GridWise Alliance Technology Council Meeting Agenda
Exascale for Grid Use
November 29, 2023 @ 3:00 PM ET

I.	Welcome & Antitrust Guidelines	**Josh Steinhardt**, Operations Director
II.	Presentation on Exascale for Grid Use	**Shri Abhyankar,** Senior Scientist, Pacific Northwest National Laboratory
III.	Questions and Discussion	**All**

GridWise Alliance
Antitrust Compliance Program Guidelines

It is the policy of the GridWise Alliance to comply fully with the antitrust laws. The Sherman Act and other applicable antitrust laws are intended to promote vigorous and fair competition and to combat various restraints of trade.

Each person who participates in GridWise Alliance activities has a responsibility to his/her employers and to the GridWise Alliance to avoid any improper conduct from an antitrust standpoint. The following guidelines will assist in meeting this responsibility:

1. GridWise Alliance meetings and discussions generally cover topics related to the generation, transmission and distribution of electricity. Should related discussions ever have any potential for competitive impact, all due care shall be taken to avoid such discussion between competitors.

2. In view of antitrust considerations and to avoid any possible restraints on competition, the following legally sensitive subjects must be avoided during any discussion between competitors:

(a) Future marketing plans of individual competitors should not be discussed between competitors;

(b) Any complaints or business plans relating to specific customers, specific suppliers, specific geographic markets or specific products, should not be discussed between competitors;

(c) Purchasing plans or bidding plans of companies in competition should not be discussed (except privately between two parties with a vertical commercial relationship such as supplier and customer); and

(d) Current and future price information and pricing plans, bidding plans, refund or rebate plans, discount plans, credit plans, specific product costs, profit margin information and terms of sale should not be discussed between competitors. All of the above are elements of competition.

3. Any question regarding the legality of a discussion topic or business practice should be brought to the attention of the GridWise Alliance legal counsel or a company's individual legal counsel for advice.

Exascale for Grid Use

November 29, 2023

Shrirang Abhyankar, Chris Oehmen

Pacific Northwest National Laboratory

# Future Grid: Bigger, Cleaner, Reliable, but with increased uncertainty

**Renewable Projections**
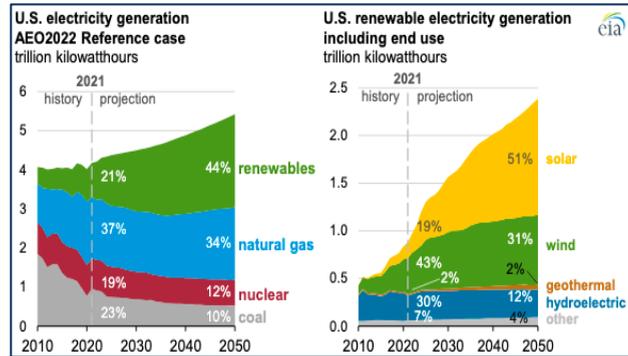
Electric Vehicles
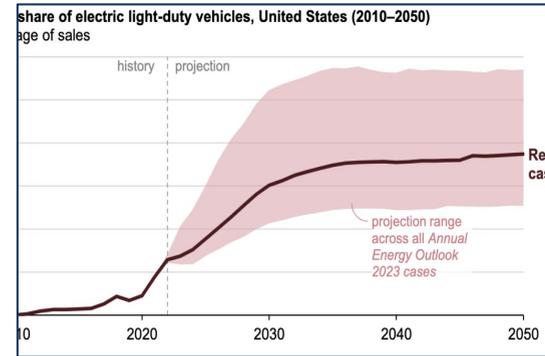
Increase in disruptions
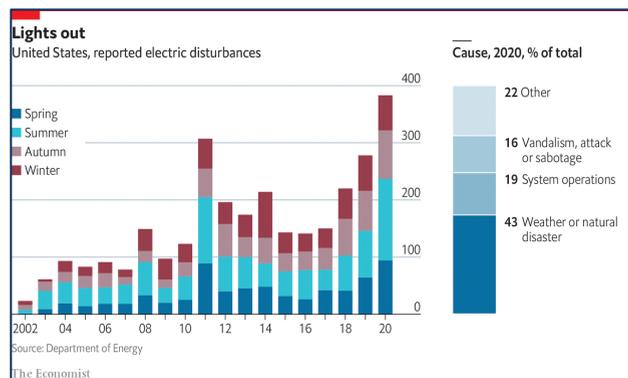
EV charging
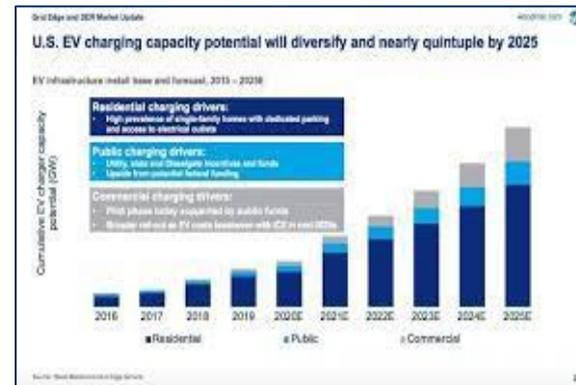
CAISO Net load "Duck" curve
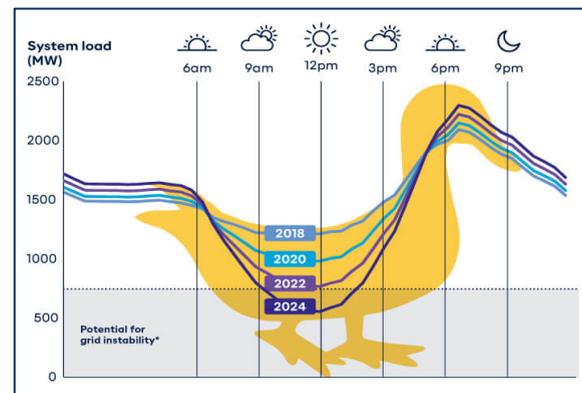
- Future grid brings promise of cheaper, reliable, cleaner, equitable electricity for all.
- Need to manage increased uncertainty from weather, renewable generation, and computer age revolution.
- Grid has evolved significantly, become bigger, more complex.
- We are developing a unique capability for regional-scale grid analysis that can:
  - Handle very large number of uncertainty scenarios
  - Concurrently address grid security concerns
  - Advanced computation

