

WBS 1.1.1.606 – Integrated Water/Power Resilience



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Project Overview

Project Summary

Water and power systems are interdependent, critical to the well-being of our communities, and at-risk due to multiple factors including climate change. This project aims to improve the resilience of our nation's water supplies and power systems through working directly with industry partners to a) develop common metrics and understanding of interdependencies and risks, b) share best practices, and develop useful tools and analysis for coordinated planning and operations for resilience, c) promote data development and sharing between water and power utilities, and d) increase efficiency, flexibility, and renewable energy development in both systems.

Intended Outcomes

- This project attempts to increase planning and coordination for the resilience of integrated water and power systems. Final products and outcomes will be a set of high-impact visuals, a cross-sector and cross-agency network of industry professionals advancing integrated resilience, an aggregation of best practices for risk assessments and integrated resilience planning, an illustrative set of case studies, and modeling tools that support resilience assessments and planning from the electrical interconnect level to the county and community level.

Project Information

Principal Investigator(s)

- Juliet Homer, Tim McJunkin

Project Partners/Subs

- U.S. Environmental Protection Agency
- Water Research Foundation
- Colorado State University
- Massachusetts Department of Environmental Protection

Project Status

New

Project Duration

- FY20
- FY21

Total Costed (FY19–FY21)

\$1,016K

Project Objectives: Relevance

Relevance to Program Goals:

- From the MYPP logic model, this project supports addressing the following challenges in the following ways:
 - Challenge: Lack of access to information to support decision-making
 - Approach: Develop and share extensive water and power data sets and visuals
 - Challenge: Addressing hydrologic uncertainties on water and power systems
 - Approach: Assess, develop, and share best practices for water and electric utilities to plan for climate variability and proactively plan for the potential impact of hydrologic uncertainties on hydropower production
 - Challenge: Limited opportunities for new, affordable hydropower growth
 - Approach: Work with industry stakeholders to identify renewable energy development opportunities, including hydropower development, at water and wastewater facilities that support resilience.
- This project also supports the Water Infrastructure and Resilience topic area described in the Hydropower Strategic Partnerships and Crosscutting Activities Overview (pg 86). See the excerpt below from page 89 of the MYPP:
 - “In future funding years, WPTO will look to execute on new visualization and operational planning tools providing insight into specific energy-water interactions and drivers to demonstrate and facilitate cooperation and optimization across energy and water assets.”

Project Objectives: Approach

Approach:

- Innovation = Extensive stakeholder engagement informs approach and analysis
- Perform stakeholder engagement and regulatory and utility support
 - Conduct stakeholder engagement including interviews and outreach to assess needs and opportunities
 - Coordinate IEEE industry task force on water and power and cross-sector advisory group
 - Conduct a high-profile workshop on water-power resilience with water and power providers
 - Participate in trainings for state policymakers on water-power resilience
 - Work with communities on disturbance impact resilience evaluation
- Assess landscape, compile data, characterize interdependencies, identify needs
 - Map landscape of entities (public and non-public) and activities in power-water resilience
 - Compile data sets and characterize interdependencies of water and energy by electrical interconnections
 - Develop interconnect-level Sankey diagrams showing energy-water interdependencies
 - Summarize research needs and DOE opportunities
- Identify best practices in planning for water and climate variability
 - Summarize best practices in electric integrated resource planning (IRP) in planning for water and climate variability and identify gaps and advanced practices needed
- Develop community water-power profiling tools and multi-agent system modeling platform


Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- High-profile workshop with water and electric utilities and workshop report on Coordination and Planning for Water and Power System Resilience
- County-level, open-source, energy-water Sankey diagrams (code, data, visuals) made publicly available
- Best practices guide for planning for water and climate variability in electric integrated resource planning
- Hydrologic and financial risk assessment with mitigations for Central Arizona Project
- Journal articles on equity and water-power resilience
- Formation of IEEE Water-Power Task Force
- Formation of Water-Power Resilience Advisory Group

