HYDRO POTENTIAL
on the

MISSISSIPPI RIVER

Western Illinois University - Quad Cities
3300 River Drive
Moline, IL

July 18, 2017
9 am - 4 pm

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Contents

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Introduction

A key outcome of the 2016 Upper Mississippi River Conference was the need to raise awareness of opportunities to implement hydroelectric power on the Upper Mississippi River and its major tributaries. "Hydro Potential on the Mississippi River" is a key first step toward reaching this goal.

The aim of this document is to serve as a resource to provide attendees with a baseline understanding of key issues that are likely to impact our collective ability to implement hydropower along the Upper Mississippi River. We realize that this document does not provide comprehensive coverage of the diverse topics that might play a role in hydropower development on the UMR and have incorporated links to more detailed materials that can be explored on an individual basis.

Whenever possible, direct links are provided to primary sources of information. For those reading this document on a smart phone, tablet, or computer, please follow the links by clicking on blue, underlined, typeface to obtain additional details or to see source information. We hope workshop attendees find this information useful as we continue work together to Raise the Grade in the Upper Mississippi River.

Kindest Regards,

Roger Viadero, Jr., Ph.D.
Professor and Director
rc-viadero@wiu.edu

Michele Rehbein
Doctoral Student
mm-rehbein@wiu.edu

Anshu Singh
Doctoral Student
a-singh2@wiu.edu

Western Illinois University
Institute for Environmental Studies
Environmental Science Ph.D. Program

WESTERN ILLINOIS UNIVERSITY

WESTERN ILLINOIS UNIVERSITY *Quad Cities*

IN THE U.S., COMMERCIAL HYDROELECTRIC POWER HAD IT'S ORIGINS IN THE UPPER MISSISSIPPI RIVER BASIN!

September 30, 1882, Appleton, WI - H.J. Rogers, a paper manufacturer, opened the world's first hydroelectric power plant on the Fox River. The hydroelectric plant powered the paper mill as well as Rogers' house.

Overview

Over the past three decades, studies have been conducted to estimate the potential for hydropower generation in the United States;[1] [2] a number of these have also included low-head hydropower opportunities in the five Upper Mississippi River (UMR) states.[3] [4] [5]

Individually, these studies offer valuable insights into the potential to implement hydropower as a part of a national movement to support renewable energy. However, a number of factors limit their use as a larger body of knowledge. For example, it is impossible to retrospectively factor in the often substantial changes in hydropower technology that have occurred over the past 30 years. Likewise, the competition between renewable and nonrenewable energy sources and the corresponding social and political support for these efforts continues to shift. Similarly, lags in economic data collection, reporting, and frequent revision complicate efforts to determine reasonable costs and benefits of proposed hydropower projects. As a result, economic projections from the literature often fail to inform current efforts to grow hydropower in UMR states.

Regardless of the vintage of any particular report, those who have studied the potential for hydropower development in the UMR states generally agree that:

- Based on the hydrologic and geomorphologic characteristics, low-head hydropower (<30 ft H_2O) is the most appropriate platform to grow hydropower in UMR states.
- Low-head hydropower systems generally have a low impact on the environment. This fact should be reflected in licensing requirements.
- The process to obtain a license to operate a hydropower facility is prohibitively long - especially for low-head hydropower systems.
- Prospective low-head hydropower developers are often not able to invest significant resources in the upfront costs of licensing. For example, the cost of conducting studies and preparing environmental reports can adversely impact a project's viability from the beginning.
- Investments in research and development efforts are needed on low-head turbine design, improved generator technology for low-head hydropower, and standardization of designs. Individual hydropower developers are not in a position to conduct this type of work.

1 Hadjerioua, B., Wei, Y., and S. Kao (2012). An Assessment of Energy Potential at Non-Powered Dams, U.S. Department of Energy, Wind and Water Power Program, DOE/EE-0711, 44 pp., http://nhaap.ornl.gov/sites/default/files/NHAAP_NPD_FY11_Final_Report.pdf, accessed 5-May 2017.

2 Small Hydro Council (2010). Small Hydro Council Initial Report, National Hydropower Association, Washington, DC, 28 pp., accessed on 26-March 2017, http://anf5l2g5jkf16p6te3ljwwpk.wpengine.netdna-cdn.com/wp-content/uploads/2011/01/Small-Hydro-Council-Initial-Report-July-2010.pdf.

3 UMRBA (1991). Nonfederal Hydroelectric Development and Licensing A Perspective from the Upper Mississippi River Basin, 92 pp.

4 Hydropower Analysis Center (2013). Hydropower Resource Assessment at Non-Powered USACE Sites, Final Report, 101 pp., accessed on 26-March 2017. http://www.hydro.org/wp-content/uploads/2014/01/Army-Corps-NPD-Assessment.pdf.

5 Hall, D., Hunt, R., Reeves, K., and G. Carroll (2003). Feasibility Assessment of the Water Energy Resources of the United States for New Low Power and Small Hydro Classes of Hydroelectric Plants, INEEL/EXT-03-00662, U.S. Department of Energy, Idaho National Engineering Laboratory, 74 pp.

Hydropower Licensing

In the U.S., the Federal Energy Regulatory Commission (FERC) issues licenses to construct, operate, and maintain non-federal hydroelectric projects that:[6]

- Are located on navigable waters of the United States.
- Occupy U.S. lands.
- Utilize surplus water or water power from a U.S. government dam.
- Are located on a stream over which Congress has Commerce Clause jurisdiction, where project construction or expansion occurred on or after August 26, 1935, and the project affects the interests of interstate or foreign commerce."

