EVERSOURCE

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Implementation of a Probabilistic Power Flow System at Eversource Energy

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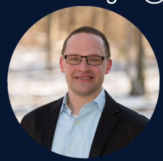

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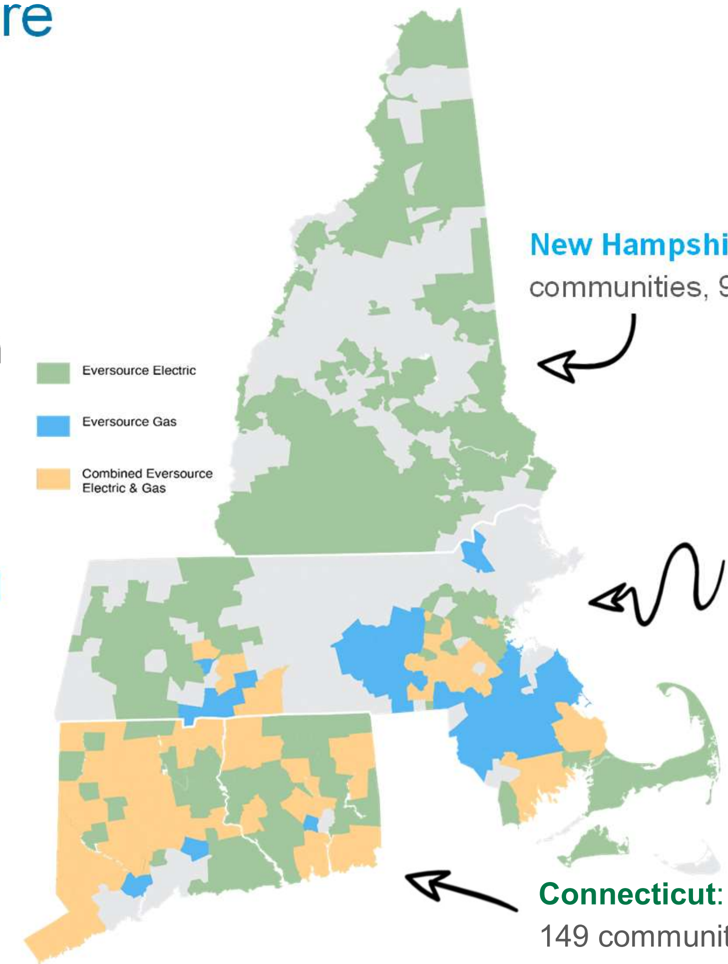
Agenda

1. Introduction
2. Purpose of the Probabilistic Load Flow (PLF) automation
3. Goals of the Probabilistic Load Flow automation
4. General flow for a PLF system
5. Synergi Solver integration in the IDE (Integrated Development Environment)
6. Scenario examples and results (visualization)
7. Project progress

Introduction – Who we are

We're New England's largest energy delivery company with **4 million customers** across 525 communities in Connecticut, Massachusetts and New Hampshire.

Eversource aims to be **carbon neutral by 2030**, and the benefits of our regional clean energy initiatives will more than offset Eversource's greenhouse gas emissions.



New Hampshire: 510,000 electric in 211 communities, 9,500 water in 3 communities.

Massachusetts: 1.4 million electric in 140 communities, 292,000 natural gas in 51 communities, 19,500 water in 5 communities.

Connecticut: 1.2 million electric in 149 communities, 232,000 natural gas in 71 communities, 198,000 water in 51 communities.

New England's Largest Energy Delivery Company

We operate more than:

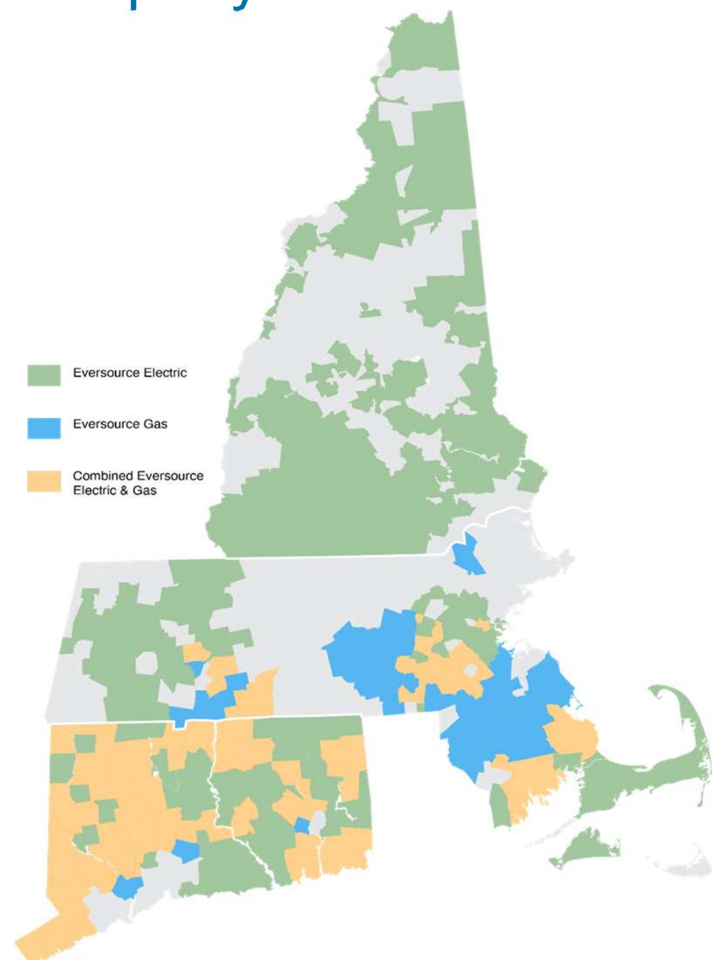
- 4,250 circuit miles of transmission lines
- 72,000 pole miles of distribution lines
- 575 substations
- 6,450 miles of natural gas distribution pipelines
- 3,600 miles of water mains across our service territory

