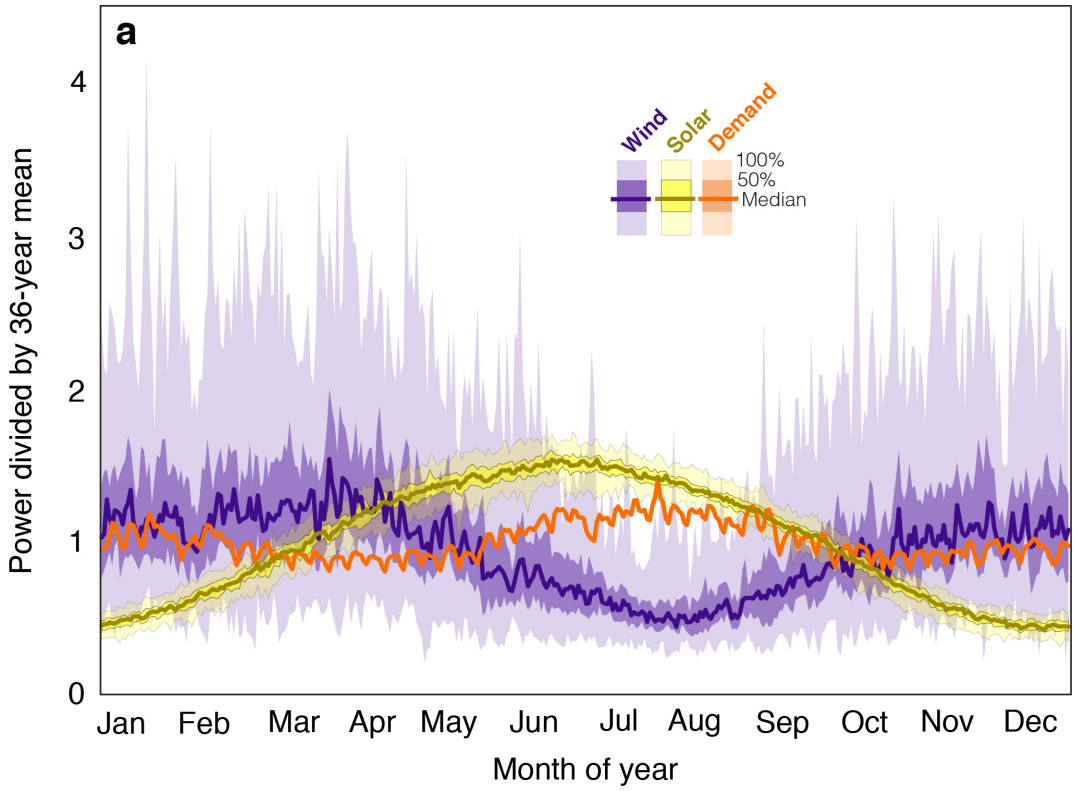
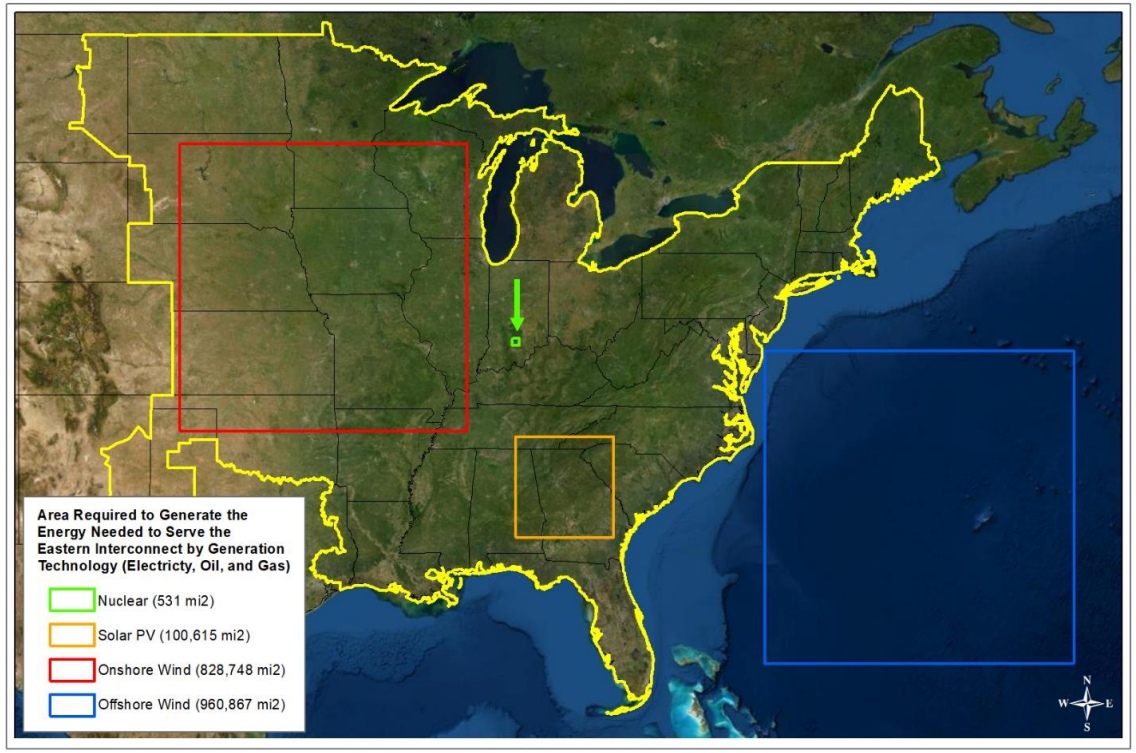
CLEAN AIR TASK FORCE

