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Small Hydropower in the United States

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October 2018

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Environmental Sciences Division

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CONTENTS

LIST OF FIGURES

ABBREVIATIONS, ACRONYMS, AND INITIALISMS

DOE	US Department of Energy
FERC	Federal Energy Regulatory Commission
ISO	independent system operator
NEM	net energy metering
NPD	non-powered dam
NSD	new stream-reach development
ORNL	Oak Ridge National Laboratory
PURPA	Public Utilities Regulatory Policy Act
QF	qualifying facility
Reclamation	US Bureau of Reclamation
RPS	Renewable Portfolio Standard
UNIDO	United Nations Industrial Development Organization
USACE	US Army Corps of Engineers

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NOTE ABOUT CONTENT

This report was prepared in response to a request from the United Nations Industrial Development Organization (UNIDO) and the International Center on Small Hydropower. It will be included in the World Small Hydro Development Report that is being released in 2019 to provide a global compilation of small hydropower data. This report was developed following content and length guidelines provided by UNIDO to ensure consistency among reports from each country, defining small hydropower as less than 10 MW. The report primarily utilizes text and data from the *2017 Hydropower Market Report*[1] as well as a previous similar report first published in 2015.[2] Information and conclusions based on the under 10 MW definition do not reflect the overall status of hydropower development in the United States.

ABSTRACT

The limited development of new hydropower in the United States in the last decade has consisted mostly of small projects (those under 10 MW). Total US hydropower generation capacity has remained fairly constant in recent decades at 80 GW**,** which includes 3.6 GW of small hydro. Currently planned new small hydro development totals 0.42 GW. The addition of hydropower generation equipment to existing infrastructure—primarily, existing non-powered dams and conduits—is the dominant trend in recent and planned new hydropower development. Federal efforts to support hydropower growth have been increasing in recent years.

KEY US FACTS

- **2018 population:** Approximately 329 million[3]
- **Area:** 9,826,675 square km[4]
- **Climate**: Varies widely according to location, including arctic regions in Alaska, tropical in Hawaii, Mediterranean in California, arid in the Southwest, and temperate across much of the country.
- **Topography:** Large central plains, hills, and low mountains in the East; mountains in the West. The highest point is Mount Denali (Alaska), which is 6,194 m above sea level. The lowest point is Death Valley (California), which is 86 m below sea level.
- **Rain pattern:** Varies according to location.
- **Overview of water resources:** Largest river systems based on flow volume are the Columbia River in the Northwest and the Mississippi River in the Southeast.

KEY US ELECTRICITY AND HYDROPOWER FACTS (2017)

- Total electricity generating capacity: **1,084,783 MW**[5]
- Total annual electrical generation: **4,014,804 GWh**[6]
- Total installed hydropower capacity: **80,089 MW across 2,248 plants**[7]
- Total hydropower generation: **270,586 GWh**[8]
- Total installed small hydro capacity: **3,612 MW across 1,646 plants**
- Total small hydro generation: **13,804 GWh**
- Untapped small hydro technical potential at non-powered dams (NPDs): **2,500 MW**
- Untapped small hydro technical potential for new stream-reach development (NSD): **4,321 MW**[9]
- Untapped small hydro technical potential at existing conduits: **Unknown**[10]
- Currently planned small hydro projects: **420 MW across 165 projects**

1. ELECTRICITY SECTOR

1.1 GENERAL INFORMATION

At the end of 2017, the United States had 1,084,783 MW of total utility-scale electricity generating capacity yielding approximately 4,000 TWh/year.[11] Natural gas was the largest source (32%), followed by coal (30%), nuclear (20%), hydropower (7%), wind (6%), and solar (1%). For many years, coal had been the largest single source of US electricity supply, but in recent years, natural gas generation has been growing rapidly, along with wind and solar (Figures 1 and 2).[12] US electricity load growth has been minimal, with an electrification rate of essentially 100% (Figure 3).