Our customers:

- Electricity: 3.2 million customers
- Natural gas: 505,000 customers (MA and CT)
- Water: 230,000 customers

Clean Energy:

- Solar (~ 1 GW) and growing
- Offshore Wind (Oersted partnership)



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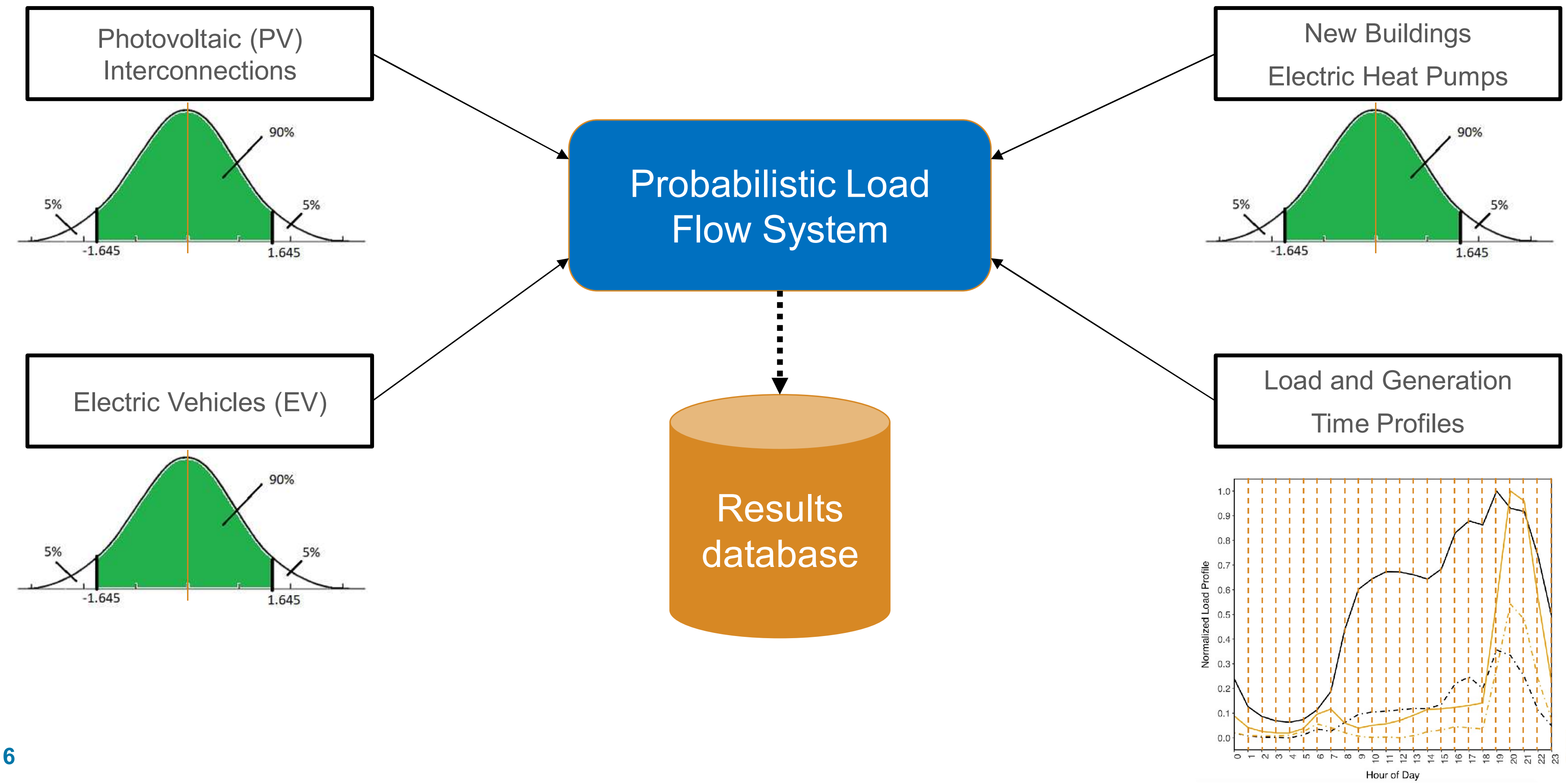
Purpose of the Probabilistic Load Flow (PLF) Automation