Minding the gaps: a technology commercialization policy agenda for decarbonization

Presentation to PCAST
January 21, 2022

Gap #1: Technologies that can provide 24/7/365 reliable electricity to complement seasonally variable renewables and take up minimal space





Tong, D., Farnham, D.J., Duan, L. *et al.* Geophysical constraints on the reliability of solar and wind power worldwide. *Nat Commun* **12,** 6146 (2021). https://doi.org/10.1038/s41467-021-26355-z

CATF/Lucid Catalyst: Spatial requirements for different electric generation sources to provide total energy to Eastern US

Gap #2: Zero carbon fuel substitute for oil and gas

Marine Shipping

Heavy Trucking

Process Heat

Ironmaking

Space Heating

Load Following Power

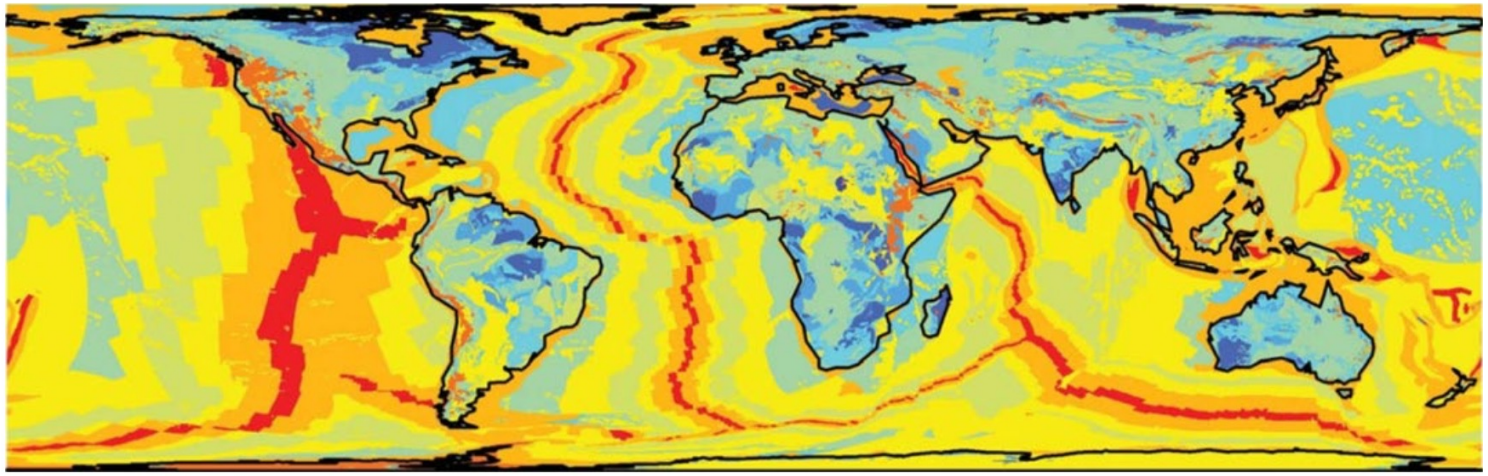
Option: CCS for industry and zero carbon gas power