FERC hydropower licenses are typically issued for a period of 30 to 50 years. Historically, FERC has used three processes to license hydropower facilities or add capacity to existing operations: the Traditional Licensing Process (TLP), Integrated Licensing Process (ILP), and the Alternative Licensing Process (ALP). Since July 2005, the Integrated Licensing Process has been the default method used to obtain a new hydropower license or to renew an existing license.[7]

FERC developed the ILP in an effort to streamline the process of hydropower licensing. According to FERC, the ILP is based on three tenants: the early identification of studies (environmental and others) needed to make informed licensing decisions, the integration of all stakeholders in the licensing process, and the establishment of a structured time line for the completion of the licensing process. In practice, the Integrated Licensing Process can take up to 7 years to complete:

- Pre-filing activities - 5 years - submission of a Notice of Intent (NOI), a plan of study (soils, water quality, fish and wildlife, cultural resources, recreation, aesthetics, land use, and tribal resources), and dispute resolution.[8]
- Post-filing activities - 2 years - submission of a license application, hearings on Environmental Assessment or Environmental Impact Analyses, and the consideration of potential alternatives.[9]

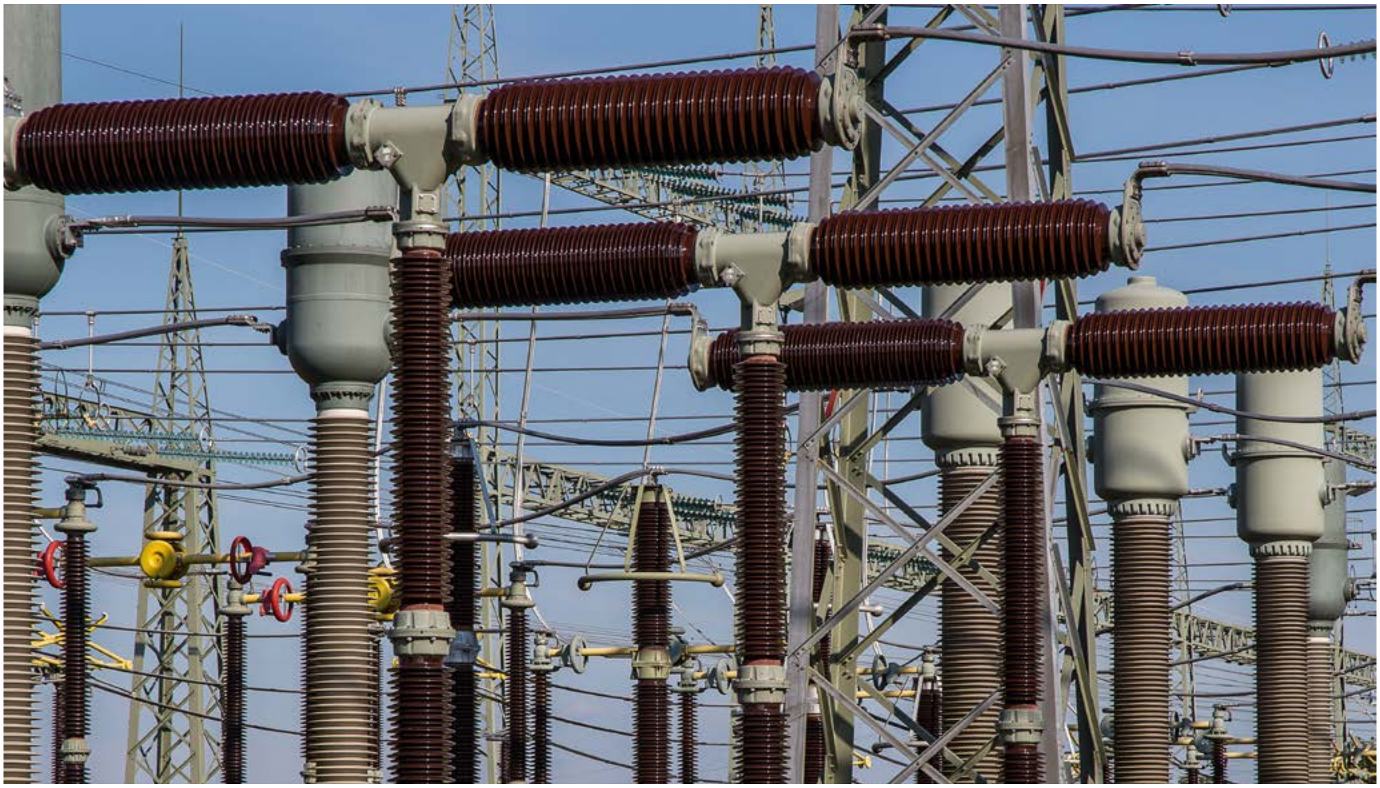
There are two important cases where hydropower developers can receive an exemption from

6 The Federal Power Act, 16 U.S.C. § 791-828(c), (1920); amended in 1935 and 1986.

7 18 CFR Part 5, 2005. Code of Federal Regulations, Title 18—Conservation of Power and Water Resources, Chapter I—Federal Energy Regulatory Commission, Department of Energy, Subchapter B—Regulations Under The Federal Power Act, Part 5—Integrated License Application Process, 2005.

8 Federal Energy Regulatory Commission, Integrated Licensing Process Pre-Filing Activity, https://www.ferc.gov/resources/processes/flow/hydro-5.asp, accessed on 2-May 2017.

9 Federal Energy Regulatory Commission, Integrated Licensing Process Post-Filing Activity, https://www.ferc.gov/resources/processes/flow/hydro-6.asp, accessed on 2-May 2017.



licensing[10] under Part 1 of the Federal Power Act:

- 10 MW exemption - applies to the construction of new hydropower facilities or the expansion of an existing operation by no more than 10 MW. This is also known as the "small/low impact" exemption. To qualify for a 10 MW exemption, the facility must be located at an existing dam or natural water feature that is not owned or operated by the federal government.[11]
- Conduit exemption - issued for hydropower operations on an existing conduit that was constructed to convey water for municipal, agricultural, or industrial consumption. Conduit exemptions are applicable to projects with a generating capacity of no more than 40 MW. Further, these facilities cannot be an integral part of any existing dam.

There are no filing fees for facilities that are granted an exemption from FERC licensing. Likewise, annual charges are waived for exempt projects that generate up to 1.5 MW. Across the five UMR states, there were a total of 17 license exemptions with a total hydropower generating capacity of 27,870 kW. Each was a 10 MW exemption. Even though it is possible to obtain an exemption from FERC licensing, developers are still required to comply with the National Environmental Protection Act (NEPA)[12] and other requirements established by

10 Federal Energy Regulatory Commission, Exemptions from Licensing, https://www.ferc.gov/industries/hydropower/gen-info/licensing/exemptions.asp, accessed on 2-May 2017.

