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Opportunities for Pumped Storage Hydropower under the Inflation Reduction Act

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U.S. DEPARTMENT OF ENERGY BATTELLE

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Disclaimer

This report contains non-sensitive data layers related to pumped-hydro infrastructure. It also contains layers on eligibility for IRA tax credits.

Tax credit disclaimer: the spatial data and mapping information is intended to inform stakeholder decision making, but it is not to be relied upon by taxpayers to determine eligibility for any credit.

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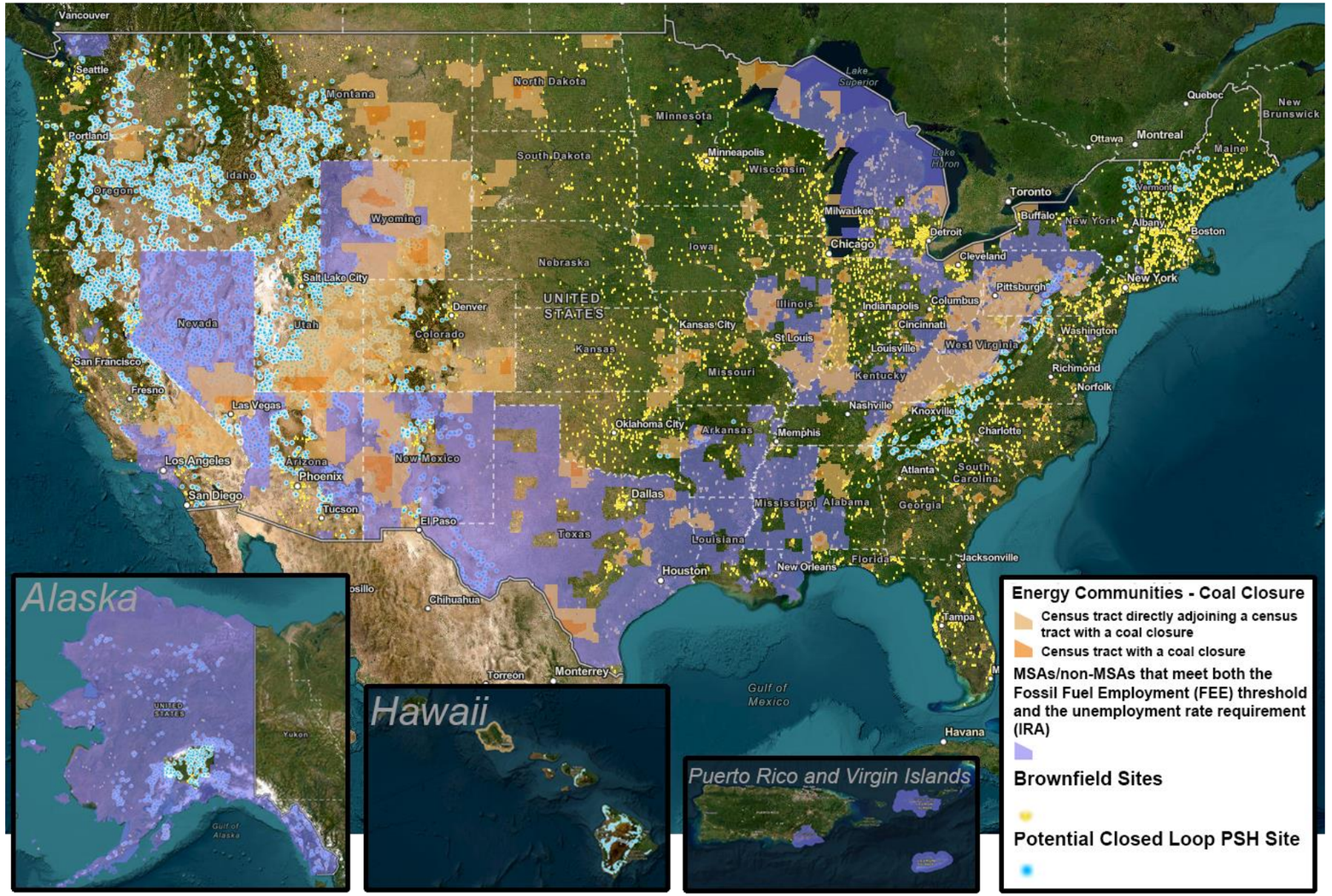
Highlights

- The Inflation Reduction Act (IRA) creates significant incentives for clean energy technologies including pumped storage hydropower (PSH).
- The investment tax credit (ITC) is expected to sunset in 2033 (or later). This decade-long window of opportunity can accommodate the lead times typically necessary for developing PSH.
- The ITC for PSH likely ranges from 6%-50%.
- Portions of the ITC are spatially dependent. 22 states have the potential for deployment of PSH at a feasible site with the maximum ITC of 50%, based on currently defined areas under the energy community tax credit bonus.
- Regions including the central Rockies, Appalachia and the California-Nevada border have especially high combined potential for site feasibility and ITC.

Web tool highlight



- The PSH IRA GIS map is available to users here
- The map draws on potential PSH sites from Rosenlieb et al., 2022
- Energy community layers are current as of Aug 2023, and drawn from the Department of Energy's mapping tool
- The PSH tool also features various energy market, policy, and infrastructure layers
- The PSH tool may be useful to stakeholders including project developers, land management agencies, and energy system operators looking to expand access to PSH

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Overview

PSH Overview

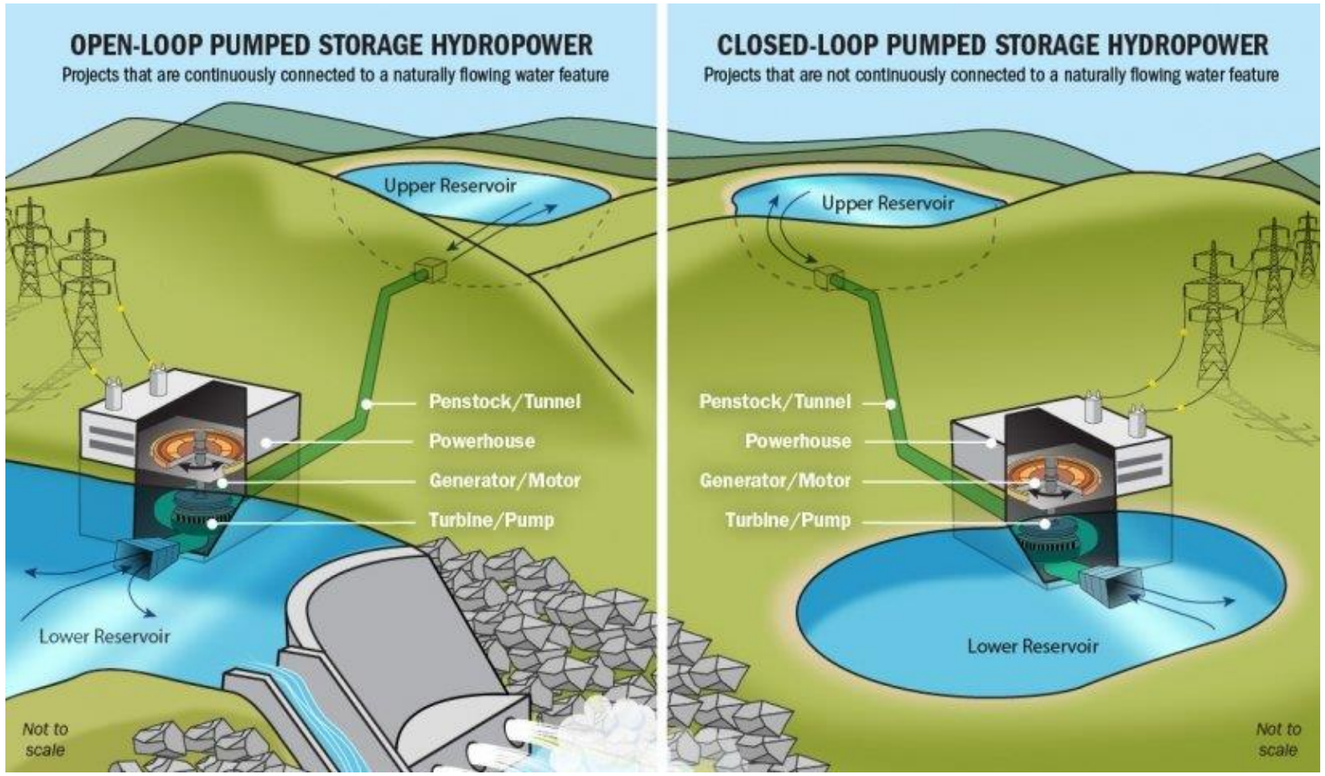

Image: DOE Water Power Technologies Office

- PSH is an established energy storage technology that currently provides about 67% of utility-scale energy storage capacity in the US, on a power basis (EIA, 2023; BloombergNEF, 2023).
- PSH is relatively unique among current, commercially deployed energy storage technologies in its ability to provide long-duration energy storage.
  - Long-duration energy storage has been identified as a key contributor to a decarbonized energy system (Denholm et al., 2022).
- No new PSH facilities have entered service in the US in the past decade.
  - The combination of IRA incentives, increased deployment of renewable energy, and PSH technology improvements set the stage for increased PSH deployment in the coming decade.

Overview of IRA Incentives for PSH

The IRA addresses several challenges that have historically restrained PSH deployment.