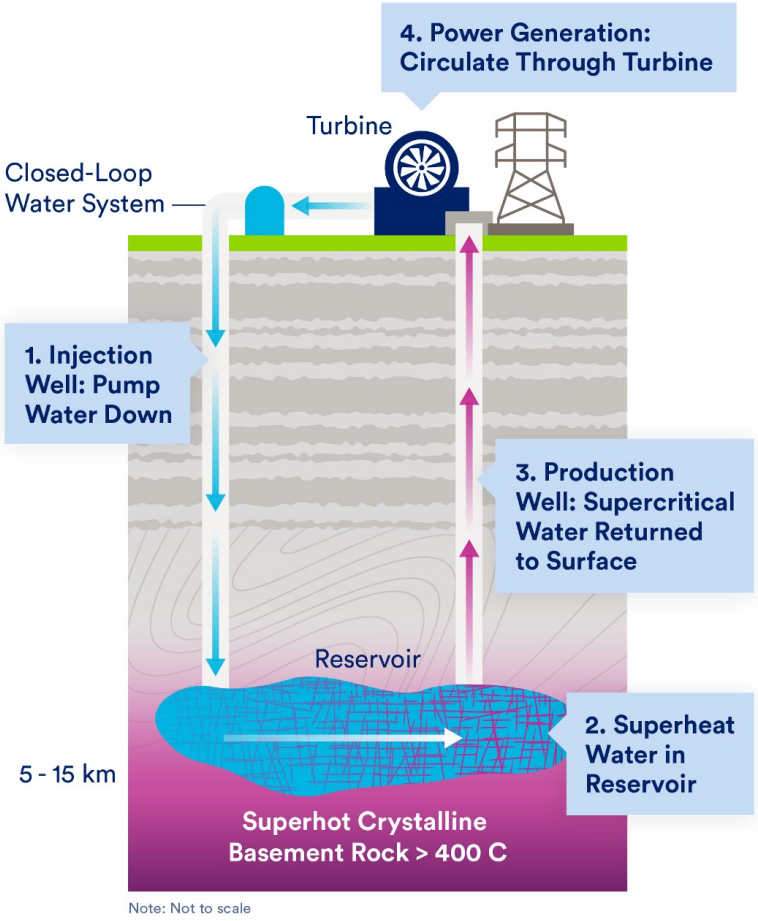
Option: Advanced, fast-to-deploy, manufacturable nuclear fission energy

Option: Deep superhot geothermal

Figure 1

Commercial geothermal systems are currently limited to the red or dark orange zones in continental areas on the map above. SHR could extend geothermal to much of the rest of the world. (Davies 2013)[9]