- Regulatory environment and oversight
  - Received funding from the MA Department of Public Utilities (DPU) to future-plan the distribution system to include significant unknowns based on forecasts for Distributed Energy Resources (DERs)
  - Electric Sector Modernization Plan (ESMP) details how to reach the DPU's established decarbonization goals
  - Planning to accommodate these additions requires significant upgrades and redesign of the integrated energy grid

Goal of the Probabilistic Load Flow (PLF) Automation

- What is Probabilistic Modeling
  - Probabilistic modeling of a power grid is a technique used to assess the reliability and performance of a power system under different operating conditions and uncertainties.
- What are the goals of the automation:
  - Ability to use probability distributions of uncertain input variables to run a Monte Carlo or alternative distribution simulation, modeling on a **large scale**, in a probabilistic load flow model.
  - The technical capabilities to evaluate the results using advanced data analytics, data visualization and decision-making processes.

Uncertainties in the electric distribution grid

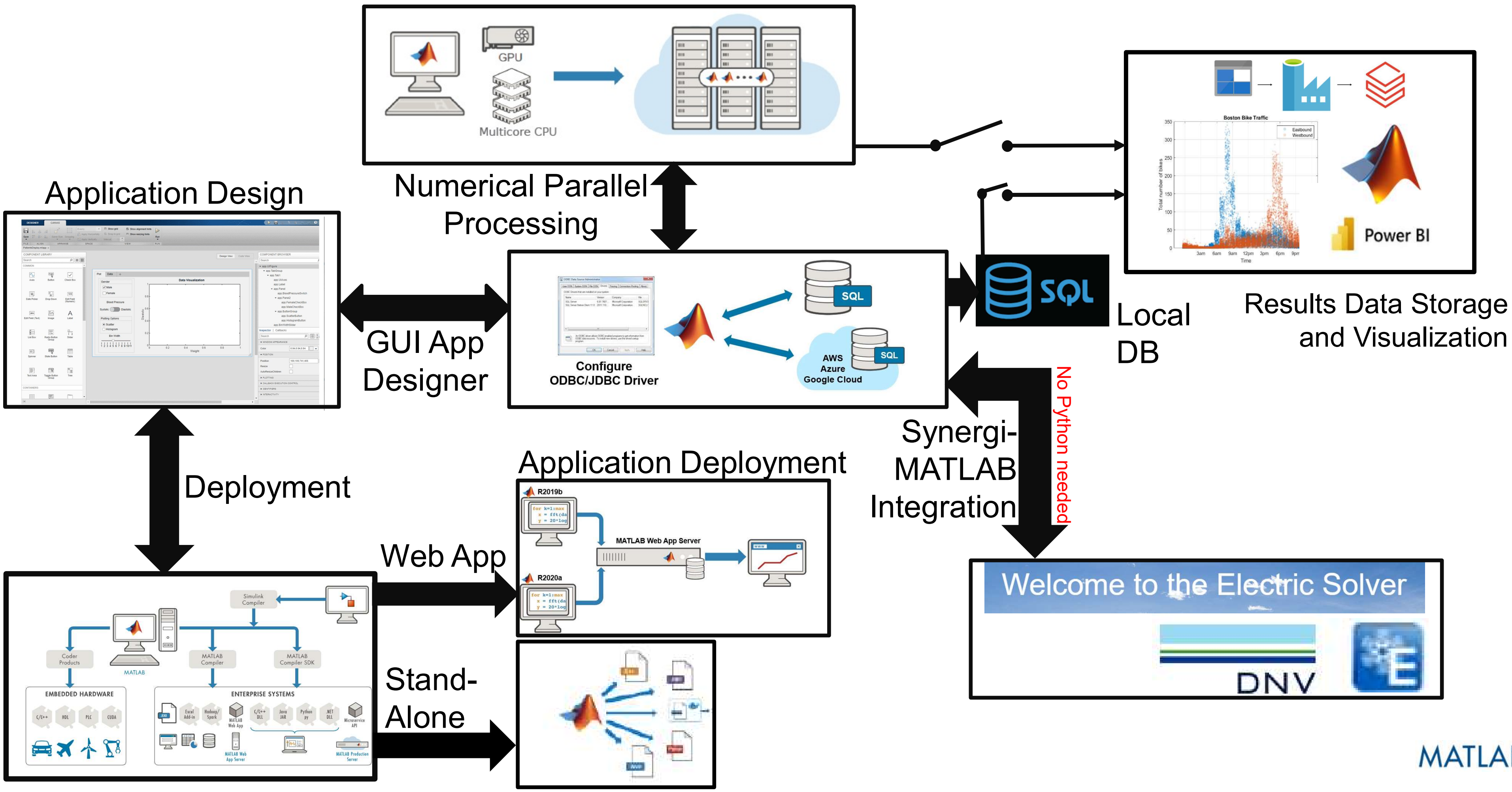


What base variables need to be probabilistically considered

- Photovoltaic (PV) Installations
    - By location
    - Size [kW]
    - Time-based irradiance profiles (8760 profiles)

