Northwest **Power** and
Conservation Council

October 5, 2022

MEMORANDUM

TO: **Council Members**

FROM: **Leann Bleakney, Energy Policy Analyst**
Oregon office

SUBJECT: **Presentation by Dr. Ted Brekken, OSU**

BACKGROUND:

Summary:

Dr. Ted Brekken, Professor in Energy Systems at Oregon State University, will talk with the Council regarding research the university has initiated regarding the integration of fast-acting energy storage into traditional hydroelectric units for improved response and stability. The research is focused on ultimately improving system performance of the hydroelectric units for increased greater operational flexibility, particularly when it comes to integration with renewable power.

This is new work, made possible by a US Dept. of Energy grant. Researchers at OSU are working in cooperation with colleagues at the University of Utah as well as the U.S. Army Corps of Engineers.

Presenter:

Ted K.A. Brekken is a Professor in Energy Systems at Oregon State University. He received his B.S., M.S., and Ph.D. from the University of Minnesota in 1999, 2002, and 2005 respectively. He studied wind turbine control at the Norwegian University of Science and Technology in Trondheim, Norway in 2004-2005 on a Fulbright scholarship. His research interests include control and modeling of renewable energy systems and electrical system resilience. He is co-director of the Wallace Energy Systems and Renewables Facility (WESRF). He has received an NSF CAREER award, the IEEE Power and Energy Outstanding Young Engineer award, and numerous teaching awards.

Background:

This is a transcript of a KGW TV story about this project that aired on July 9, 2022.

CORVALLIS, Ore. — More and more, how we get our electricity is critically important. And there are a lot of reasons for that, from increasing needs to climate change. As a result, researchers at Oregon State University are looking at how to make systems more efficient and flexible — and they've got a federal grant to do it.

In the Pacific Northwest, hydropower has long been the top source of renewable energy. The Columbia River Basin leads the nation in hydropower production. But hydropower is not without its downsides for rivers, fish and other animal habitats. And the dam and power generation system, despite updates, is 100-year-old technology.

So part of the OSU research is to revisit hydropower plants and figure out what can be done to bring them into the modern age. " ... and see what we can do to make them more flexible so that they play well together, and we leverage that capacity with some of the modern sources we have by using some storage that we have called 'super capacitors' — so that's short-term energy storage," said Eduardo Cotilla-Sanchez. Cotilla-Sanchez is an associate professor of engineering and computer science, and one of three OSU faculty on the project, helped by three graduate students.

The team is looking at hydropower storage improvements and how to make the entire electric grid system more flexible as it receives more power from solar and wind generation. It's a big job.

"The power grid is the largest machine ever created by humans, so it is very tricky to do research when we need the grid to be connected to it right now," said Cotilla-Sanchez.

Researchers look to prototypes and computer-generated models to do a lot of the research work. Over the next three years they hope to find advancements large and small that can make a difference over the next five to ten years and have lasting impact for decades to come.

"I think the idea is to try to get the most out of the resources that we have locally. And locally is the cheapest that we can do in order to transport electricity — because if we send it far then we have a lot of losses," Cotilla-Sanchez said.

OSU's work is covered by $1.9 million in U.S. Department of Energy grants, part of a total $8 million in grant money for the project. Other entities involved in the larger project include researchers at University of Utah and the U.S. Army Corps of Engineers.

Hybrid Hydropower-Storage Units for Greater Operational Flexibility

Ted Brekken
Professor
Oregon State University

Oregon State University
College of Engineering

Funded By

- Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy (EERE)
- Funding Opportunity Announcement (FOA) Number: DE-FOA-0002417: “Technology Innovation to Increase Hydropower Flexibility (HYDROWIRES)”

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Project Partners

- Oregon State University
  - **Ted Brekken**
  - Eduardo Cotilla-Sanchez
  - Yue Cao
- University of Utah
  - Masood Parvania
  - Jairo Giraldo
- US Army Corps of Engineers
  - Sean Brosig
- Western Electricity Coordinating Council (WECC)
  - Enoch Davis

