



U.S. Hydropower Market Report Update (October 2022)

Megan Johnson
Rocío Uría-Martínez

Oak Ridge National Laboratory



These slides provide updates to some of the key metrics included in the [Hydropower Market Report \(January 2021 edition\)](#). The Hydropower Market Report aims to continuously improve publicly available, comprehensive information on the U.S. hydropower fleet and the industry that supports it and develops new projects.

The updated content shown here covers the following topics:

- Installed capacity and generation trends
- Regional generation and drought trends
- Investment on rehabilitations and upgrades to the existing hydropower fleet
- December 31, 2021 snapshots of the hydropower and pumped storage hydropower project development pipeline
- Hydraulic turbine import and export trends
- Any changes to relevant policies and/or markets

Unless otherwise noted, these are the regions used in the slides.

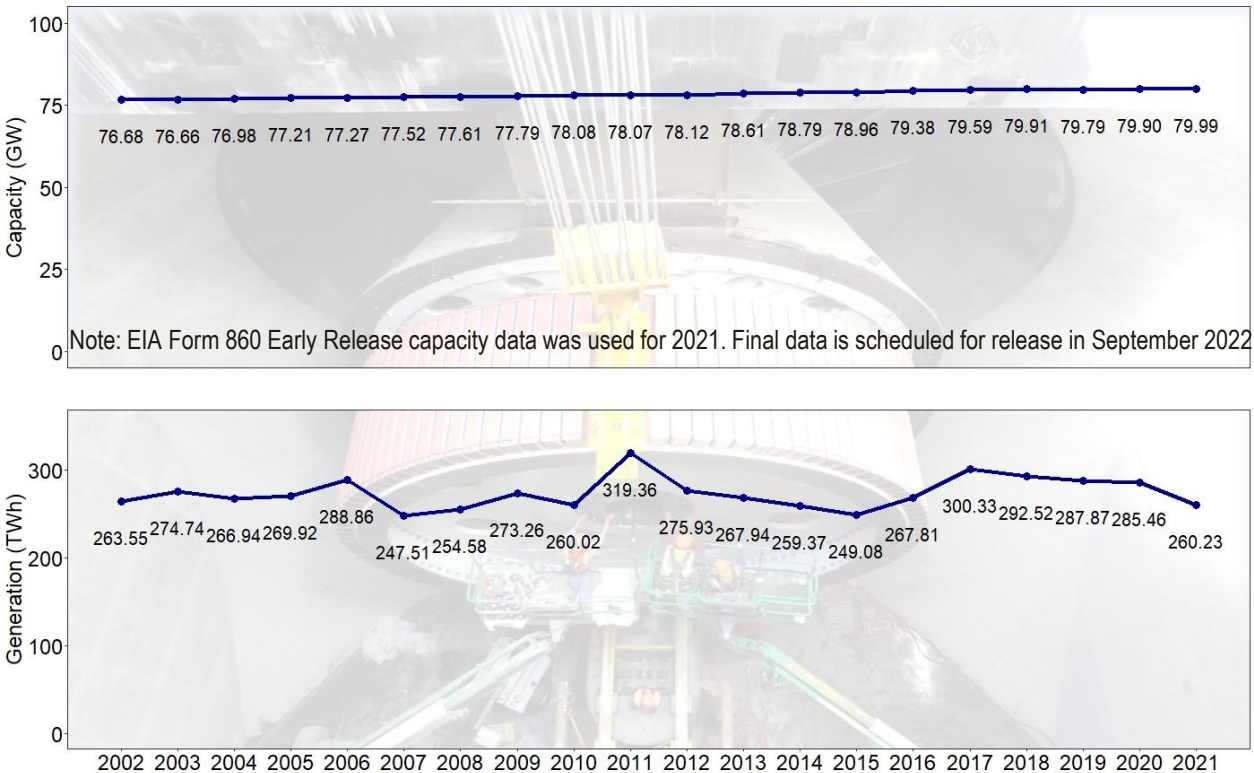
The last year of data shown in each of the plots will be 2021 except for slide 4 which includes some preliminary 2022 data.

U.S. Hydropower Market Report Regions



This work has been funded by the Water Power Technologies Office, Office of Energy Efficiency and Renewable Energy of the U.S. Department of Energy under Contract No. DE-AC05-00OR22725. Any errors in this document are the sole responsibility of the authors.

U.S. hydropower capacity remained stable in 2021 while hydropower generation saw a significant decline.



Sources: EIA Form 860 (capacity), EIA Form 923 (generation), Electric Power Monthly (2021 generation)