- Electric Vehicle (EV)
    - By location
    - Installed charger size [kW]
    - Time-based travel patterns

Integrated Development Environment



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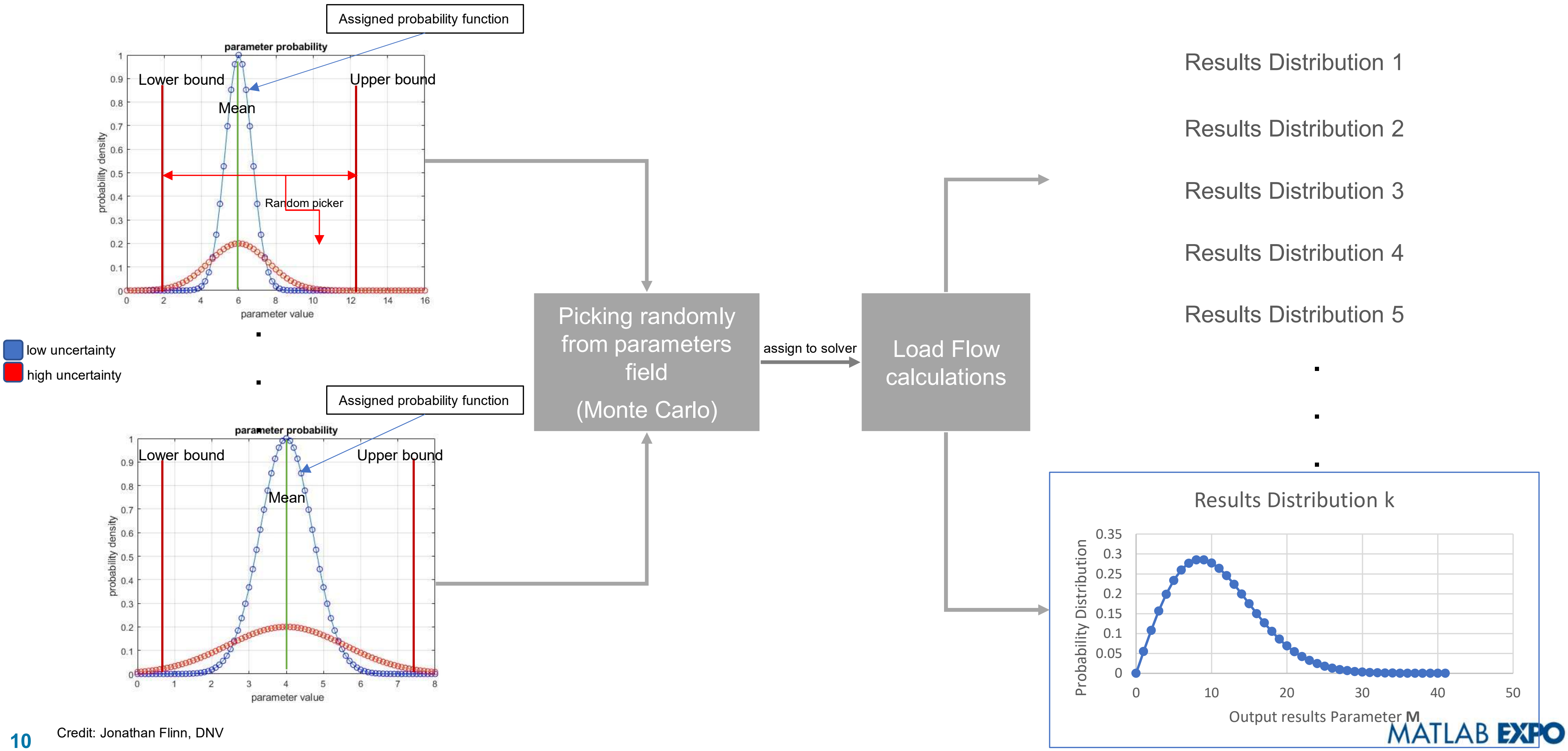
Hardware system supporting Probabilistic Load Flow