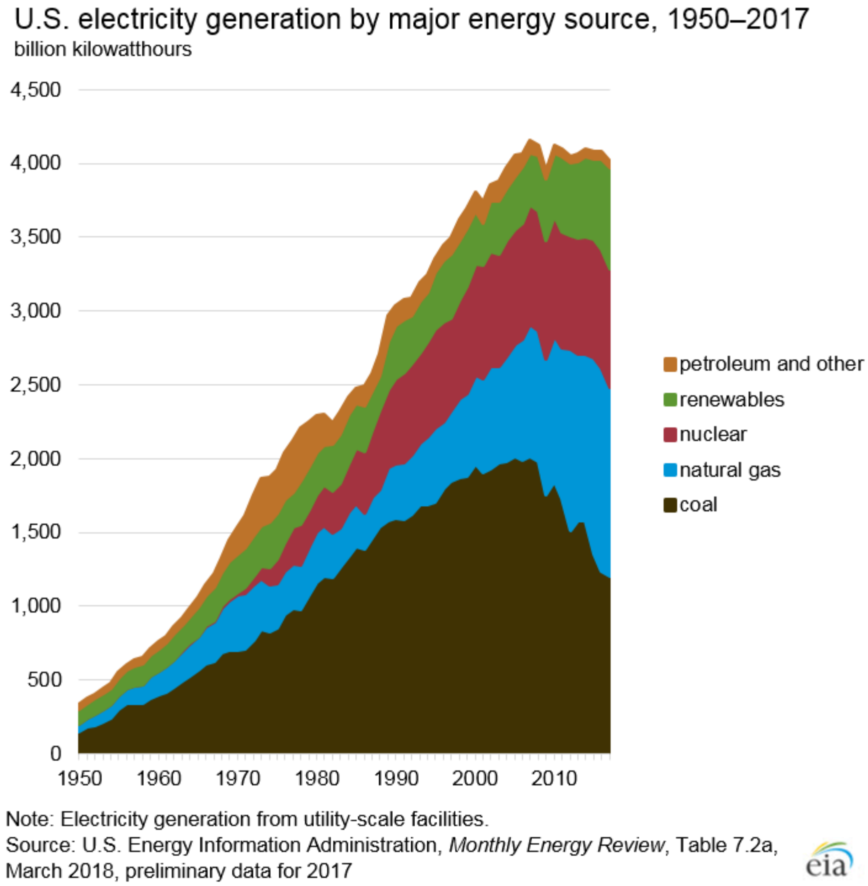

Figure 1: US electricity generation by major energy source, 1950–2017.

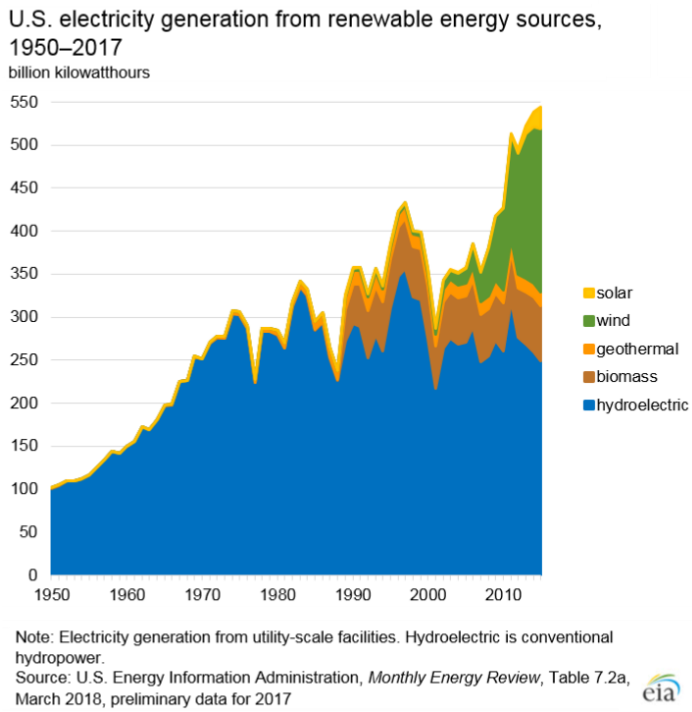

Figure 2: US electricity generation from renewable energy sources, 1950–2017.

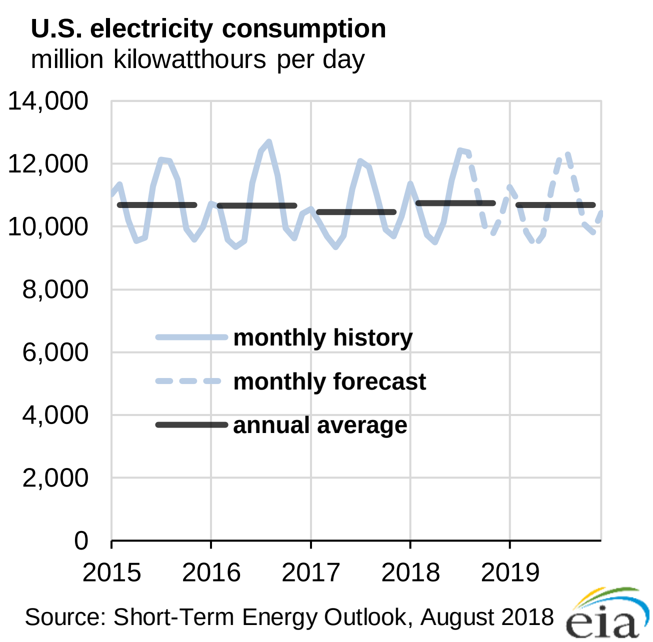

Figure 3: Trends in US electricity consumption.
Source: US Energy Information Administration, Washington, DC, August 2018.[13]

1.2 DESCRIPTION OF ELECTRICITY SECTOR

Historically, the US electricity industry has consisted of a mix of private and public utilities that generate and deliver electricity to customers within exclusive franchise service territories. More than 3,000 electric utilities currently operate across the country.

More recently, some US states and regions have established competitive markets for both electricity generation and delivery. This has resulted in new entrants to all segments of the electricity industry, including generation, transmission, and delivery.

Because of the historically exclusive nature of utility service territories, the electric industry has been subject to a high degree of government regulation. Investor-owned utilities are regulated by the states in which they operate. Municipal utilities are operated by local governments and are overseen by local elected or appointed officials. Electric cooperatives are governed by a board of directors elected from the cooperative's membership.