Challenge	How IRA addresses challenge
PSH has relatively high capital costs. This hinders deployment in the field and in modeling studies (Cohen and Mowers, 2022; Jorgenson et al., 2022).	The IRA enables PSH to access an investment tax credit (ITC) of 6%-50%. This effectively reduces capital cost and improves PSH economics significantly.
PSH projects have long development times. The process of permitting, engineering, procurement, construction, and commissioning can take a decade (Hadjerioua et al., 2022).	The ITC will likely be available for ten years, with a phase-out possibly from 2033. This decade-long window is compatible with the lead time necessary to develop a new PSH facility.
Workforce availability is a concern widely shared across the industry, including PSH construction, manufacturing, and operations (Uría-Martínez et al., 2022).	The ITC prevailing wage and apprentice incentive may help attract, retain, and develop workforce. Constructing a PSH facility becomes an opportunity for local economic development.

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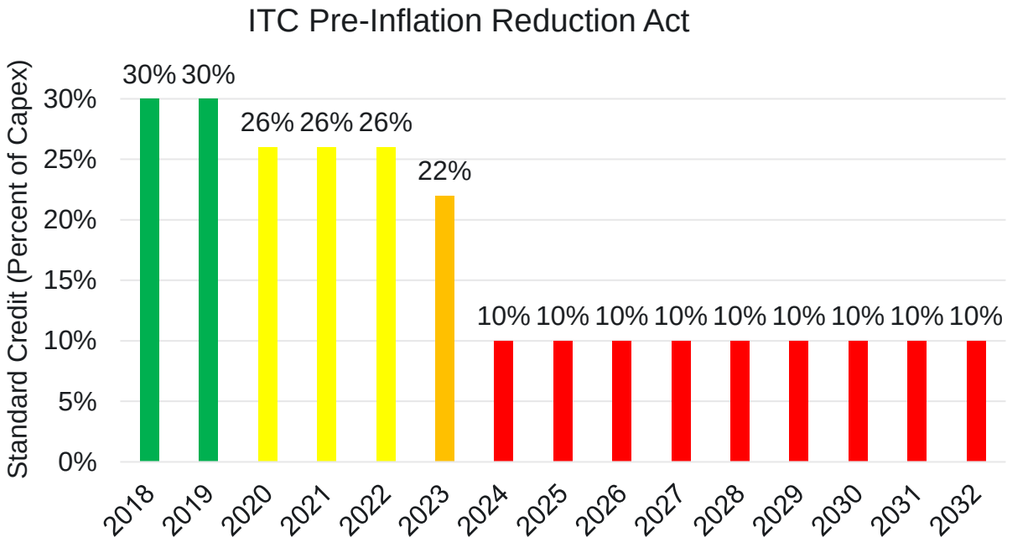
IRA Incentives for PSH

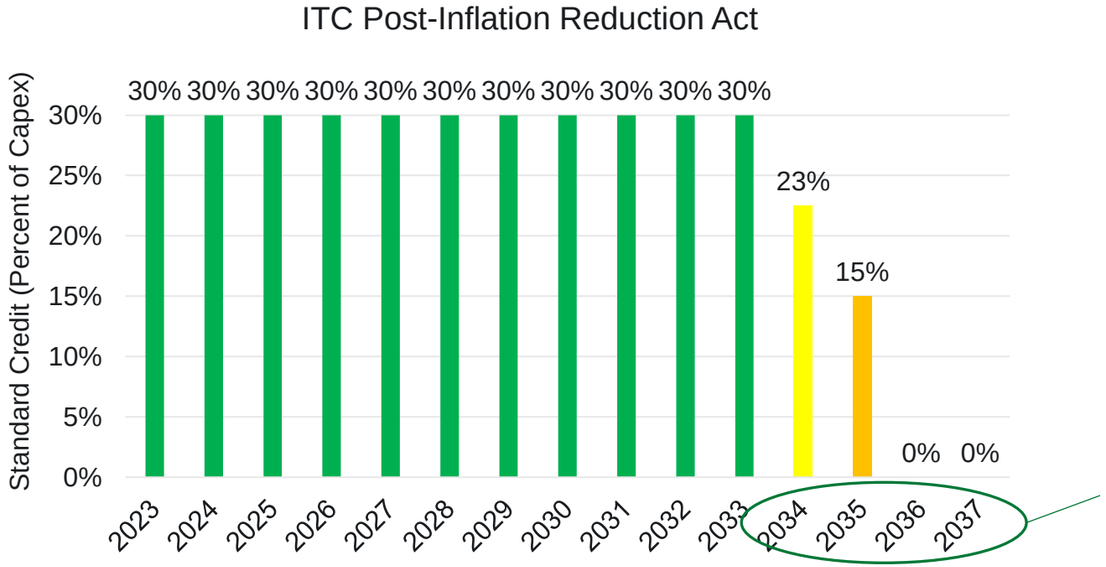
Overview of IRA incentives applicable to PSH

Provision	Discussion	Reference
Investment tax credit (ITC)	The ITC has been extended to energy storage technologies, expected to include PSH, with capacities greater than 5 kWh. There is no upper capacity limit, nor any restriction on the source of energy stored. The ITC consists of a base credit and bonus credits for fulfilling additional criteria. In 2025, the ITC transitions to a technology-neutral clean electricity investment credit. In this report, we refer to both as the ITC.	26 USC §48; 48E
Qualifying advanced energy project credit	This credit may be sought to re-equip, expand, or establish an industrial or manufacturing facility for the production or recycling of energy property, including energy storage and waterpower technologies.	26 USC §48C(e)
Elective pay	This new mechanism is expected to make certain clean energy tax credits accessible to entities that do not have a federal tax liability. This could be significant for electric cooperatives or tribal or local governments that pursue PSH development. Using this mechanism may require fulfilling other requirements, like domestic content.	Guidance from Internal Revenue Service (IRS)
Transferability	This new mechanism allows eligible entities to sell tax credits to a third party. It may be available for entities that cannot benefit from the elective pay mechanism.	

Additional provisions may be applicable.

ITC Phase In and Out

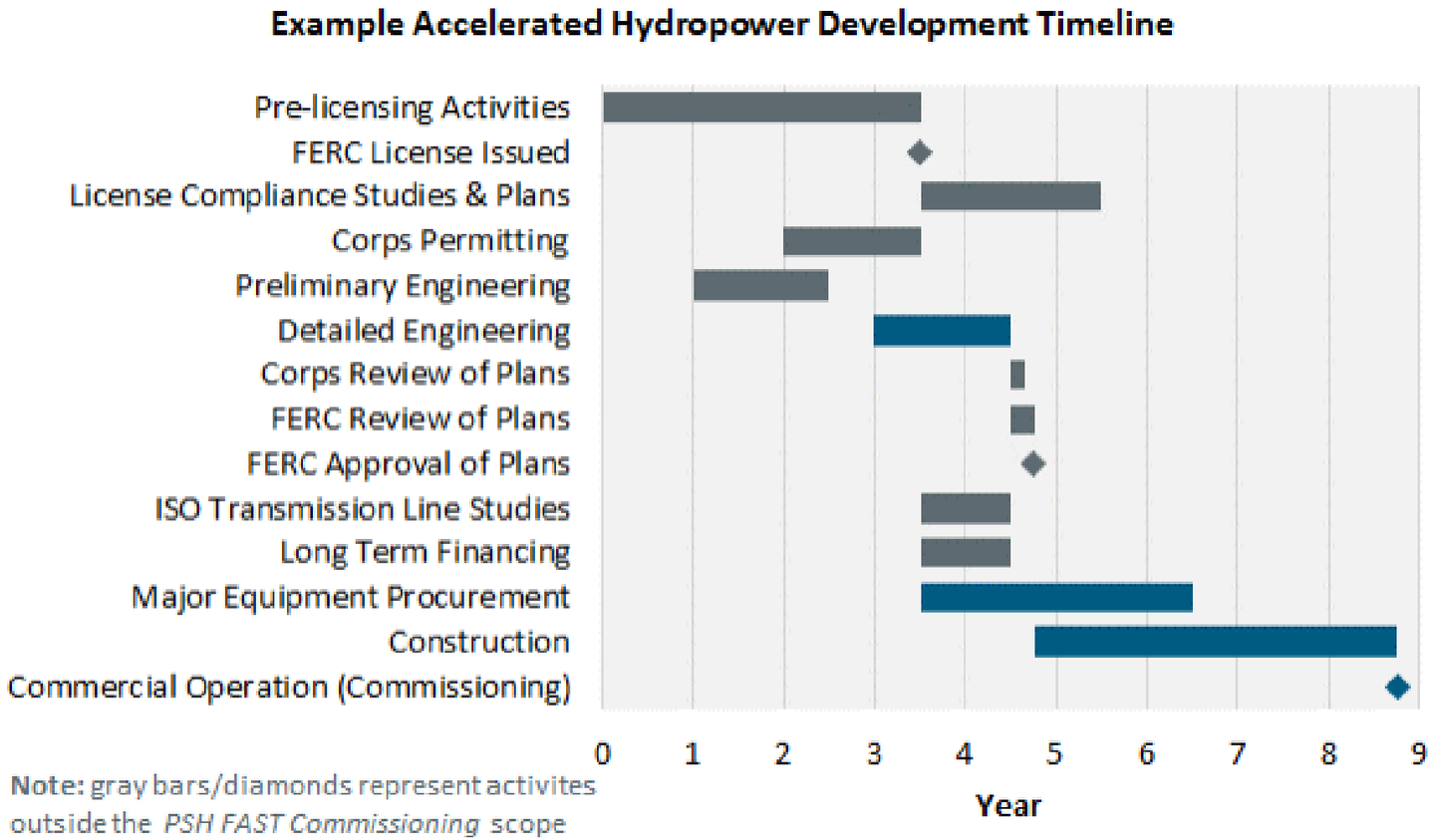




- Prior to the passage of the IRA, the ITC began slowly phasing out in 2020, and would have terminated as a perpetual 10% tax credit for commercial entities in 2024
- The IRA extends the standard 30% ITC to the later of:
  - The year 2033
  - The year in which electricity sector greenhouse gas emissions are less than 25% of 2022 emissions
- The law also allows hydroelectric and energy storage projects to qualify for the tax credits, and will transition to a technology-neutral "clean electricity investment credit" in 2025