Outline

?	What is Exascale?
⚙	Exascale Grid Optimization (ExaGO) Toolkit
🕙	ExaGO performance
👁	Visualization using large-language models

What is Exascale?

THE DAWN OF GPU-ACCELERATED EXASCALE
MAJOR LEAPS IN PERFORMANCE DRIVING THREE PHASES OF SUPERCOMPUTING
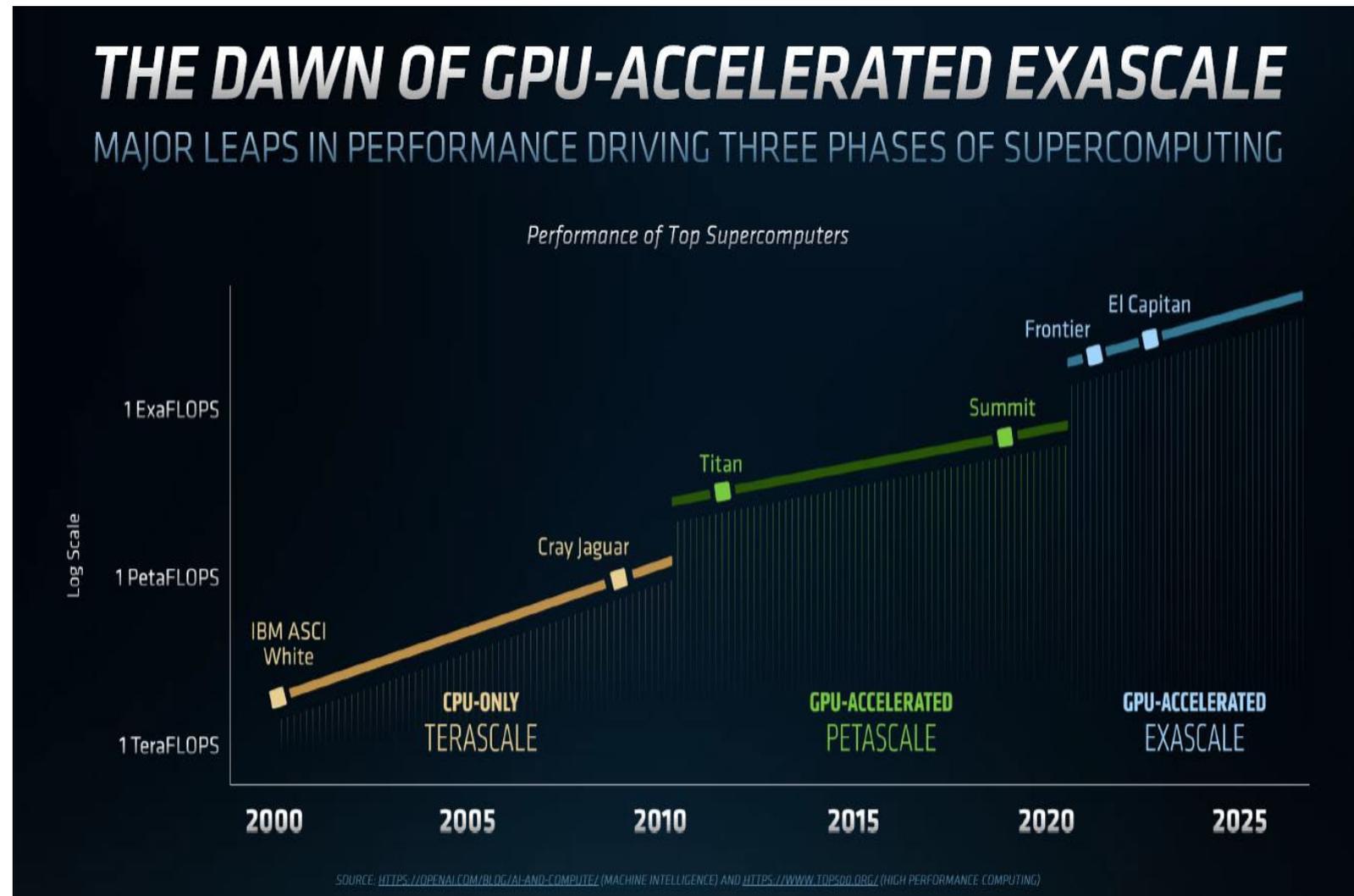
- 10^18 (1 quintillion or billion billions) calculations per second (FLOPS)
- Current frontier in computing
- GPU-based acceleration