The Federal Energy Regulatory Commission (FERC), an independent agency of the US government, regulates the interstate transmission of electricity. A key outcome of industry restructuring in recent years has been the formation of independent system operators (ISOs) that administer the transmission grid on a regional basis, including some portions of Canada. These entities were established to provide nondiscriminatory access to transmission for both electricity generators and distribution companies in competitive markets. The ISOs also perform centralized day-ahead dispatch of the generation resources in their service area to produce a least-cost production schedule for each hour of the next day, resolve gaps between generation and demand in real time, and operate ancillary service markets. The US-based ISOs are regulated by FERC.

The move toward greater competition in electricity supply and delivery has helped foster a shift in electricity generation sources, as noted in Figure 1.

1.3 ELECTRICITY TARIFFS

Electricity tariffs are a product of a utility's generation, transmission, distribution, and administrative costs, as well as return on investment in the case of investor-owned utilities. Recent electricity rates have been relatively stable with low annual growth, partly in response to low wholesale prices resulting from an abundance of natural gas (Figure 4). In 2017, average US electricity prices were as follows: residential: 12.9 cents/kWh; commercial: 10.68 cents/kWh; and industrial: 6.91 cents/kWh.[14]

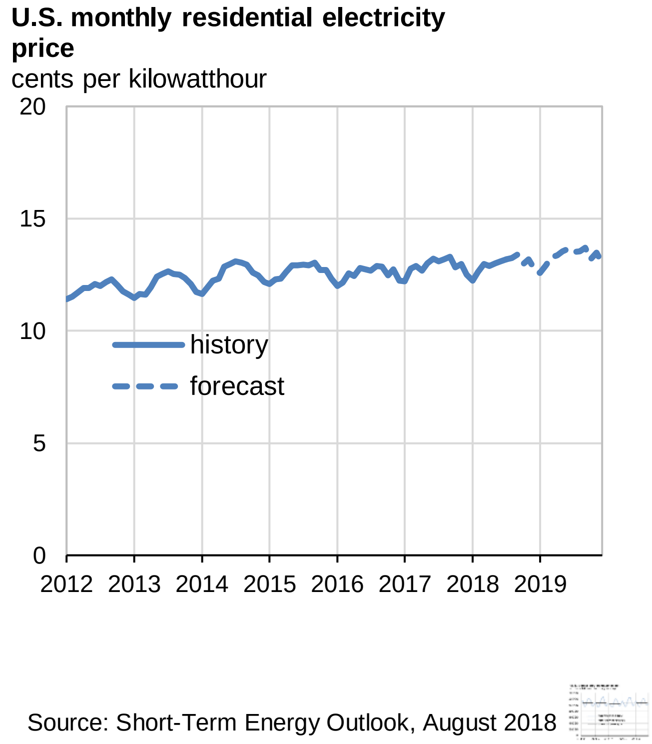

Figure 4: Trends in US residential electricity prices.
Source: US Energy Information Administration, DC, August 2018.[15]

2. HYDROPOWER AND SMALL HYDROPOWER

US hydropower generating capacity (including projects of all sizes) increased by 2,042 MW from 2007 to 2017, bringing installed capacity to 80.09 GW across 2,248 separate plants (Figure 5). Of this net increase, almost 70% resulted from refurbishments and upgrades to the existing fleet. Most of the 117 new hydropower plants that have started operation since 2007 involved additions of hydropower generation equipment to NPDs (38) or conduits (74). The median size of new plants is less than 10 MW.[16]

Roughly half of US hydropower capacity is located in three states: Washington, Oregon, and California.[17] Three federal agencies—the US Army Corps of Engineers (USACE), the US Bureau of Reclamation (Reclamation), and the Tennessee Valley Authority—own nearly half of US hydropower capacity.

Most of the installed US hydropower capacity comes from large projects built between 1930 and 1970. Since the 1980s, most new hydropower capacity additions have been small.[18]

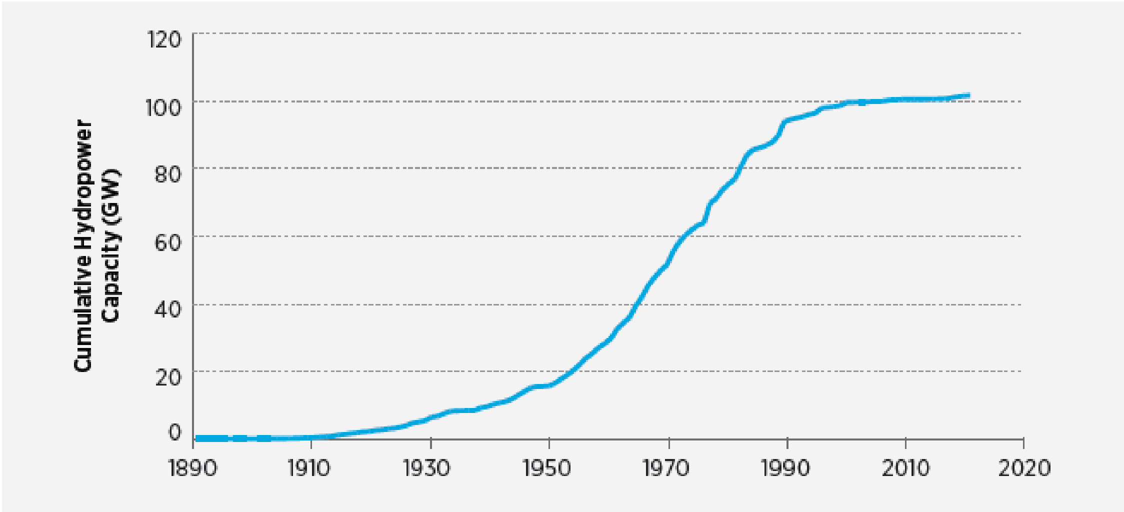

Figure 5: Cumulative US hydropower generating capacity, 1890–2015. The chart includes both conventional hydropower and pumped storage. *Source:* DOE, *Hydropower Vision*[19]

