AGI Updates and Research Highlights

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# PNNL-WSU Advanced Grid Institute (AGI)

The PNNL-WSU AGI brings together complementary and synergistic expertise, combining the unique talents and resources of the partner institutions, to address major challenges in important mission areas that neither partner can achieve alone.

Overarching strategy

- Identify strategic area of research focus aligned with regional needs and organization strengths

- Recognized as expert in power and energy related issues

- Broaden impact at the national level by linking regional issues with national energy concerns

Key Scientific/Technical Challenges

Regional Focus
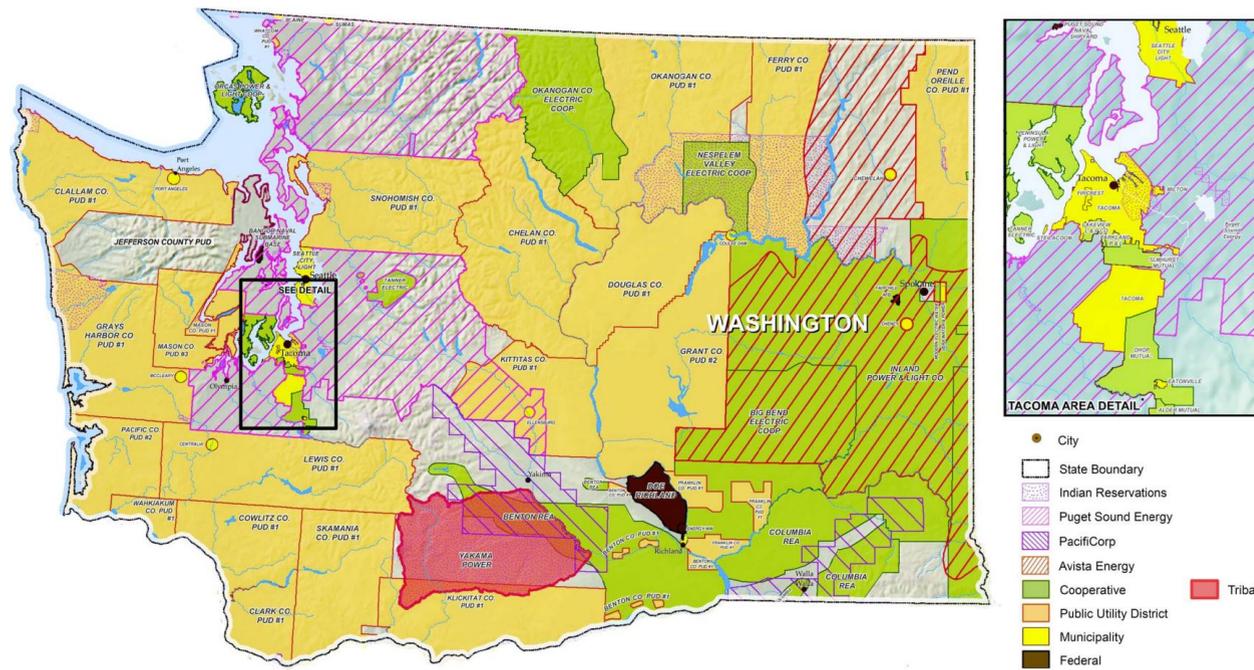
Northwest - shaped by decentralized coordination

and a regionally coordinated public process

- 22 balancing authorities,
- ~ 60 utilities in Washington State
- Regional diversity - urban, rural, and indigenous communities
- Integrate large loads driven by AI data center growth
- Unique threats to grid resilience: wildfires, snowcap melting, storms

- **Increasing grid complexity and scale with grid-edge transformation**
- **Changing paradigm for grid modelling and control: Inverter-based resources**
- **Cross-domain and cross-infrastructure influences – AI, data centers, large loads, market, technology**

AGI Strategy: Research Focus

ADVANCED GRID INSTITUTE

Goal: **_To specializes in system-centric approaches to assist with building affordable, reliable and secure regional grid._**

- We will achieve this by:
  - ➢ Advancing energy analytics upon integrating cross-infrastructural, cross-sectoral, and multi-domain information/influences
  - ➢ Developing targeted products/services for grid planners/operators for future grid readiness

- Strategic Area of Research Focus:
  - ➢ Energy Analytics and Decision Support
  - ➢ Power Electronics Influence on Power Systems
  - ➢ Resilience to All-hazards

