

National Laboratory of the Rockies

# A Workflow for Enabling Modelica Building and District Models for DRTS-Ready FMUs

Presented by Nicholas Long
American Modelica & FMI Conference 2026, Atlanta, GA
National Laboratory of the Rockies
October 14, 2026

*Photo from Adobe Stock 256750697*

# Outline and Acknowledgements

- Outline
  - Integrated Energy Systems Platform
  - Objective of Enabling thermal-electric energy assets for hardware in the loop integration through FMUs
  - FMU Workbench
  - Demonstration 1: Demand Response
  - Demonstration 2: Thermal Energy Networks
  - Next steps

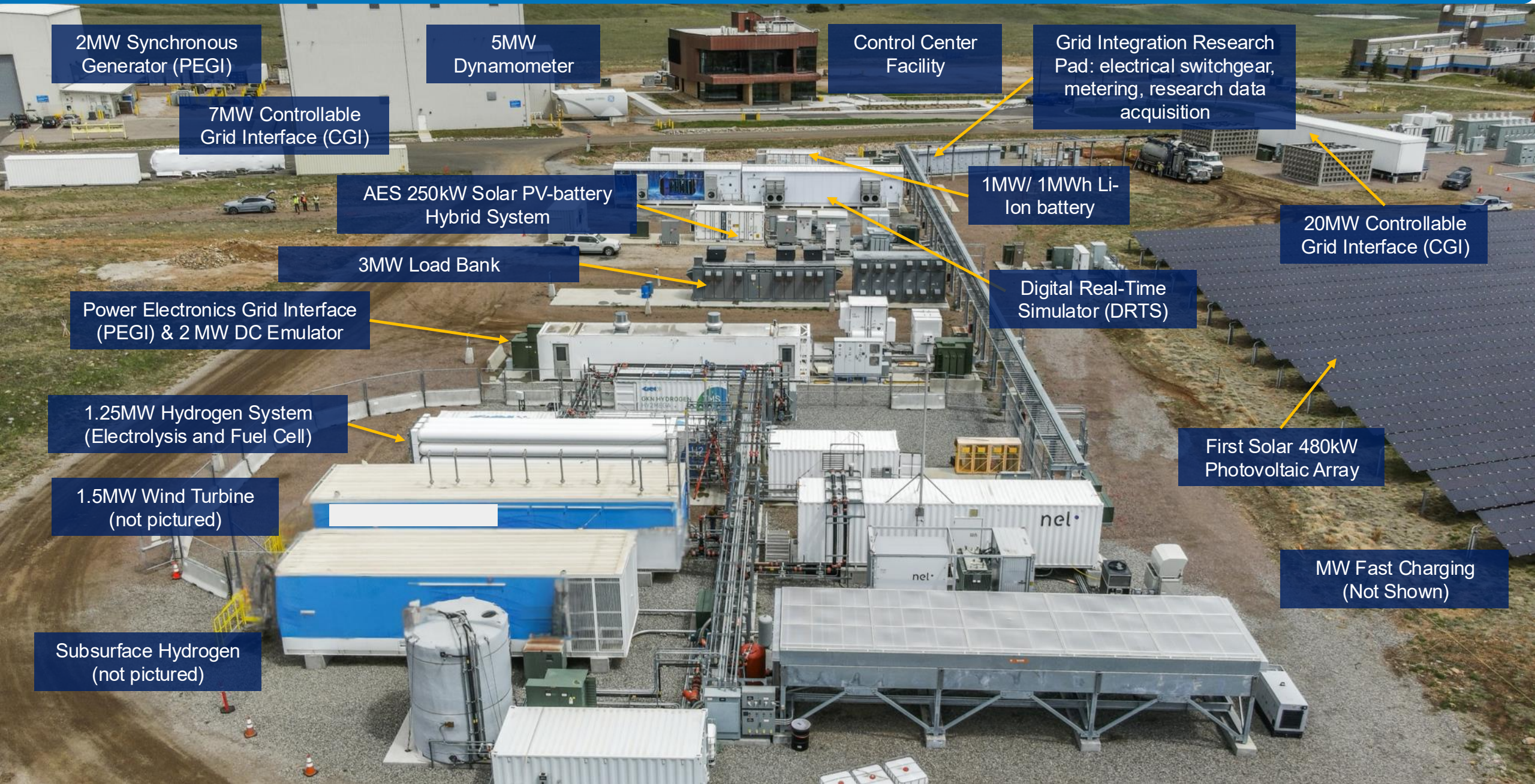

- NLR Team:
  - Whitney Trainor-Guitton, PhD & PI
  - Nicholas Long, PhD, PE
  - Brian Ball, PhD
  - Andy Olson, PhD
  - Nischal Guruwacharya, PhD
  - Julian Osorio, PhD
  - Rebecca Barney, PhD
  - Anique Dittrich