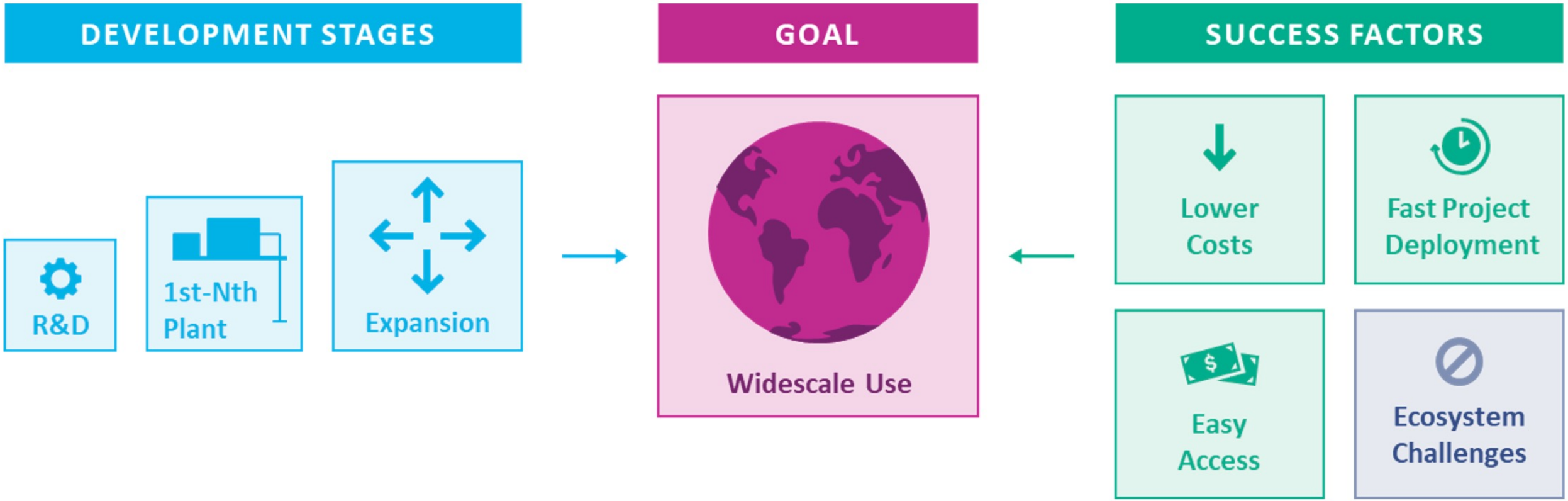




Superhot rock geothermal (SHR) is geothermal everywhere: competitive, energy dense, dispatchable/firm zero carbon power with hydrogen production, though deep drilling to" superhot "conditions >400C producing 10X energy per well.

Option: Lower cost hydrogen and ammonia from natural gas, nuclear, and renewables

From R and D to large scale deployment



Policy design principles for deep decarbonization innovation

Innovation requires a suite of policies addressing all stages and factors.

The pool of potential technology options must be expanded through more and better R&D

R&D must begin with the end in mind. Technology designs must be developed with cost reduction, speed of construction and scale of deployment in mind from the beginning

Commercial demonstration projects must be developed all the way through Nth of a kind. This will allow development costs to spread over more units, and achieve learning by doing

Expansion stage-focused policies should be simple, certain, and widescale (e.g. investment tax credits for clean technologies with direct pay, contracts for differences etc)

Creating supporting ecosystems. Ecosystem issues cut across technologies: the ability to physically access existing infrastructure as well as have clear regulatory and commercial rules that facilitate market access; issues related to equity, employment, and economic development are also relevant. To address this range of issues, policy efforts need to move from beyond thinking about project or technology policies to systems planning

Innovation must be approached as a global effort. US is an innovation engine, but the solutions that will matter need to scale globally

Rethinking business models is part of innovation. US policy needs to not just address "kit"

Cross-cutting commercial and deployment needs: the need for planning and spatial awareness

This transition will require an unprecedented buildout of clean energy generation and transmission, as well as CCS and hydrogen transport and storage