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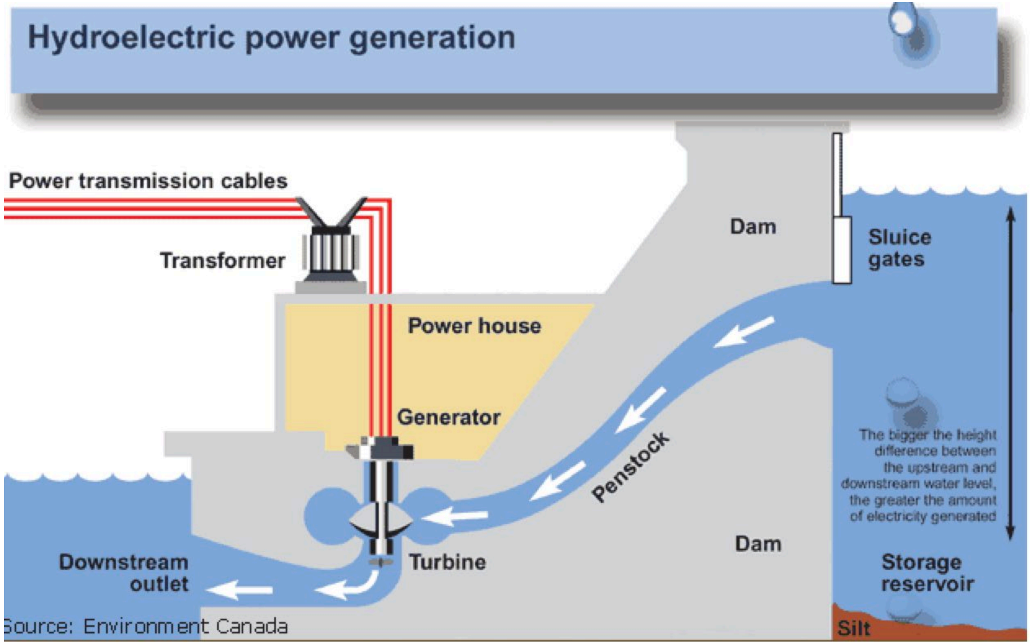
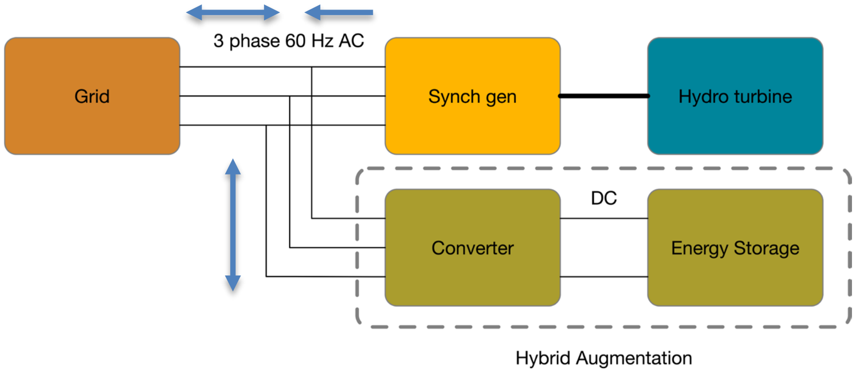
Traditional Hydropower Units



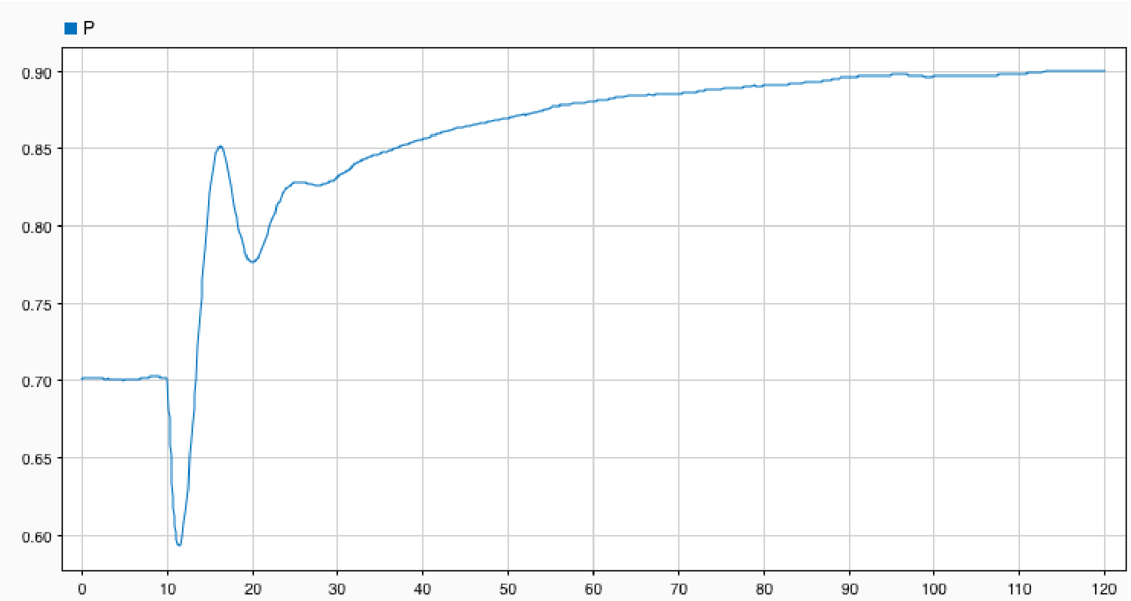
- Generator is synchronous: direct electromagnetic connection between the speed and torque of the mechanical shaft and the voltage and current at the generator terminals
- Provides inertia, frequency regulation, and voltage control
- Very stable, but response limited by generator inertia, water inertia, and generator inductance