BUILDING
ARIES
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Energy Systems Integration Facility

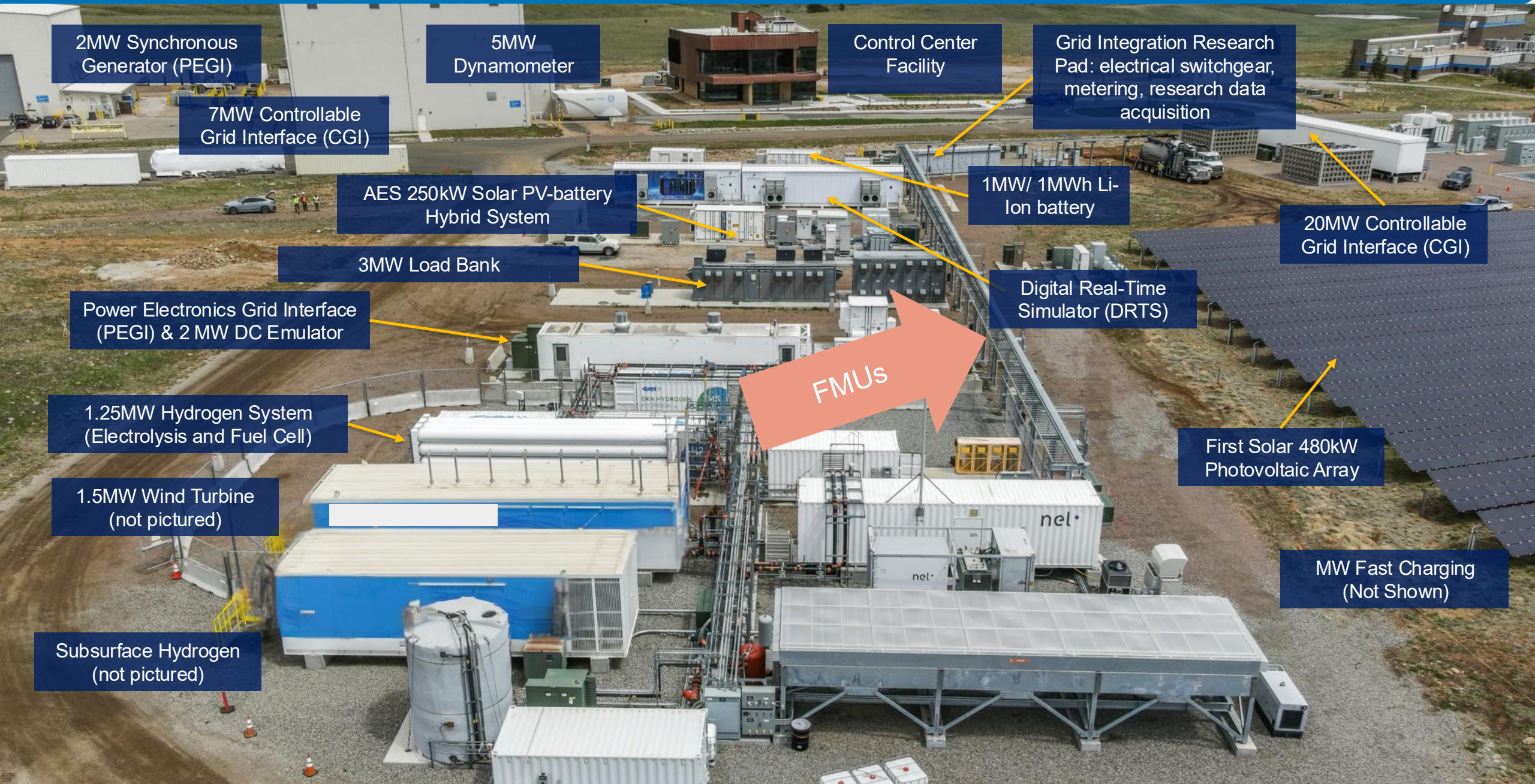

Flatirons Campus


Virtual Emulation Environment