2.1 SMALL HYDROPOWER DEFINITION

For this report, small hydropower is defined as hydropower projects under 10 MW, consistent with international definitions.

2.2 SMALL HYDROPOWER OVERVIEW

As of 2017, the existing fleet of US small hydropower plants consisted of 1,646 plants with a combined generating capacity of approximately 3,612 MW.[20] The Northeast and the Southwest are the two regions with the highest number of small hydropower facilities (537 and 434, respectively). On average, the US small hydropower fleet generated 13,804 GWh per year for the period 2007–2017, approximately 5% of total US hydropower generation.

2.3 SMALL HYDROPOWER LICENSING PROCESS

Developers of small hydropower facilities need to follow different approval processes depending on ownership, project type, and other project attributes. Most projects require a FERC license or exemption from licensing. Although the exemption process is typically shorter than the licensing process, they both typically take multiple years.

Seeking authorization for development of hydropower at USACE-owned dams involves obtaining a Section 408 approval from USACE in addition to a FERC license. Typically, the two processes have been implemented sequentially, with most of the work needed to obtain USACE approval taking place after a FERC license was issued. Securing federal authorization for development of hydropower at Reclamation-owned dams does not typically involve FERC, but rather a Lease of Power Privilege process.[21]

The Hydropower Regulatory Efficiency Act of 2013 introduced a quicker, easier pathway to regulatory approval for the subset of projects involving the addition of hydropower to non-federal conduits (typically, existing pipelines and canals) with capacities of less than 5 MW. A developer for one of these projects needs to notify FERC of the intention to construct a hydropower facility. It will typically receive “qualifying conduit” status, completing the federal approval process, within 60 days unless FERC or the public contest the project’s ability to meet the eligibility criteria.

2.4 UNTAPPED SMALL HYDROPOWER RESOURCES

Potential new hydropower resources in the United States are classified into the three categories below.

Non-powered Dams

A national assessment of the capacity and energy potential realized from the addition of hydropower to NPDs identified 397 dams with technical potential capacities in the 1–10 MW range. The total estimated technical potential capacity for NPDs under 10 MW is about 2,500 MW. Their combined annual technical energy potential is 4,777 GWh.[22]

New Stream-reach Development

A national assessment of NSD resources published in 2014 identified a potential technical capacity of 4,321 MW across 1,035 sites with estimated project sizes of less than 10 MW. The annual generation potential of these projects was estimated at 23,374 GWh.[23]

Conduits

There has not yet been a comprehensive federal resource assessment of conduit hydropower, although some state and federal agencies have started to compile relevant data.

A 2012 study by Reclamation examined the energy development potential at Reclamation-owned facilities.[24] That study and a related supplement found that 191 Reclamation canals had at least some level of hydropower potential and that 70 of those sites could be considered economically viable for development. This report concluded that there is 104 MW of potential capacity and 365 GWh of potential annual generation at the 373 Reclamation canals studied.[25]

In 2018, Oak Ridge National Laboratory developed a methodology for analysis of the untapped hydropower generation potential of public water systems.[26] A total of approximately 12 MW of potential conduit hydropower capacity was estimated in Oregon and 34 MW in Colorado. Their corresponding annual hydroelectricity energy supply is estimated to be 65 GWh/year in Oregon and 202 GWh/year in Colorado.

2.5 PLANNED SMALL HYDROPOWER PROJECTS

As of the end of 2017, the US hydropower “pipeline” of planned projects contained 214 projects with a combined capacity of 1,712 MW (Figure 6). Of these, 165 were small projects with a total combined capacity of 420 MW.