Hybrid Hydropower-Storage Units



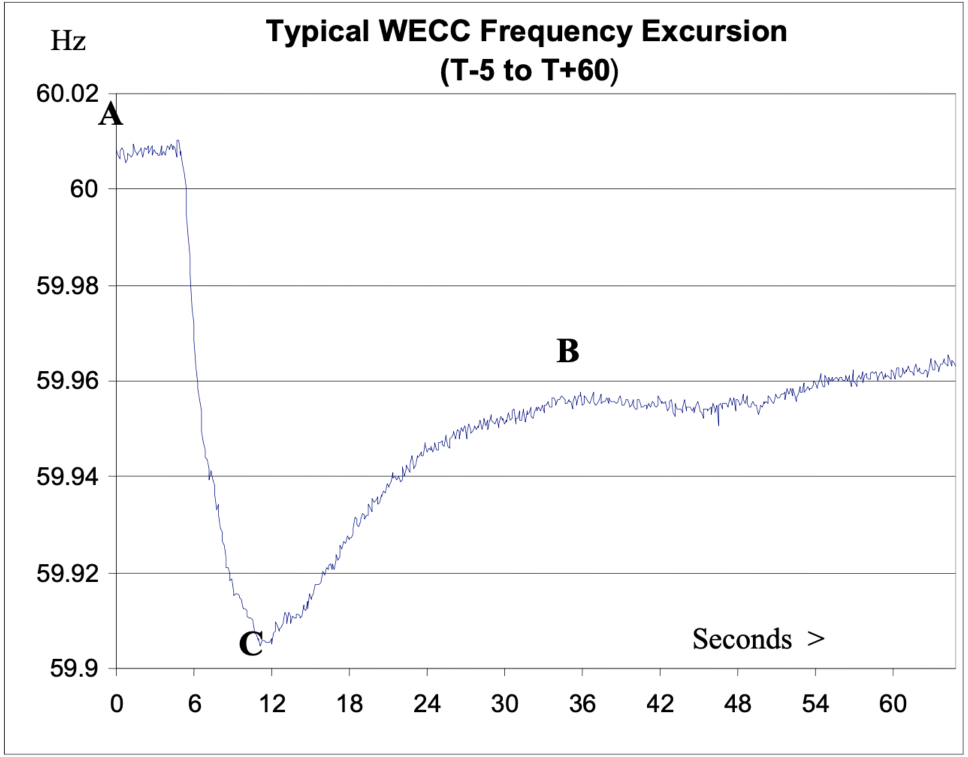
- Augment existing hydroelectric unit with a parallel energy storage path to create a *hybrid* hydroelectric unit
- Benefits:
  - Energy storage for buffering short term wind and solar variation
  - Increased active and reactive power control for better frequency and voltage regulation
  - Improved power quality

Example: Improvement to Transient Response



- Traditional hydropower units are limited in their response time by the inertia of water, and by non-minimum phase characteristics

WECC frequency stability during transients (several seconds)



[“Balancing and frequency control,” tech. rep., North American Electric Reliability Corporation (NERC), January 2011.]