Not shown: Possible extension depending on electricity sector greenhouse gas emissions

PSH Permitting and Development Timelines

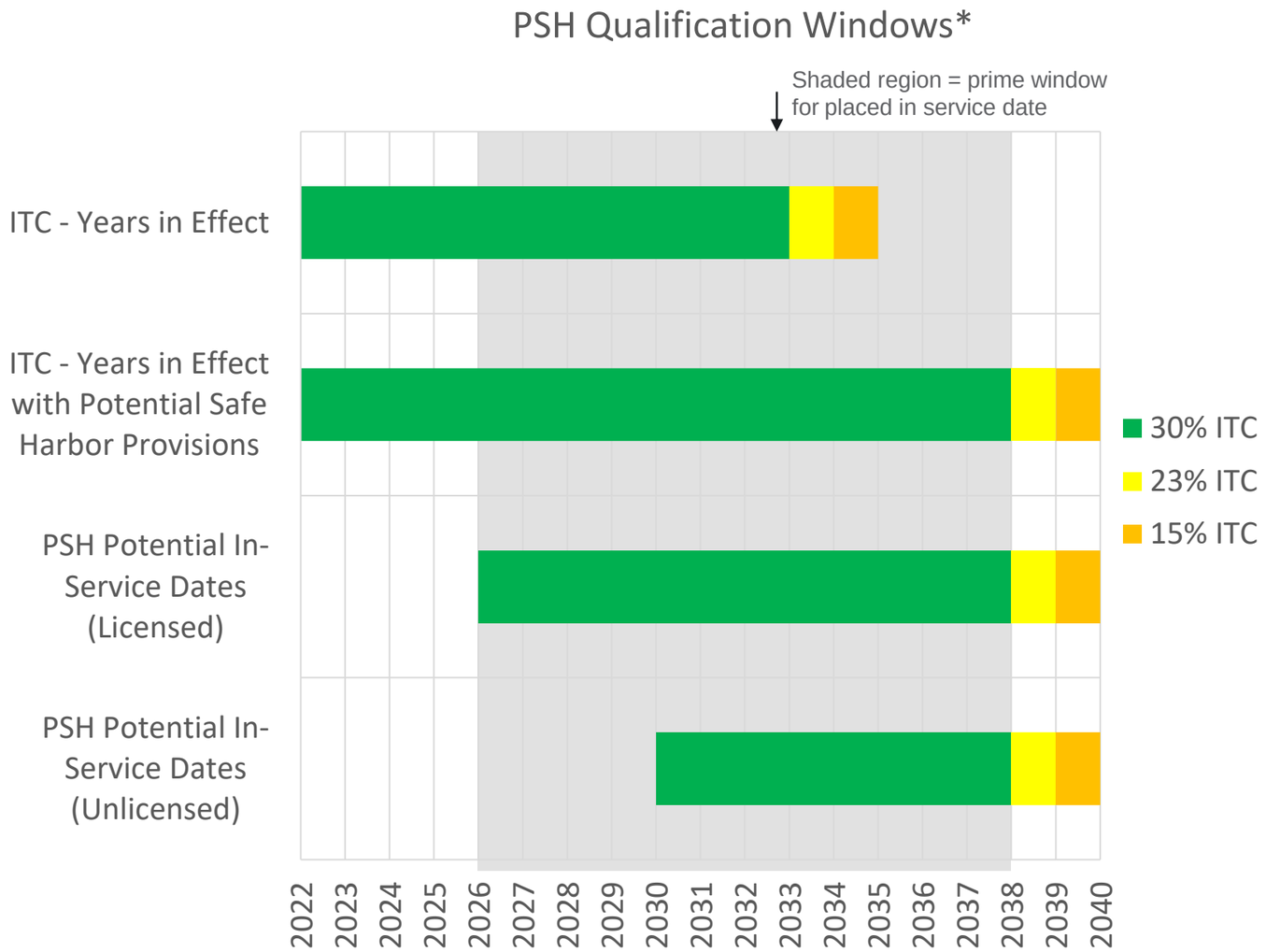


Note: gray bars/diamonds represent activites outside the *PSH FAST Commissioning* scope

Source: Hadjerioua, et al., 2020

- Development timelines for PSH are long, and can often last for a decade or more (Hadjerioua, et al., 2020)
  - FERC licensing alone takes an average of 6 years for open-loop projects
- However, timelines could be reduced to roughly 6 years in certain conditions
- Closed-loop projects can also be eligible for accelerated FERC approvals (Levine, et al., 2021)

ITC Window for PSH Projects

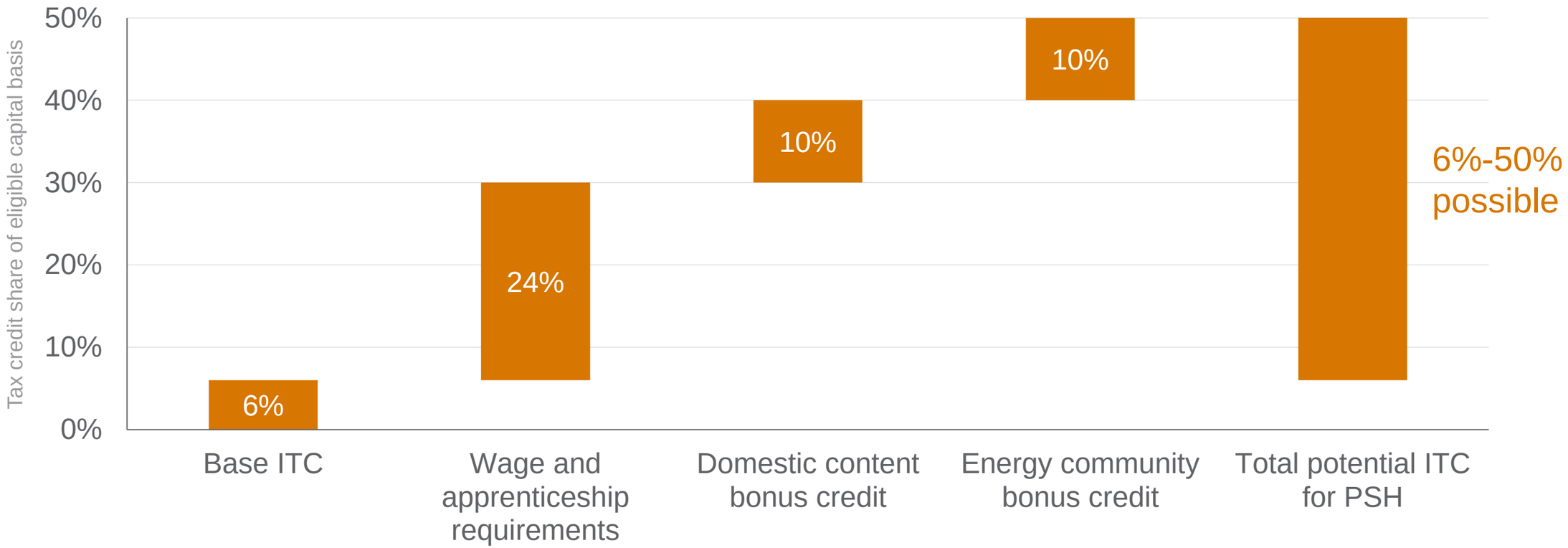


* Assumes project meets wage and apprenticeship requirements, timelines based on FAST commissioning goals (Hadjerioua, et al., 2020)

- While the ITC is scheduled to expire beginning in 2033, safe harbor guidance *could* provide an additional 5 years in which projects can qualify for the credit.
  - Requires the projects to begin construction during the full ITC period
- This is critical for PSH projects with significant construction timelines.
- Licensed projects are likely to require at least 4 years to reach interconnection, while unlicensed projects are likely to need at least 8.
- As a result, 2026-2038 is likely to be the prime window for PSH projects to enter service if they are seeking the ITC.
- Extension of the standard ITC beyond 2033 is possible depending on electricity sector greenhouse gas emissions.