R&D Area 1: Energy Analytics and Decision Support

ADVANCED GRID INSTITUTE

Changing nature and requirements of the grid at the edge interfacing
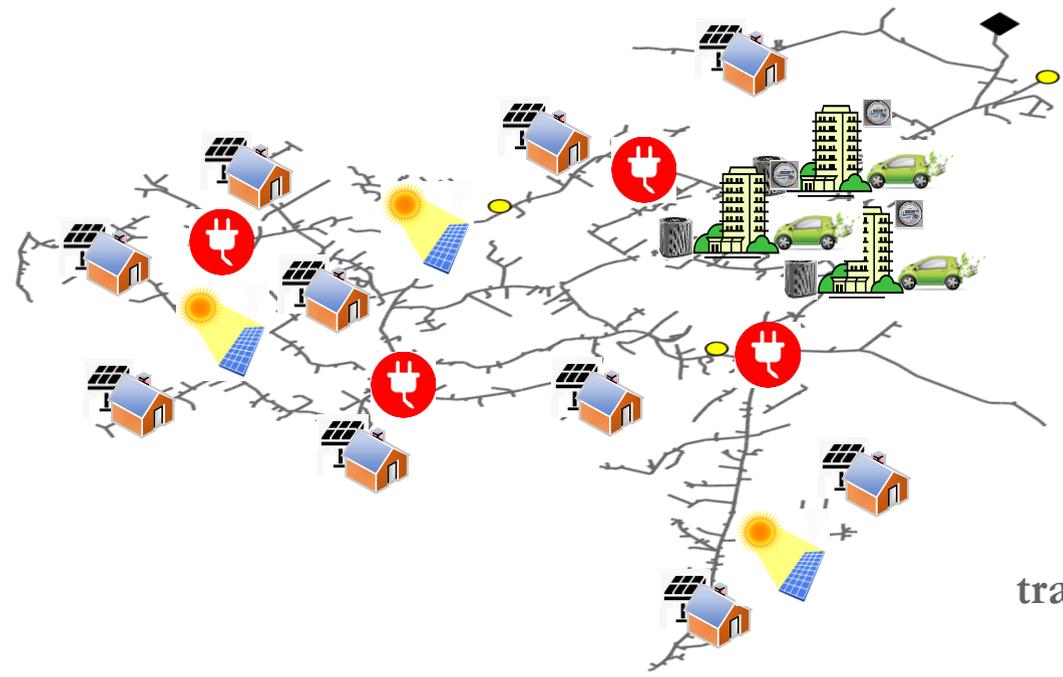
Scalability for interconnected T&D systems

Voltage Class
- ±500 kV DC
- 500 kV
- 345 kV – 360 kV
- 230 kV – 287 kV
- Lower Voltages

Economywide electrification (including transportation) could increase U.S. electricity consumption by up to 38% by 2050.

https://www.wecc.org/

System of systems – complexity

ISO/RTO

Market Parameters | AReg

Market Agent

TReg Telemetry | Clearing Price RegD Signal

DER Aggregator

BFax | **Dispatch Signals** | BFax

DER Aggregation
| BESS | BESS |
| BESS | BESS |

DER Aggregation
| BESS | BESS |

AReg – Assigned Regulation
RegD – Fast Regulation

TReg – Total Regulation
BFax – BESS Distribution Factors
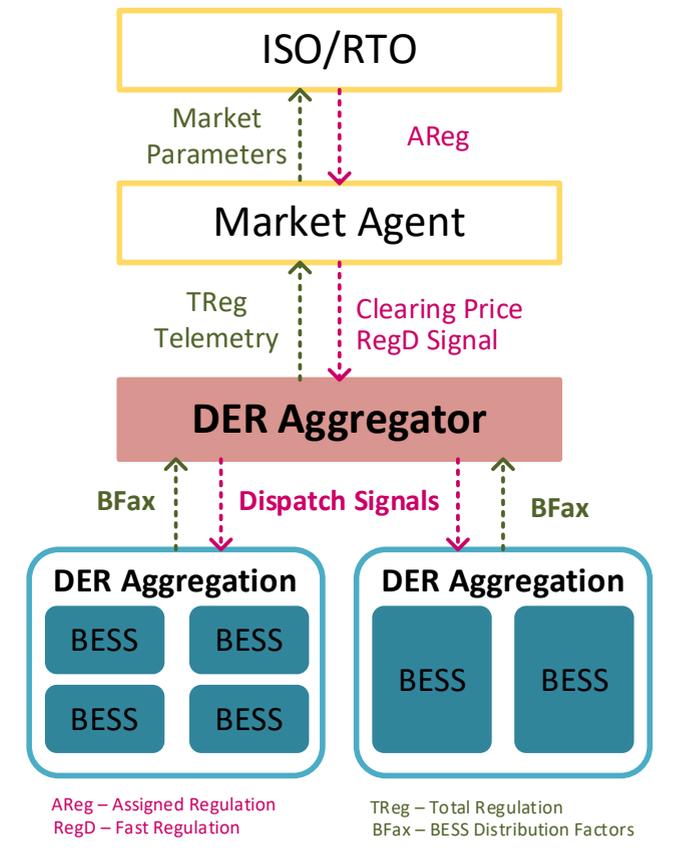
- **Growing complexity of Grid operations: Scalable simulation, optimization, and learning is key to plan and operate the complex power grid.**

R&D Area 1: Energy Analytics and Decision Support

Research Focus

- Synergistic integration of model, data, and advanced analytics to analyze the large-scale power grid with grid-edge resources and develop system-level decision-support solutions.