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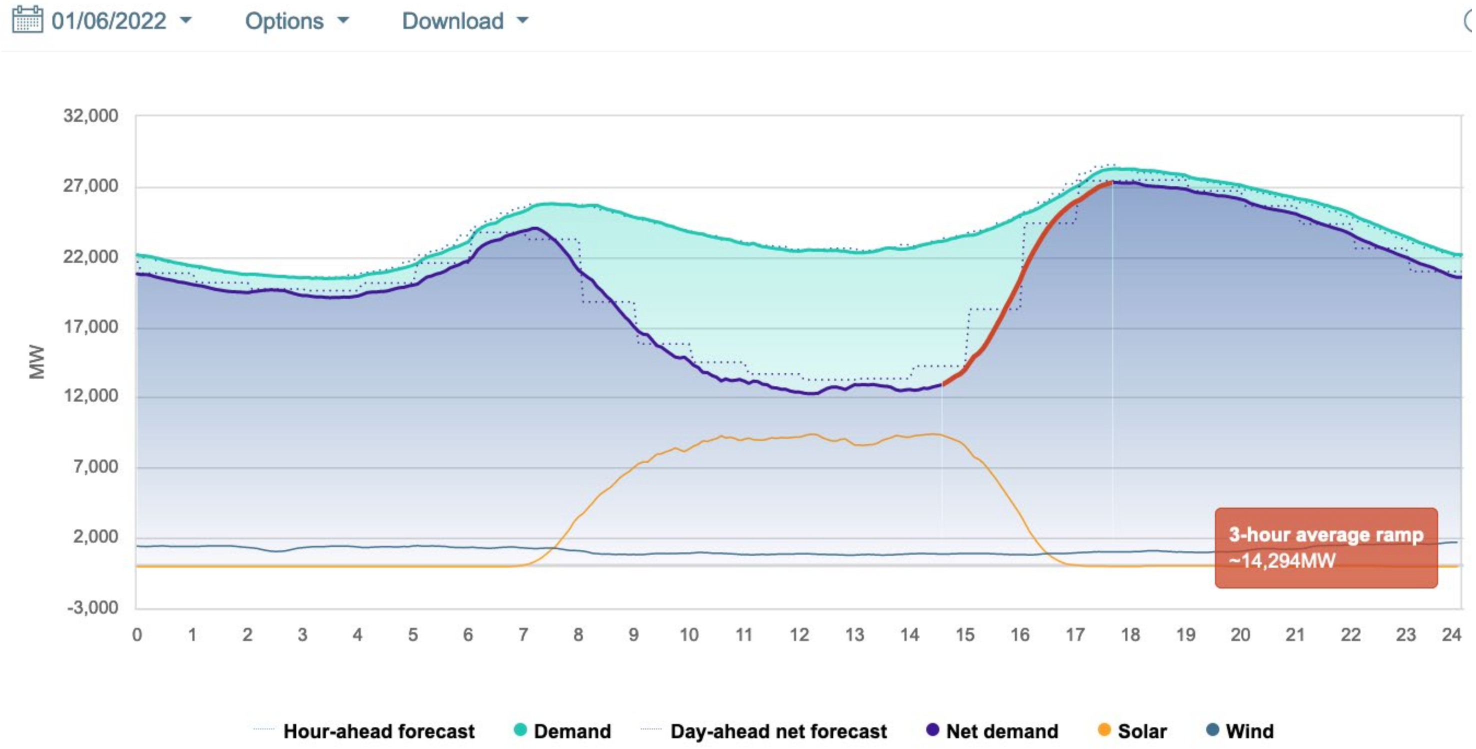
WECC stability: ramp in net load over hours