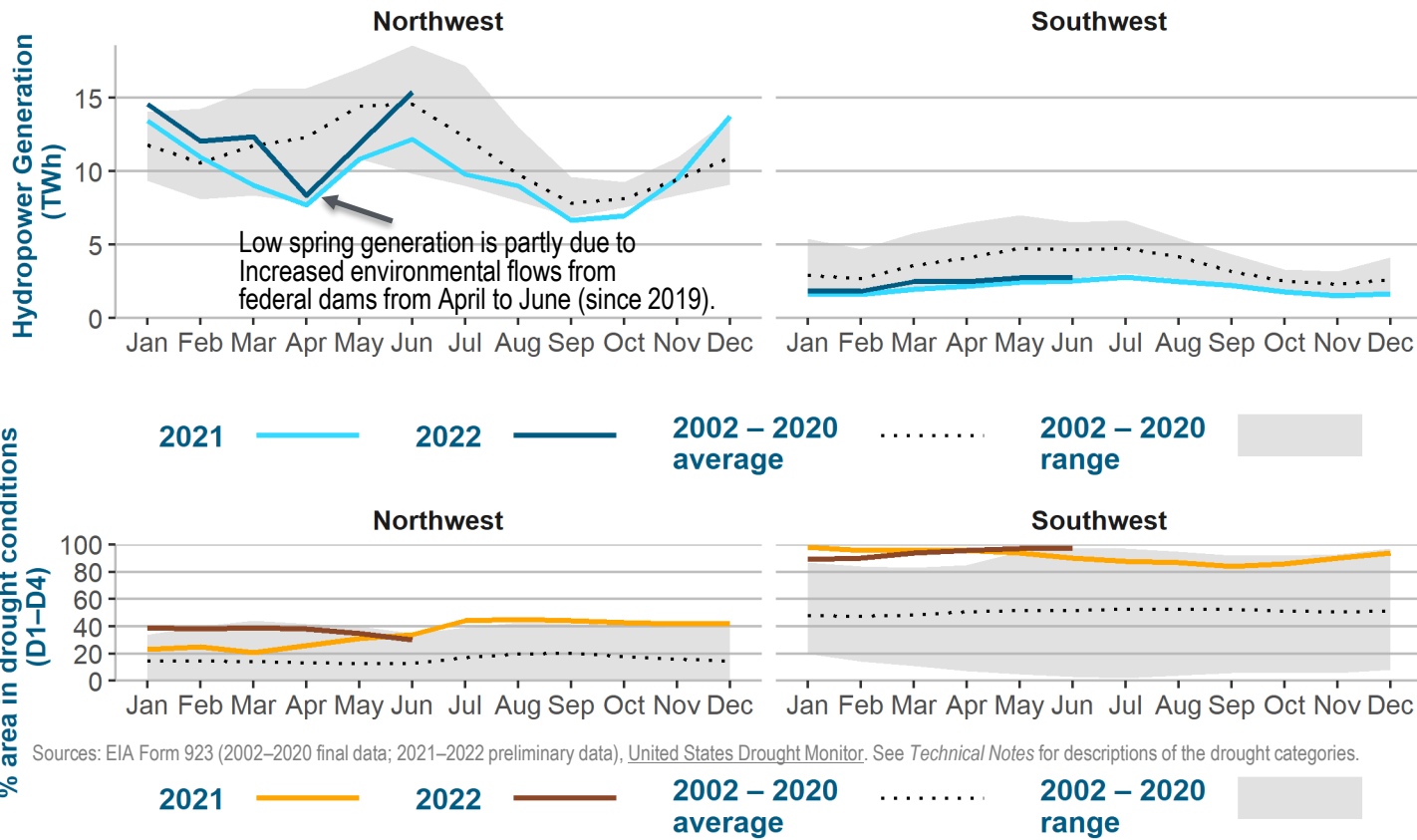
Installed capacity increased by ~90 MW in 2021, over 50% from new projects.

- Eight new FERC-permitted projects with a combined capacity of 46 MW came online:
 - Three retrofitted non-powered dams: Red Rock (Iowa, 36.4 MW), Matilda Hamilton Fee (Kentucky, 2.6 MW), Upper Collinsville (Connecticut, 1 MW)
 - Three new stream-reach developments: Reynolds Creek (Alaska, 5 MW), Rock Creek (Oregon, 0.85 MW), Kupreanoff Microhydro (Alaska, 0.0015 MW)
 - Two conduits: Dividers (Colorado, 0.185 MW), Division Booster (Washington, 0.025 MW)
- Seventeen plants had capacity additions or uprates adding ~230 MW.
 - 96 MW Bad Creek PSH in South Carolina
- Capacity derates, including one plant retirement, amounted to ~190 MW.

Hydroelectric generation in 2021 was 260.2 TWh (almost 9% decrease relative to 2020).

- Hydropower generation accounted for 31.5% of U.S. renewable electricity generation and 6.32% of total generation (U.S. total generation increased ~3% in 2021 relative to 2020).

Drought conditions in the western half of the country were the main contributor to the drop in U.S. hydropower generation in 2021; in the Southwest, generation was the lowest in at least 20 years.

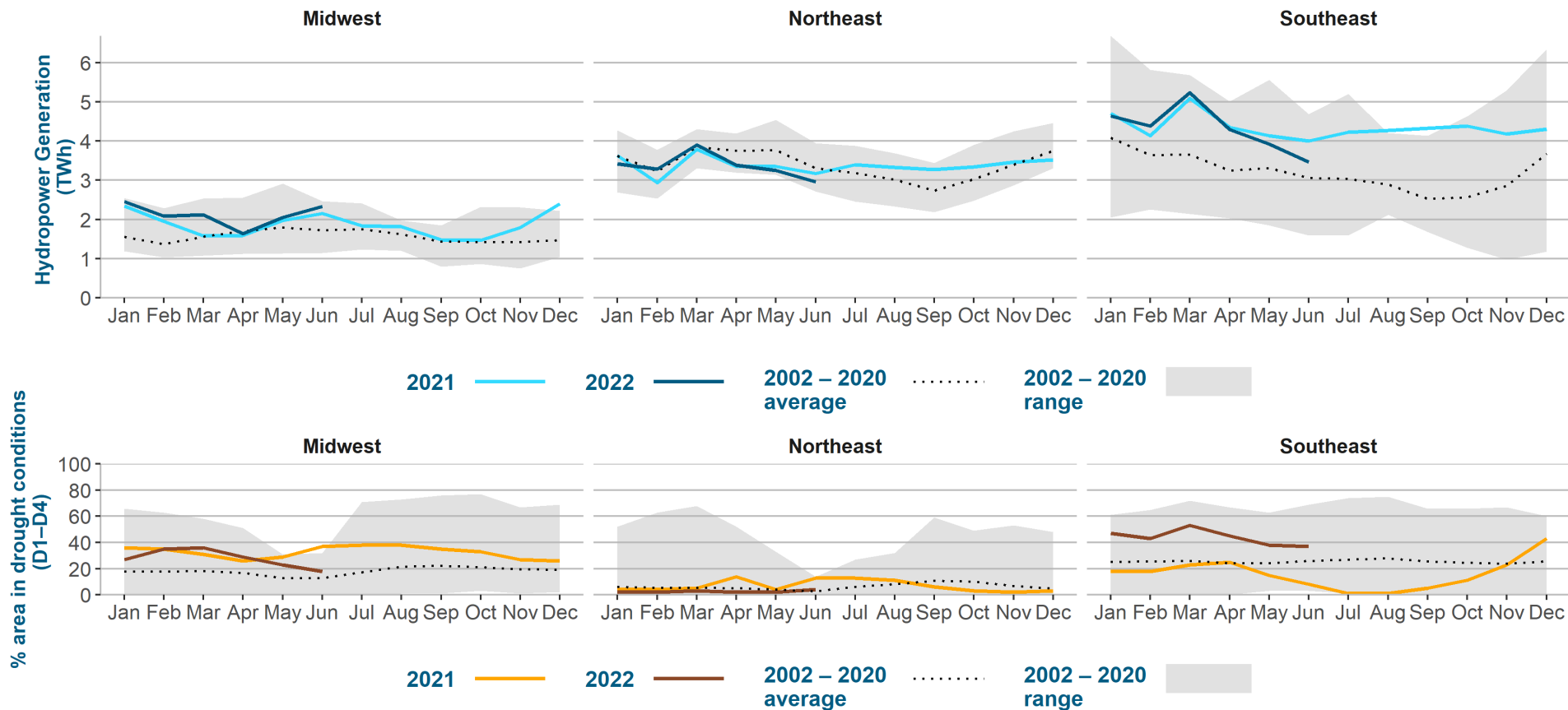


Turner et al. (2022) use statistical hydropower generation models to evaluate the hydropower effects of 21st century Western droughts relative to those from 20th century droughts.