Outcomes:

- Increased focus on resilience by existing industry organizations who've participated in workshops and advisory groups, including related spin-off activities
- Trainings for utilities and regulators on planning for climate variability based on best practices guide
- Uptake and use of open-source water-energy data and Sankey diagrams
- More informed and integrated resilience decision making by water and electric utilities




ENERGY EFFICIENCY AND RENEWABLE ENERGY AT WATER UTILITIES VIRTUAL WORKSHOPS

The U.S. Environmental Protection Agency (EPA) is updating the *Power Resilience Guide* to include more information, tools, and case studies on implementing energy efficiency and renewable energy technologies at drinking water and wastewater utilities. EPA is hosting two, two-part virtual workshops this summer to engage drinking water and wastewater utilities, water associations, state and federal agencies, and other stakeholders on the current practices, opportunities, and challenges in increasing energy efficiency measures and utilizing renewable energy to increase power resilience at water utilities.

If you have any questions, please contact [Lauren Wisniewski at wisniewski.lauren@epa.gov](mailto:Lauren.Wisniewski@epa.gov) or [Steve Clark at clark.stephen@epa.gov](mailto:Steve.Clark@epa.gov).

ENERGY EFFICIENCY AT WATER UTILITIES PARTS 1 & 2	RENEWABLE ENERGY AT WATER UTILITIES PARTS 1 & 2
June 29 - 30, 2022 12:30pm - 3:30pm ET/9:30am - 12:30pm PT	August 9 - 10, 2022 12:30pm - 3:30pm ET/9:30am - 12:30pm PT
This two-part workshop will include presentations and discussions on: <ul style="list-style-type: none">• Energy assessments• Utility experiences with implementing energy conservation practices and energy efficiency technologies• Flexible demand• Funding and economic benefits• Opportunities and challenges	This two-part workshop will include presentations and discussions on: <ul style="list-style-type: none">• Solar power• Wind power• Batteries• Biogas and combined heat and power• In-line/conduit hydropower• Economic and resiliency benefits to renewable energy• Opportunities and challenges
Please register for both parts of this workshop here: https://h2o.watersystems.com/h2o/watersystems/centralaz/191815722d41c355080e27260e419343964	Please register for both parts of this workshop here: https://h2o.watersystems.com/h2o/watersystems/pnw/2810240c271f3e3b326c099b2c2e01f6a2



Utility resource, asset, and contingency planning with climate variability

Juliet Homer, Alan Cooke, and Kamila Kazimierczuk
Pacific Northwest National Laboratory (PNNL)

PNNL Brownbag
December 6, 2021

June 3, 2022 | 1

Project Timeline - PNNL

FY 2020

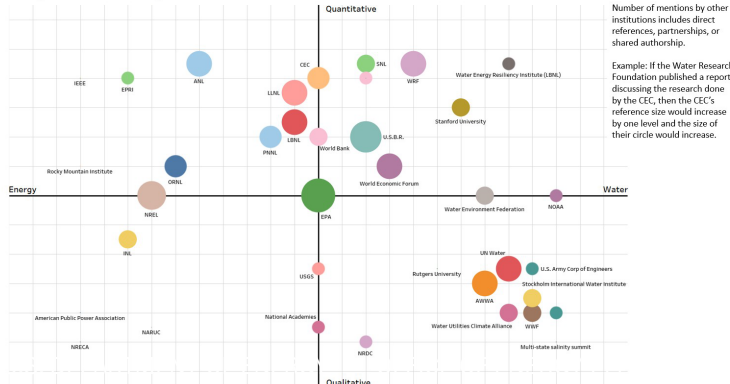
- Literature review (resilience measurement variables and approaches, threats, and strategies)
- Landscape analysis (organizations, reference amount, research initiatives, lab research)
- Extensive interviews with 30+ stakeholders
- Established IEEE Task Force on Water-Power Systems
- Mind Manager mapping of w/p resilience interconnections, threats, and potential resilience strategies

FY 2021

- Summary memo of research and development opportunities for DOE WPTO (from interviews and landscape assessment)
- Water-energy Sankey diagrams and comprehensive dataset by electric interconnection
- High-impact stakeholder workshop and workshop report
- White paper on planning for water and climate variability in electric utility Integrated Resource Plans
- Two journal articles on water-power resilience

Question posed: Who is providing valuable/citable research in this space and where is it broadly focused?