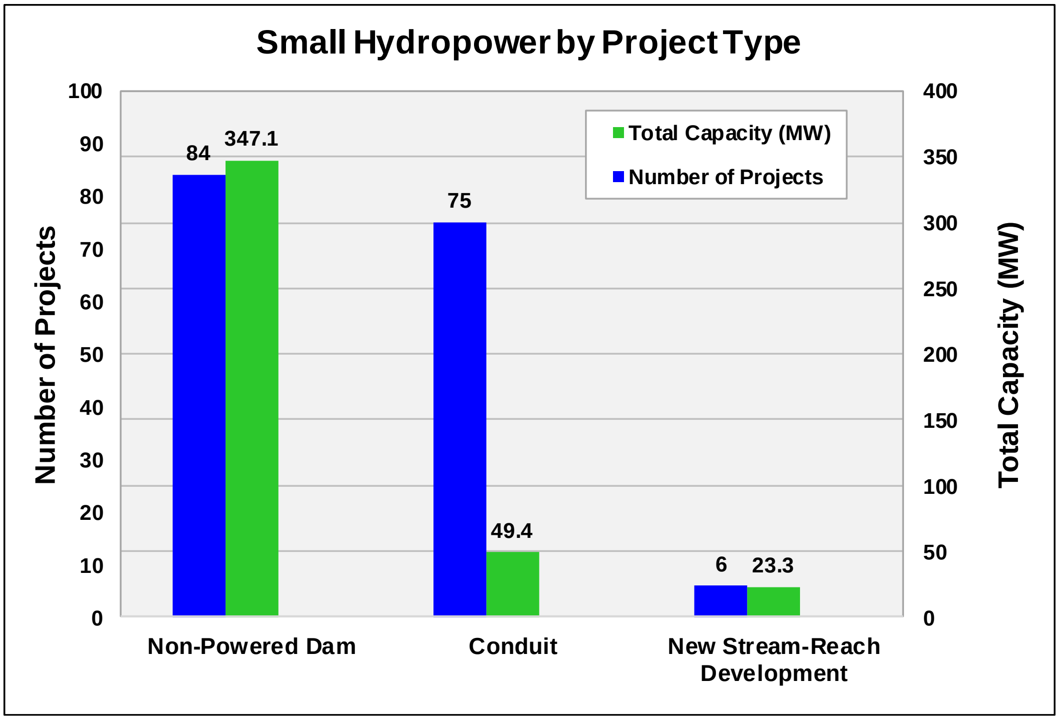

Figure 6: Planned small hydropower project development pipeline by project type, 2017.

The majority of planned new small hydropower projects involve adding hydropower generation to existing dams or conduits. Only six projects would develop new stream-reaches. The median capacities of small NPD and NSD projects are 4 and 5 MW, respectively. The median capacity of conduit projects is significantly smaller (0.42 MW).

The Southwest is the leading region by number of planned projects but ranks last in terms of proposed capacity (Figure 7). Most planned small hydropower capacity in the Southwest involves the addition of generation capacity to existing irrigation and water supply conduits; such projects are typically smaller than NPD or NSD sites.

Most proposed development is undertaken by private entities (Figure 8). Within the public category, most developers are municipalities (16 projects) or irrigation and water supply districts (42).

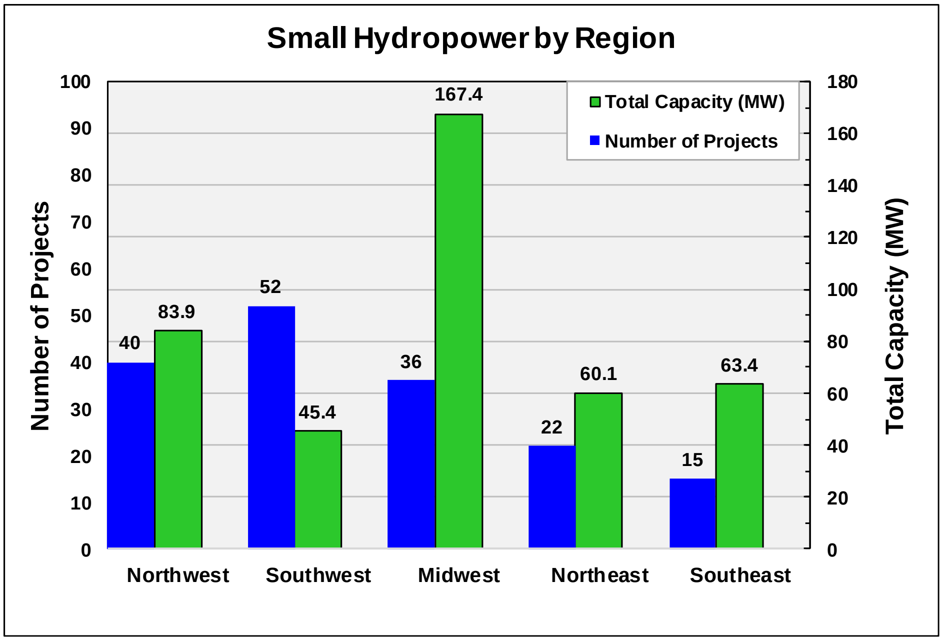

Figure 7: Planned small hydropower project development pipeline by region, 2017.