- If repeated today, some of the 20th century droughts (1976–1977; four different years in 1924–1931) would have resulted in similar or larger loss of hydropower than the worst drought years of the 21st century to date.
- The U.S. West contains diverse hydropower climate regions which are typically not severely affected at once by any single drought resulting in relative stability in total hydropower generation across the region.

- In the Northwest, 2021 hydropower generation was 10% below the 2002–2020 average.
 - Since July 2021, the percentage of area under drought conditions (~40%) has been at the upper end of the 2002–2020 range.
- In the Southwest, 2021 hydropower generation was 41% below the 2002–2020 average.
 - More than 80% of area in the region was in drought conditions; 40% or more was in the extreme (D3) or exceptional (D4) categories.
- In the first half of 2022, the percentage of area in the Southwest under D3 or D4 drought categories decreased but generation did not increase relative to 2021.

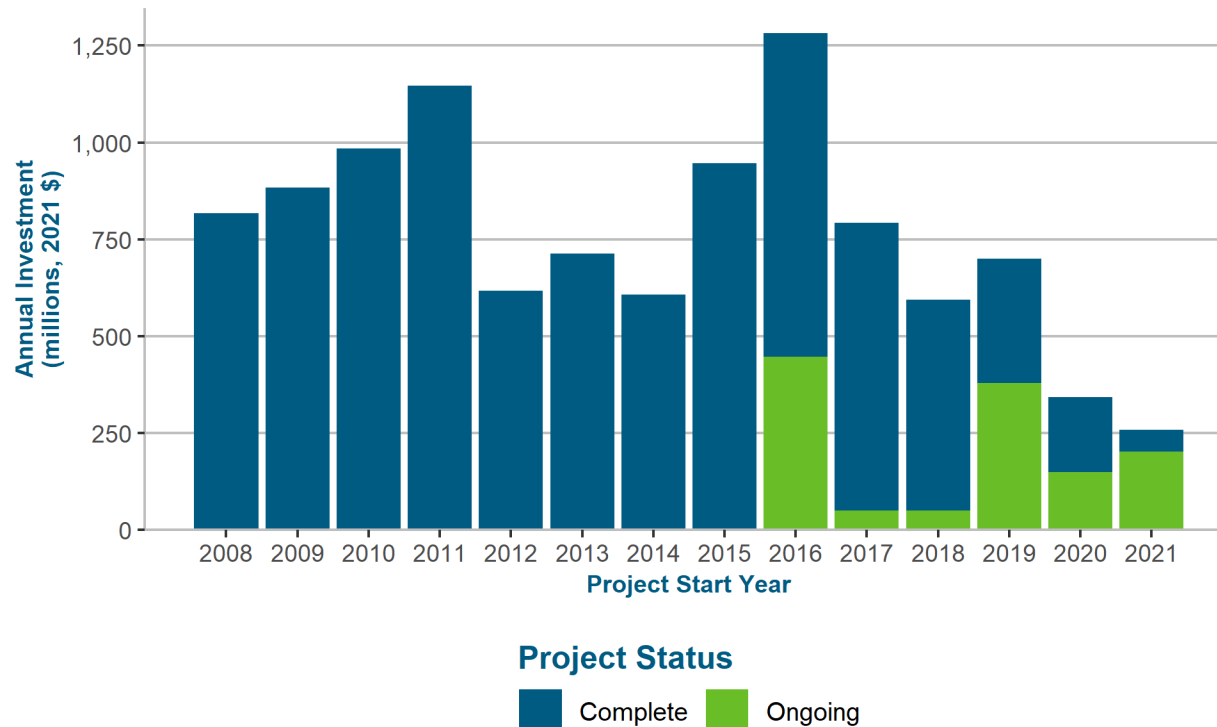
In the rest of the country, hydropower generation was at or above average in 2021 (except for the Northeast during the spring months).



Sources: EIA Form 923 (2002–2020 final data; 2021–2022 preliminary data), [United States Drought Monitor](#). See *Technical Notes* for descriptions of the drought categories.

- Midwest + Northeast + Southeast accounted for 44% of U.S. hydropower generation in 2021 instead of their average share of 36% in 2002–2020.
- In the first half of 2022, the percentage of area in the Southeast under D3 or D4 drought categories increased but hydropower generation remained at similar levels as in 2021.

New investment in hydropower rehabilitations and upgrades (R&U) continued to decline in 2021 amid COVID 19-related restrictions and supply chain issues.



Source: Industrial Info Resources

Note: This plot provides a December 2021 snapshot of completed or ongoing R&U projects started since 2008.

See *Technical Notes* for further details about the data shown in this plot and description of the regions.

- Twenty-two new R&U projects at 18 hydropower plants started in 2021 with a total estimated value of \$256 million.
 - Eight of the projects involved refurbishments or upgrades to turbine-generator units.
 - Refurbishment of four units at Barkley Hydro Power Station accounted for 38% of the new 2021 investment.
 - Eight projects are refurbishments of hydropower station cranes at USACE plants with combined value of ~\$41 million.
- Distribution of 2021 new investment by owner type:
 - Federal: 91% of new projects (20) accounting for 78% of investment
 - Public, non-federal: 9% of new projects accounting for 22% of investment
- The value of tracked R&U investment since 2008 is over \$9.76 billion distributed among 194 hydropower facilities.
 - Value by region: Northwest (34%), Southwest (13%), Midwest (16%), Northeast (12%), Southeast (25%)

At the end of 2021, 130 new hydropower projects with a combined capacity of 1,500 MW were in the development pipeline; non-powered dam retrofits accounted for 96% of the proposed new capacity. Additionally, 22 upgrade projects will add 243 MW to the existing fleet.