Exascale Computing Initiative

- DOE Office of Science + NNSA

- 35 software projects + 8 hardware projects

- Vendors: AMD, NViDia, Intel, ..

- Application projects:
  - Cancer research, Mini-reactor design, urban planning, high-energy physics,plasma physics, **electric grid,** wind plant flow, combustion engine design, …

- https://www.exascaleprect.org/

Frontier Supercomputer at Oak Ridge National Laboratory

Exascale Stochastic Grid Dynamics (ExaSGD) project

Challenge problem:
Emergency planning of
assets for extreme events

https://www.exascaleproject.org/research-project/exasgd/
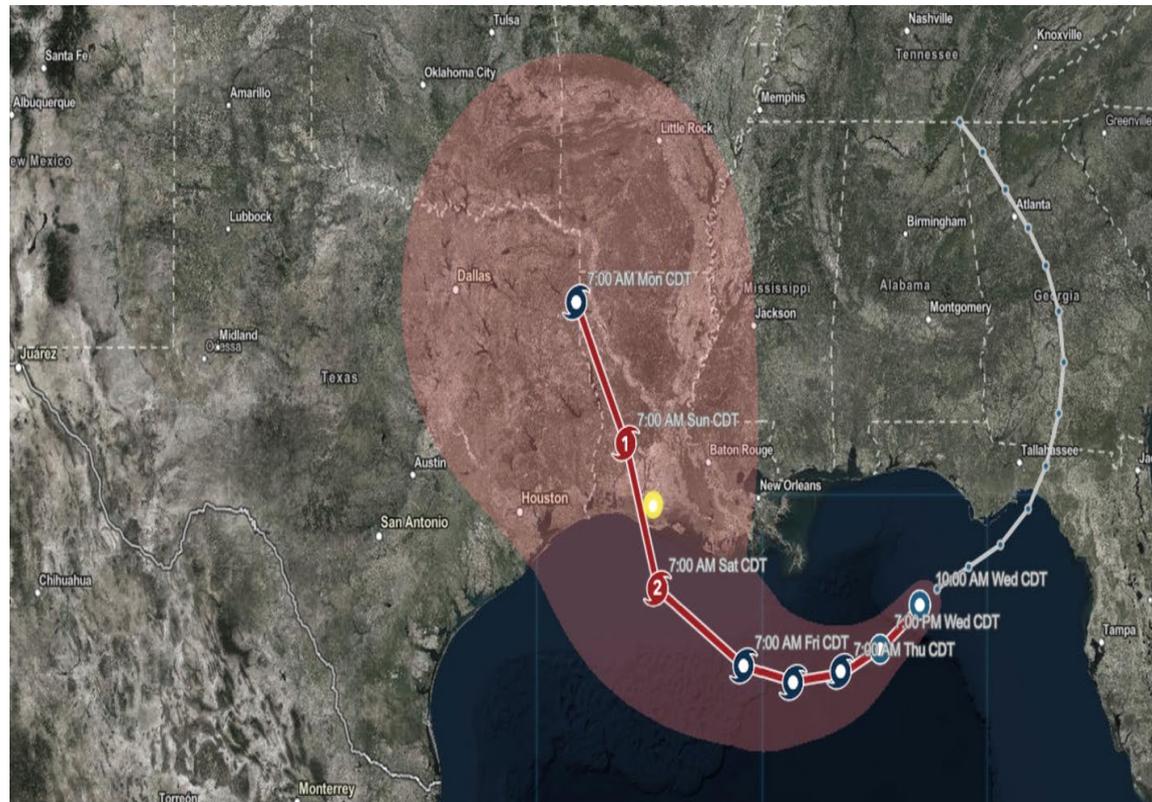
- Regional-scale nodal-level planning
- Ability to assess thousands of scenarios in quick time
- Concurrently adhere to voltage and reactive power concerns
- Integrate best-in-class computational advancements
- Usable from laptop to supercomputers to cloud