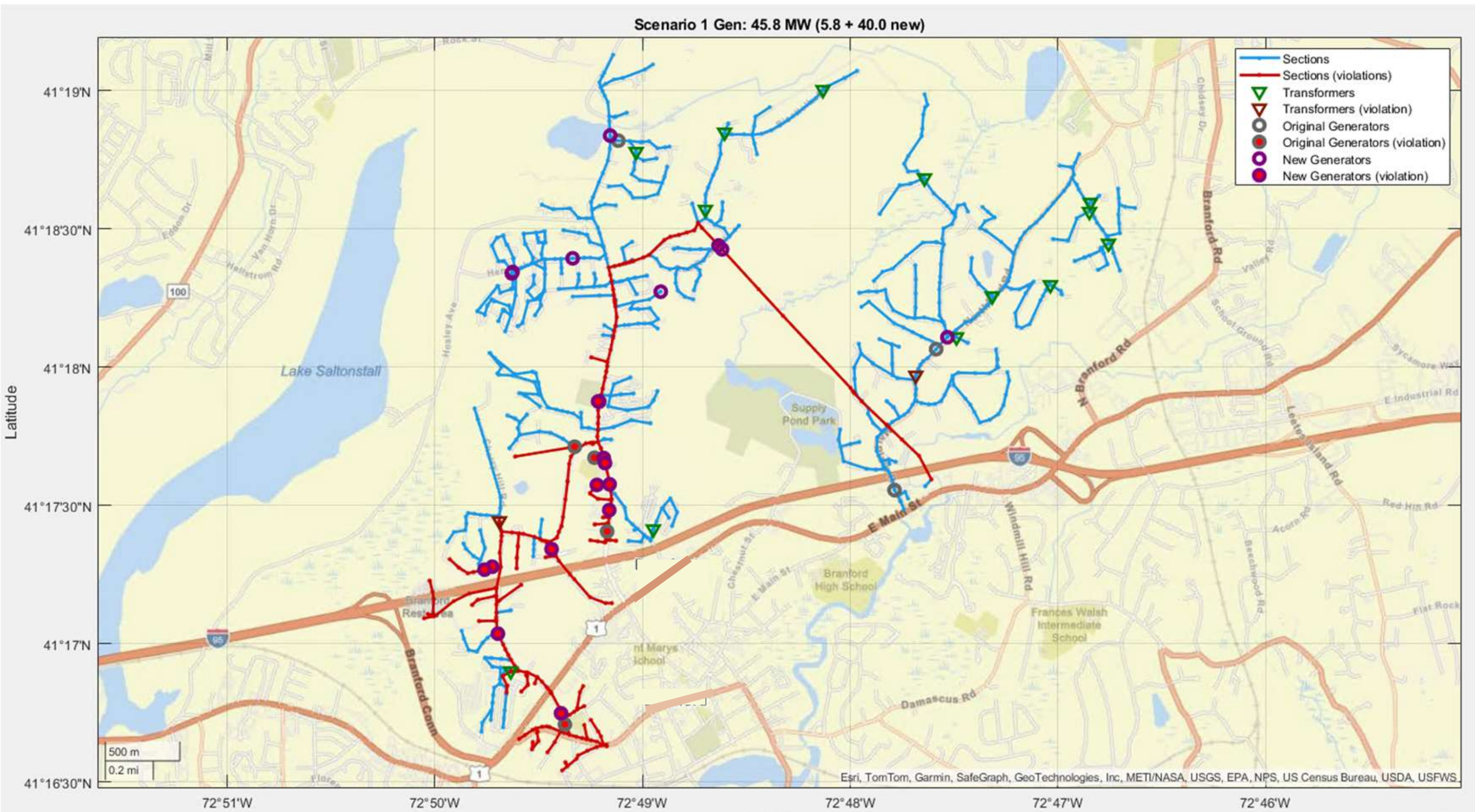
- Power Flow Calculations ($10^5 – 10^6$)
- Processing of electrical power flows scenarios
- Synergi Solver 6.27 (64-bit)
- It is critical to **parallelize** the processing of large numbers of electrical power flow scenarios.
- The MATLAB Parallel Computing Toolbox allows the **Synergi Power Flow Solver (COM)** to be parallelized into multiple individual instances.
- The Probabilistic Load Flow project is supported with two computational processing machines, each having the following properties:
  - 16 TB of Solid Stage Hard drives
  - 512 GB of RAM
  - CPUs: 2x Intel Xeon Gold 6448Y (64 cores total)
  - GPUs: 4 x NVIDIA RTX A6000
- **All grid models for one State can be processed in 80 seconds**

Probabilistic parameter variations



Credit: Jonathan Flinn, DNV

Probabilistically moving of Load and Generation



Random Section assignment for:

- ❑ Location
- ❑ Size [kW]