Size by Number of Mentions by Other Institutions

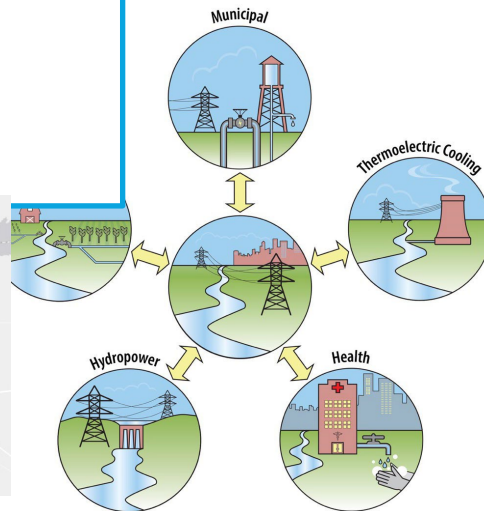
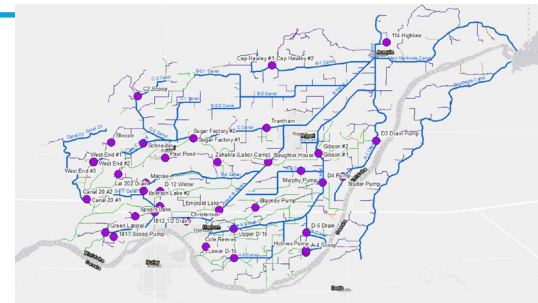
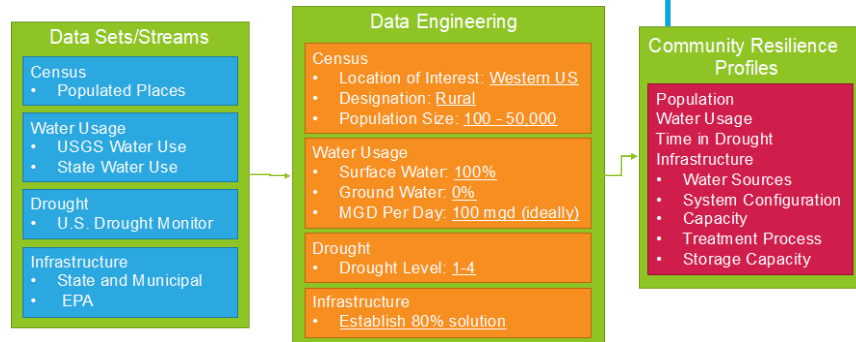
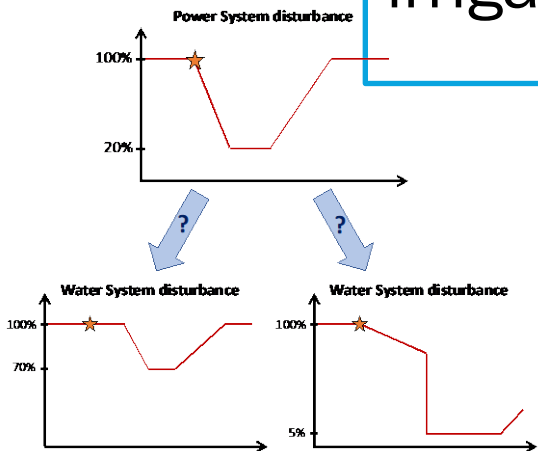