# ARIES At-Scale Infrastructure at Flatirons Campus

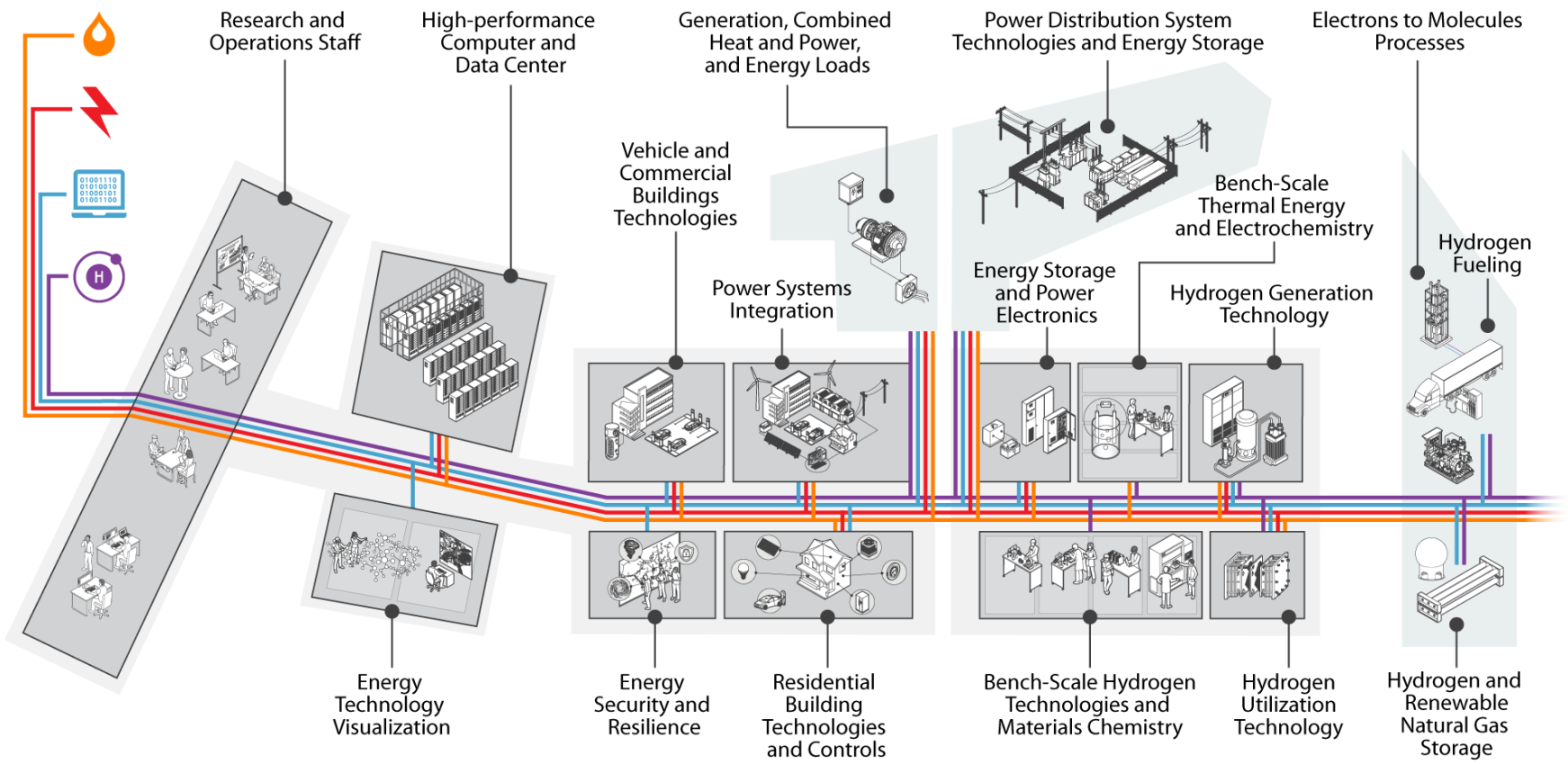


# ARIES At-Scale Infrastructure at Flatirons Campus



# ARIES Assess at ESIF

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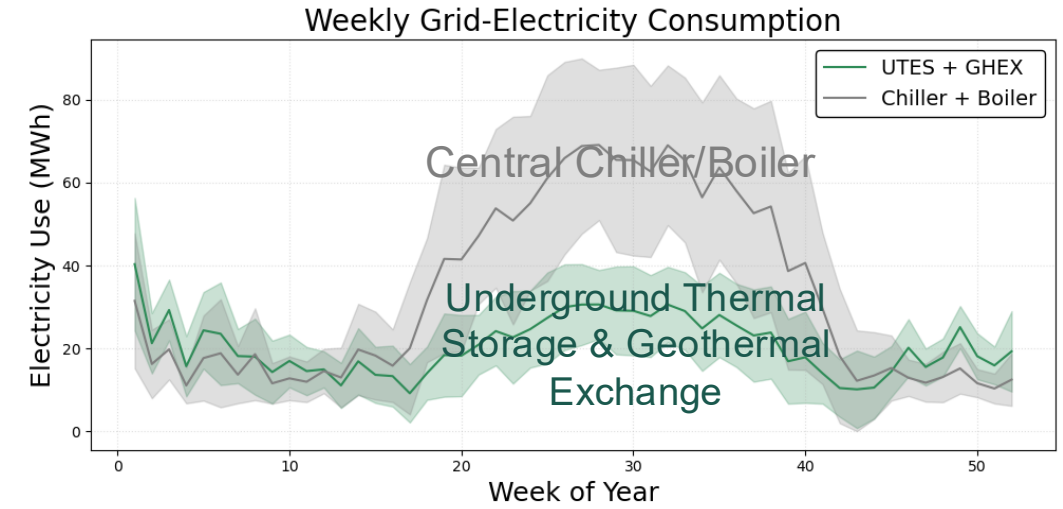