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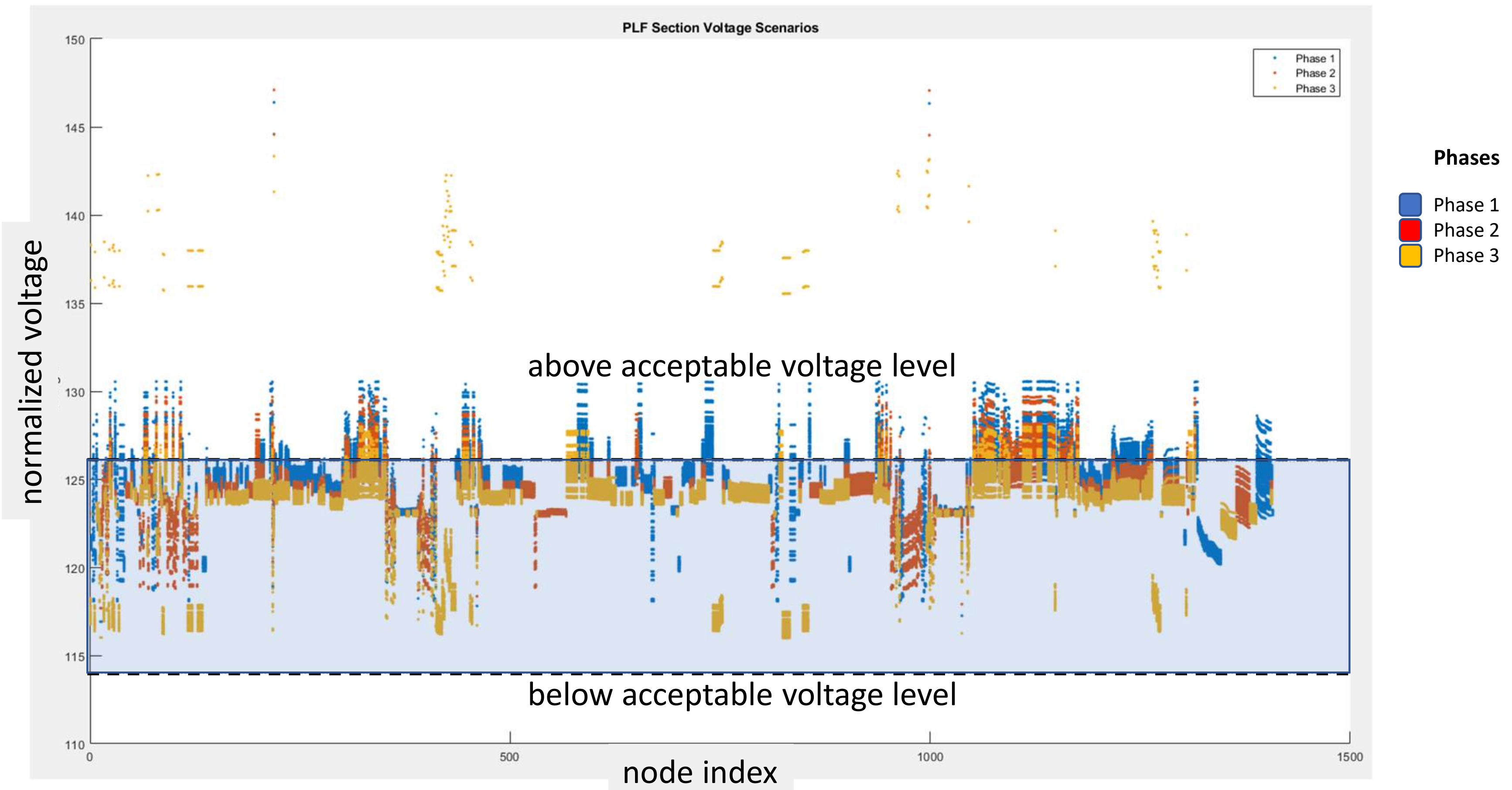
Voltage and Load violations

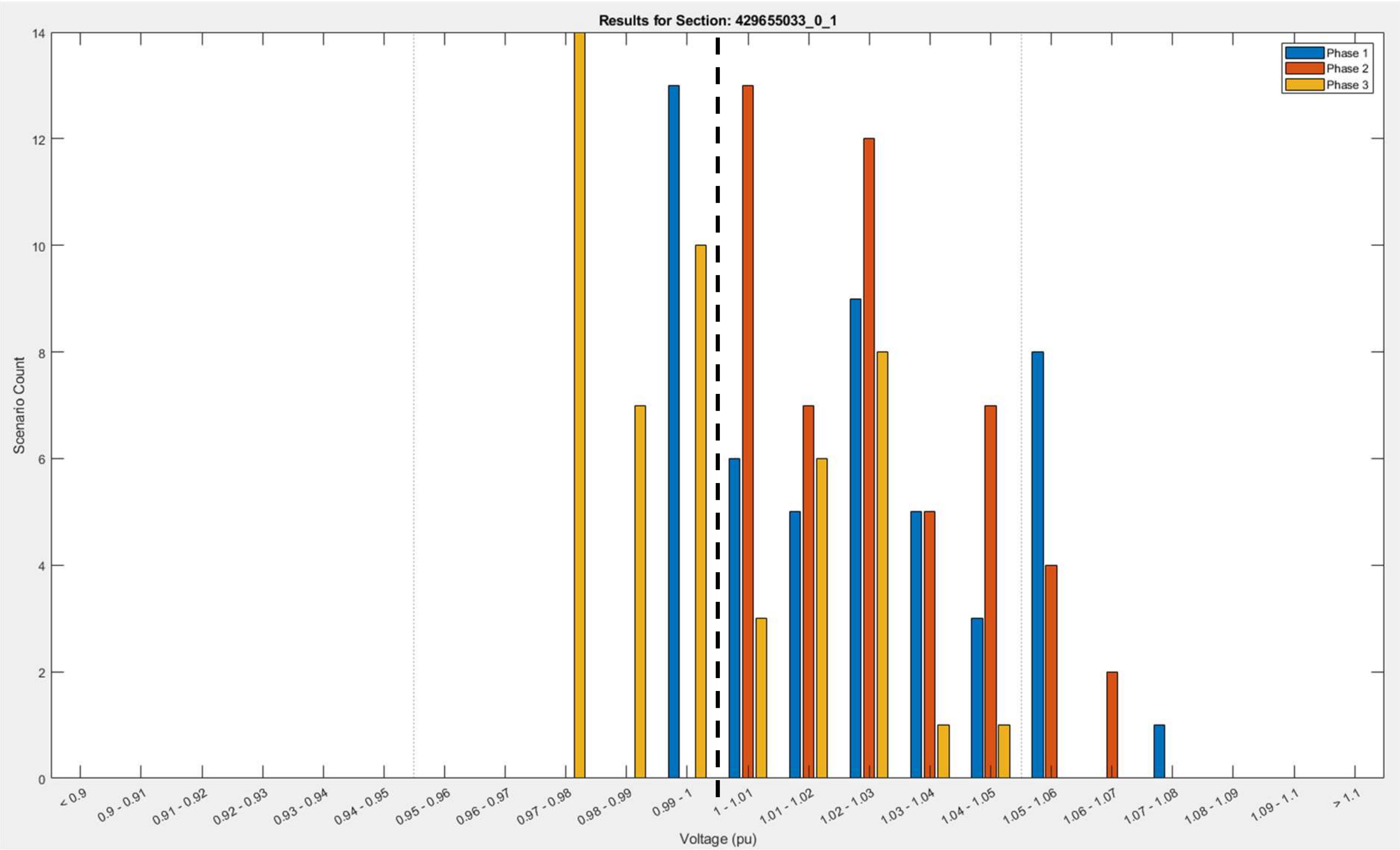
- Voltage violations
  - Voltages need to be constrained to a small and standardized range around operating voltage. Reliability of standard electrical equipment depends on the Utility Company to deliver the correct voltages.
  - Any voltages beyond the acceptable ranges need to be corrected for, either with additional grid equipment or different grid settings.