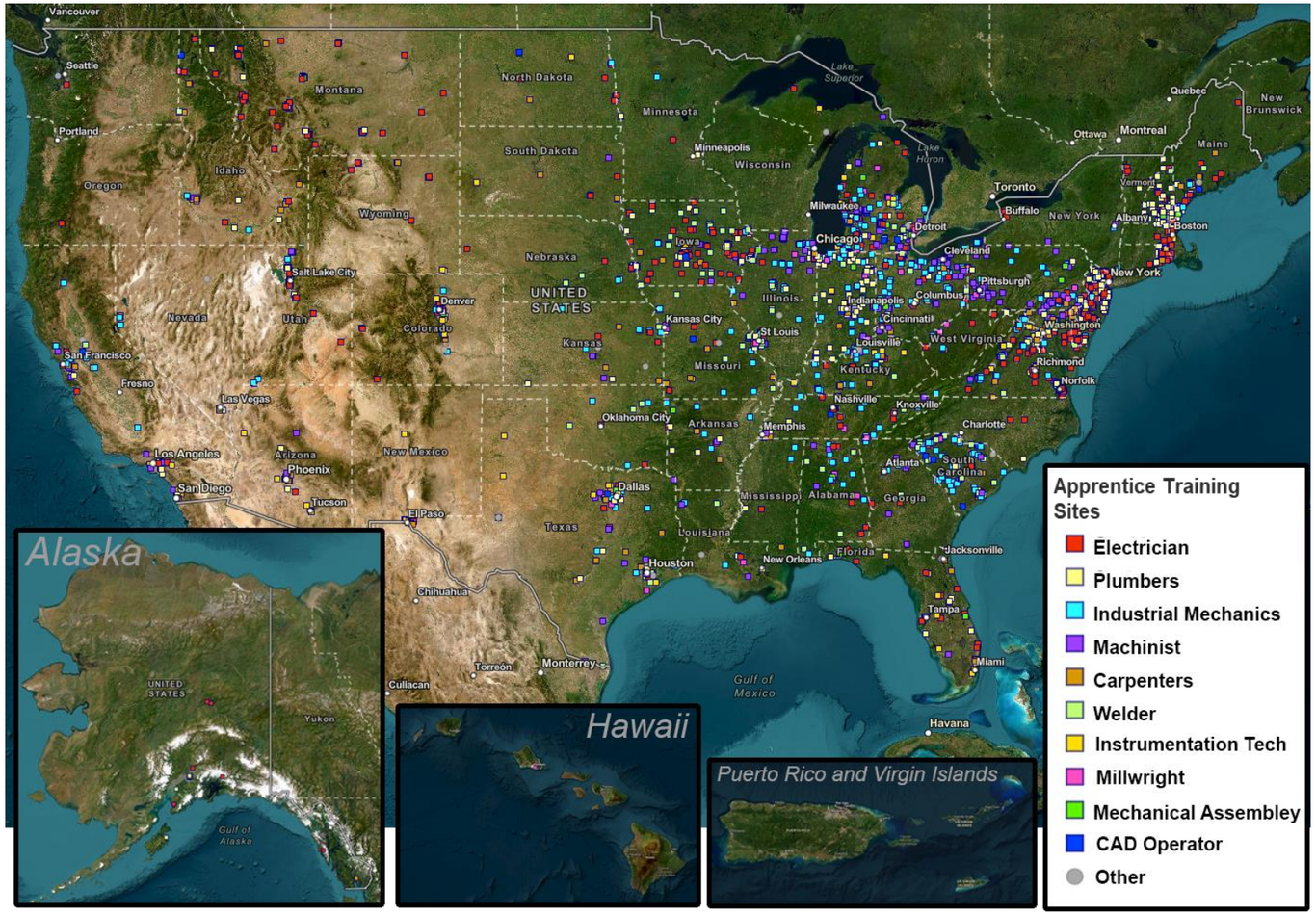
ITC Value Range

The ITC consists of a base credit with bonuses for meeting additional criteria:



- *Illustrative, non-comprehensive summary subject to additional guidance.*
- *Bonus credit amounts may be reduced if wage and apprenticeship requirements are not met.*
- *There is also a low-income communities bonus for certain energy projects with a capacity under 5 MW.*

Wage and Apprenticeship Requirements



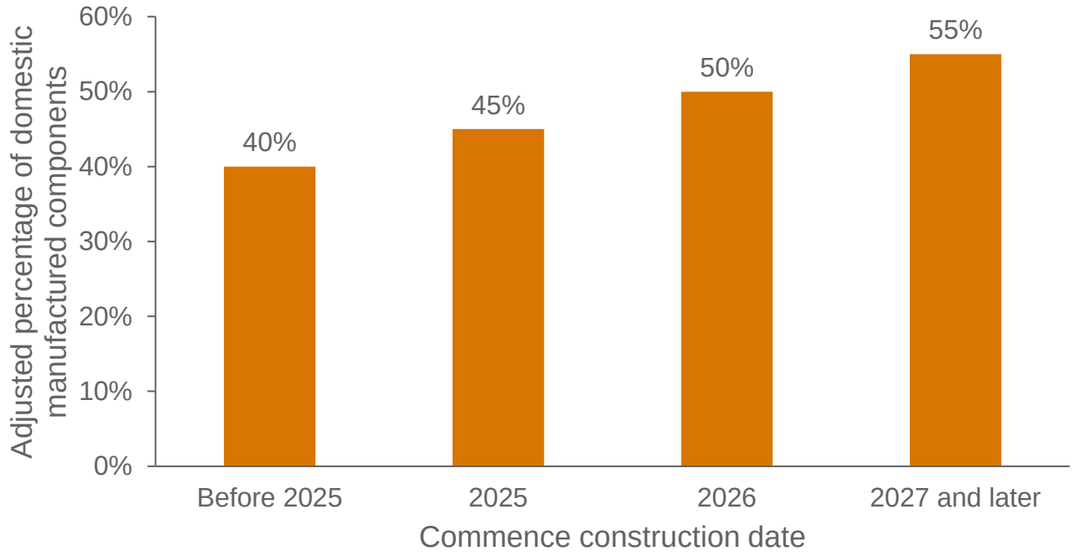
- While the base ITC is 6%, developers can claim a 30% ITC if they conform to certain wage and apprenticeship requirements.
- Laborers and mechanics must be paid the prevailing wages during the construction period and for any subsequent alterations or repairs of the facility.
  - Prevailing wages are locally dependent and based on what similar workers would receive in the area.
- Developers must also have 10-15% of total labor hours be performed by qualified apprentices depending on when construction begins.
  - PSH developers need a steady supply of skilled labor (Daw et al., 2022).
- Alternatively, developers may pay a penalty to receive the standard 30% ITC if they are unable to meet these requirements.
- There are over 8,000 apprentice training sites that train workers that are critical to PSH development.
  - Many of these are close to potential PSH sites.

Domestic Content (10 percentage-point bonus)

- To achieve this bonus, qualifying facilities must demonstrate that:

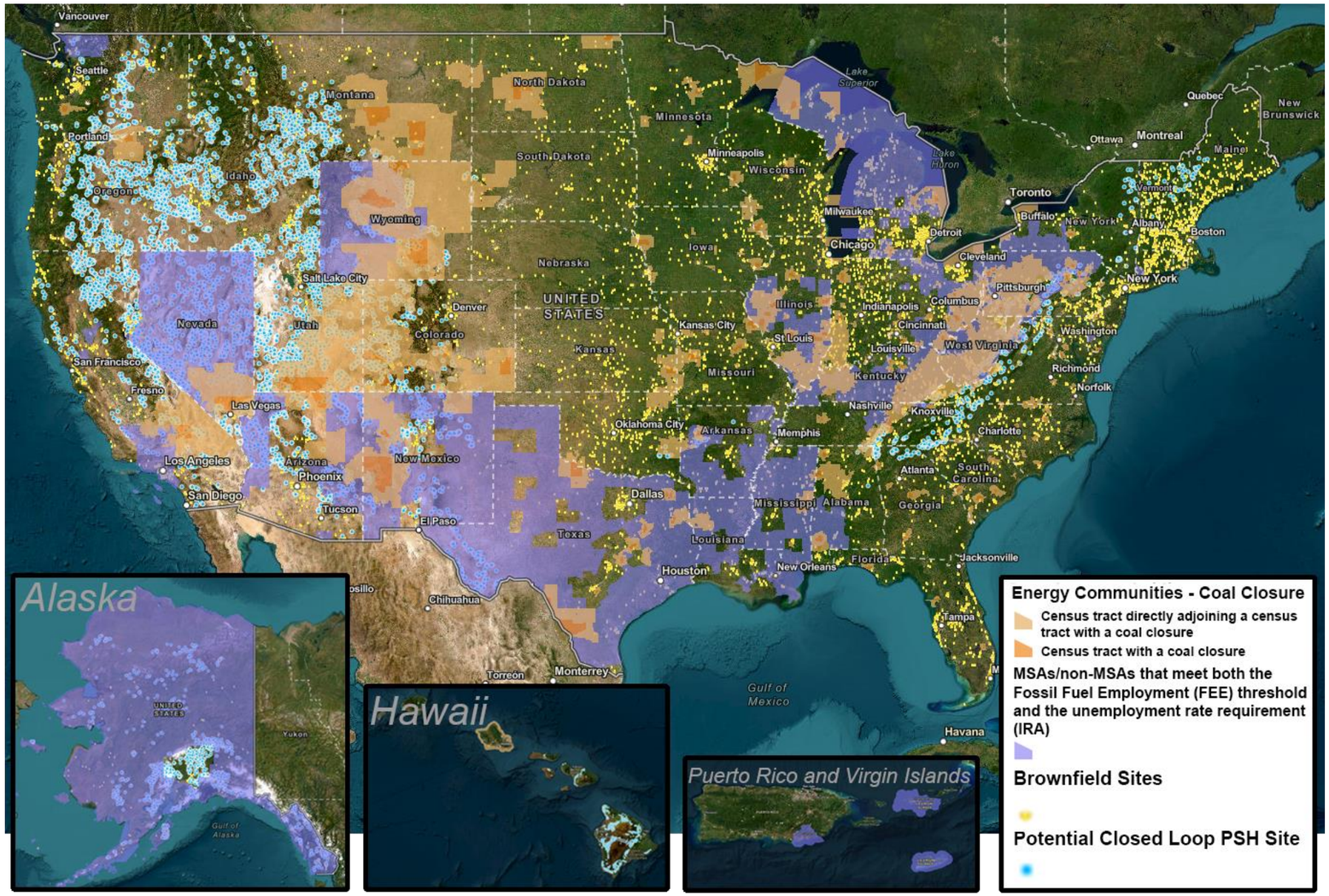
  "Any steel, iron, or manufactured product which is a component of such facility (upon completion of construction) was produced in the United States."