11 Title 18, Conservation of Power and Water Resources, Chapter 1, Federal Energy Regulatory Commission, Subchapter B, Regulations Under the Federal Power Act, Part 4, Licenses, Permits, Exemptions, and Determination of Project Costs, Subpart K, Exemption of Small Hydroelectric Power Projects of 10 Megawatts or Less, Code of Federal Regulations (2014), 18 C.F.R. §§ 4.101-4.108

12 Title 42, Public Health, Chapter 55, National Environmental Policy (1970).

resource management agencies.[13]

Hydroelectric Power Production in UMR States

According to the U.S. Energy Information Administration (EIA), 117,000 megawatts (MW) of electric power were generated by the five UMR states in 2016. A breakdown of energy production in UMR States is presented in Figure 1. Among UMR states, Illinois was the lead producer of electric power at ~45,000 MW which was more than double the electricity generated by the next highest electric producing state of Missouri.

In 2016, UMR states generated ~1,970 MW of hydroelectric power. In comparison to the total

13 Title 16, Conservation, United States Code.

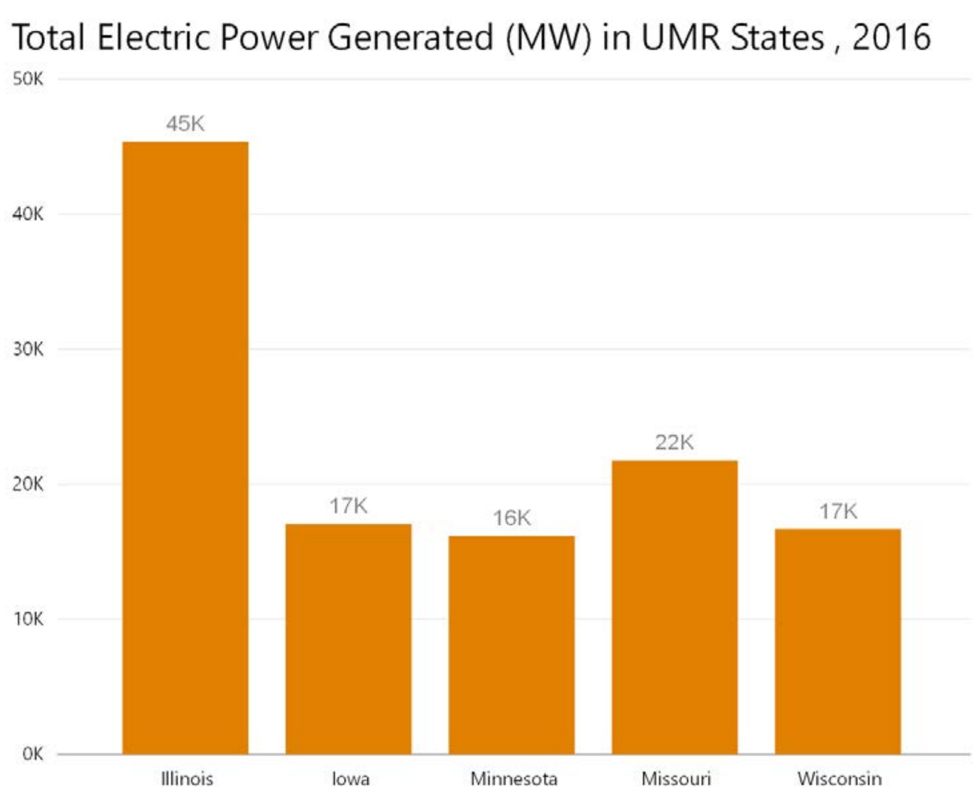


Figure 1. Total electric power generated in UMR States in 2016.

only 1.2 % of electricity produced in UMR states was generated by hydropower in 2016.

energy production of UMR states, hydroelectric power amounted to 1.2% of the region's total energy production portfolio.

A breakdown of hydroelectric power generation in UMR states is presented in Figure 2. Among UMR states, Missouri generated the most hydroelectric power (~1,200 MW) in 2016. Missouri's hydroelectric power generation came from 4 conventional hydropower facilities and 3 pumped storage generators. Notably, Missouri was the only UMR state in which both conventional and pumped storage hydropower were used to generate electricity.

Wisconsin, the second highest hydroelectric power generator in the UMR, produced 362 MW across 66 power plants. Due to the lower topographic relief in Wisconsin, hydroelectric