- Load violations:
  - The power flow in the electrical grid depends on customer's load behavior and the irradiance dependent injection of renewable energy.
  - Grid equipment needs to be pro-actively upgraded <u>before</u> grid power flows exceed critical load thresholds.

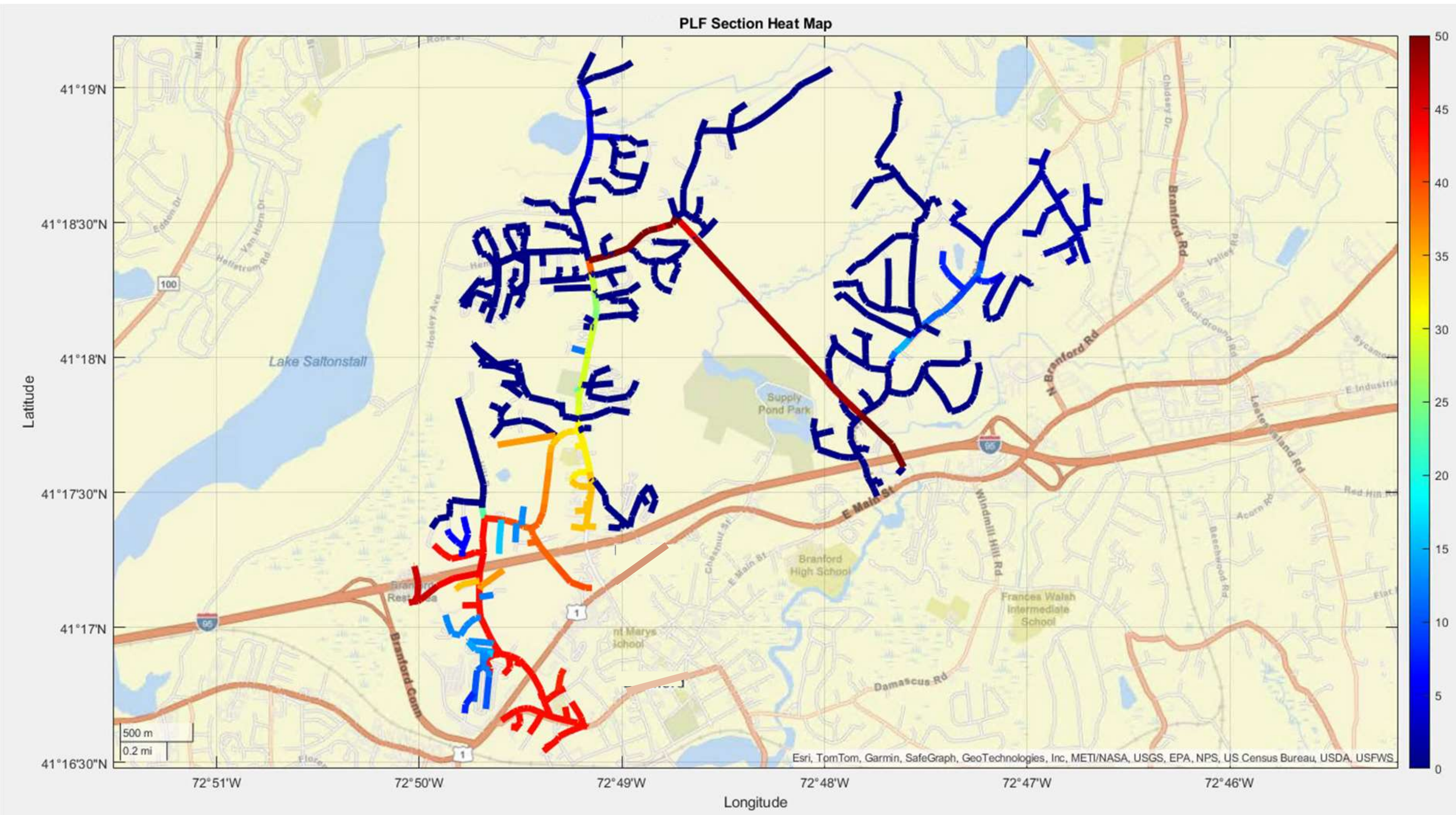
Probabilistic voltage results vs. grid nodes (example)