- A certain share (by cost) of manufactured components must also be produced in the US. This percentage increases over time:



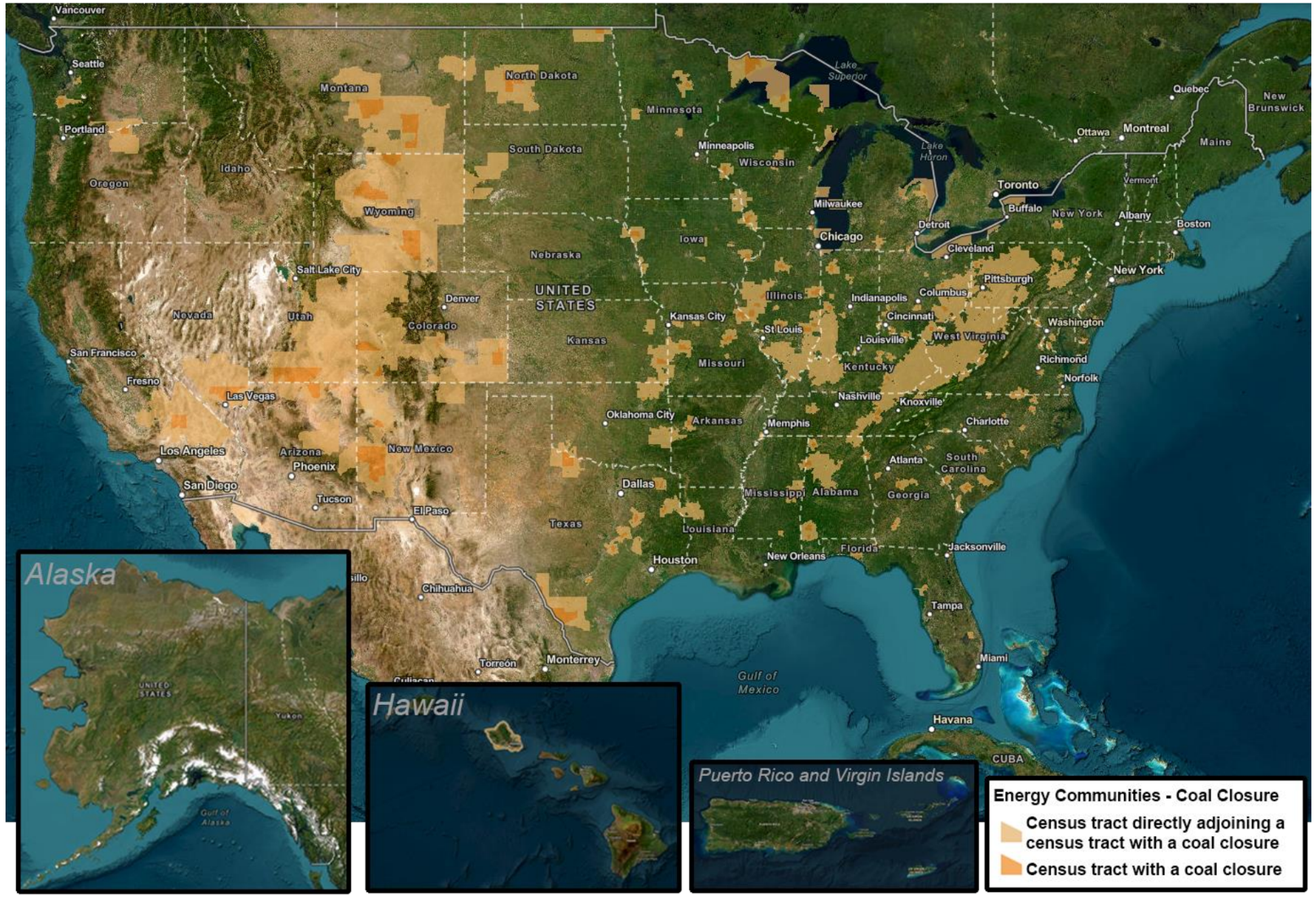
- PSH facilities often require custom components. Most materials for civil works and construction can be supplied domestically.
- There are potential challenges for domestic manufacturing of certain PSH components (Uría-Martínez et al., 2022):
  - Large (greater than 10 tons) steel castings and forgings
  - Large (greater than 100 MW) generator stator windings
  - Microchips and digital components
- Domestic content exceptions may be triggered if:
  - "The inclusion of steel, iron, or manufactured products which are produced in the United States increases the overall costs of construction of qualified facilities by more than 25 percent"
  - "Relevant steel, iron, or manufactured products are not produced in the United States in sufficient and reasonably available quantities or of a satisfactory quality."
- The IRS has released initial domestic content guidance.

Energy Communities (10 percentage-point bonus)



- The energy community bonus has several geospatially-determined components, in general:
  - Areas with a recently closed coal mine or coal-fired electricity generating unit
  - Areas with significant fossil-related employment or tax revenues
  - Brownfields
- Projects sited in these areas may qualify for an additional 10 percentage-point ITC.
- Energy community sites are expected to change over time as brownfields, coal power plants and mines, and fossil fuel employment and tax revenues change.
- The IRS has released guidance and the Department of Energy has created a mapping tool.

Qualifying Advanced Energy Project Credit



- This credit may be sought to re-equip, expand, or establish an industrial or manufacturing facility for the production or recycling of energy property, including energy storage and waterpower technologies.
- Program guidance identifies as eligible “pumps and turbines for pumped hydropower storage systems; and the specialized components of any such equipment, including equipment for sensing communication, and control.”
- This program is capped at $10 billion in overall credits, with $4 billion set aside for projects located in certain energy communities.
- Unlike the ITC, this program is expected to function like a grant in that projects compete for an allocation of credit.

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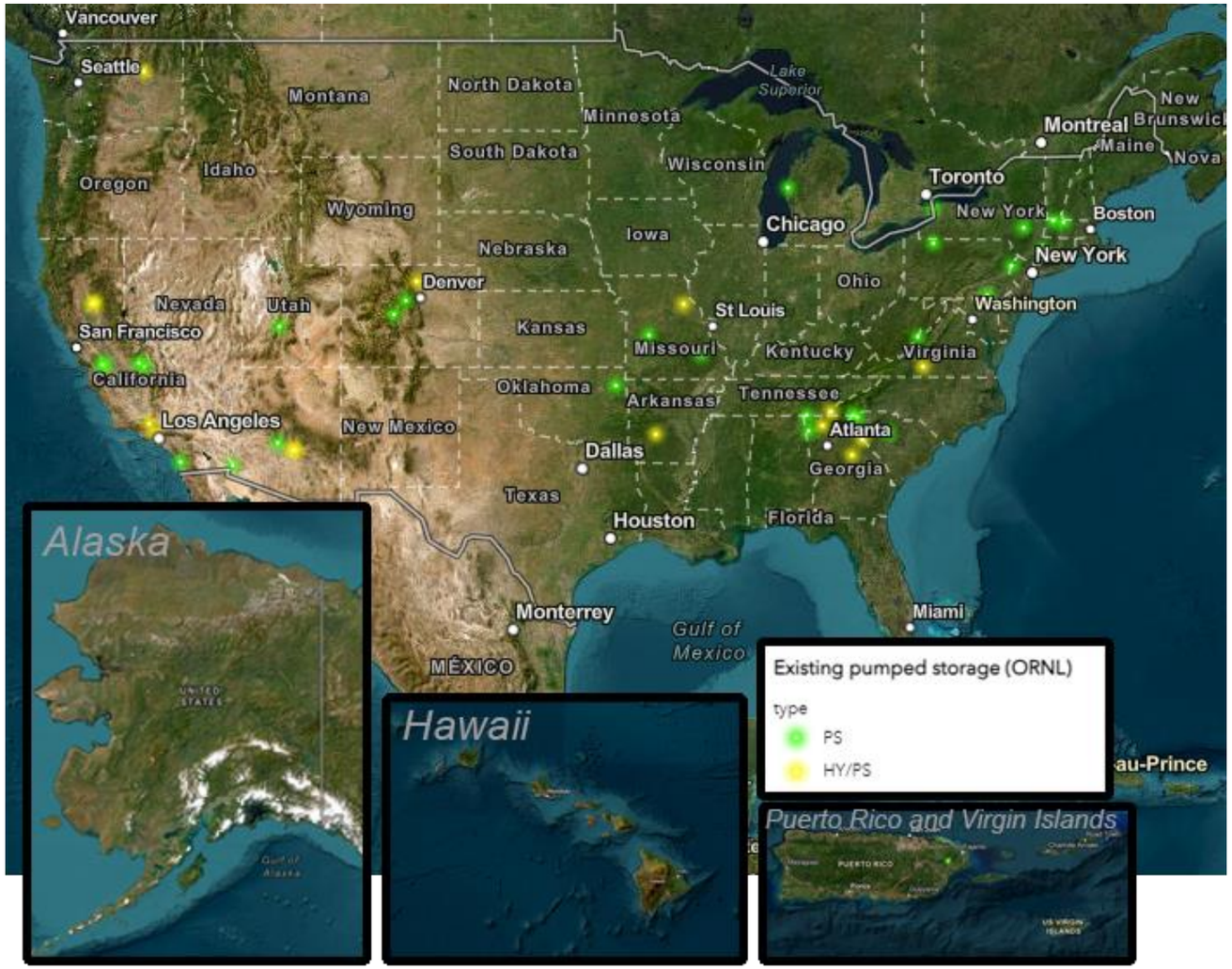
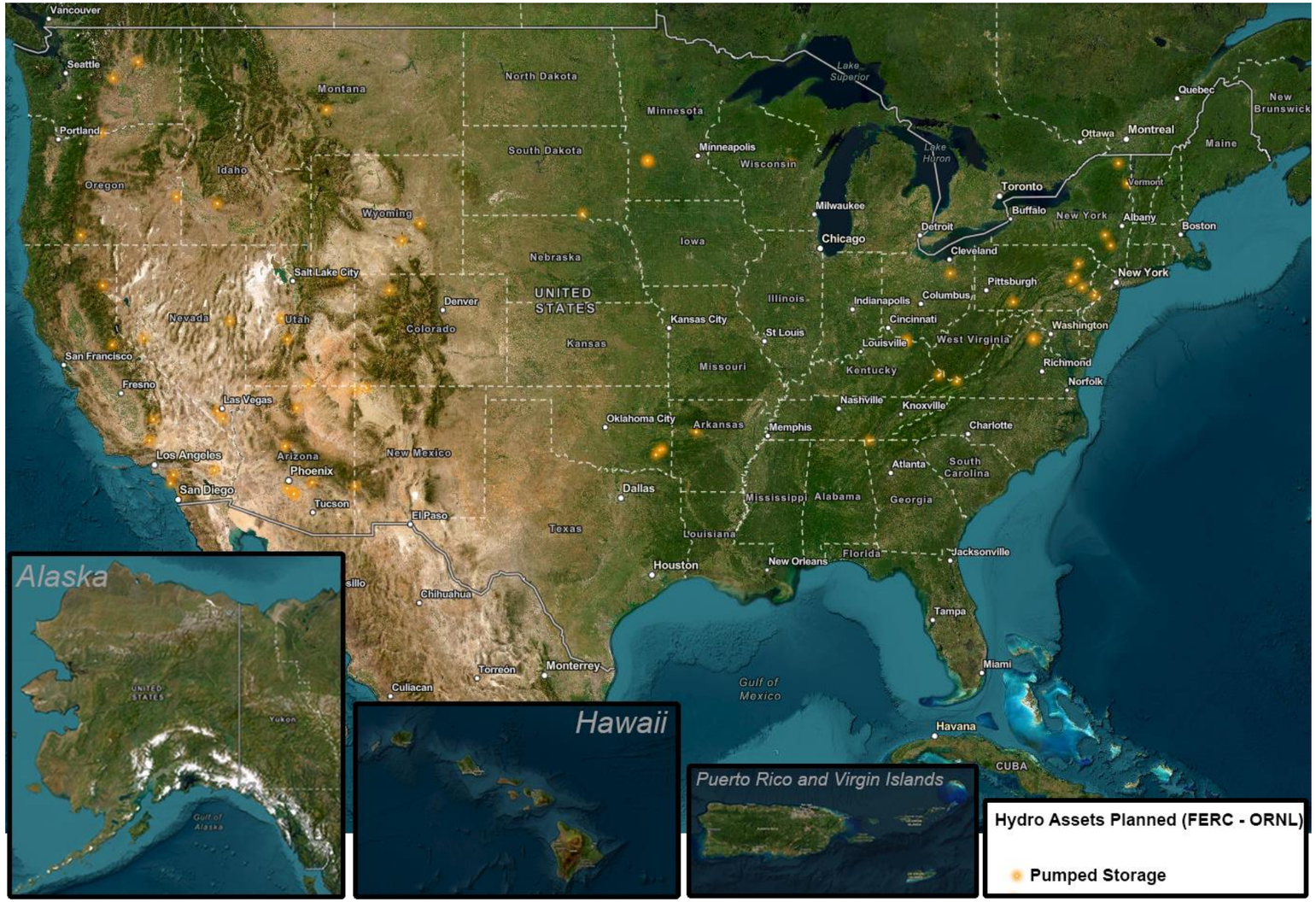
Additional considerations and tool functions