Dennis Schroeder, NLR

# Motivation

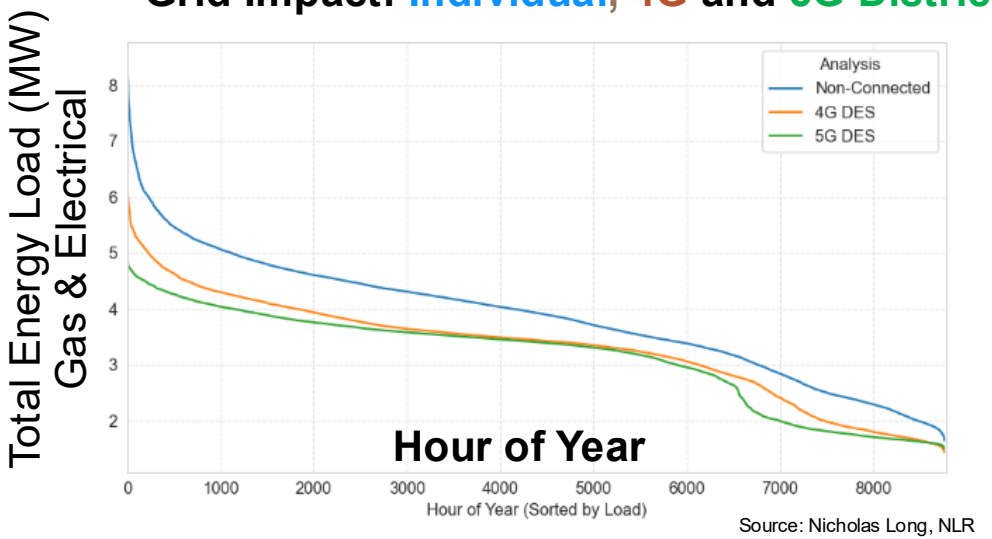
Coordination of thermal-electrical grids is an opportunity to achieve energy abundance that is affordable and secure.