Key Topics

- Scalable Approaches for Grid Modeling and Optimization
- Synergistic Integration of Physics-based and Machine-Learning Approaches
- Foundational Contributions to Optimization under Uncertainty

Key Personnel

- PNNL: Kevin Schneider, Jason Fuller, Jim Ogle, Jacob Reidt
- WSU: Anamika Dubey, Assefaw Gebremedhin, Rahul Gupta, Alan Love

Target Sponsors

- Target Sponsors: NSF, DOE (OE, SETO)

# SPOKANE Connected Communities (DOE Funded)

Nature of WSU PNNL collaboration:

- Led by Edo with WSU and PNNL as collaborators. WSU subcontracted by Avista.

- **Research Outcomes:** Scalable decision-making framework to extract grid services from the grid-edge resources including grid-interactive buildings and distributed energy resources.
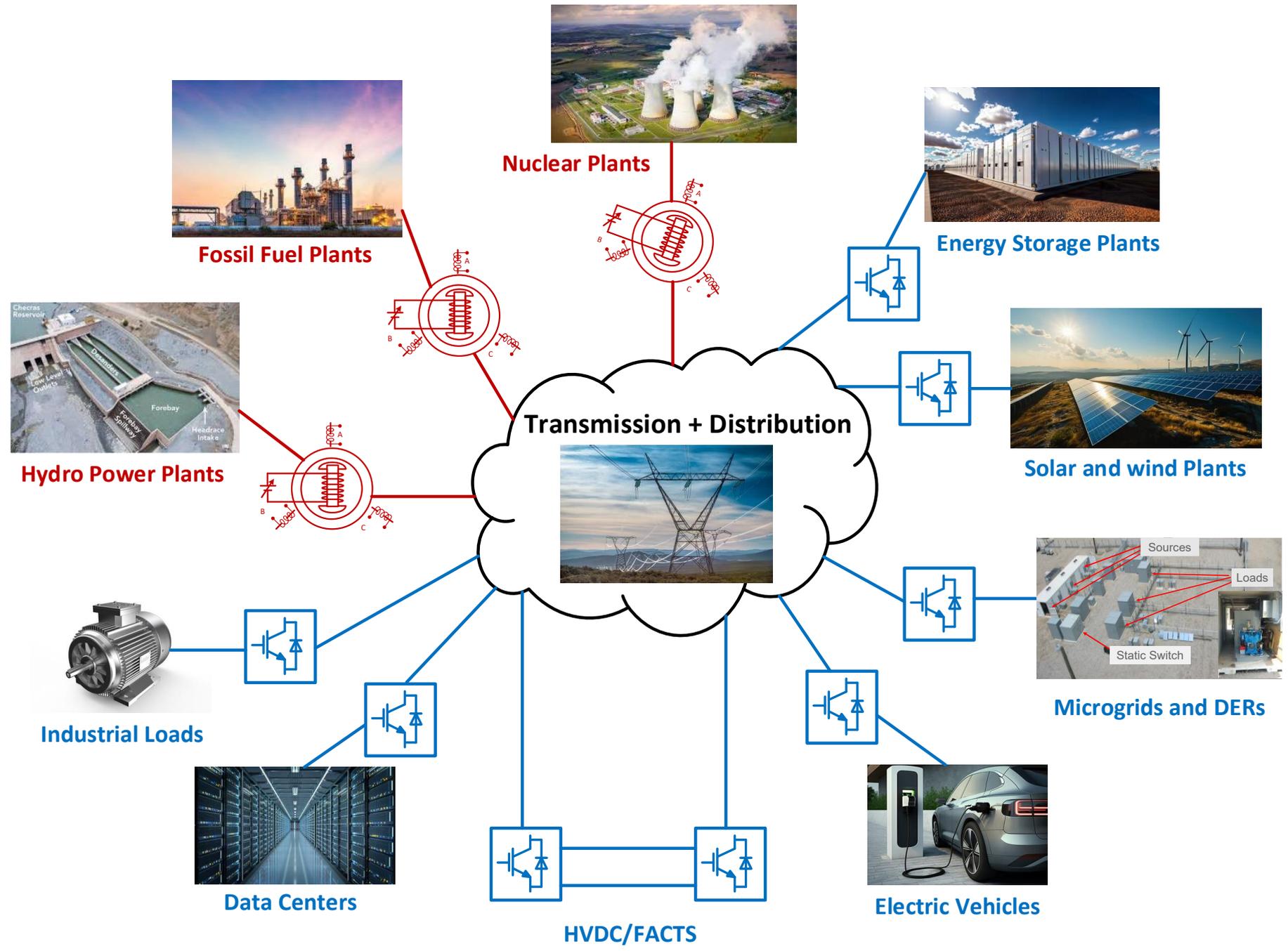
#students supported: 3 students