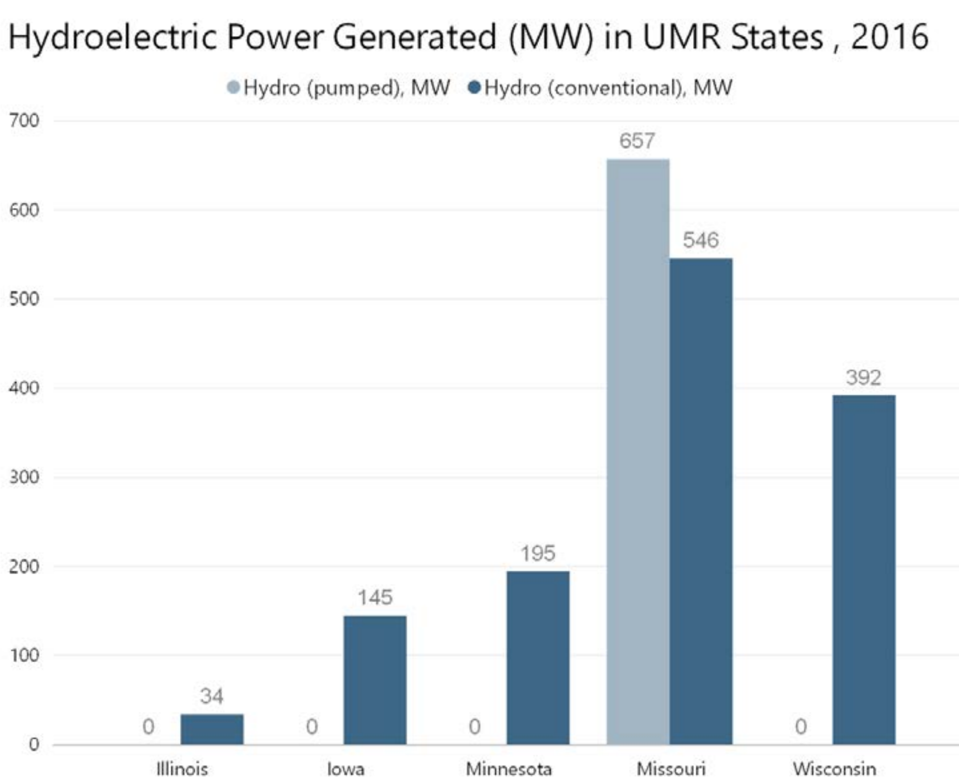


Figure 2. Hydroelectric power generated in UMR States in 2016.

power generation in this state was distributed in smaller increments over a greater number of generating sites. Recall that Illinois produced the most electric power of all five UMR states; however, hydroelectric power amounted to less than 0.1% of the state's energy portfolio.

Hydroelectric Power Production Systems

All hydropower systems operate by converting the energy contained in water into electrical energy. Regardless of scale, all viable hydropower systems require a reliable and abundant supply of water in addition to sufficient water pressure to move the turbines that create electric energy. In hydropower systems, water pressure results from differences in the height of flowing water.

Conventional Hydropower

In a typical reservoir-based hydropower system (Figure 3), a dam is constructed on a river to create an elevated body of water. Water is released from the reservoir through a turbine that drives an electric generator.

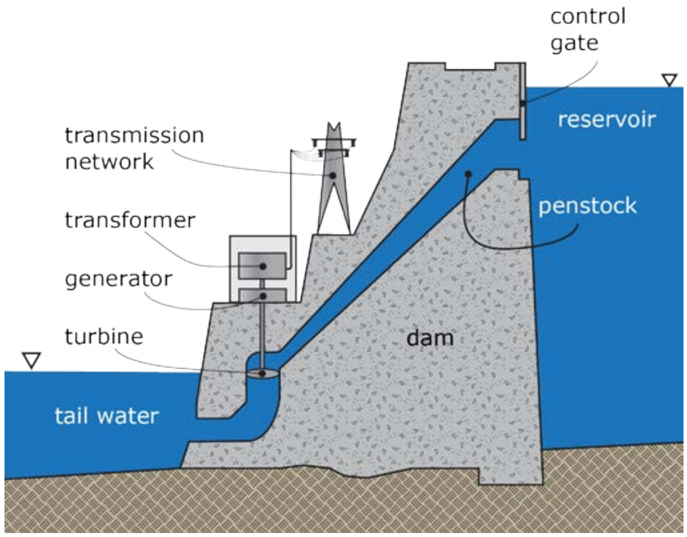


Figure 3. Schematic of reservoir-based hydropower system.

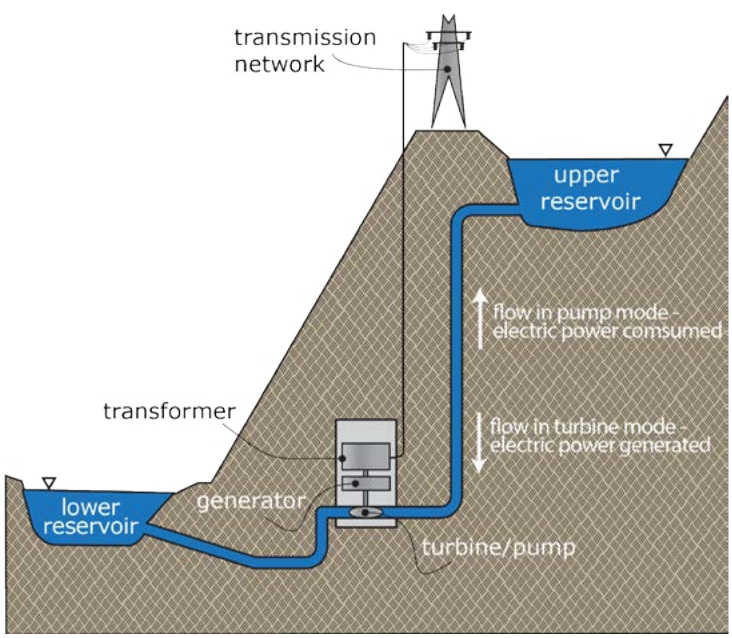


Figure 4. Schematic of pumped storage hydropower system.

Decaying vegetation and soil organic matter in hydropower reservoirs can be a significant source of greenhouse gases.

An iconic example of a reservoir-based hydroelectric power system is the Hoover Dam located in Arizona and Nevada. The dam is 726 ft (221 m) tall and generates an annual average of 4.2 billion kilowatt-hours of power. Seventeen main turbines are driven by water that falls an average of 520 ft in elevation.

The Upper Mississippi River is an abundant source of water; however, elevation differences within and between adjacent UMR pools have generally been considered to be insufficient to support commercial-scale hydropower facilities.[14] A significant exception is Lock and Dam (LD) 19 at Keokuk, IA, which is home to Ameren Missouri's Keokuk Hydropower Plant (134 MW generating capacity). Additionally, there is a hydroelectric power plant located at Lock and Dam 2 in Hastings, MN, though it generates only ~4,400 kW.

Unlike fossil fuel-based power plants, hydroelectric generators do not produce greenhouse gases (GHGs). However, reservoir-based hydropower systems can actually be a significant source of GHGs. For example, carbon dioxide and methane gases are released when vegetation and soil organic matter are inundated and decompose. Rates of GHG production were reported to decrease exponentially with age.[15] Similar, researchers have reported that GHG production in hydropower reservoirs is highest at sites closer to the equator.[16] Barros *et al*. estimated that ~4% of global carbon emissions come from hydroelectric power reservoirs.[17]

Pumped Storage Hydropower

In addition to conventional hydropower systems, pumped storage hydropower is used to help operators meet peak electric power demands and balance the load on the electric distribution grid. In these systems (Figure 4), operators pump water to a reservoir located at a higher elevation where it is stored. During times of high electric power demand, operators can release water from the storage reservoir through turbines which produce electric power on an as-needed basis. In 2016, there were three pumped storage hydropower facilities in the UMR states; all three were located in Missouri.