U.S. DEPARTMENT OF

ENERGY

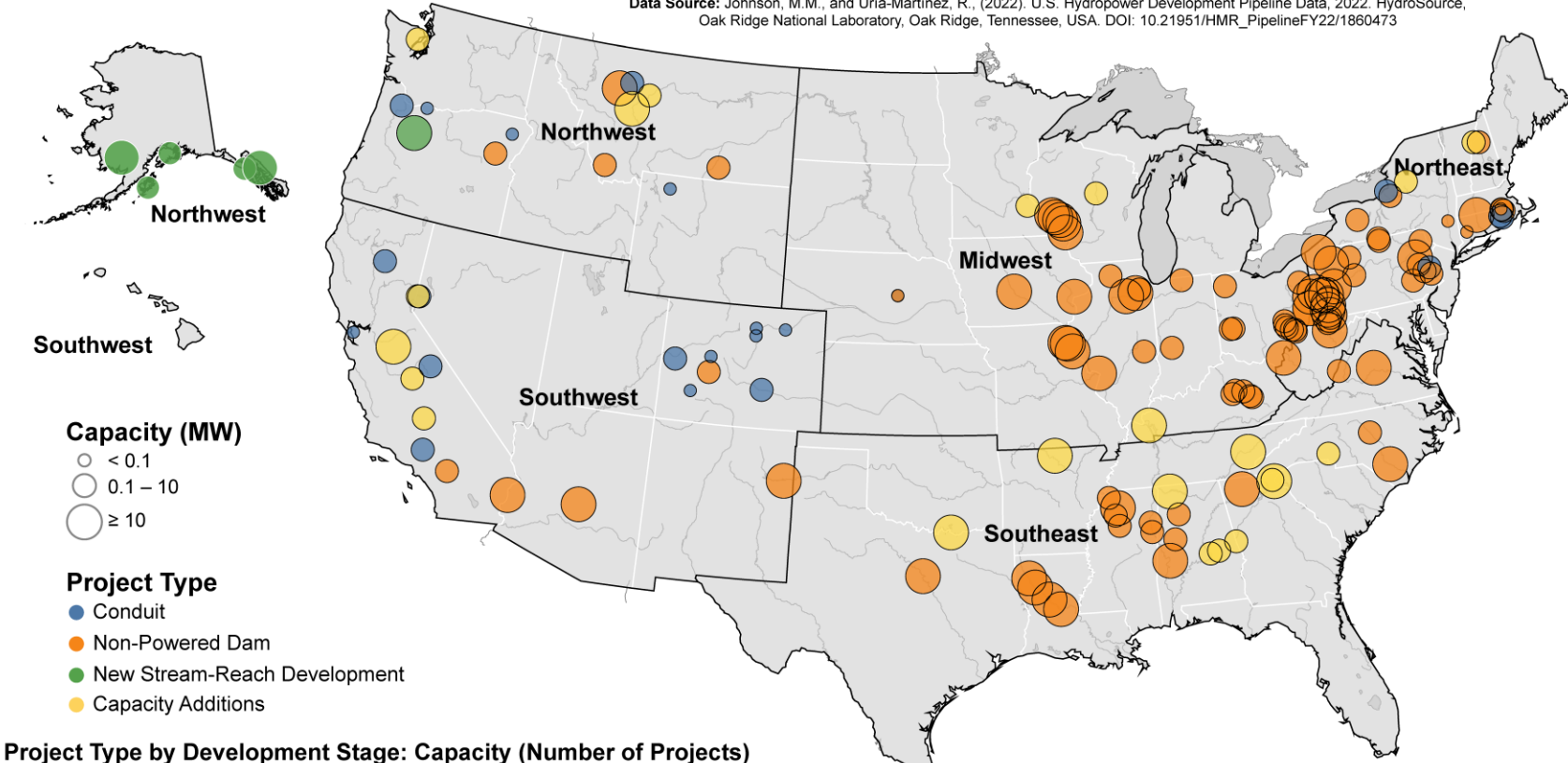
Energy Efficiency & Renewable Energy

Note: The map presents a snapshot of the development pipeline as of December 31, 2021.

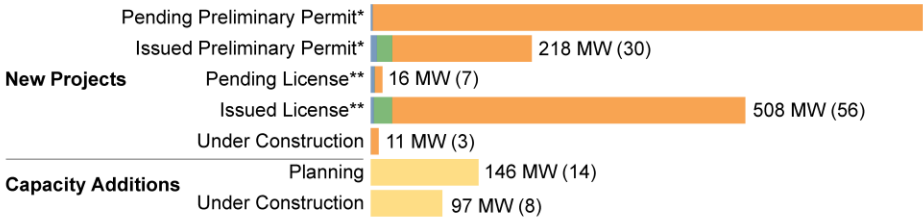
U.S. Hydropower Development Pipeline, 2022

Map Source: Schmidt, E., Johnson, M.M., and Uria-Martinez, R. 2022. U.S. Hydropower Development Pipeline Map FY2022. HydroSource, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA. DOI: 10.21951/HMR_PipelineMaps/1864509

Data Source: Johnson, M.M., and Uria-Martinez, R., (2022). U.S. Hydropower Development Pipeline Data, 2022. HydroSource, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA. DOI: 10.21951/HMR_PipelineFY22/1860473



Project Type by Development Stage: Capacity (Number of Projects)



*Projects in the Pending Preliminary Permit and Issued Preliminary Permit stages are undergoing feasibility studies and have high attrition rates. Projects that have submitted a Notice of Intent to file a license application are also included in the Issued Preliminary Permit stage.