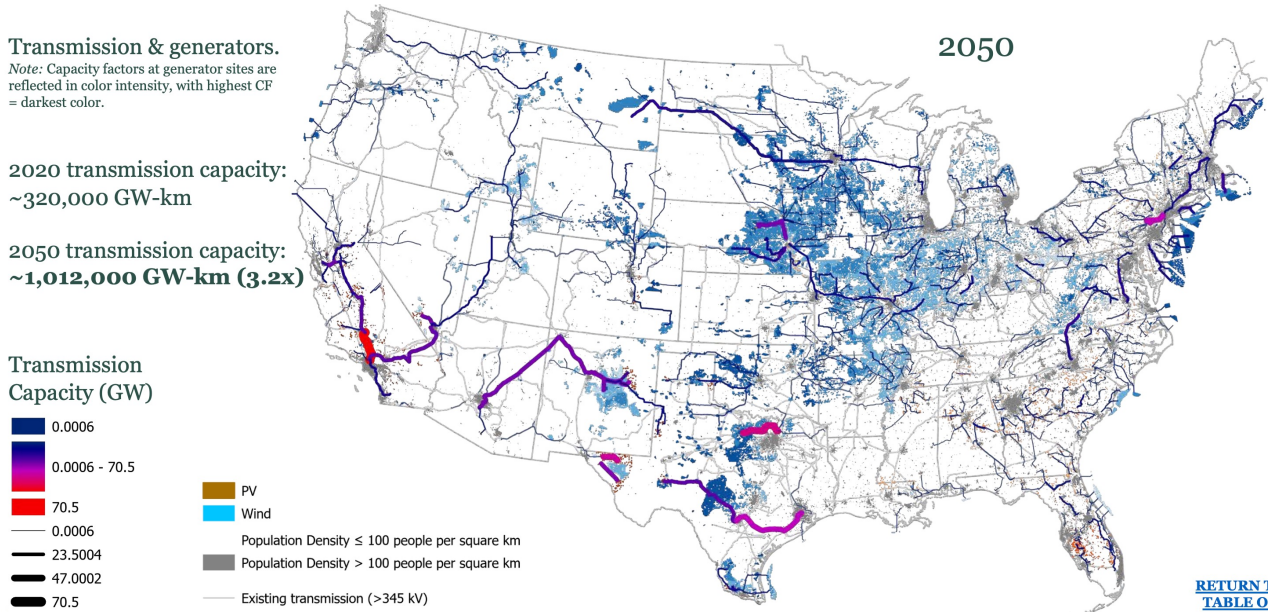
It is unlikely that this buildout will successfully occur project-by-project on a bottom-up basis

There needs to be support for risk-informed system spatial and sequential planning, building public awareness and buy-in, including economic development incentives

- This is an essential predicate to any "permitting reform"

We need support for systematic re-use of existing energy and non-energy brownfield sites, consistent with equity and environmental justice goals

Targeted RD&D of innovative transmission approaches (reconductoring, undergrounding, corridor re-purposing, superconducting) could also be helpful



Source: Larson et al, Princeton Net Zero America Project

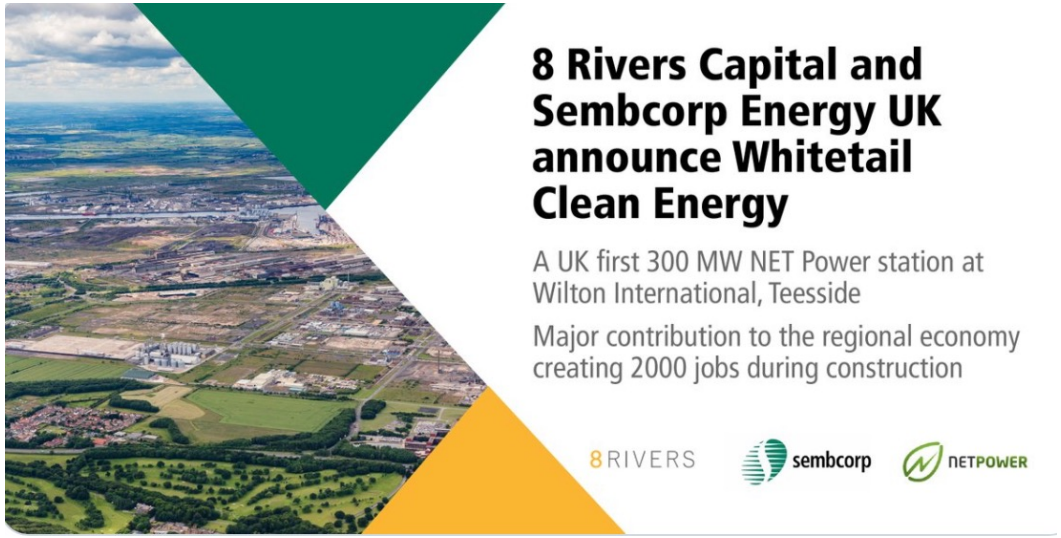
Carbon carbon and storage (CCS) policy priorities

Getting to commercialization of CCS is the key next step.