Probabilistic voltage results vs. one grid node (example)



Heatmapping of risk areas



frequency of violations

Probabilistic Planning – risk-based decision making

Risk = Probability x Violation Consequence

Risk tolerance defines what risks are acceptable

Probability/Likelihood	Consequence				
	A Not hazardous	B A certain hazard	C Hazardous	D Critical	E Very critical
5 Highly probable					
4 Very probable					
3 Probable					
2 Improbable					
1 Highly improbable					

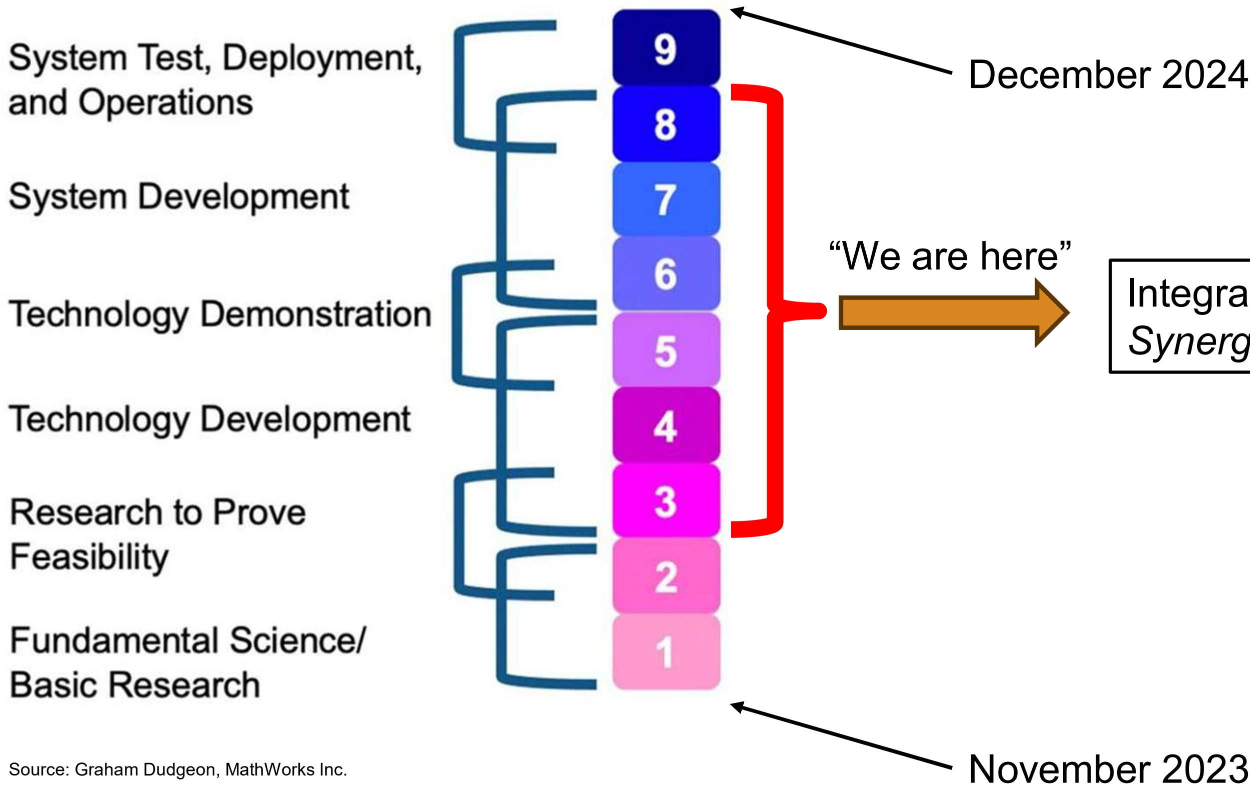
Unacceptable risks must be managed – either control probability or control consequence.

Adding reclosers reduces consequence of failure by reducing duration of outage. Adding Tree-Wire overhead conductors also reduces consequence.

Re-conductoring reduces the probability of failure by increasing the current capacity of the line.

Credit: Jonathan Flinn, DNV

Project phases



Integrated Development Environment is set. *Synergi Solver* connected to MATLAB.

Source: Graham Dudgeon, MathWorks Inc.

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Thank you

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