Thermal Energy Network (TEN) (10-40°C)

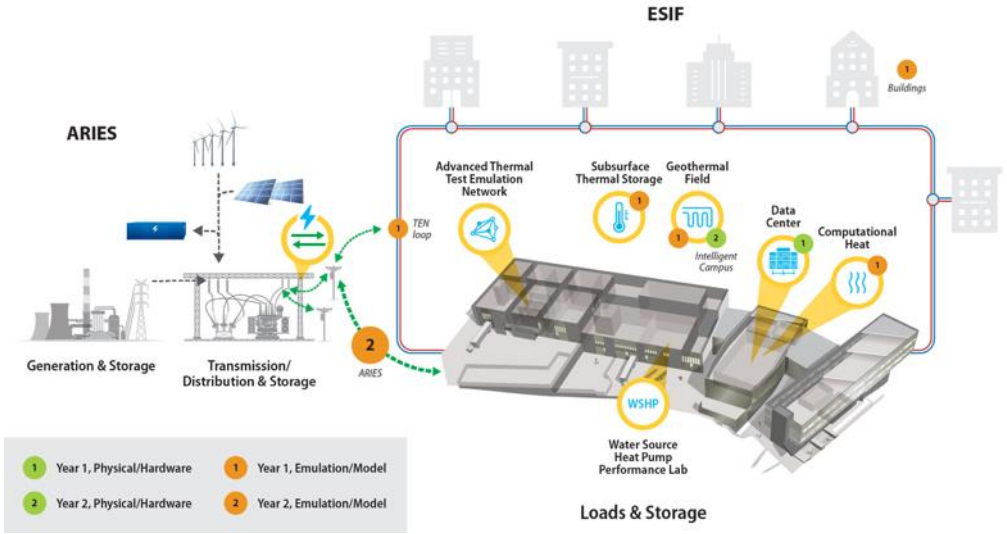
- thermally connected buildings through horizontal piping and distributed heat pumps
- implicit thermal storage
- reduce purchased electricity and/or grid flexibility