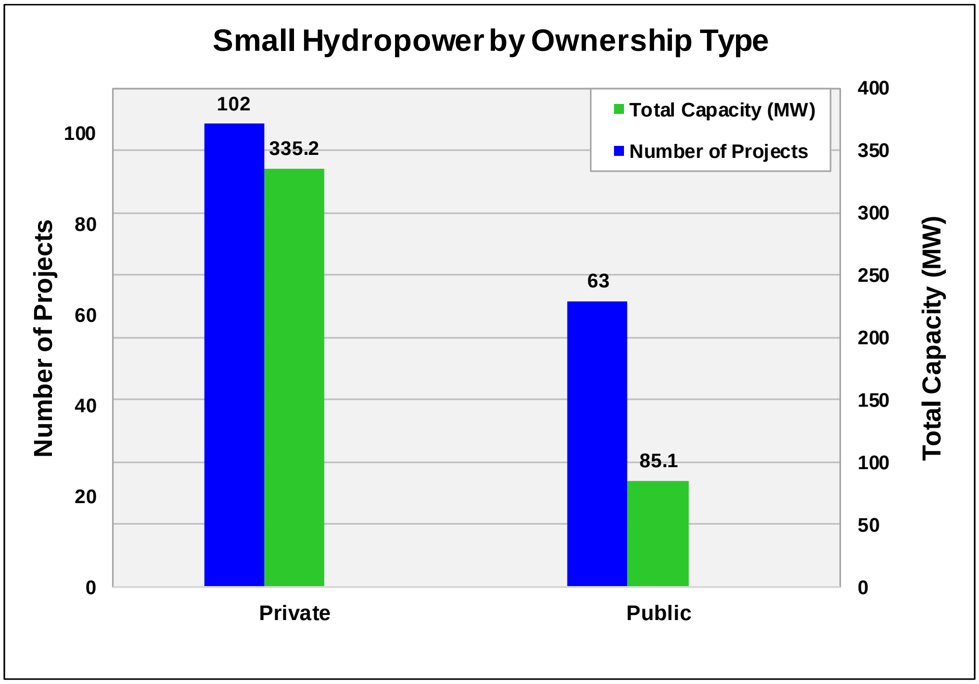

Figure 8: Planned small hydropower project development pipeline by ownership type, 2017.

Projects in the Pending Permit and Issued Permit stages are undergoing feasibility evaluations (Figure 9). Attrition rates are high at these early stages of the development process. A project with a Pending Application has submitted an application for a federal permit. Projects with Issued Authorizations have already received their federal authorization and are more likely to proceed to construction. However, obtaining additional permits at the state or local level, finalizing engineering designs, negotiating power purchase agreements, and finalizing project financing are additional necessary steps before starting construction that usually take place at the Issued Authorization stage. These additional steps often pose challenges for small project developers, resulting in delays and cancellations of projects, so it is difficult to predict what percentage of the 62 small projects with Issued Authorizations totaling 125 MW will complete construction.

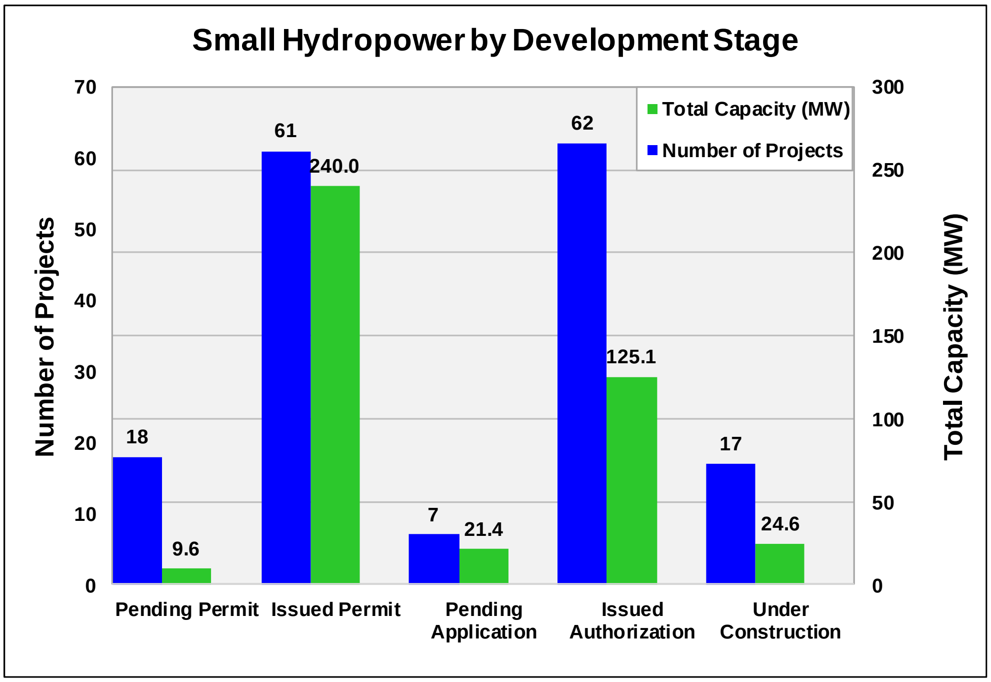

Figure 9: Planned small hydropower project development pipeline by development stage, 2017.

2.6 FINANCIAL MECHANISMS FOR SMALL HYDROPOWER

2.6.1 Federal Policy

A US Department of Energy (DOE)-administered federal incentive program supports the development of new small hydropower projects at existing dams or conduits. In 2014, Congress provided the initial funding allocation for the Section 242 Program, a hydropower incentive program that was created through the Energy Policy Act of 2005. The program has received congressional appropriations every year since 2014. Facilities can receive up to $750,000 per year for up to10 years, subject to availability through ongoing congressional appropriations. The program's incentive payments are paid on a per-kilowatt-hour-generated basis, with payment amounts depending upon overall program participation. The program's incentive payments have ranged from 0.9 cents/kWh to 1.5 cents/kWh. Although congressional authorization for the Section 242 Program expired in 2015, already-participating hydropower facility owners are allowed to receive up to 10 years of payments, provided that congressional appropriations continue to fund the program. Legislation also has been introduced in the United States Congress to reauthorize the Section 242 Program beyond its initial 10-year authorization, which would enable projects built after 2015 to also become eligible for 242 Program incentive payments.