Targeted Impacts:

- Layered architecture for decision support combining distributed and edge-control paradigms

- Develop new OpenFMB usecase for layered distribution operation

- Demonstrate advanced layered control architectures on Avista feeders, in collaboration with PNNL, Avista, OES, and Edo.
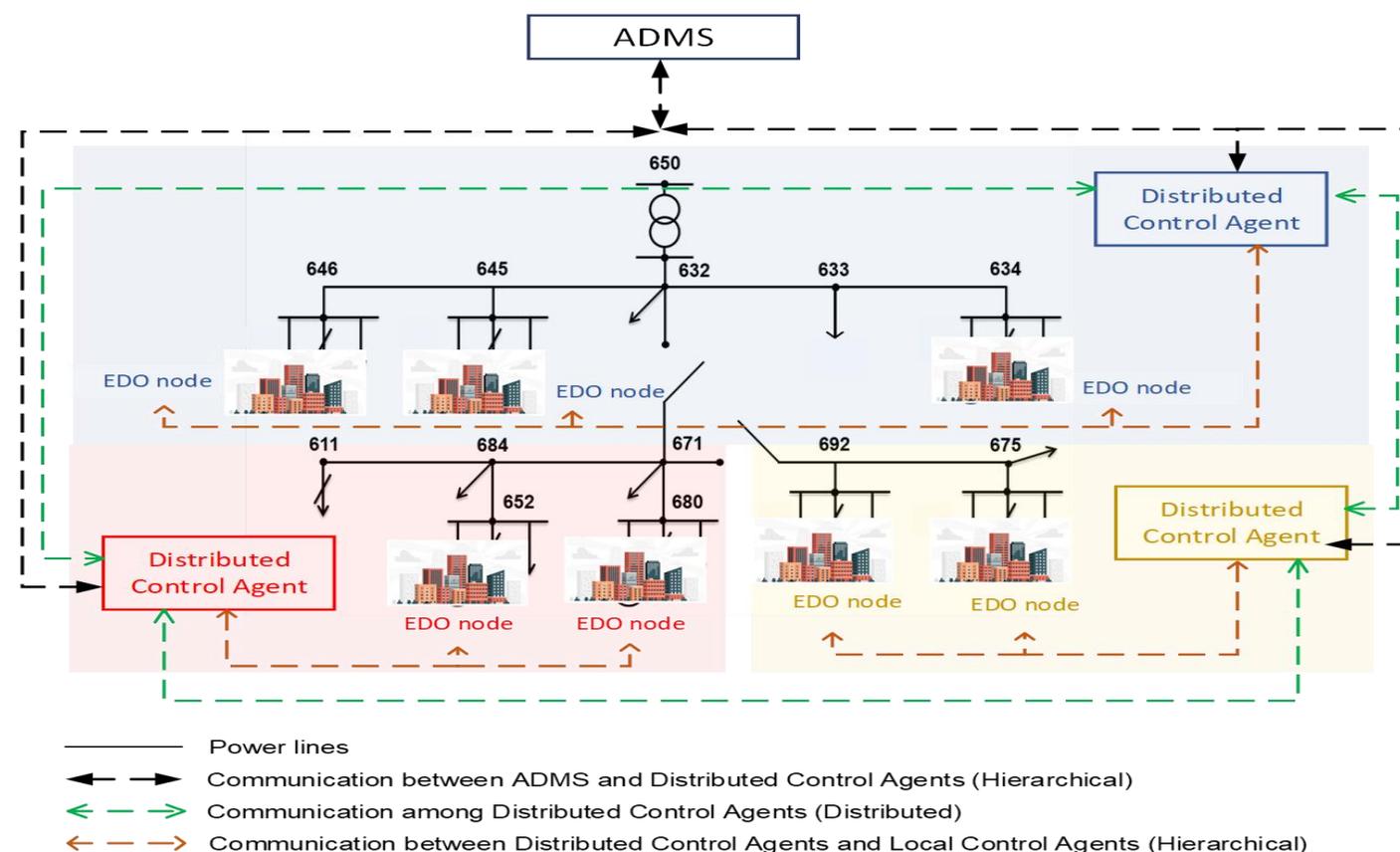
R&D Area 2: Power Electronics Influence on Power Systems

- Power electronics plays a vital role in power systems across generation, transmission, distribution, and loads