**Grid Impact: Individual, 4G and 5G District**



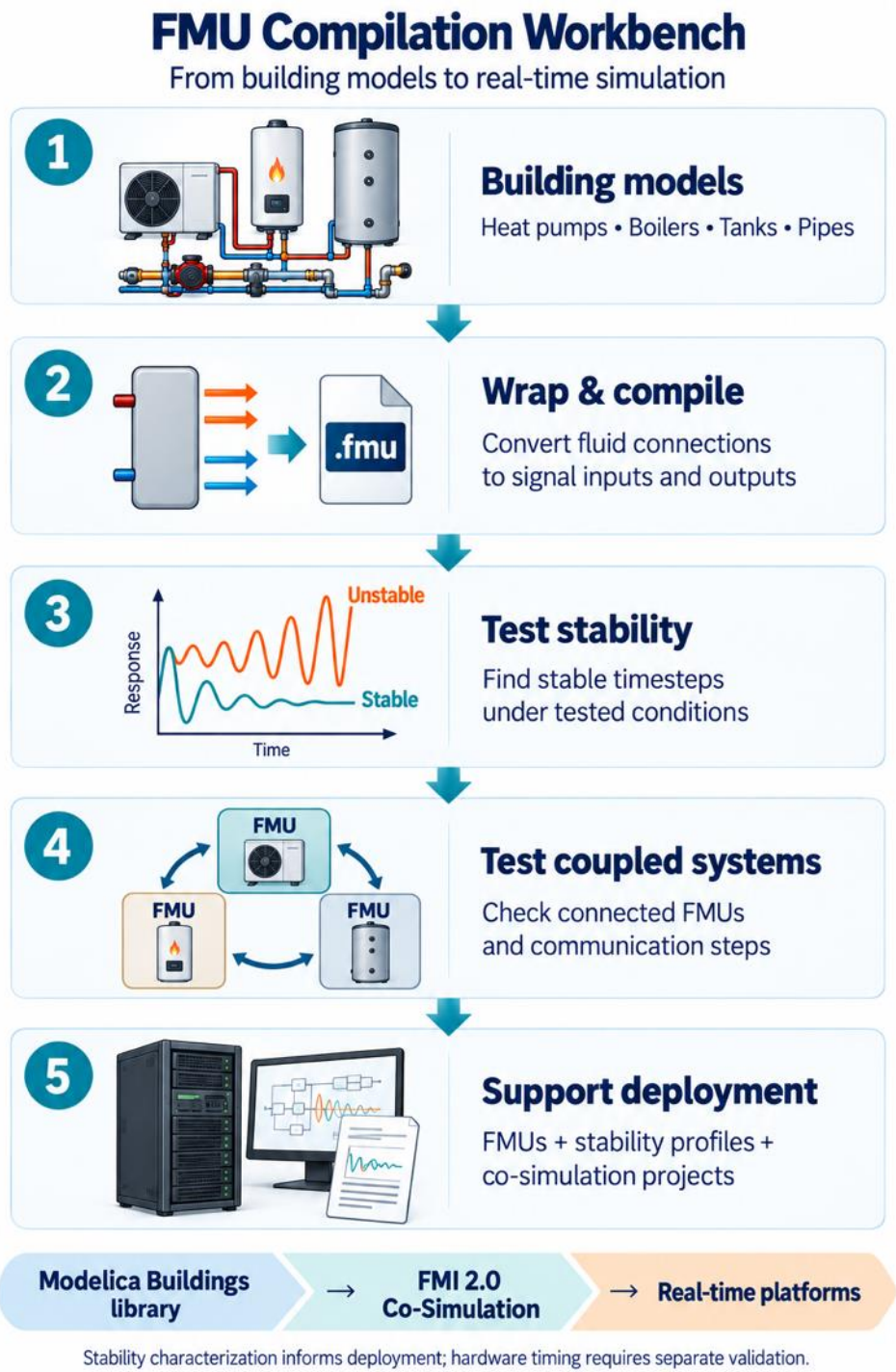

Source: Nicholas Long, NLR




Source: Whitney Trainor-Guitton, NLR

# Objective and Methodology

- How to have researcher's models rapidly deployed on real-time platforms for scalable and Controller Hardware-in-the-Loop (CHIL) analysis?
- Each model needs validation (of digital twin) and comprehensive response analysis before integration
- Leverage FMUs for consistency and deployability
- Thorough documentation and spec sheets for each component
- To be open sourced: https://github.com/NatLabRockies/FMU-compilation-workbench




Source: Codex

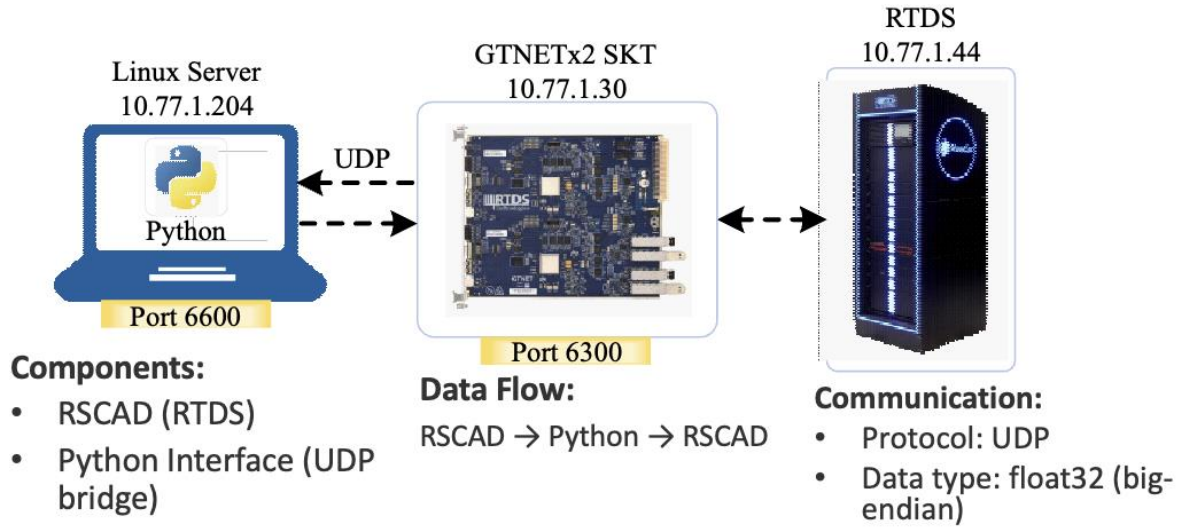
Stability characterization informs deployment; hardware timing requires separate validation.