Exascale Grid Optimization (ExaGO) Toolkit

ExaGO is a state-of-the-art high-performance tool for large-scale decision making under uncertainties
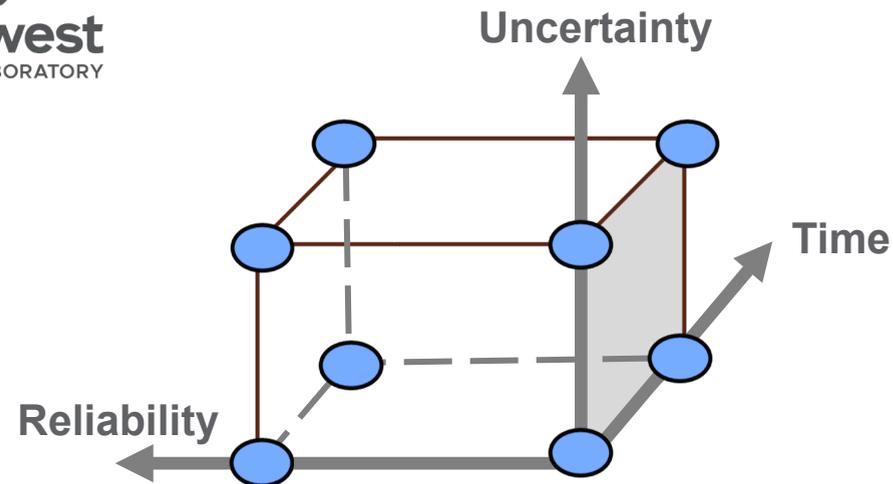
- Open-source software tool for large-scale decision making under uncertainty for
  - Renewable integration (uncertainty)
  - Security and vulnerability (reliability)
  - Scheduling (time)
- Advanced optimization for inter-regional planning with voltage security, reactive power concerns
- Laptops to Supercomputers

https://github.com/pnnl/ExaGO

ExaGO Capabilities

Problem composability

Uncertainty · Time · Security

Application and Solvers

OPF	Multiperiod OPF	SCOPF	Stochastic OPF	
OPFLOW	TCOPFLOW	SCOPFLOW	SOPFLOW	Applications
ExaGO				
HiOp	Ipopt		TAO	Solver
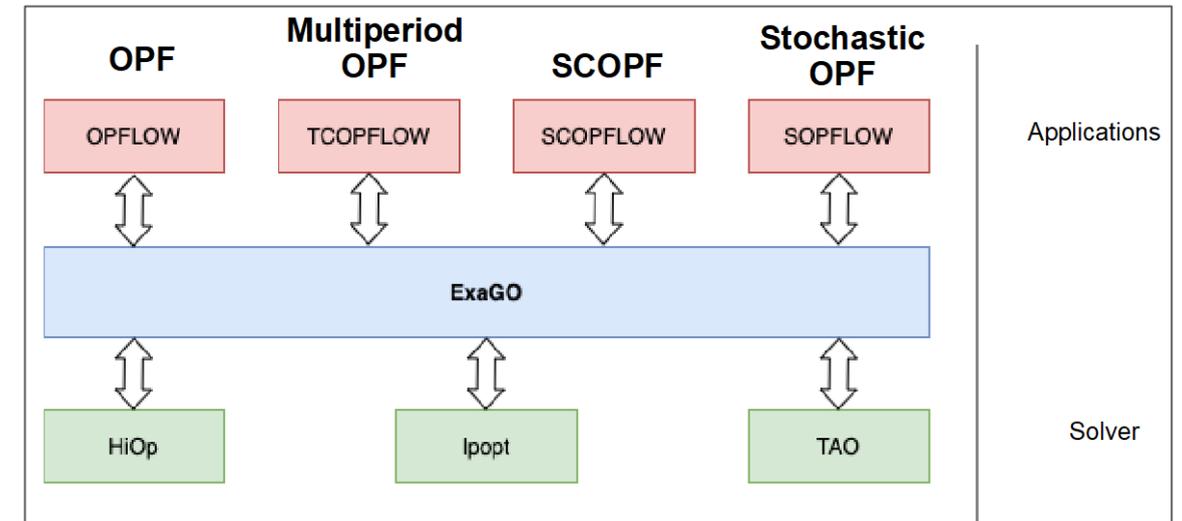
Detailed ACOPF modeling

- Line flow limits
- Voltage limits
- Bus power balance
- Quadratic costs

- PV/PQ switching
- Automatic governor control
- Ramp up/down signals
- Multi-objective
- Initialization

Standard ACOPF · Advanced · Future · Feasibility

- Storage
- Reserves
- Flexible demand
- Piecewise costs
- PSSE input
- Soft constraint limits