- Power electronics changes the physics of power systems, bringing new challenges and opportunities

Nuclear Plants

Fossil Fuel Plants

Energy Storage Plants

Hydro Power Plants

Transmission + Distribution

Solar and wind Plants

Industrial Loads

Microgrids and DERs

Data Centers

HVDC/FACTS

Electric Vehicles

R&D Area 2: Power Electronics Influence on Power Systems

Research Focus

- Develop advanced *modeling capability* and *analytical approaches* to investigate the stability and reliability of power grids with a high penetration of power electronics

Key Topics

- New stability theories to understand the new dynamics caused by power electronics
- Innovative electromagnetic transient (EMT) modeling for power electronics
- Integrated power electronics control and system protection co-design
- Data center and inverter stability and reliability impact analysis

Key Personnel

- PNNL: Wei Du, Quan Nguyen, Jim Follum, Marcelo Elizondo
- WSU: Mani Venkatasubramanian, Saeed Lotfifard, and new hires

Target Sponsors

- DOE (OE, SETO, WETO), NSF (EPCN)

AGI ADVANCED GRID INSTITUTE

- Driven by the AI technology, the size of power-electronics-based data centers can reach hundreds of megawatts, or even thousands of megawatts, and the power oscillations can reach 5-30 Hz when training the AI models
- This new type of loads brings challenges to the power grid, and innovations in power electronics technologies are needed to mitigate their impact
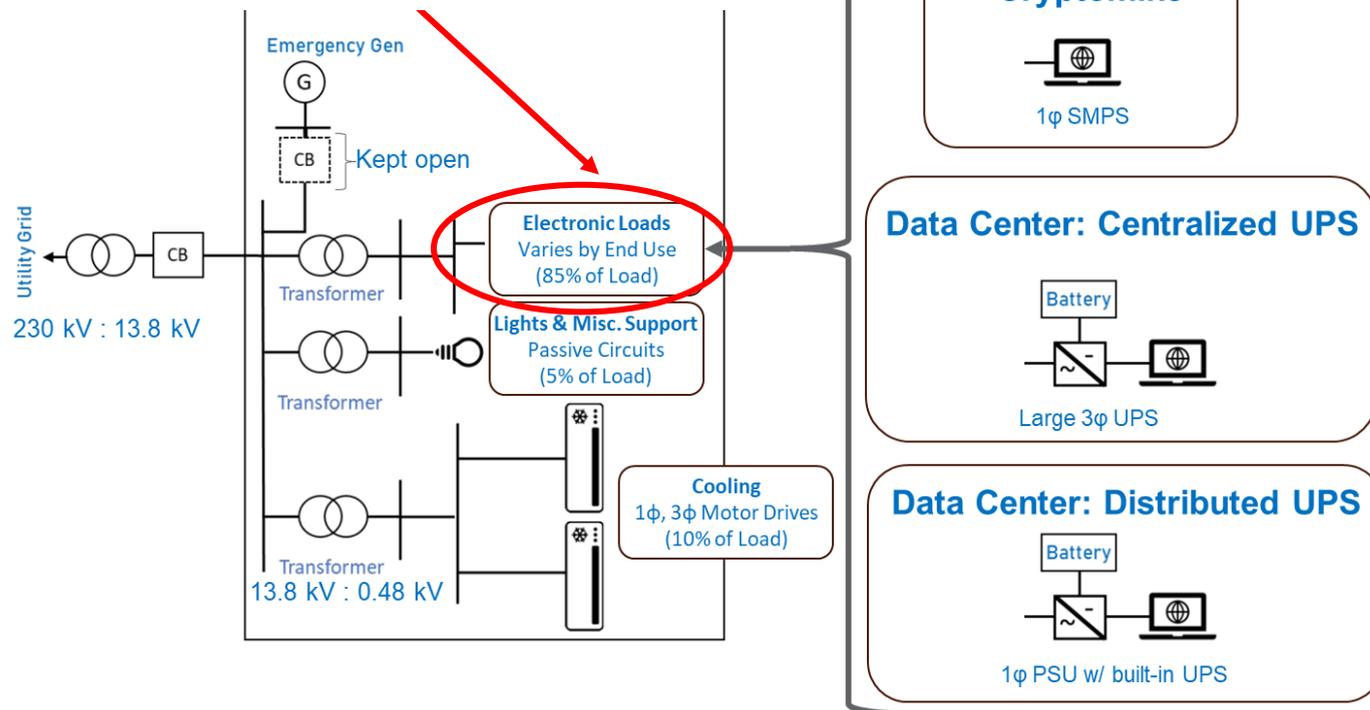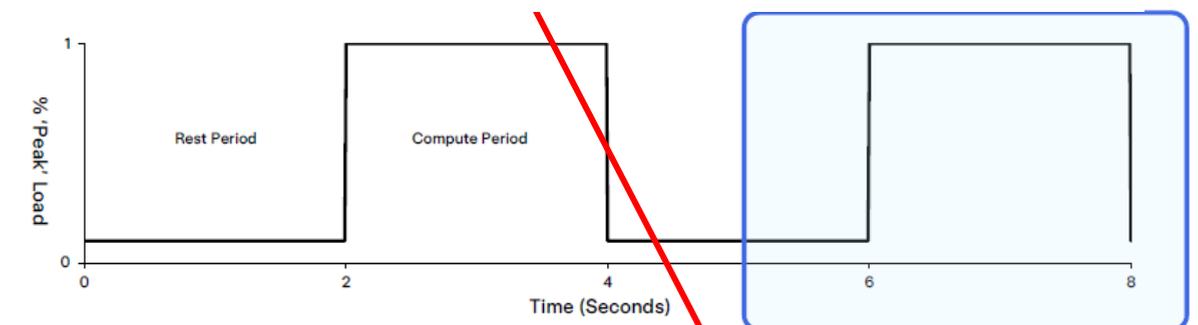
85% loads are power-electronics-based