Existing PSH facilities



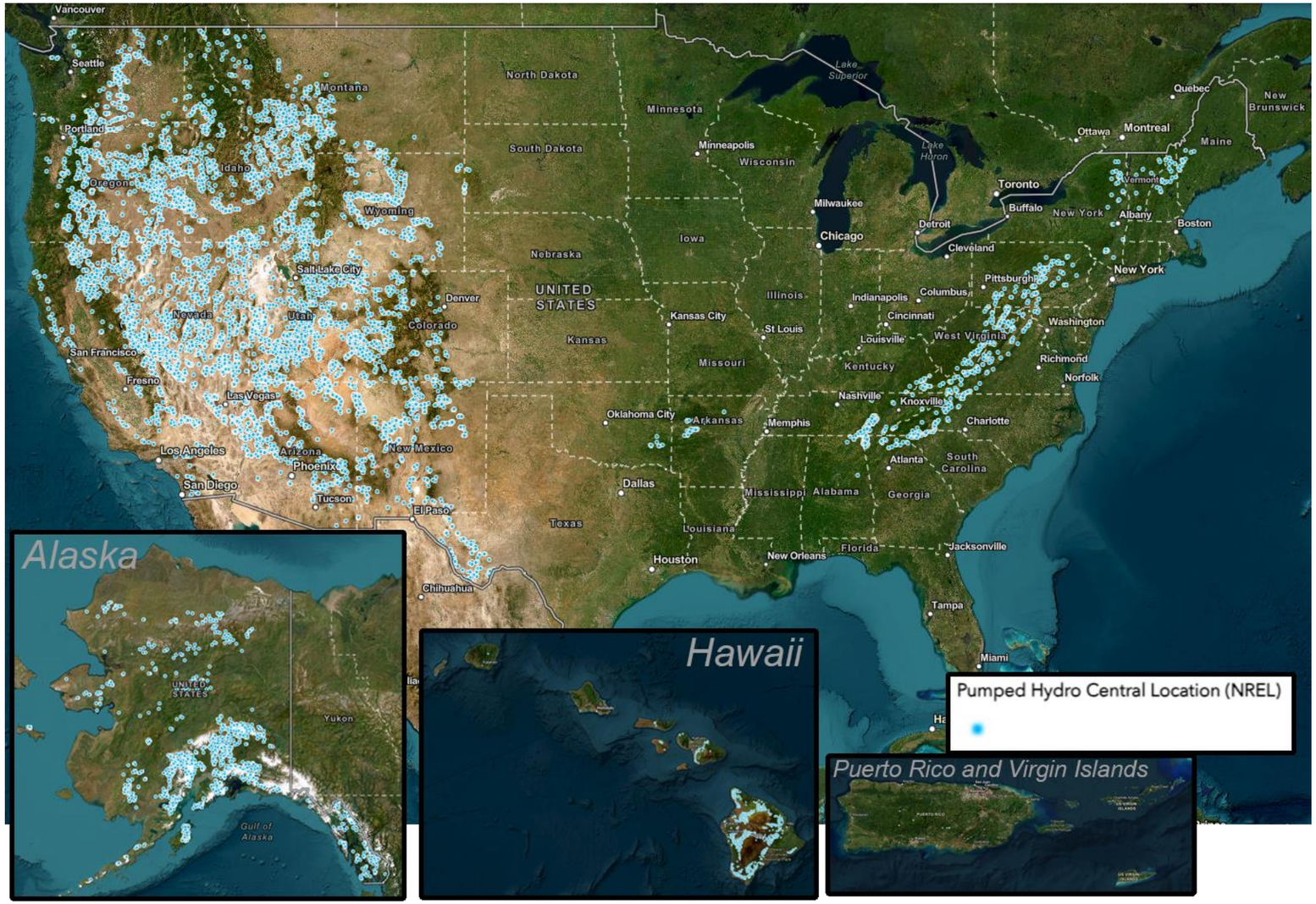
- There are currently 43 operational PSH facilities in the US, with a combined nameplate capacity of 22 GW.
  - All of these plants are open-loop facilities.
- Most were constructed between 1960 and 1990, with the most recent facility entering service in 2012 in California.
- Capacity upgrades may be eligible for the ITC: existing PSH facilities could be valuable locations for expansion.
- Existing facility locations are an important consideration in future site planning to assess:
  - Where PSH has previously been successful.
  - Where PSH demand may already be fulfilled.
  - Where synergies may exist for taking advantage of existing topography, hydrology, infrastructure, and policies.