Project Timeline - INL

FY 2020

Notational construction of w/p resilience measures during response and recovery. Community w/p profiling tools and multi-agent system modeling platform Exemplar: irrigation district

Define interface between profiling tool and model – consider additional use cases



Project Budget

FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
0	\$326,235	\$689,616	\$1,015,851

- Project began in FY20
- Funding is split between PNNL and INL. Total PNNL = \$751k; Total INL = \$265k

End-User Engagement and Dissemination

- PNNL dissemination/engagement strategy – results to date:
 - Extensive interviews with 30+ water and power system industry professionals
 - Invitational only workshop in April 2021 with 72 attendees
 - IEEE Task Force on Water and Power Systems formed through this project with 133 members from around the world
 - Advisory group established based on April 2021 workshop with representatives from key industry organizations
 - Two invited presentations to the National Association of Regulatory Utility Commissioners
 - Publication:
 - “Resilience of Interdependent Water and Power Systems: A Literature Review and Conceptual Modeling Framework,” Water – K. Oikonomou, et. al.
DOI:10.3390/w13202846
 - Active case study work being performed with Central Arizona Project and the Massachusetts Department of Environmental Protection
 - Working active engagements with U.S. Environmental Protection Agency, Water Research Foundation, Water Environment Foundation, DOE Advanced Manufacturing Office

End-User Engagement and Dissemination

- INL dissemination/engagement strategy – results to date:
 - Publications:
 - “Integrated water-power system resiliency quantification, challenge and opportunity,” [Energy Strategy Reviews](https://www.energy.gov/eere/energy-strategy-reviews) – M. Roni, et. al. DOI: [10.1016/j.ser.2021.100796](https://doi.org/10.1016/j.ser.2021.100796)
 - “Integrated Water-Power System Resilience Analysis in a Southeastern Idaho Irrigation District: Minidoka Case Study” – A. Toba, et. al. DOI: [10.3390/su131910906](https://doi.org/10.3390/su131910906)
 - Engagement with Irrigation District – acquired data – shared results – further engagement has been slowed by availability of stake holder
 - Strategic hire plan: Dr. Dawn Davis, Natural Resources and Water Resources - Law, Management and Policy emphasis, member of Shoshone-Bannock Tribes
 - Outreach to Navajo Technical University – future outreach.

Performance: Accomplishments and Progress (cont.)

- [Workshop report Coordination and Planning for Water and Power System Resilience published](#)
- [White Paper Published: Review of Water and Climate Change Analysis in Electric Utility Integrated Resource Planning](#)
- Two invited presentations to the National Association of Regulatory Utility Commissioners on results of April 2021 workshop with utilities
- New Water Environment Federation Energy Management Task Force on Energy grew out of our April 2021 workshop
- EPA developed new workshop series on efficiency and renewable energy at water and wastewater facilities based on engagement and partnership.
- Invited presentation to the National Council on Electricity Policy (regulators, legislators, Governor's energy office staff, state energy offices) on White Paper on Water and Climate Variability in Integrated Resource Planning
- Publications:
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12:30pm - 3:30pm ET/9:30am - 12:30pm PT

This two-part workshop will include presentations and discussions on:

- Energy assessments
- Utility experiences with implementing energy conservation practices and energy efficiency technologies
- Flexible demand
- Funding and economic benefits
- Opportunities and challenges

Please register for both parts of this workshop here:

<https://horsleywittevents.webex.com/horsleywittevents/onstage/q.php?PRID=c752efccc3d5b68b5e27b0e419343964>

RENEWABLE ENERGY AT WATER UTILITIES PARTS 1 & 2

August 9 - 10, 2022
12:30pm - 3:30pm ET/9:30am - 12:30pm PT

This two-part workshop will include presentations and discussions on:

- Solar power
- Wind power
- Batteries
- Biogas and combined heat and power
- Inline/conduit hydropower
- Economic and resiliency benefits to renewable energy
- Opportunities and challenges

Please register for both parts of this workshop here:

<https://horsleywittevents.webex.com/horsleywittevents/onstage/q.php?PRID=2a5c97cf3aebb906a99ba254ee9046a2>

New Infographic developed

COMPARING WATER & ELECTRICITY DELIVERY SYSTEMS



3,000
Electric Utilities
in the U.S.