Low-Head Hydropower

Low-head hydropower systems are employed in cases where water flow is sufficient but headloss is less than approximately 30 ft H_2O. Low-head hydropower systems have correspondingly low electric generating capacities (<1 MW) when compared with conventional hydropower systems and are often referred to as "low-head/low power" systems. In low-head hydropower systems (see Figure 5), water is collected at an elevated upstream location and is conveyed under gravity in a pipeline to a turbine that is situated at a lower elevation. Prior to being discharged into a turbine chamber, the velocity of water is increased typically by

14 U.S. Energy Information Administration (2016). EIA-923, Detailed Electric Power Data, revised 27-April 2017, accessed 28-April 2017, https://www.eia.gov/electricity/data/eia923/xls/f923_2016.zip.

15 Abril, G., Guérin, F., Richard, S., Delmas, R., Galy-Lacaux, C., Gosse, P., Tremblay, A., Varfalvy, L., Aurelio Dos Santos, M., and B. Matvienko (2005). Carbon dioxide and methane emissions and the carbon budget of a 10-year old tropical reservoir (Petit Saut, French Guiana). Global Biogeochemical Cycles, 19, GB4007, doi:10.1029/2005GB002457..

16 Fearnside, P. (2005). Brazil's Samuel Dam: Lessons for hydroelectric development policy and the environment in Amazonia, Environmental Management, 35, 1–19.

17 Barros, N., Cole, J., Prairie, Y., Bastviken, D., Huszar, V., del Giorgio, P., and F. Roland (2011). Carbon emission from hydroelectric reservoirs linked to reservoir age and latitude, Nature Geoscience, 4, 593–596.

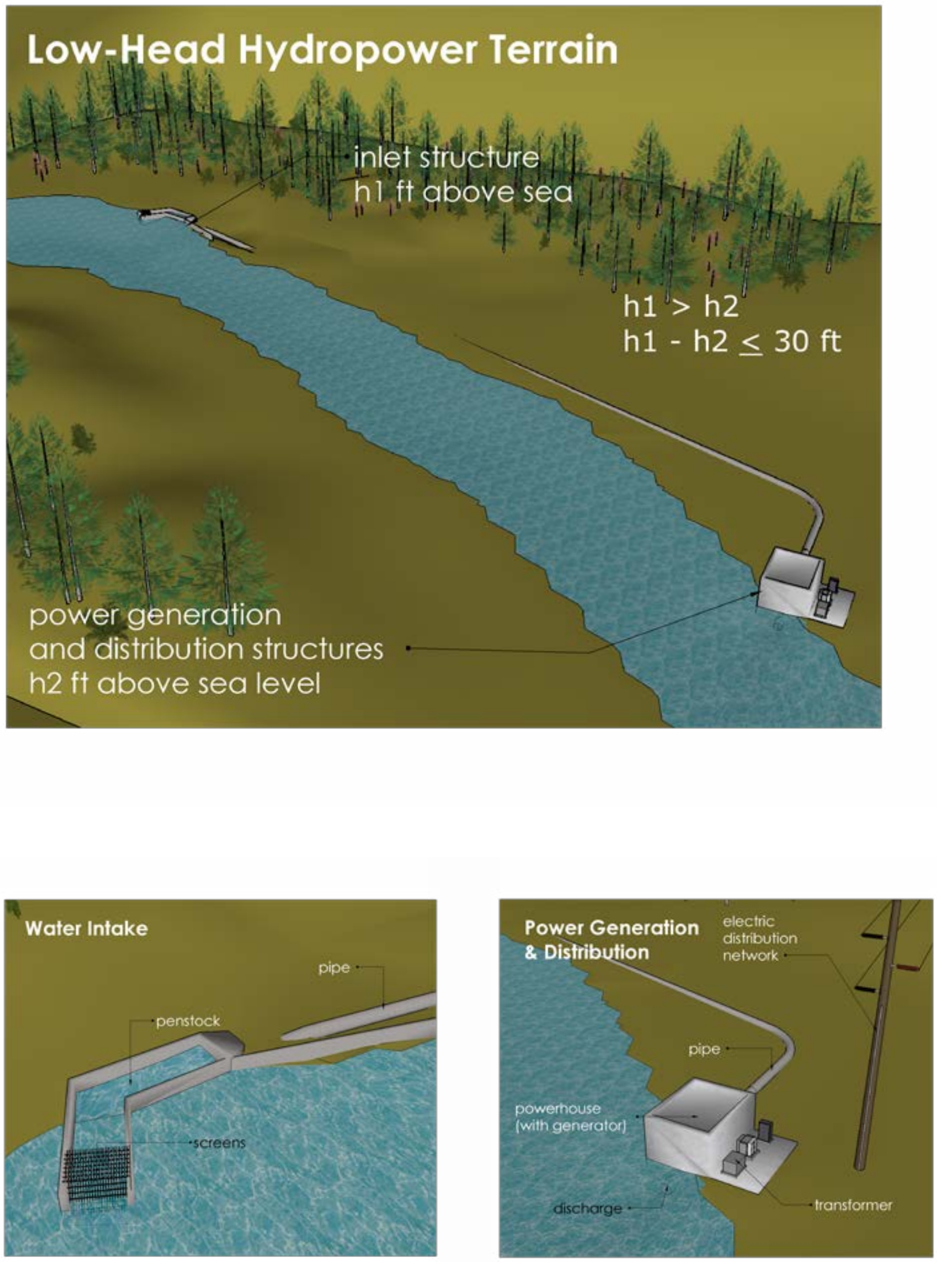
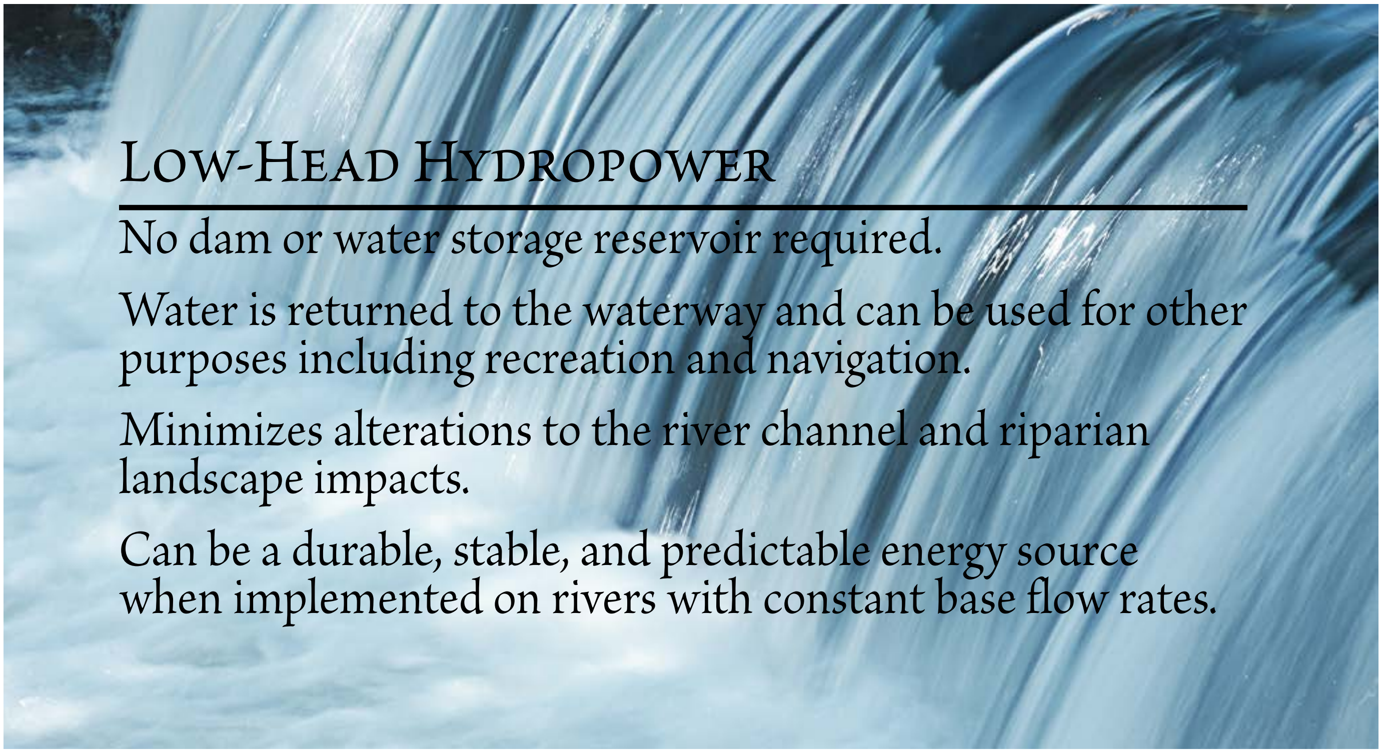