2.6.2 State Policy

Some states, including those below, have created programs and policies specifically to financially support the development of small hydropower.[27]

California. Some types of small hydropower projects are eligible for incentive funding through the state's Self-Generation Incentive Program.

Colorado. Colorado provides $15,000 feasibility grants for eligible entities, as well as low-interest (2%), long-term (30-year) loans that can fund project construction.

Oregon. Oregon provides financial assistance to small hydropower developers through the Energy Trust of Oregon.

3. RENEWABLE ENERGY POLICY

3.1 FEDERAL POLICY

The Public Utilities Regulatory Policy Act (PURPA), signed into law in 1978, opened the door to competition in the US electric power industry, particularly in the generation sector. PURPA conferred special rates and regulatory treatment on a new class of generators known as qualifying facilities (QFs). These consist of co-generation facilities and small power production facilities, with the latter defined as facilities generating 80 MW or less using a renewable energy source (i.e., hydro, wind, solar, biomass, waste, or geothermal).[28] PURPA required electric utilities to interconnect with and purchase power from QFs at the utility's "avoided cost," defined as the cost that the utility would otherwise incur in either generating the power itself or procuring power from other sources.

With the Energy Policy Act of 2005, Congress made an important modification to PURPA, providing relief from PURPA's mandatory purchase obligation if FERC determines that QFs have nondiscriminatory access to the market. In this context, FERC determined that an ISO generally provides a sufficiently competitive market structure to support elimination of the PURPA purchase requirement for utilities operating within the ISO. At the same time, however, FERC established that "small QFs" do not have nondiscriminatory access to wholesale markets. Therefore, the PURPA purchase obligation for utilities remains in force for small QFs,[29] making it possible for small hydropower generators to secure utility power purchase agreements. In May of 2018, FERC announced that it would launch a review of PURPA to examine issues involved in PURPA implementation and ways to address them.

The federal government also provides tax incentives to spur renewable energy development, including the production and investment tax credits; both of these expired at the end of 2016 for hydropower but are still available for other renewable energy technologies through 2021. Small hydro has also been eligible for federal accelerated depreciation tax treatment, and some states offer tax incentives and exemptions.

3.2 State Policy

Individual US states have adopted policies to encourage renewable energy development. The most prominent of these policies has been the adoption of a renewable portfolio standard (RPS). An RPS is a market-based policy that requires electric utilities and other retail electricity suppliers to supply a minimum percentage of their electricity sales from eligible renewable energy sources.

As of July 2017, 29 states and the District of Columbia had instituted RPS policies, covering 56% of total US retail electricity sales (Figure 10).[30] Significant RPS-related policy revisions in recent years include increased RPS targets for many states. In 2018, the California legislature approved legislation calling for California electric utilities to provide electricity using 100% clean energy by 2045.

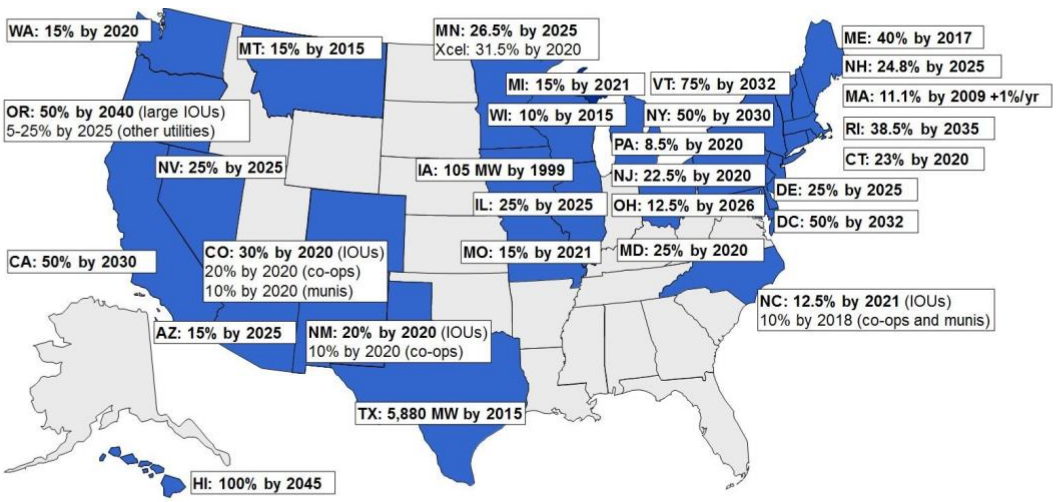

Figure 10: Status of renewables portfolio standard policies, July 2017.
Source: Lawrence Berkeley National Laboratory, Renewables Portfolio Standards

Small hydro projects are typically RPS eligible, whereas large hydro projects are often excluded from RPS eligibility. Common hydropower restrictions for RPS eligibility include those based on capacity, type, and environmental sustainability criteria. One environmental standard is the Low Impact Hydropower Institute certification standard, used for RPS eligibility in a variety of states.[31] Many RPS policies also have old requirements, such as for "new" development, which can disqualify hydro production from RPS eligibility.