PSH Development Pipeline



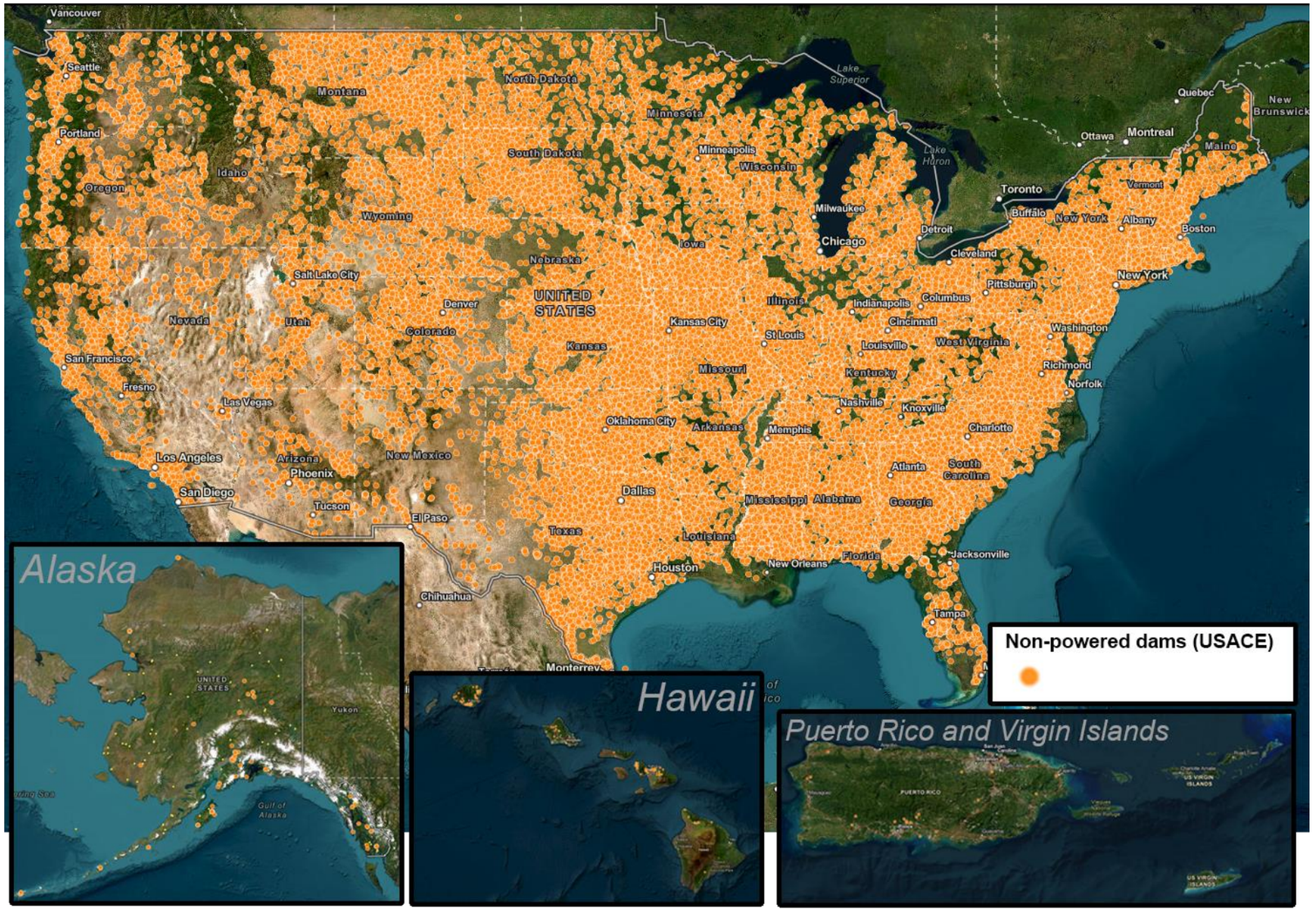
- There are currently 96 PSH facilities in the development pipeline in the US, with a combined nameplate capacity of 91 GW (Uría-Martínez, et al., 2023)
- FERC is responsible for licensing all non-federal hydropower projects and oversees 55% of US facilities (Aldrovandi, et al., 2022)
  - The FERC licensing process covers environmental and recreational impacts of these projects and on average takes 6 years to complete
  - Of the projects in the pipeline, 3 facilities have been authorized by FERC and an additional 7 have advanced beyond the feasibility stage
- Facilities in the permitting stage are likely to be able to claim the ITC, if construction has not started
- Small closed loop projects may be eligible to apply for FERC approval through an expedited permitting tract that takes two-years

Closed-Loop PSH Feasibility



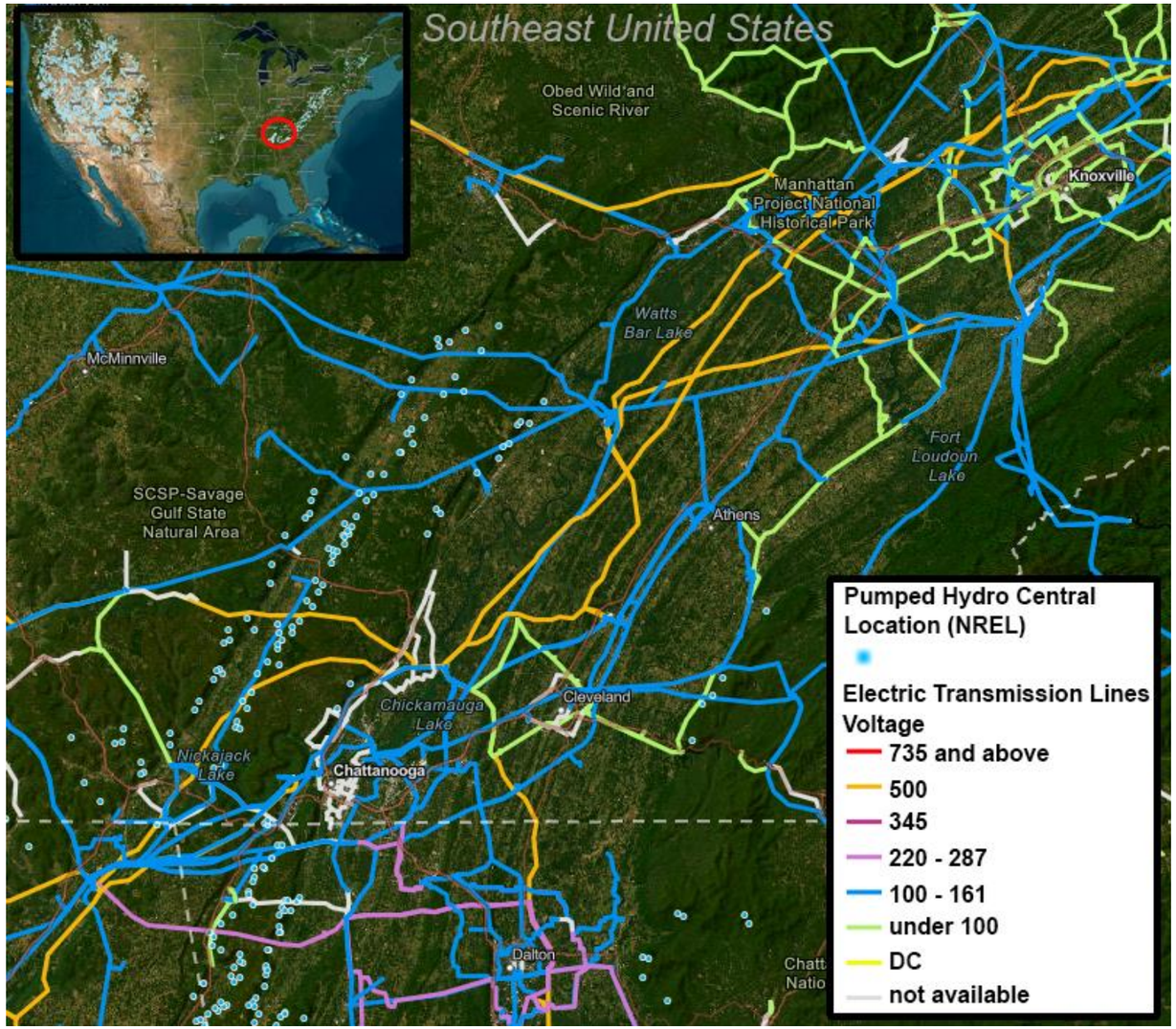
- PSH is spatially dependent on topography and hydrology.
- A recent evaluation of the technical potential of closed-loop PSH in the US (Rosenlieb et al., 2022) identified:
  - ~15,000 reservoir pair sites
  - 35 terawatt-hours of combined storage potential
  - 3.5 terawatts of capacity at 10-hour storage
- Closed-loop facilities may be more attractive for future development in the US because environmental impacts are generally less than those of open-loop facilities, which connect to naturally-flowing watercourses (Saulsbury, 2020).

Non-Powered Dams



- Only 3% of the 90,000+ dams in the US are equipped to generate electricity (US EIA, 2019).
- Non-powered dams may offer significant potential for PSH development as an expansion to existing structures.
- Adding PSH to a non-powered dam could potentially qualify for the investment tax credit, as it would be a new investment in energy storage.

Transmission Infrastructure



- PSH has synergies with transmission infrastructure. PSH facilities have a relatively large capacity and provide relatively long duration energy storage, meaning connection to transmission infrastructure will likely be critical to project feasibility. Scale also enables PSH to act as a transmission asset (Twitchell et al., 2022).
- Regional transmission organization (RTO) and independent system operator (ISO) regulations and markets will likely experience changes in the coming decade due to increased deployment of renewable energy and storage. Compensation mechanisms for long-duration energy storage may emerge (Bhatnagar et al., 2022).