Figure 5. Schematic illustrations of a low-head hydropower system (overview - top, inlet detail - bottom left, power generation and distribution - bottom right).



Low-Head Hydropower

No dam or water storage reservoir required.

Water is returned to the waterway and can be used for other purposes including recreation and navigation.

Minimizes alterations to the river channel and riparian landscape impacts.

Can be a durable, stable, and predictable energy source when implemented on rivers with constant base flow rates.

reducing the cross sectional area of the pipe to create one or more "nozzles".

As water moves through a pipe, some pressure head is lost due to friction between water and the pipe walls as well as pipe fittings such as valves and elbows. In general, the loss of pressure head is higher in longer pipelines, pipes with smaller diameter, and higher water flow rates. Likewise, the pressure head loss in pipes made with smooth material (concrete pipe) is lower than the rougher materials (corrugated steel pipe). In order to minimize the loss of pressure head in the water conveyance system, the choice of pipe dimensions and material are key considerations which must be factored into the design of low-head hydropower systems.

Turbines used in low-head hydropower systems are specially designed to operate efficiently with relatively low pressure head and water flow rates that are often much lower than used in conventional hydropower generators. Kaplan (propeller) turbines, screw-type, and hydrokinetic generators are often used for low-head hydropower generation. In some cases, cross flow turbines are used for low-head hydropower production. An extensive body of information is available on low-head hydroelectric power in the United States, including resources from the federal government, tribal consortia,[18] industry associations,[19] and private industry.

Many stakeholders are understandably concerned about the ways any diversion of water can

18 The Tribal Energy and Environmental Information Clearinghouse (TEEIC). Energy Resources, Low-Head Hydropower, Resources and Technology, Office of Indian Energy and Economic Development, Bureau of Indian Affairs, U.S. Department of the Interior, accessed on 1-May 2017, https://teeic.indianaffairs.gov/er/lhhydro/restech/uses/.

19 National Hydropower Association (NHA). Waterpower Library, accessed 1-May 2017, http://www.hydro.org/resources/.

impact the environment, navigation, and recreation. Low-head hydropower systems utilize a small fraction of total river flow and generally don't require significant infrastructure changes to existing waterways. This corresponds to lower construction costs as well as fewer impacts to local environments. Since low-head hydropower systems don't require the construction of large reservoirs, greenhouse gas production by these systems is not a significant issue.

Challenges to Low-Head Power Implementation on the UMR

Representative challenges that limit the growth of low-head hydropower on the Upper Mississippi River include:

1. The FERC hydropower licensing process - length and ambiguity.

   FERC is able to issue preliminary permits for a maximum of three years. Unfortunately, this time frame is often not sufficient for applicants to complete the required multi-year studies that are needed to obtain a full license.[20] For example, the review process required for new hydroelectric generating stations as well as for retrofitting existing dams to produce hydropower can be prohibitively long. As a consequence, some applications fail to advance in the approval process because federal resource agencies are often unable to meet the time line for required reviews.