NUMBER OF UTILITIES

There are 17 times more water utilities operating in the U.S. than electric utilities, even though they share the same amount of total consumers: **300 Million**



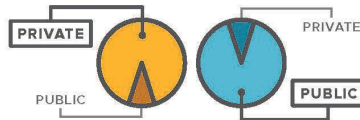
50,000
Water Utilities
in the U.S.



84%
Private Owned
VS
16%
Public Owned

PRIVATE OWNED vs. PUBLIC OWNED

The majority of electricity customers are served by privately-owned utilities, while the majority of water customers are served by publicly-owned utilities.



88%
Public Owned
VS
12%
Private Owned



10 LARGEST
Private Owned
VS
511 COUNTIES
Service Areas

SIZE & TYPE OF LARGEST UTILITIES

The 10 largest electric utilities are privately owned and serve 37 times as many counties as the 10 largest water utilities, which are publicly owned.



10 LARGEST
Public Owned
VS
14 COUNTIES
Service Areas



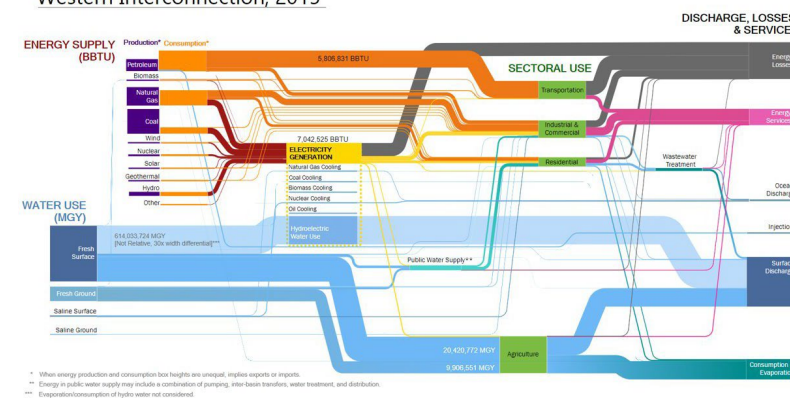
Performance: Accomplishments and Progress

- INL FY19-21
 - Development of notional measure of the water/power nexus resilience curve
 - Development of community water/power "at-risk" profile tool
 - Development of multiagent water power modeling platform and risk framework.

Future Work

- PNNL/INL project divided into two projects with different emphasis in FY22
 - Working to maintain peer-review and awareness connection between laboratories
- PNNL:
 - Publish and share Sankey diagram, data sets, and code for interconnect level and county-level water-energy interdependencies. Two publications:
 - Journal of Open-Source Software
 - Nature Communications
 - Second paper on water and electric utility planning for climate variability
 - Conduct workshops and trainings
 - Publish two papers on equity and resilience at the energy-water nexus
 - Perform and document hydrology and financial risk analysis for Central Arizona Project; develop materials and trainings for other water providers based on the work
 - Additional workshops and coordination with industry partners advisory group
 - If applicable, develop new tools to support energy-water resilience planning and operations

Western Interconnection, 2015



Future Work

- INL: Community Water/Power Resilience
 - Focus on outreach to underserved communities – initial focus on regional Native Tribes – gaining appreciation of the sensitivities and approaches that create a network of trust.
 - Utilization of “Community Resilience profiles” to identify at-risk communities
 - Model validation on tribal use case
 - Preliminary study of “source” geoengineering – possibilities, challenges, potential for unintended consequence

Q&A