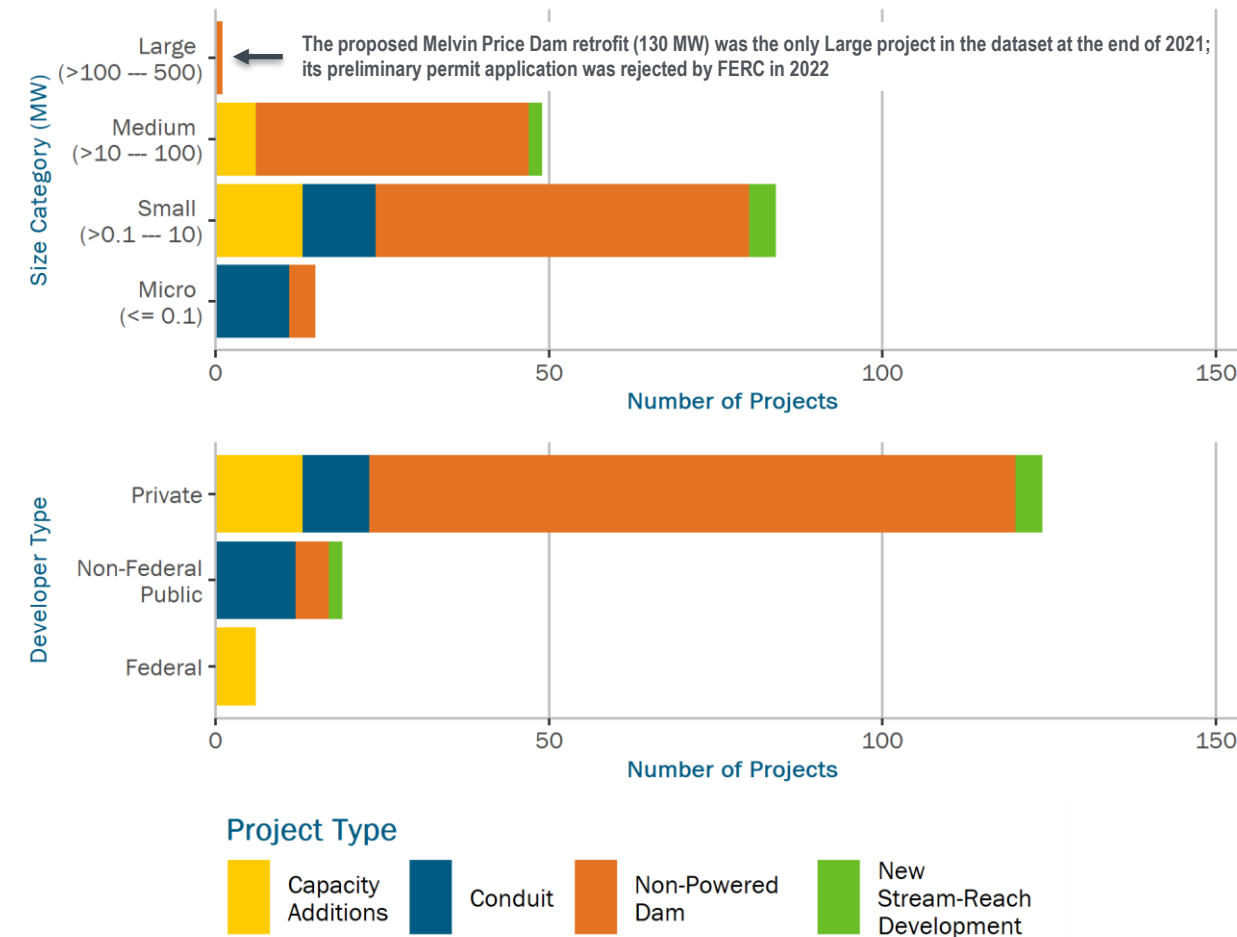
**Pending License includes projects that have applied for authorization from FERC or Bureau of Reclamation. Issued License includes projects that have received federal authorization from one of the two agencies.



In 2021, 34 preliminary permit applications were submitted but most did not provide sufficient information to be accepted by FERC; the number of license application submissions and construction starts were very low.

- Twenty-nine of the 34 pending preliminary permits at the end of 2021 corresponded to applications filed in 2021 by a single private developer.
 - FERC rejected all these permit applications in 2022 due to application deficiencies.
 - The developer has resubmitted the applications for seven of them.
- FERC received one license application, two exemption applications, and one request for qualifying conduit status in 2021.
 - These five projects have a combined capacity of 10.4 MW.
- Fifty-five percent (280 MW) of the capacity in “Issued License” stage corresponds to 13 non-powered dam projects in Louisiana and Pennsylvania
 - All these projects propose adding hydropower to existing non-powered USACE-owned dams.
 - The licenses for all these projects were issued four or more years earlier.
 - Securing required USACE permits, power purchase agreements, and project land rights are the reasons cited by these licensees in their requests to FERC for extensions of construction start deadlines.
- The three projects in construction at the end of 2021 are:
 - Two non-powered dam retrofits: Marseilles Lock & Dam in Illinois (10.26 MW) and Albion Dam in Rhode Island (0.42 MW)
 - Construction at Marseilles Lock & Dam started in January 2016; there has been very limited progress in construction activities since November 2019 due to a combination of weather conditions, pandemic-related delays, and project funding issues. FERC has requested a revised construction schedule from the developer in September 2022.
 - Construction at Albion Dam started in May 2021.
 - One conduit project: North Loup Canal in Nebraska (0.03 MW)
 - Construction started in May 2021.

Most new hydropower projects in the development pipeline were small (≤ 10 MW) and pursued by private developers. The federal hydropower fleet accounted for almost two thirds of ongoing capacity additions to existing facilities.