   Since 2010, FERC has taken a number of steps to make the licensing and license exemption processes more efficient for developers of small-scale hydropower systems; these include a pilot licensing program with the State of Colorado in addition to enhanced web-based support for applicants. However, significant obstacles remain. A more complete discussion of this issue is provided at www.hydroreform.org.

   Since low-head hydropower systems have modest power generation capacities relative to reservoir-based systems, low-head hydropower can be used to greatest advantage on the UMR if generating systems are distributed along the length of the

20 Title 16, Conservation, Chapter 12, Federal Regulation and Development of Power, Subchapter 1, Regulation of the Development of Water Power and Resources, United States Code (1935). Title 16 amended by the Energy Power Act (2005).

river as opposed to being concentrated in a handful of key locations. It is not clear how such a network of low-head hydropower systems might be viewed by FERC from a licensing point of view.

2. Coordination and cooperation among stakeholders.

   As noted above, a distributed network of low-head hydropower systems is likely to cross multiple jurisdictional boundaries. The key to future progress on this front will be coordination and cooperation between municipal, county, state, and federal stakeholders and regulators along with private industry.

3. Impacts of global climate change.

   There is substantial uncertainty surrounding the impacts global climate change might have on water abundance in both the near and distant future.[21] However, since low-head hydroelectric power doesn't produce greenhouse gases, the expansion of its use in the UMR and beyond may help efforts to combat greenhouse gas production that occurs even in reservoir-based hydropower systems.[22]

4. Costs and financing.

   Cost of licensing-related studies. Since low-head hydropower systems have modest power production capacities relative to more traditional reservoir-based systems, the upfront costs associated with the licensing and/or the license exemption processes can be prohibitive for investors.

   Fixed fees for FERC licensing. In general, the fees required to obtain a FERC license are independent of the capacity of a proposed hydropower system. As a result, licensing fees typically constitute a larger fraction of up-front costs for low-head hydropower producers. In the case of facilities with a 10 MW exemption from FERC licensing, these operations are exempt from annual fees on the first 1.5 MW of production capacity. In some cases, this policy can favor the construction of multiple sub 1.5 MW low-head systems which undermines any economy of scale that could be achieved by installing a single 10 MW generating unit.

5. Support for research and development.

   Investments are required to support research and development into advanced technologies for low-head hydropower production. Based on the cost issues identified earlier, research and development activities are not likely to be supported to a meaningful extent by individual low-head hydropower producers.

21 Naza, B., Kao, S., Ashfaqa, M., Rastogia, Meia, R., and L. Bowling (2016). Regional hydrologic response to climate change in the conterminous United States using high-resolution hydroclimate simulations, Global and Planetary Change, 143, 100-117.

22 Barros ***et al***. (2011).

What About other Renewable Energy Sources?

Wind generation[1]

takes advantage of a free source of renewable power, doesn't utilize fossil fuels, doesn't emit pollutants, and can be sited on land that can be simultaneously used for other purposes. For example, a number of wind farms are located on land that is also used for row crop production. However, some prime locations for wind power generation have greater value when used for other purposes.

When compared with other energy generation technologies, wind turbines can require a high initial investment. Wind turbines can also negatively affect the visual aesthetic as well as adversely impact migratory birds and bats.[2] [3] Since electricity isn't produced when wind velocities are low, the operational cycle of wind power generators is variable.

Solar power[4] is a clean and abundant source of renewable energy that can be used on individual residences as well as utility-scale solar farms. Solar power generating systems can produce energy for decades and contain many components that can be recycled after a system is decommissioned. These systems are generally low maintenance and can be used at locations across the globe. However, solar power generating systems only produce electricity during daylight hours.

Solar generating power systems can also require a large land area. For example, the world's largest solar power facility is the Longyangxia Dam Solar Park in China which contains 4 million solar panels on 10 mi^2 (~27 km^2) of land to generate 850 MW of power.[5] Unlike wind power generation, solar power typically precludes the use of land for other purposes.

1 Argonne National Laboratory (2017). Wind Energy Guide, accessed on 10-April 2017, http://windeis.anl.gov/guide/basics.

2 Piorkowski, M., and T. O'Connell (2010). Spatial Pattern of Summer Bat Mortality from Collisions with Wind Turbines in Mixed-Grass Prairie. American Midland Naturalist, 164 (3), 260-269.

3 Barclay, R., Baerwald, E., and J. Gruver (2007). Variation in Bat and Bird Fatalities at Wind Energy Facilities: Assessing the Effects of Rotor Size and Tower Height. Canadian Journal of Zoology, 85 (3), 381-387.