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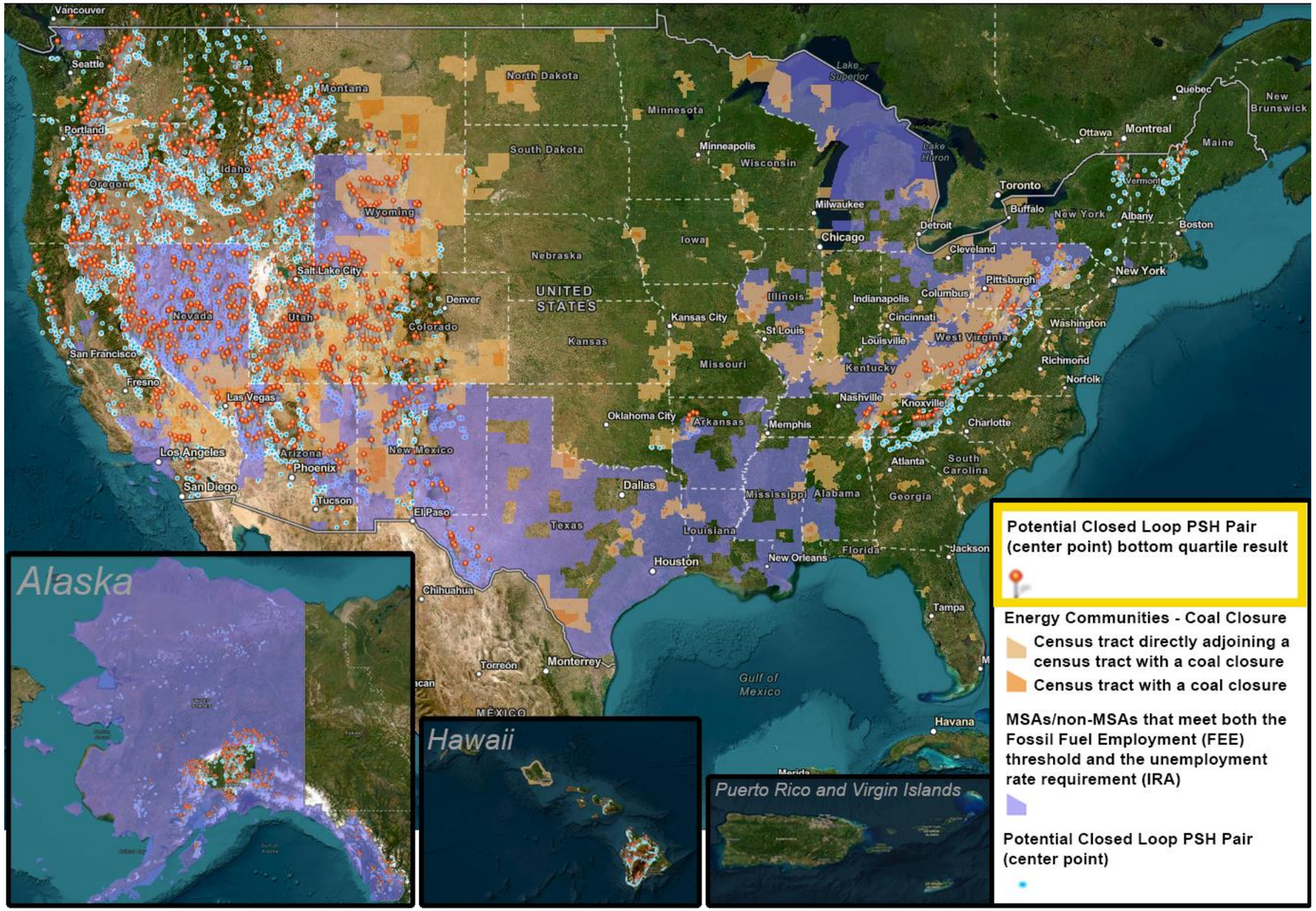
Conclusions

High ITC Credit Locations for PSH



Potential PSH plants that are very low cost and are able to claim bonus credits for the ITC may have excellent commercial potential

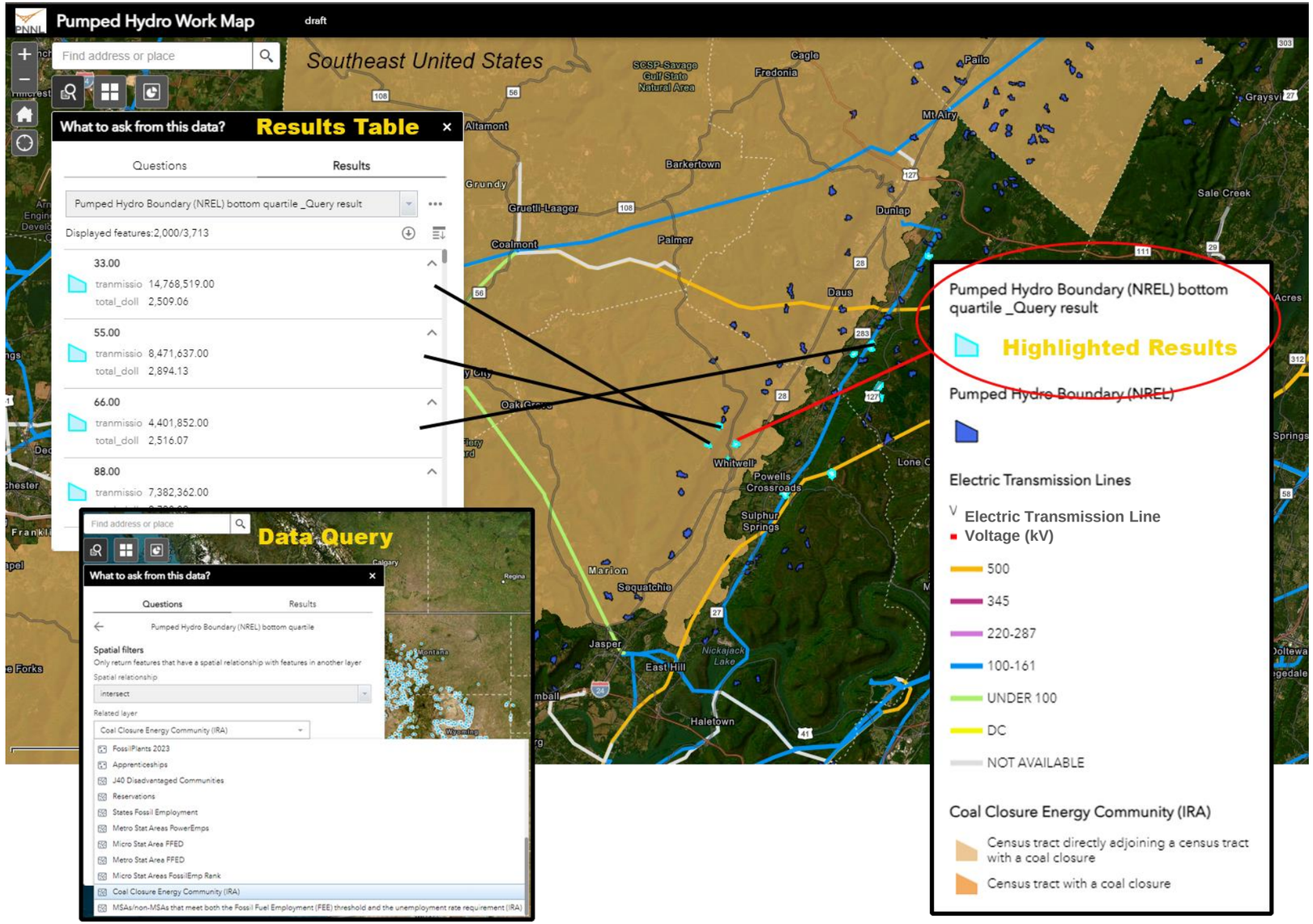
This map shows the lowest quartile of projects in terms of cost alongside IRA energy communities

Areas of particular interest include:

- The Sierras (particularly along the Nevada/California boarder)
- Appalachia
- The Four Corners region/ southern Rocky Mountains

Users can filter and query this tool for low-cost projects, that intersect or are certain distances from key IRA components

Web tool query function



- The web tool can perform queries with metadata and layers.
- The potential closed-loop PSH sites (Rosenlieb et al., 2022) contain cost estimate metadata that can be filtered.
  - Estimated costs do not include the potential investment tax credit.
- This example is demonstrating an illustrative query of:
  1. Selecting a geographic area of interest
  2. Searching for the lowest quartile of potential closed-loop PSH site cost estimates
  3. Intersecting these with a layer of interest, like the coal closure energy community tax credit bonus
  4. Displaying other layers of interest to gauge, e.g., distance from highlighted sites to electric transmission lines

Conclusions

- The Inflation Reduction Act could have major effects on pumped storage hydro development
- Some PSH projects could qualify for an investment tax credit of up to 50% of capital costs
- Significant opportunities for development exist in Appalachia and the Mountain West, where there is a high coincidence of energy communities and low-cost potential PSH sites
- Workforce issues will be critical for PSH development, as the IRA has prevailing wage and apprenticeship requirements
- Stakeholders will also have to pay careful attention to development timelines, as PSH construction requirements and the IRA safe harbor provisions provide a limited window for ITC qualification

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Data Layers and Sources

Layer	Source	Link
PSH Supply Curves	NREL Closed-Loop Pumped Storage Hydropower Supply Curves	https://www.nrel.gov/gis/psh-supply-curves.html
Transmission lines	DHS Homeland Infrastructure Foundation Level Database	https://hifld-geoplatform.opendata.arcgis.com/datasets/electric-power-transmission-lines
Apprentice	DOL National Apprenticeship Data	https://www.dol.gov/agencies/eta/apprenticeship/about/statistics/2021
Brownfields	EPA EnviroAtlas	https://www.epa.gov/enviroatlas/enviroatlas-brownfields
Energy Communities Coal Closures	NETL Energy Community Tax Credit Bonus	https://arcgis.netl.doe.gov/portal/apps/experiencebuilder/experience/?id=a2ce47d4721a477a8701bd0e08495e1d
Energy Communities Fossil Employment	NETL Energy Community Tax Credit Bonus	https://arcgis.netl.doe.gov/portal/apps/experiencebuilder/experience/?id=a2ce47d4721a477a8701bd0e08495e1d
American Indian/Alaska Native/Native Hawaiian Areas	US Census Bureau Boundary and Annexation Survey	https://catalog.data.gov/dataset/tiger-line-shapefile-2018-nation-u-s-current-american-indian-alaska-native-native-hawaiian-area
J40 Communities	Climate and Economic Justice Screening Tool	https://screeningtool.geoplatform.gov/en/downloads#3/33.47/-97.5
Existing Hydro Facilities	ORNL Existing Hydropower Assets	https://hydrosource.ornl.gov/dataset/existing-hydropower-assets-eha-unit-database-2023
Planned Hydro Facilities	ORNL U.S. Hydropower Development Pipeline Data	https://hydrosource.ornl.gov/dataset/us-hydropower-development-pipeline-data-2023
Non-powered dams	USACE Dams of the Nation	https://nid.sec.usace.army.mil/#/
Other generators	EIA US Energy Atlas	https://atlas.eia.gov/datasets/eia::power-plants/explore