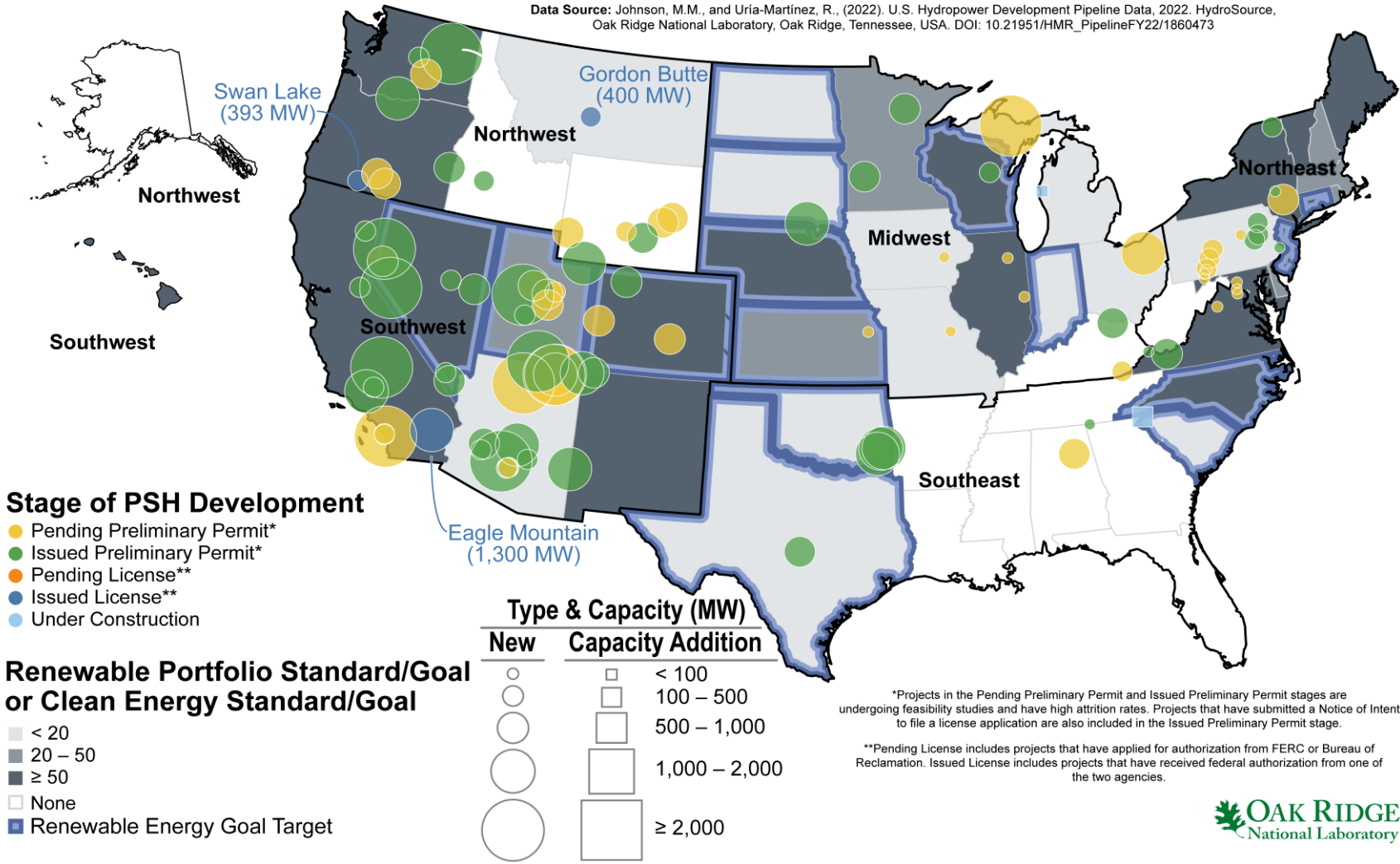
- Fourteen of the 22 proposed conduit projects have received 'qualifying conduit' determination from FERC; the rest either require a FERC license or a lease of power privilege from Reclamation.
 - All qualifying conduit projects in the pipeline are ≤ 1 MW even though the capacity limit for non-federal conduits to be able apply for "qualifying conduit" determination is 40 MW.
- Six capacity addition projects in the federal fleet (plants owned by USACE or TVA) would add 122.8 MW of capacity.
 - The 13 capacity addition projects in the private fleet propose a combined additional 73 MW.

At the end of 2021, 96 new pumped storage hydropower projects were in the U.S. development pipeline and 3 of them already had a FERC license. Additionally, two project upgrades will add 250 MW to the existing fleet.

Note: The map presents a snapshot of the development pipeline as of December 31, 2021.

U.S. Pumped Storage Hydropower Development Pipeline, 2022

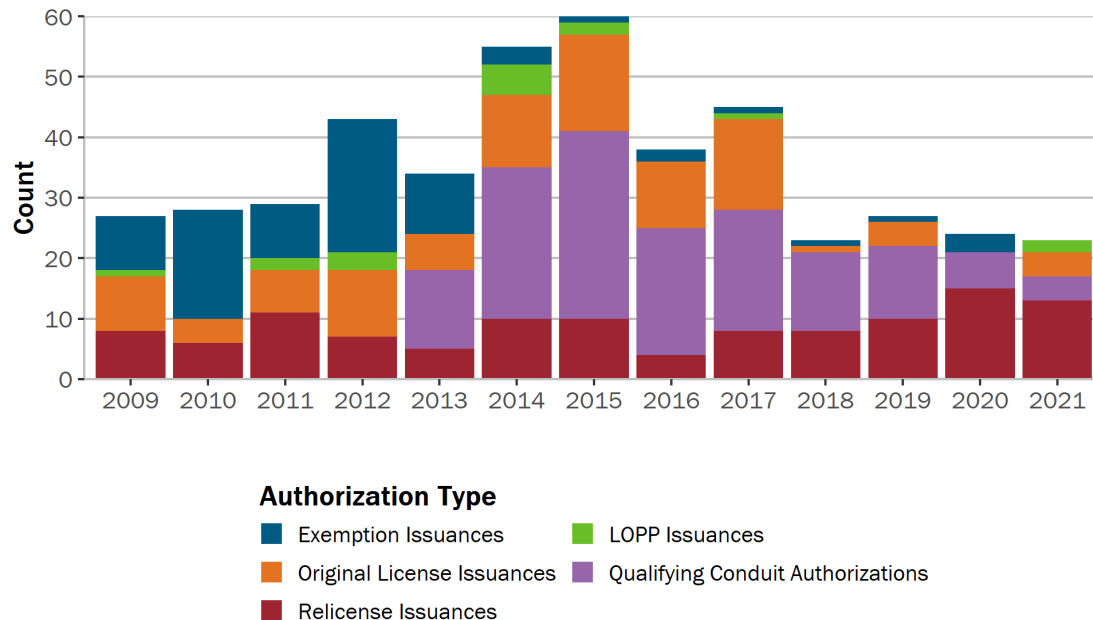
Map Source: Schmidt, E., Johnson, M.M., and Uriá-Martínez, R. 2022. U.S. Pumped Storage Hydropower Development Pipeline Map FY2022. HydroSource, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA. DOI: 10.21951/HMR_PipelineMaps/1864510
Data Source: Johnson, M.M., and Uriá-Martínez, R., (2022). U.S. Hydropower Development Pipeline Data, 2022. HydroSource, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA. DOI: 10.21951/HMR_PipelineFY22/1860473



Investor-owned utilities showed significant interest in PSH development in 2021 by submitting 12 preliminary permit applications for projects in the Northwest, Southwest, and Southeast.