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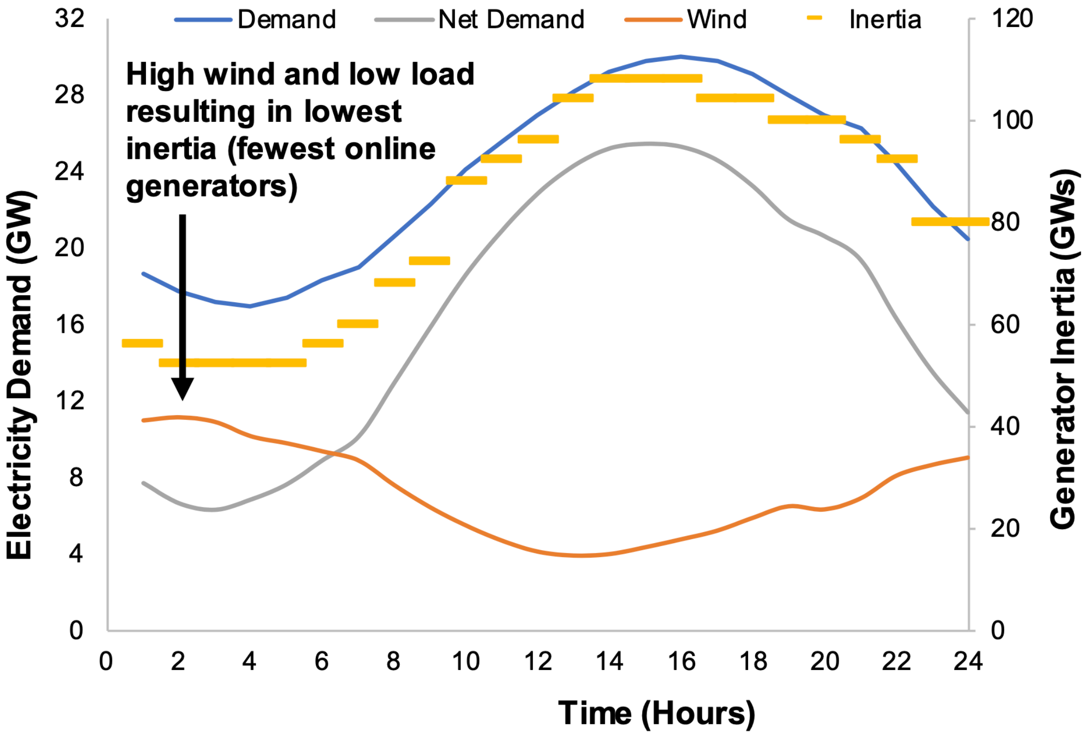
Inertia: modern loads and generation generally means lower total inertia

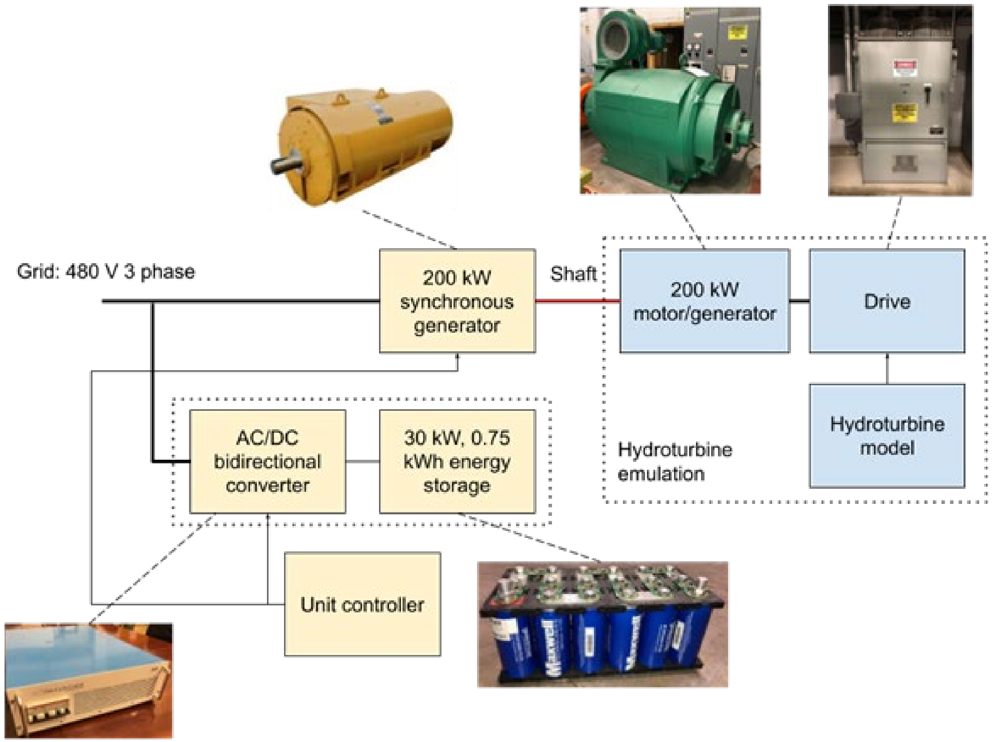


["Inertia and the Power Grid: A Guide Without the Spin," NREL Technical Report, May 2020]