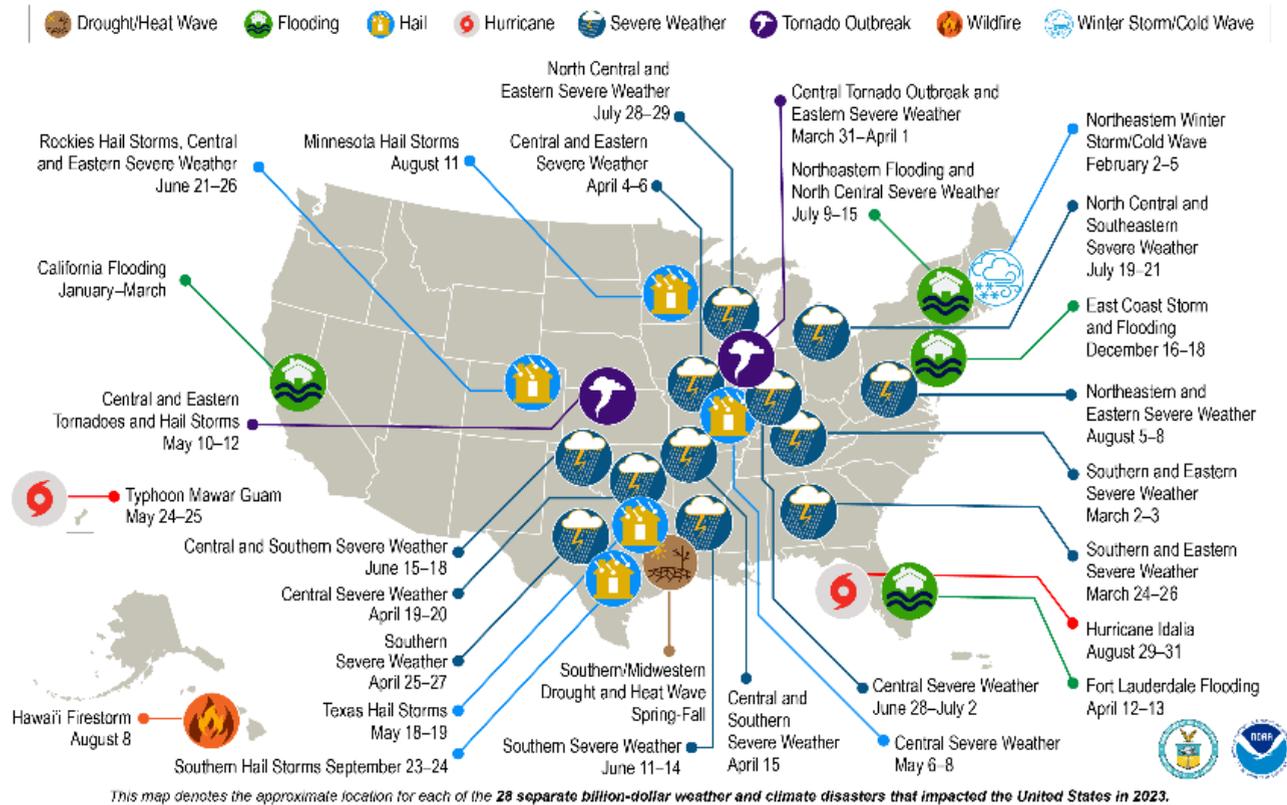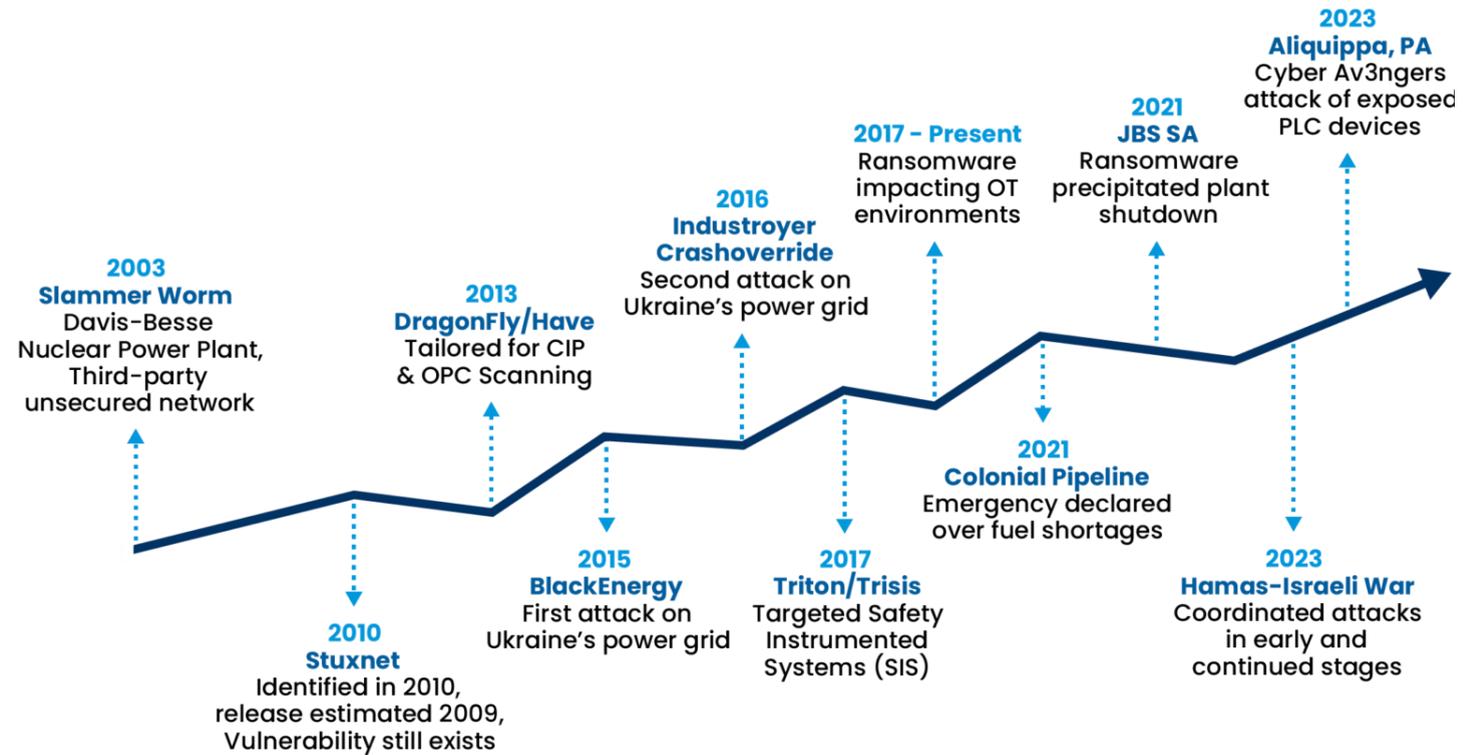**① Power oscillations can reach 5-30 Hz**