- Load curtailment
- Bus power imbalance
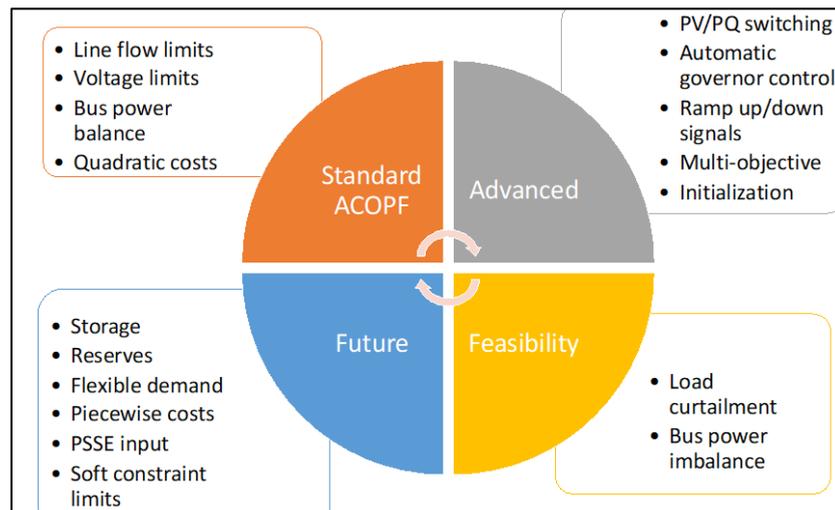
Distributed algorithms

GPU implementation
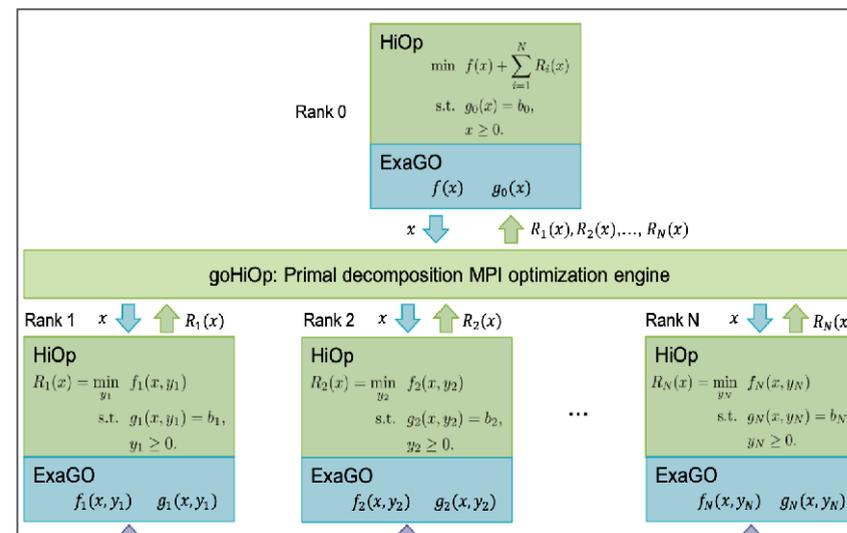
CPU-GPU implementation
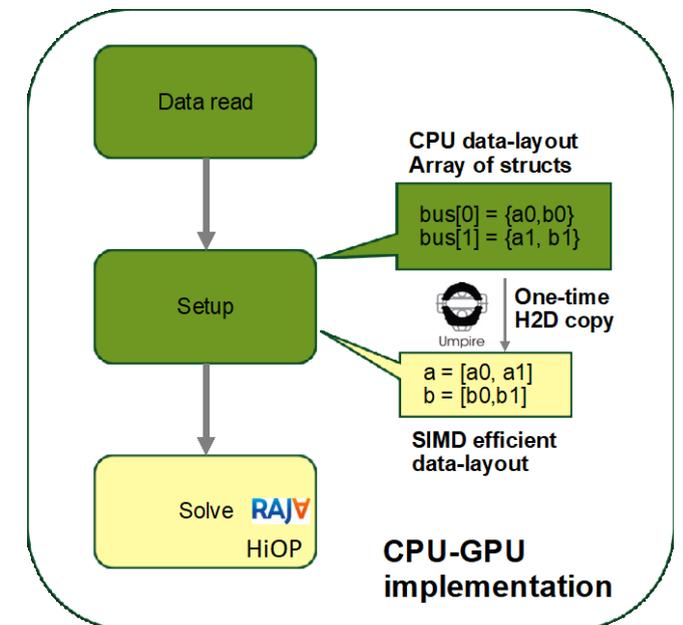
From small to big (2020 – 2022)