Project Plan

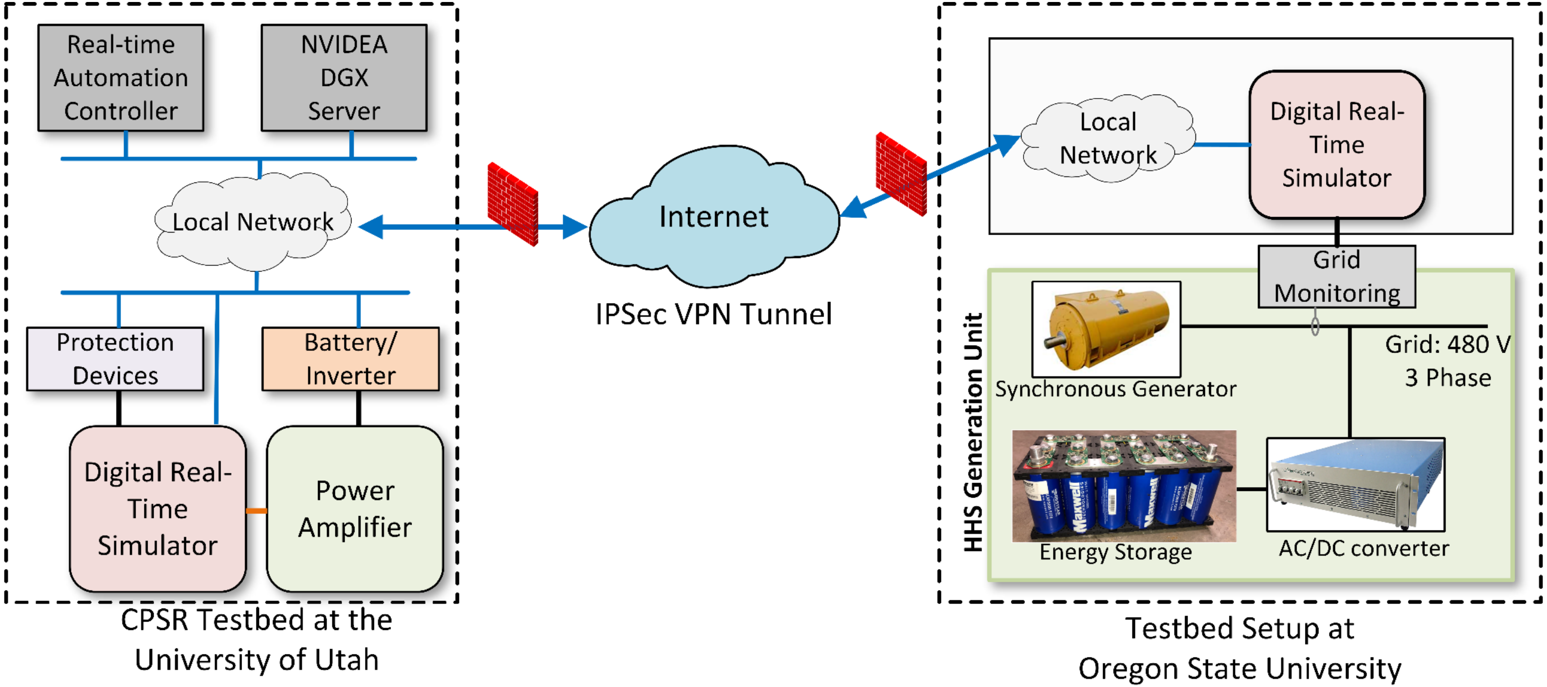
- Development and testing of experimental model in WESRF lab
- Validation with simulation model
- Integration of simulation model into large-scale simulation model of western grid
- Market and development plan

Experimental Testbed



- WESRF lab at Oregon State University
- Design for 200 kW
- Real-time digital twin

Integration of Experimental Model to Large Scale Grid Model



Project Outcomes

- Technical and economic value of adding energy storage to hydropower units
- Perhaps can extend value and lifetime of existing units
- Better integration of renewables and inverter based loads
- Improved system transient stability
- Improved power quality