# Two Thermal/Electric Demonstration Projects

Deploying research developed models (Modelica and Python) on Real-Time Digital Simulator (RTDS)

- Demand response using 5 FMUs on RTDS
- Python-based thermal energy network connected to RTDS microgrid

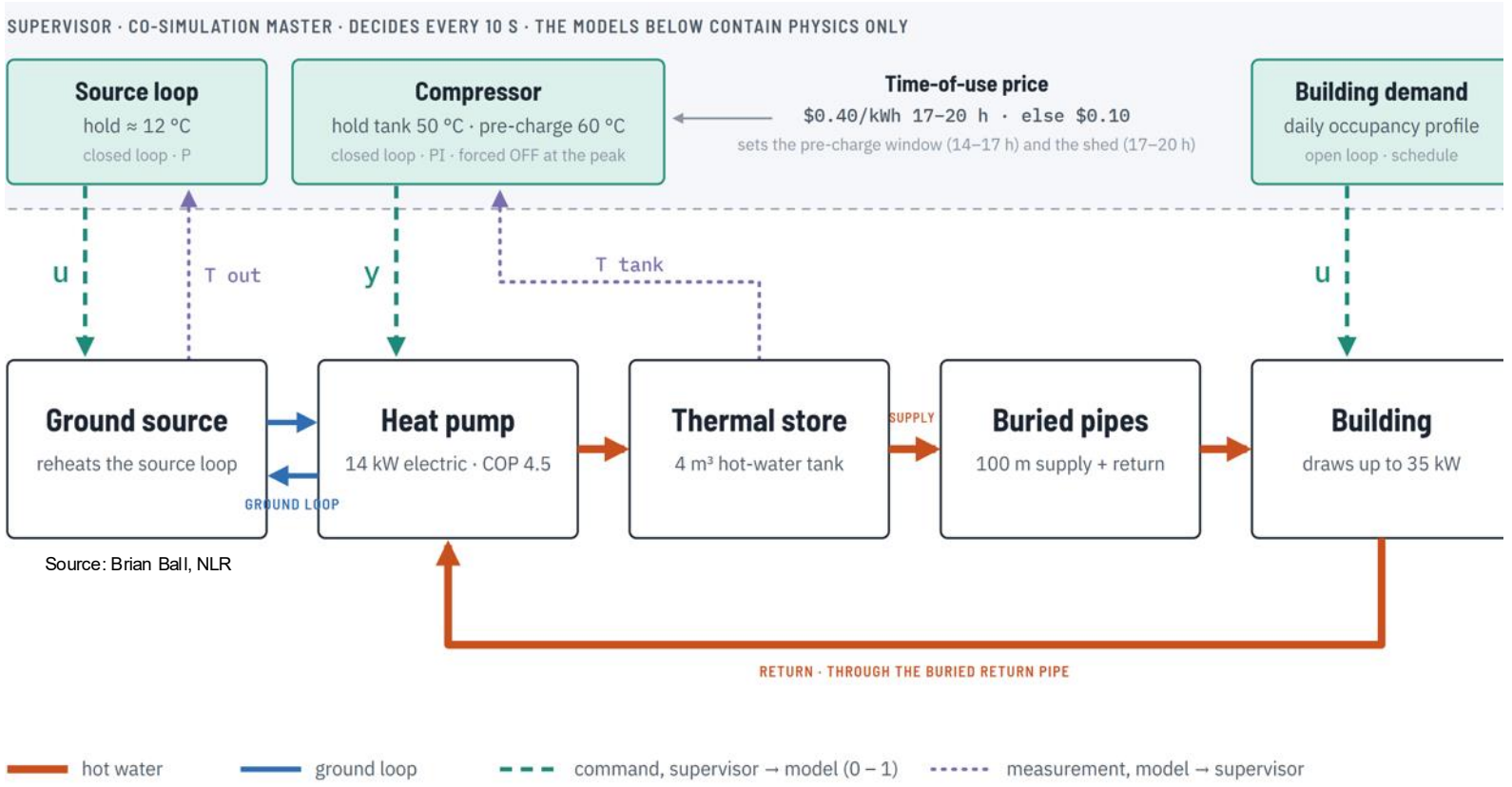





Sources: RTDS and Andy Olson, NLR

# 1: Demand-Response Control Strategy

- Run researcher models via FMU on RTDS
- Transient system-level thermal-electric demand-response validation
- Supervisory control
- 50kW substation
  - Storage tank, buried pipe, building load, heat pump, building loads
- Question: Can RTDS match performance of local Modelica models?




Source: Brian Ball, NLR

# 1: Demand-Response Control Strategy




| Before 14 h | 14–17 h | 17–20 h | After 20 h |
|---|---|---|---|
| Hold tank near 50°C; meet building demand normally | Increase tank target to 60°C and run HP harder | Set HP y = 0; building is supplied from storage | Recover tank and return to baseline target |

# 1: RTDS/RSCAD vs Baseline Results

**Normal**

Tank stays near 50°C with small oscillations caused by load and distribution dynamics.