Illinois FY20

N-1 contingency Constrained ACOPF

s_0 → s_1, s_2, s_3

Texas FY21
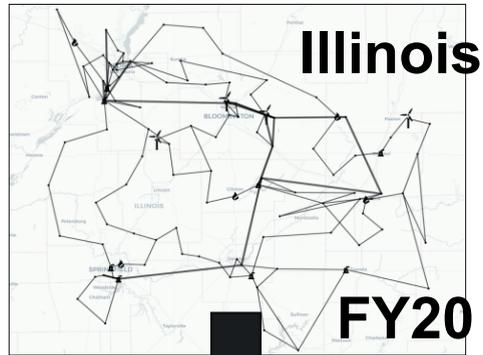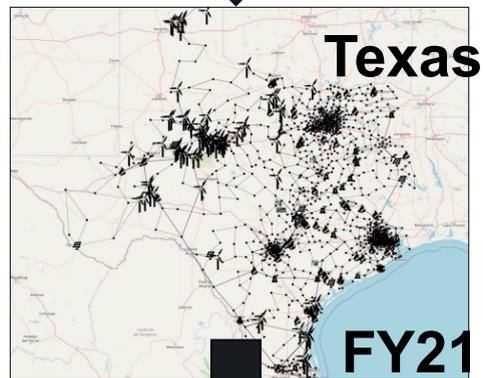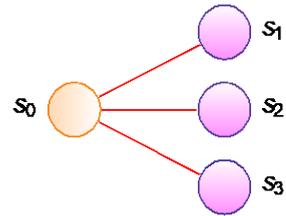
N-1 contingency Constrained ACOPF + Wind generation uncertainty

s_0 → $s_0 c_1$, $s_0 c_2$
s_1 → $s_0 c_1$, $s_0 c_2$

Western Interconnect FY22
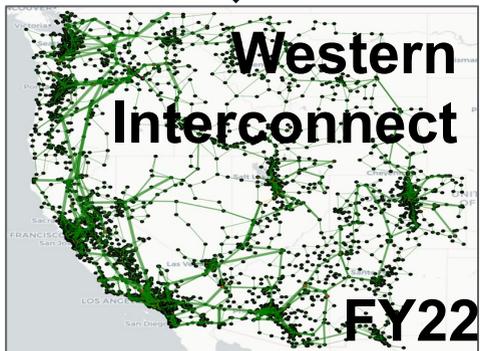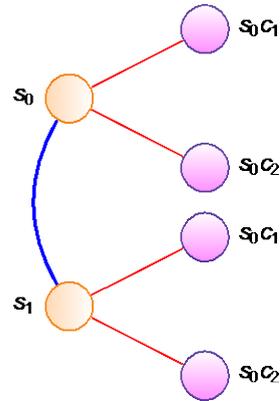
Summit Supercomputer @ ORNL

- 10,000 scenarios
- 2000 nodes
- 12,000 NVIDIA GPUs

Crusher
Pre-exascale machine

- 1,000 scenarios
- 128 nodes
- ~1,000 AMD GPUs

… To Exascale (2023)

US supercomputer breaks exascale barrier

14 June 2022

Share

The US Department of Energy's (DOE) Frontier supercomputer system at Oak Ridge National Laboratory (ORNL) has been ranked as the fastest computer in the world, as well as becoming the first to break the exascale performance barrier.
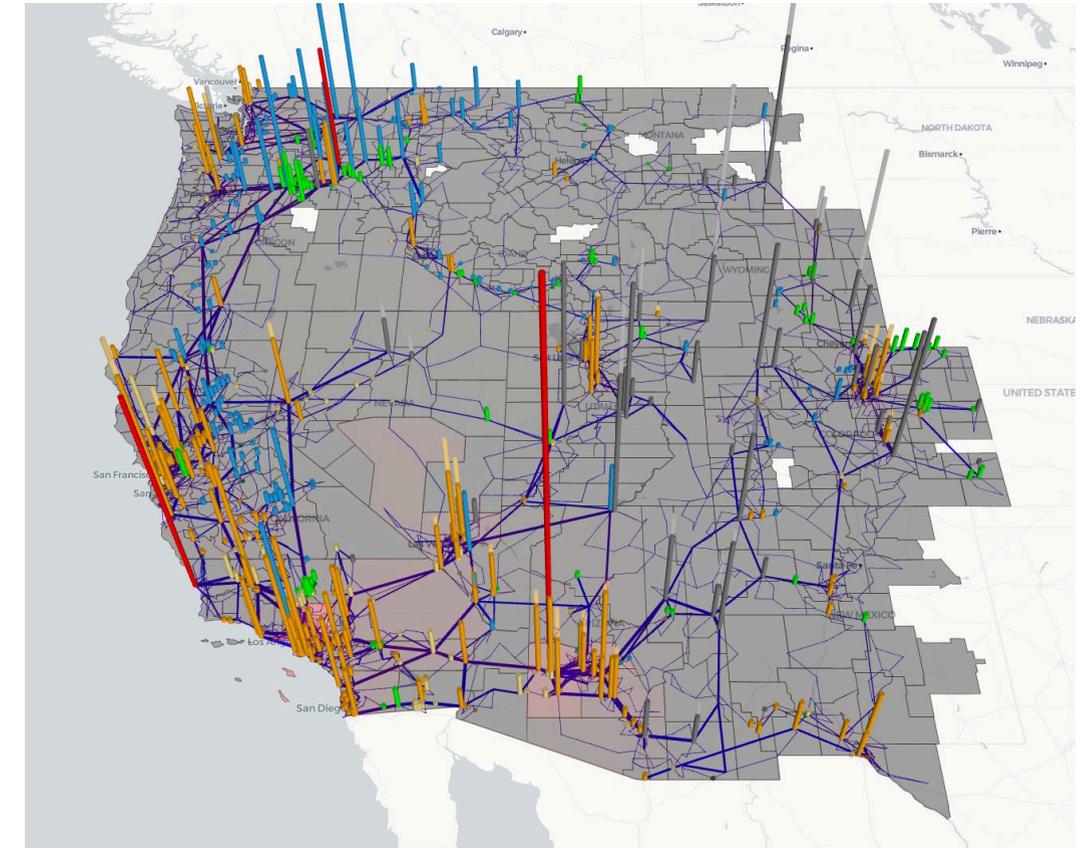