- There were PSH projects under consideration in every region.
 - The Southwest had the largest fraction of projects (42 out of 96) and largest average project size (1,062 MW versus 210MW–682MW in other regions).
- Seventy-nine of the 96 projects are closed-loop (i.e., not continuously connected to a naturally flowing water feature).
 - Closed-loop projects may be eligible for the expedited [two-year FERC licensing process](#) that became available in 2019.
- Several investor-owned utilities (IOUs) brought projects into the FERC development pipeline in 2021.
 - Four IOUs submitted preliminary permit applications for 12 PSH projects in 2021.
 - Alabama Power Company (Chandler Mountain 800 MW project in Alabama), Public Service Company of Colorado (Unaweep Pumped Storage 800 MW in Colorado), PacifiCorp submitted 10 permit applications for PSH projects across the Northwest (OR, WY, WA, UT).
 - Duke Energy is conducting a study to double the capacity of the Bad Creek PSH (SC, 1,400 MW) as part of its relicensing process.
 - This uptick in PSH studies by IOUs is an indication that the need for long-duration energy storage is arising in long-term planning for these utilities and PSH appears as an attractive option to meet it.
 - The ability of IOUs to finance PSH development through their rate base and integrate PSH within the portfolio of assets that serves their customers removes some of the post-licensing steps presenting challenges for private developers (securing financing, negotiating power purchase agreements).
- The developers of the Goldendale Energy Storage Project (WA, 1,200 MW) submitted a license application to FERC in June 2020.
 - FERC has accepted the application and declared it ready for environmental analysis in 2022.
- FERC docket filings in 2021 show that the three licensed PSH projects are continuing their pre-construction activities:
 - P-13123 (Eagle Crest, CA): developer submitted progress report regarding project land rights.
 - P-13642 (Gordon Butte, MT): developer requested an extension of time to start construction in December 2021.
 - P-13318 (Swan Lake, OR): developer requested an extension of time to start construction and fulfill other license compliance terms and FERC granted the request.

FERC issued four original hydropower licenses and 13 relicenses in 2021.



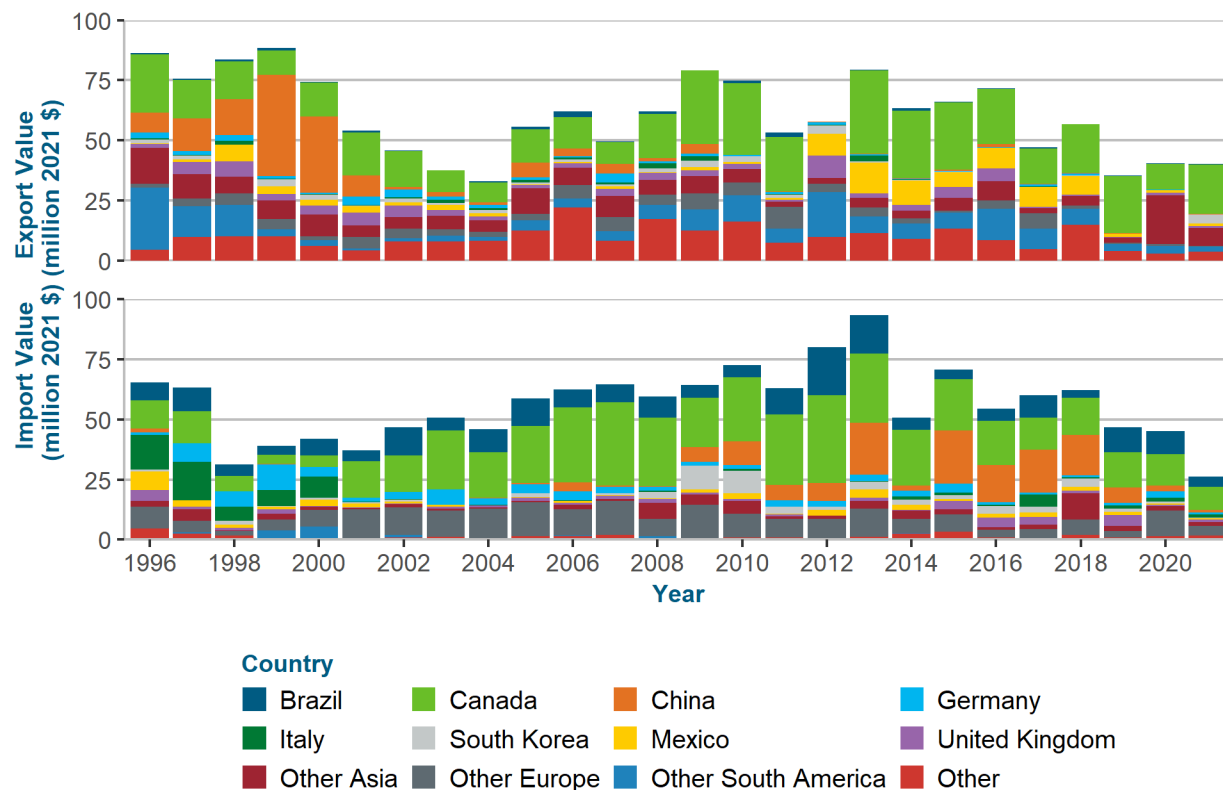
Sources: U.S. Hydropower Development Pipeline Data and Metadata, 2022,
DOI: [10.21951/HMR_PipelineFY22/1860473](https://doi.org/10.21951/HMR_PipelineFY22/1860473)

Notes:

- Licenses and exemptions that have been terminated post-issuance are also included in this plot.
- The plot includes authorization issuances for both hydropower and PSH projects

- Twenty-three hydropower projects were issued authorizations in the U.S. in 2021:
 - Authorizations issued by FERC:
 - Four original licenses with a combined capacity of 5.75 MW
 - Thirteen relicenses with a combined capacity of 621.49 MW
 - Four “qualifying conduit” determinations with a combined capacity of 1.06 MW
 - Authorizations issued by Bureau of Reclamation:
 - Two new leases of power privilege (LOPPs); first issued LOPPs since 2017
- Relicensing activity has increased significantly in the 2020s.
 - The number of relicense issuances in 2020-2021 has been higher than in any year of the 2010s.
 - The number of relicense applications submitted has vastly outpaced relicense issuances in 2020 and 2021.
 - Thirty-one relicense applications were submitted in 2021, five more than the previous year.
 - At the end of 2021, there were 93 pending relicense applications.
 - A few licensees submitted license surrender applications (two in 2020; five in 2021).
 - All are small projects.
 - Three of them are Michigan projects that experienced dam failures during a major flooding event.

U.S. hydraulic turbine import values continued to decrease whereas export values held steady relative to the previous year.



Source: United States International Trade Commission (USITC) Interactive Tariff and Trade Data
See *Technical Notes* for country selection criterion

- Hydraulic turbines and turbine parts are the only hydropower equipment component for which international transactions can be tracked from USITC data.
- Total export value in 2021 was ~\$40 million, a slight decrease from 2020 but was ~36% below the 2010–2020 average.
- Total import value in 2021 (\$26.25 million) decreased by 42% relative to the previous year and was the lowest since at least 1996.
 - Canada continues to be a significant exporter (36% in 2021) of turbines and turbine parts to the U.S., followed by Brazil and several European countries.
 - The low import value in 2021 is consistent with the small new investment in R&U and limited construction activity for new projects reported in the previous slides.