A feed-in tariff is another policy that some states and utilities have adopted to incentivize electricity procurement from smaller renewable energy generators. A feed-in tariff provides a guaranteed payment stream at a fixed price for the renewable energy generator.

A small hydropower system installed adjacent to a local electricity load can typically take advantage of net energy metering (NEM). Under a NEM agreement, generated electricity is used directly by an adjacent facility; any excess generation can be exported to the utility grid for later use, and the generator receives a one-for-one credit at full retail value for any electricity generated onsite. Most US states have some form of NEM requirement, providing a potent economic incentive for distributed renewable energy generation, including small hydropower.[32]

4. RECENT TRENDS IN SMALL HYDROPOWER

4.1 LEGISLATIVE REFORM

The Hydropower Regulatory Efficiency Act of 2013 directed FERC to explore a 2-year licensing process for hydropower development at existing NPDs. FERC published its report in May of 2017.[33] In October of 2018, Congress passed the America's Water Infrastructure Act, legislation which included provisions to help streamline federal regulatory approval processes for hydropower. The bill shortens, from 60 to 45 days, the FERC process for qualifying conduit determination required by the 2013 Hydropower Regulatory Efficiency Act and replaces the 5 MW cap on qualifying conduit hydropower with a 40 MW cap. The bill also requires FERC to establish an expedited licensing process for NPD projects that will shorten the FERC decision timeframe for license applications to 2 years or less. The bill also requires FERC, USACE, and the US Department of the Interior to develop a list of existing federal NPDs that have the greatest potential for hydropower development.

4.2 US ARMY CORPS OF ENGINEERS HYDRO PROCESS REFORM

A 2012 DOE NPD report identified 12,000 MW of new hydropower capacity (projects of all sizes) across the United States. Most of that potential—7,200 MW—resides at USACE NPDs.[34] In July 2016, FERC and USACE signed a memorandum of understanding that seeks to improve coordination between the two agencies related to the permitting process for NPD projects at USACE-owned dams. In 2018, USACE completed a policy report, that proposes to "update processes related to how USACE will review certain requests by others to alter a USACE civil works project," including the Section 408 process related to hydropower project development at USACE-operated dams. Any improvements in USACE administrative procedures would likely help streamline hydro development.

4.3 RECORD FEDERAL SUPPORT FOR HYDROPOWER

In recent years, Congress has provided record levels of funding for DOE's hydropower program. For fiscal year 2018, DOE received $105 million. Of this total, $70 million is directed to support marine and hydrokinetic energy programs, and $35 million will support the hydropower and pumped storage program, some of which supports small hydropower. In August of 2018, DOE's Water Power Technology Office announced up to $9 million in funding for innovative design concepts for standard modular hydropower and pumped storage hydropower. The first topic area in the funding opportunity seeks to stimulate innovative design concepts for small, low-head hydropower plants capable of lowering capital costs and reducing the environmental impacts of development at NSD sites.

5. CONCLUSION

Small hydropower is the most cost-effective type of new hydropower development available in the United States because it typically uses existing infrastructure, including existing NPDs, canals, and pipelines. Record federal support for hydropower, along with recent legislative reforms, may help small hydropower achieve its substantial untapped potential. However, developers of new small hydropower may still face some challenges, including those described below.

Regulatory approval challenges. Developing new hydro projects has proved challenging in recent decades because of uncertain federal regulatory processes that have made it difficult for public- and private-sector investors to obtain long-term, low-cost financing to support project development.

Market challenges. In addition to the challenge posed by market competition from other electricity generating technologies (including natural gas, wind, and solar), hydropower's full value to the electric grid in terms of ancillary services and operational flexibility typically is not financially compensated in the current US electricity market.

Lack of comprehensive information regarding potential conduit sites. Although federal agencies have completed nationwide hydropower resource assessments for existing NPDs and NSD, a comprehensive national assessment regarding conduit opportunities has not been undertaken. These include water supply pipelines, which represent perhaps the most economically feasible type of new hydropower development because they can typically take advantage of higher energy value available through NEM.[35]

Risk aversion regarding new technology. Existing dam and conduit owners are typically cautious and risk-averse with respect to the water systems for which they are responsible, making it difficult for them to recognize opportunities to develop hydro project sites. Furthermore, many water agencies have no understanding of available small hydropower technologies. Newer, more-cost-effective small hydropower technologies do not typically have long operational track records, making potential investors shy away from adopting them.

Lack of standardized technology. Almost every hydro project is custom engineered, presenting associated high engineering costs because each project is site specific.

*Electrical interconnection***.** Uncertainty in the cost, timing, and technical requirements of grid interconnection can be challenging for small hydropower and other distributed energy resources because interconnection processes can be expensive and time consuming.

Electrical inspection. Because very few small hydropower projects are installed each year, most electrical inspectors are not familiar with them. Therefore, it can be difficult to secure electrical inspection approval for very small plants that are net metered. Small hydropower is not addressed in the National Electrical Code. Furthermore, the US small hydropower industry is not yet large enough to support mass manufacturing of standardized products that have completed independent certification. Costs associated with post-manufacture, in-the-field product testing and approval to ensure product safety can adversely affect a project's economic feasibility.

State and local policy issues. Challenges to small hydropower development can come from state and local regulatory policies, including regulatory issues associated with water quality certifications and other state and local environmental requirements.

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