- Large-scale grid optimization (ACOPF) problem with 100,000 what-if scenarios with wind uncertainties and contingencies
- Over 7 billion variables
- Under 20 minutes execution time

ExaGO visualization

What you see is what you select

- Limited Flexibility
- Learning curve
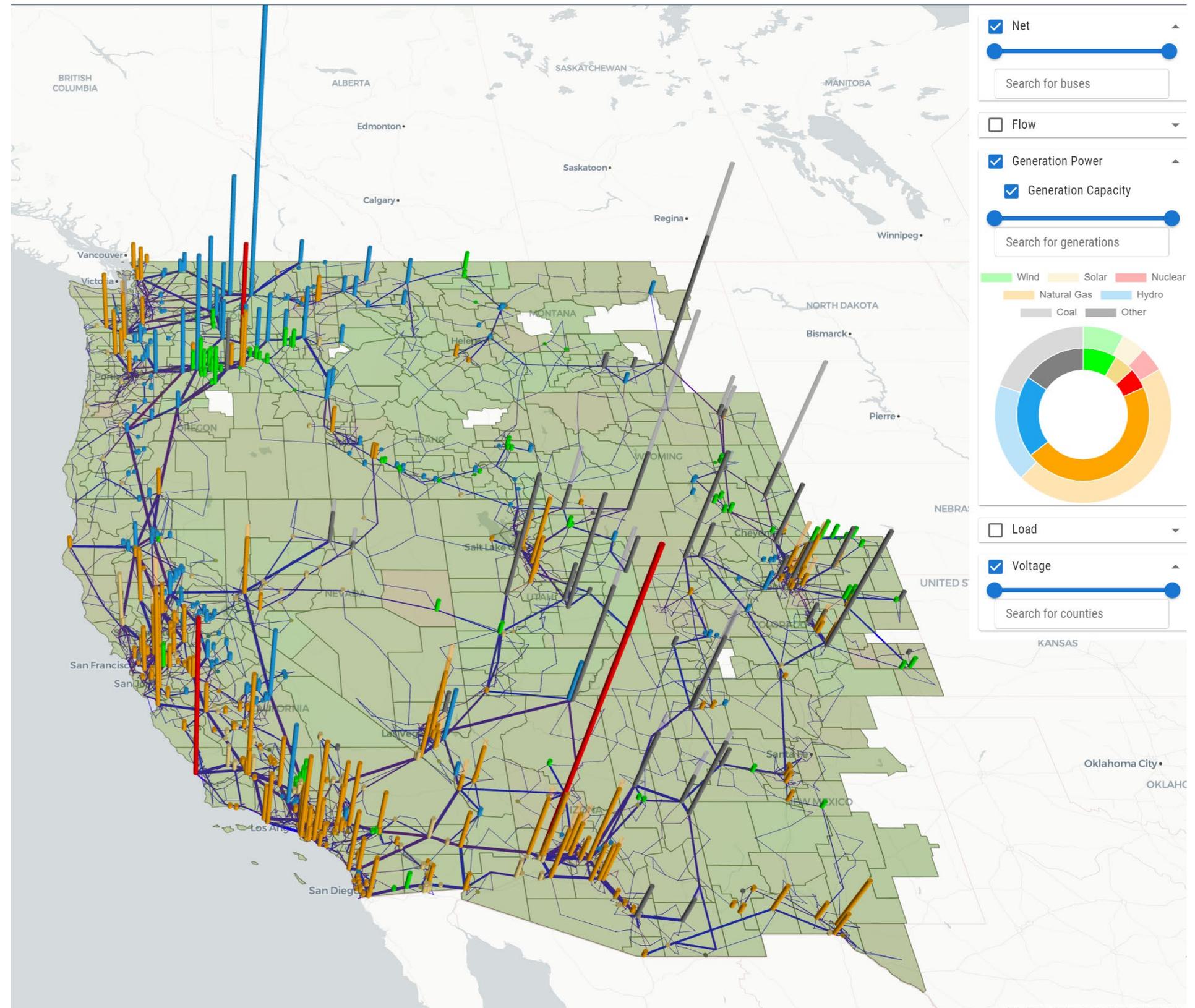
Large Language Models

- Human-computer interaction through natural language
- Ask a question, get ~~an~~ "the" answer
- Tremendous growth over last several years
- How can LLMs be used for grid analysis?