Image Credit: Brett Ross
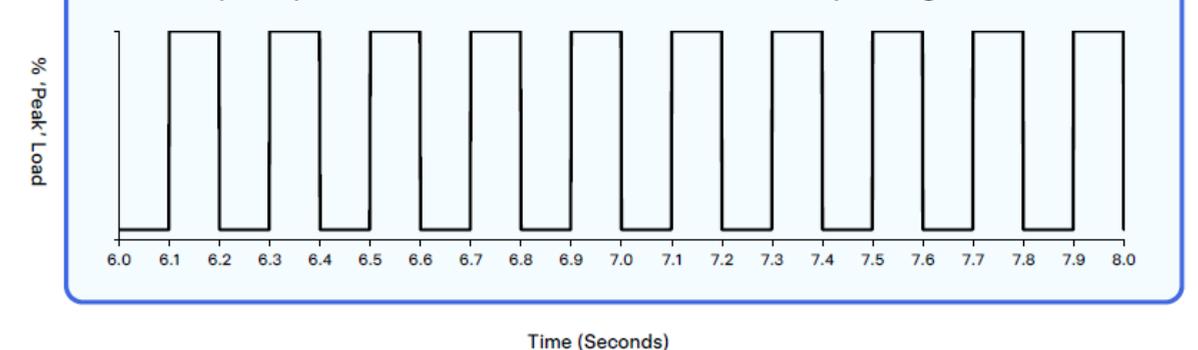
Image Credit: Tesla Energy