Higher 45Q credit values for CCS and Direct Air Capture are needed for deployment, along with direct pay and a 2030 commence construction window (all included in the Build Back Better Act)

Continued and consistent funding for the first 4 or 5 new projects of a kind, not just the first one

Further dedicated investment in CO2 transport and storage, including Basin Scale Management and a strategic plan for offshore storage



Superhot geothermal policy priorities

Commercialization requires investment in demonstrations, laboratory support, and rapid learning from drilling many wells.

- Establish a dedicated program, including a national laboratory, focused on SHR geothermal research and development and provide at least $30 million per fiscal year for 5 years
- Provide at minimum $70 million per fiscal year to support SHR power production demonstrations

Plasma drill prototype

Advanced nuclear fission priorities

Advanced fission has substantial promise to aid climate and energy access, but costs need to come down dramatically, and deployment sped up from 10 GW globally to 100+ GW/year (moving from "projects" to commoditized "products")

R and D

- Focus on pathways to significantly reduce nuclear costs and schedule – consider a cost target
- Explore potential to repower/reuse existing coal and other energy sites
- Focus on multi-sector applications such as hydrogen production, industrial heat; work with adjacent industries
- Continued R&D investment in high-assay low-enriched uranium and other waste reprocessing or transformation pathways
- Strategic and accelerated low dose radiation health research

Demonstration

- Prioritize designs with inherent capability and a clear line of sight to low cost in each application
- Support multiple builds of designs, not just "first of a kind," with declining federal cost share

Deployment

- Support for construction of large scale "Gigafactory" manufacturing facilities
- Direct pay ITC/PTC for advanced nuclear
- Federal "contracts for differences" to reduce market risks
- Expand ability to use federal power purchase agreements, expand beyond current ten year limit
- Expand tax advantaging and other support for redevelopment at existing coal plant sites

Infrastructure/ecosystem

- Continue to support risk-informed licensing at Nuclear Regulatory Commission suitable for advanced designs
- Reset on nuclear waste: determine requirements for consent-based siting

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Zero carbon fuels priorities

The regional clean hydrogen hubs program of the Infrastructure Investment and Jobs Act provides a critical flexible, versatile vehicle for end-to-end demonstration of zero-carbon fuels technologies and systems at commercial scale. **This program should be expanded** from the current $8B authorization (for 4 hubs) to at least $15B (for 6 or more hubs) to allow additional technologies, industries, and geographies. Once expanded, the program could work synergistically with specific RD&D including items such as those below:

Incentives for broad production of zero-carbon fuels such as a hydrogen production tax credit

A program to demonstrate substantial steam extraction volumes from an existing operating commercial nuclear reactor and use in a co-located high(er) temperature electrolysis system

Marine sector decarbonization would substantially benefit from a program to refine ammonia-fired reciprocating engine technology for shipping applications, including NOx control and ammonia slip prevention, as well as shipboard fueling systems and bunkering technology, and to demonstrate these in commercial operation on at least one Pacific and one Atlantic shipping route (e.g., LA-Singapore and Houston-Rotterdam)

Funding for initial hydrogen fuel-cell heavy truck production and deployment, with fueling infrastructure, in several key US markets (port-area drayage and high-traffic corridors such New York – Chicago)

A program to develop and demonstrate in commercial operation "single-digit" dry low-NOx combustion systems for utility gas turbines and industrial furnaces burning very high hydrogen-content (> 90%) fuels that don't rely on external diluent (e.g., no water, steam, nitrogen, or CO2 addition)