What you see is what you **ask**

- Generative AI (ChatGPT) based decision support
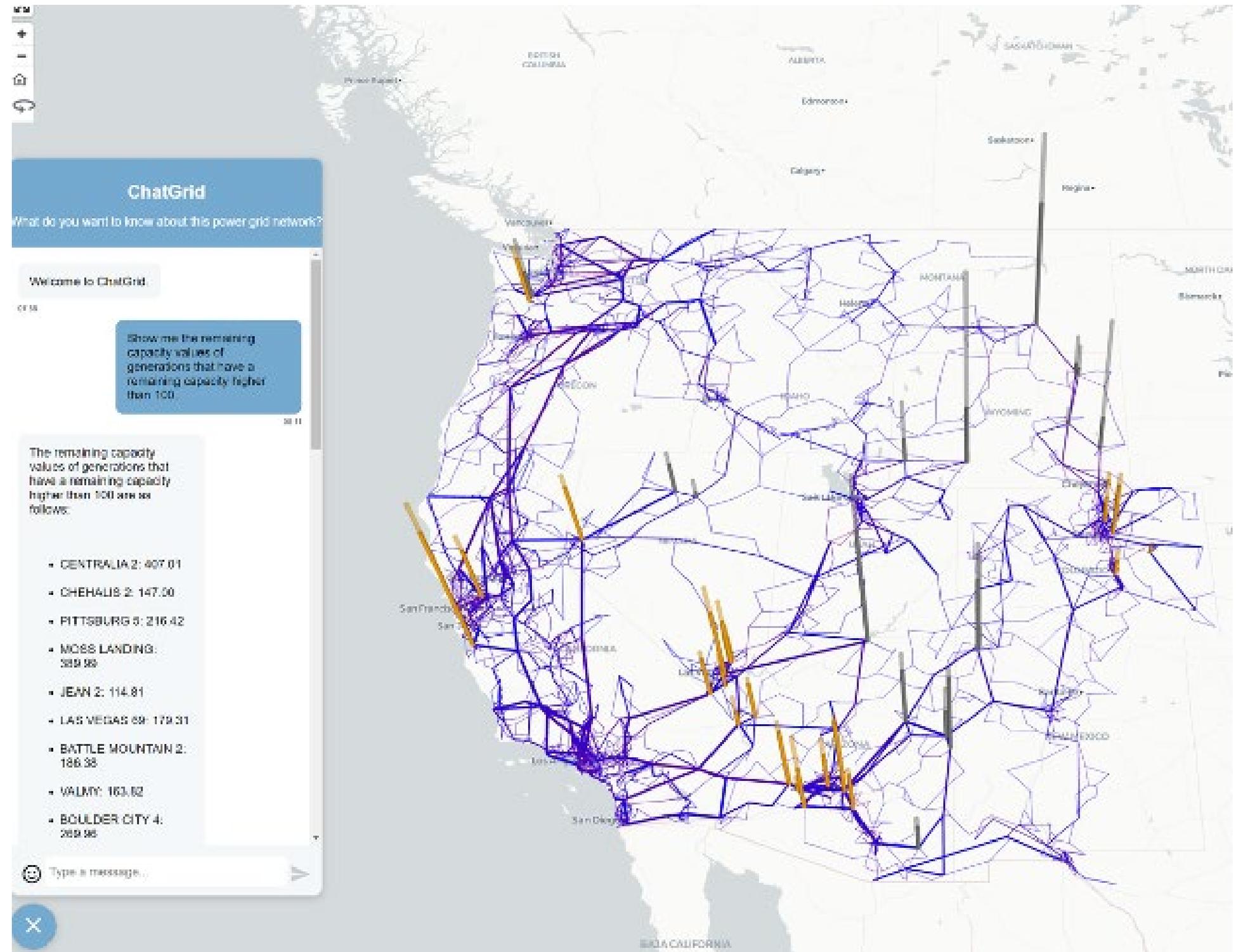
On-going/Future Activities

- Energy Earthshot Floating Offshore Wind Integration Study

- Stochastic Reliability Assessment Studies for NAERM

- Cloud deployment

- Usability

Github repository

Contact: Shri Abhyankar
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Thank you