A new DOE report summarized U.S. hydropower (and PSH) supply chain status, challenges, and opportunities.

- In February 2021, Executive Order 14017 “America’s Supply Chains” directed DOE to prepare a report on supply chains for the energy sector industrial base to identify risks and strategies to enhance resilience.
 - In response, DOE produced [11 deep-dive supply chain assessments](#), including one for hydropower and PSH.
- The [U.S. Hydropower Supply Chain Deep Dive Assessment](#) describes the supply chain, summarizes current challenges based on interviews with industry participants, and identifies opportunities to address the challenges.
- The United States has a mature supply chain that serves the 4th largest hydropower and 3rd largest PSH fleets in the world.
- Pennsylvania, California, and Washington are the top 3 states by number of hydropower supply chain companies.
- Two of the three largest global turbine original equipment manufacturers (OEMs) have manufacturing facilities in the U.S.
 - There has been strong consolidation in turbine manufacturing industry through mergers and acquisitions, especially for units > 30 MW.
 - Generators tend to be supplied by the turbine OEMs but often manufactured by different companies.
- Machine shops play an important role in refurbishing mechanical components (e.g., gates) and reverse engineering pieces such as valves for which the OEM no longer exists.

Challenges

- **Steel castings > 10 tons** for turbine runners and other components cannot be procured from U.S. foundries
- **Stator windings** for large generators are very difficult to procure domestically
- Limited hydropower **workforce availability**
- Electronic components have **opaque supply chains** and high rates of obsolescence
- **Longer lead times** to procure replacements since 2020

Opportunities

- Incentives that stimulate fleet modernization activities can contribute to **reshoring** of additional manufacturing activity
- Adoption of **additive manufacturing** processes can address lack of domestic sourcing options or extinct supply chains for some components
- Leverage **federal procurement rules** to increase domestic content of manufactured hydropower components for federal fleet refurbishments

The Bipartisan Infrastructure Law was the most important federal policy milestone for U.S. hydropower in 2021.

- The **Bipartisan Infrastructure Law (BIL)**, signed into law in November 2021, includes appropriation authorizations for several incentives relevant for U.S. hydropower.
 - \$753M for hydropower incentives
 - \$125M to fund the hydroelectric production incentives of Section 242 of the Energy Policy Act (Epact) of 2005
 - Non-federal hydropower production added to an existing dam or conduit
 - Non-federal hydropower facility < 20MW constructed in an area with inadequate electric service
 - \$75M to fund the hydroelectric efficiency improvement incentives from Section 243 of the Epact of 2005
 - Applies to capital improvements at existing hydropower facilities improving efficiency by $\geq 3\%$
 - \$553M to fund incentive payments for capital improvements in existing hydropower facilities (new Section 247 of Epact of 2005):
 - Improving grid resilience (improved ability to respond to changing grid conditions, ancillary services provision, integrating variable renewables, managing accumulated reservoir sediments)
 - Improving dam safety (e.g., maintenance or upgrade of spillways, replacement or upgrade of floodgates, natural infrastructure restoration for flood risk reduction, dam stability improvements)
 - Environmental improvements (e.g., improvements in fish passage, water quality improvements, enhancing downstream sediment transport, recreation access improvements)
 - \$800M for rehabilitation of dams with high hazard potential and safety projects to maintain/upgrade dams
 - \$800M for river restoration through removal of dams and in-stream barriers with consent of dam owner
- DOE administers the Section 242, Section 243, and Section 247 incentives of Epact of 2005.
 - On June 30, 2022, DOE released a [Request for Information](#) around the definitions, program structure, and selection criteria under Section 243 and Section 247 incentives.
 - Application opening dates for the incentives are to be determined.
- Other federal agencies, including Department of Homeland Security, Department of Commerce, and Department of Agriculture, administer the \$1.6B authorized for dam rehabilitation and river restoration.

- Installed U.S. hydropower capacity increased by ~90 MW in 2021, over half coming from new projects.
- Driven by persistent drought conditions in the West, U.S. hydropower generation in 2021 (260.2 TWh) dropped by almost 9% relative to 2020 and was ~7% below the 2010–2020 average.
- Hydropower generation accounted for 31.5% of renewable electricity generation and 6.32% of total electricity generation in 2021.
- The project pipeline at the end of 2021 shows continued strong interest in development of new hydropower and PSH projects.
 - Most projects are either retrofits of existing non-powered dams (102 projects; 1.4 GW), conduits (22 projects; 20.2 MW), or pumped storage facilities (96 projects; 72.7 GW)
 - Sixty-two hydropower projects and three PSH projects already have FERC authorization.
- In 2021, most of FERC's permitting activities had to do with the relicensing of existing hydropower facilities (31 relicense applications submitted; 13 relicenses issued).
- Both new investment in U.S. hydropower rehabilitation and upgrade (R&U) projects and hydropower turbine import value declined significantly in 2021 relative to average values during the past decade amid COVID-19 related restrictions and supply chain constraints.
- The Bipartisan Infrastructure Law, signed into law in November 2021, includes \$753M appropriation authorizations for hydropower-specific incentives and other \$1.6B for dam safety and river restoration purposes for which hydropower projects may also be eligible.

Slide 4:

- The U.S. Drought Monitor considers the following drought categories:
 - D0: abnormally dry
 - D1: moderate drought
 - D2: severe drought
 - D3: extreme drought
 - D4: exceptional drought
- Detailed explanations of the metrics associated with each category and the types of impacts associated with them are available at <https://droughtmonitor.unl.edu/About/WhatistheUSDM.aspx>

Slide 5:

- The full value of each project is assigned to the project start year. The green portions of the bars in slide 5 correspond to projects that have not yet been completed as of December 2021.
- Minimum total investment value of projects tracked by Industrial Info Resources (IIR) is \$1 million.
- Updates to project value or completion date can also results in changes in the total estimated value for a given year from one snapshot to the next.

Slide 11:

- The 8 individual countries shown in the plot correspond to the 8 countries with the largest total trade flows (imports or exports) over 1996–2021.

*For further inquiries about the content of these slides, please contact the authors:
Megan M. Johnson (johnsonmm@ornl.gov) and Rocío Uría-Martínez (uriamartiner@ornl.gov).*