R&D Area 3:Grid Resilience to All Hazard Threats

28 separate billion-dollar weather-related disasters in 2023 [1]

Power Grid Cyber-Resiliency: increasingly more sophisticated attacks [2]

In 2024, Check Point Research documented 1,162 cyberattacks on utilities, a 70 percent increase compared with the same period in the prior year. [3]

[1] *Billion-Dollar Weather and Climate Disasters, Apr. 1, 2024 [Online]. Available at: https://www.ncdc.noaa.gov/billions/

[2] https://blueridgenetworks.com/ot-security-when-the-cure-is-worse-than-the-disease/

[3] https://klrd.gov/2024/12/18/grid-security/

R&D Area 3:Grid Resilience to All Hazard Threats

Research Focus

- Develop **grid-impact models** to understand the effects of cyber and natural threats on the power grid resilience and solutions for **secure grid operations**

Key Topics

- Hazard-Grid Impact Models and Risk Assessment
- Actionable Solutions to enhance Grid Resilience
- Attention to Grid Investment Decisions and Affordability

Key Personnel

- PNNL: David Manz, David Judi, Nathalie Voisin
- WSU: Anamika Dubey, Noel Schulz, Ji Yun Lee, Monowar Hasan

Target Sponsors

- NSF (CLIMA, CHIRP), DOE (CESER)

DOE Resilience Center EARNEST

- Led by Stanford
- Equitable solutions for energy resilience
- $20M total funding. WSU funding at $2M, PNNL funding at $1M
- Close collaboration between WSU, PNNL, Avista, and regional Tribes.

Equitable, Affordable & Resilient Nationwide Energy System Transition
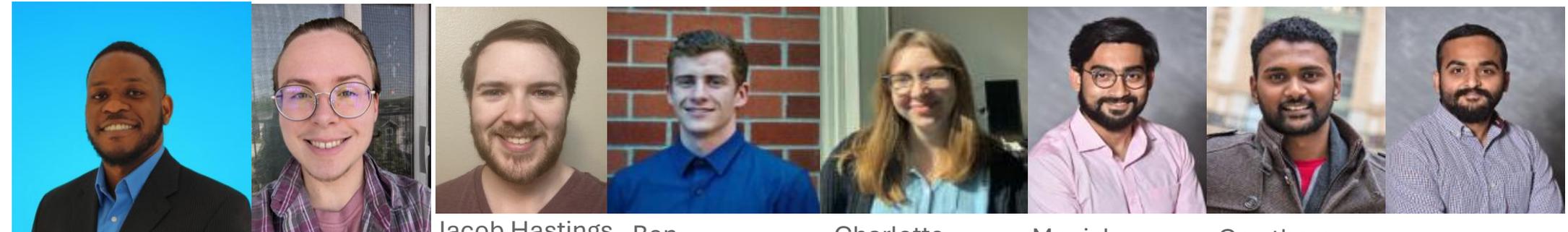
AGI Ecosystem

AGI Industry Advisory Board

- Eleanor Ewry | Supervisor Strategic System Planning | Puget Sound Energy
- Nicole Rutherford | Chief Technology Innovation and Strategy Officer | Bonneville Power Administration
- Greg Zweigle |Chief Technology Officer | Schweitzer Engineering Laboratories
- Mike Diedesch | Avista Grid Innovation Lab Manager | Avista
- Uzma Siddiqi | Sr. Manager of Grid Modernization and Strategic Technology | Seattle City Light
- Larry Bekkedahl | Senior Vice President, Advanced Energy Delivery | Portland General Electric
- William Rambo| Director of Technology at POWER Engineers
- Mark Lauby| Senior Vice President and Chief Engineer at North American Electric Reliability Corporation (NERC)
- Avnaesh Jayantilal| Chief Technology Officer Grid Innovation at GE Vernova

AGI Ecosystem
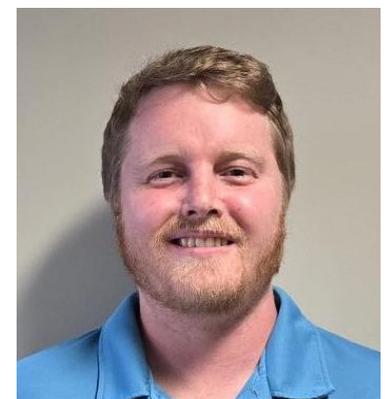
AGI Supporting Team

Jesenia Hernandez, PNNL

Karla Grimaldo PNNL

Krause, Ginger PNNL

Jake Baumgartner, WSU

Joseph Franklin, WSU

Jeannine Burke, WSU

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Thank you for your support of AGI!

Advanced Grid Institute

https://natlab.wsu.edu/grid/

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