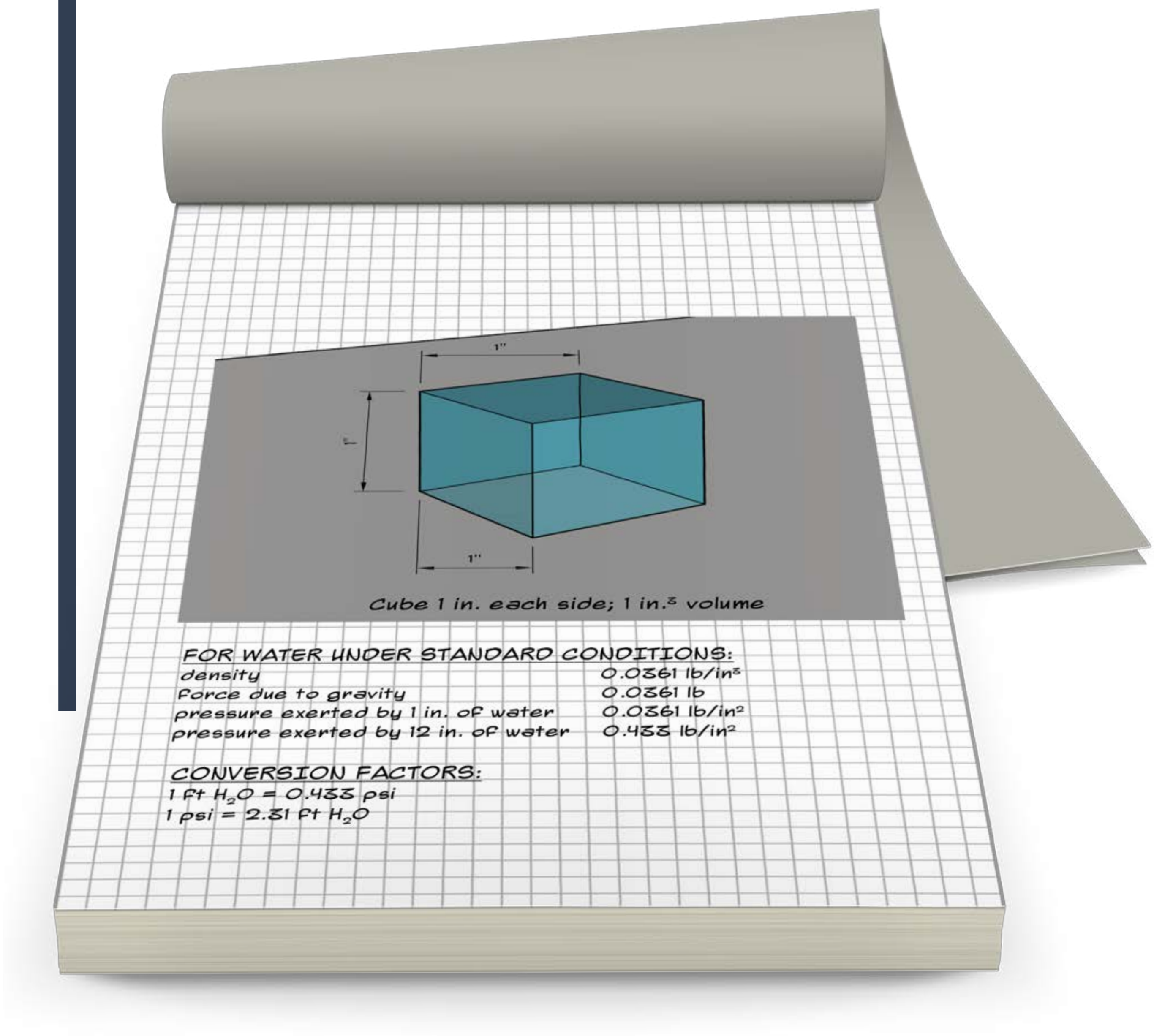
4 US DOE (2017). Solar Energy Technology Basics, accessed on 10-April 2017. https://energy.gov/eere/energybasics/articles/solar-energy-technology-basics.

5 NASA (2017). Longyangxia Dam Solar Park, NASA Visible Earth, accessed on 17-April 2017, https://visibleearth.nasa.gov/view.php?id=89668.

How Does Water Height Relate to Water Pressure?

Water resource engineers often refer to water pressure as "pressure head" and water pressure is represented in units of "ft of water" (ft H_2O).

Consider a small cube with sides that are each 1 in long. This container holds 1 in^3 of water; the area of its base is 1 in^2 and its depth is 1 in. The density of water under standard conditions is 0.0361 lb/in^3. In the 1 in^3 container, water exerts a force of 0.0361 lb. Since the area of the base is 1 in^2, the pressure exerted by 1 in of water is 0.0361 lb/in^2 (psi). When 12 containers are stacked on one another, the pressure exerted at the bottom of the 1 ft tall water column is 0.433 psi.



Links

The following are representative links to information related to hydroelectric power development with an emphasis on low-head hydropower and the Upper Mississippi River. This is not a comprehensive resource; rather, it is a starting point to help better inform the thinking of those who are interested in low-head hydropower on the UMR.

Federal Energy Regulatory Commission (FERC), https://www.ferc.gov

- FERC Hydropower, https://www.ferc.gov/industries/hydropower.asp
- FERC Exemptions from Licensing, https://www.ferc.gov/industries/hydropower/gen-info/licensing/exemptions.asp
- FERC Small/Low-Impact Hydropower Projects, https://www.ferc.gov/industries/hydropower/gen-info/licensing/small-low-impact/get-started/projects-nearby.asp

Hydropower Reform Coalition, http://www.hydroreform.org

International Energy Agency (IEA) Technology Cooperation Programme on Hydropower, http://www.ieahydro.org

International Rivers, https://www.internationalrivers.org/campaigns/the-world-commission-on-dams

Low Impact Hydropower Institute (LIHI), http://lowimpacthydro.org

National Hydropower Association (NHA), http://www.hydro.org

- NHA Waterpower Resources - links, files, *etc.*, http://www.hydro.org/resources

Oak Ridge National Laboratory - Innovations in Hydropower, http://hydropower.ornl.gov

Tribal Energy and Environmental Information Clearinghouse (TEEIC), Bureau of Indian Affairs, U.S. Department of the Interior, https://teeic.indianaffairs.gov/er/lhhydro/restech

Union of Concerned Scientists - Renewable Energy, http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy

Upper Mississippi River Basin Association, http://umrba.org

U.S. Army Corps of Engineers (USACE)

- Center of Expertise: Hydroelectric Design Center, http://www.nwp.usace.army.mil/HDC
- Mississippi Valley Division, http://www.mvd.usace.army.mil
- St. Louis District, http://www.mvs.usace.army.mil
- Rock Island District, http://www.mvr.usace.army.mil
- St. Paul District, http://www.mvp.usace.army.mil

U.S. Bureau of Reclamation, Department of the Interior, Hydropower Program, https://www.usbr.gov/power/edu/links.html

U.S. Department of Energy (DOE) Water Power Program, https://energy.gov/eere/water/water-power-technologies-office

U.S. Energy Information Administration (EIA) - Electricity, https://www.eia.gov/electricity
Hydro Research Foundation, http://www.hydrofoundation.org

U.S. Fish and Wildlife Service (FWS), https://www.fws.gov/ecological-services/energy-development/hydropower.html