**Pre-charge**

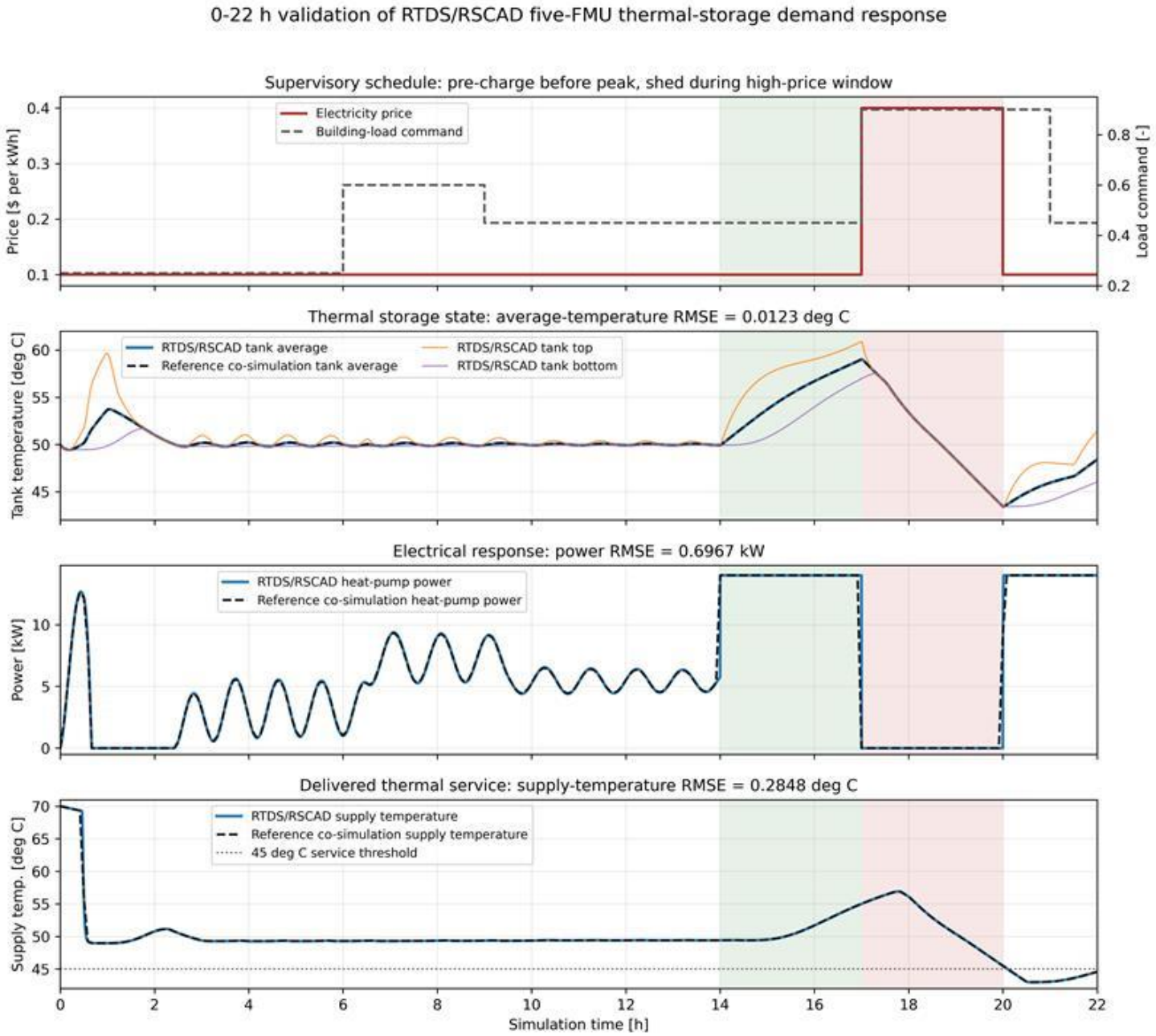
Tank average rises toward 59°C; top temperature rises first, indicating useful stratification.

**Peak shed**

Heat pump is off; stored heat is drawn down to serve the building during the red peak window.

**Recovery**

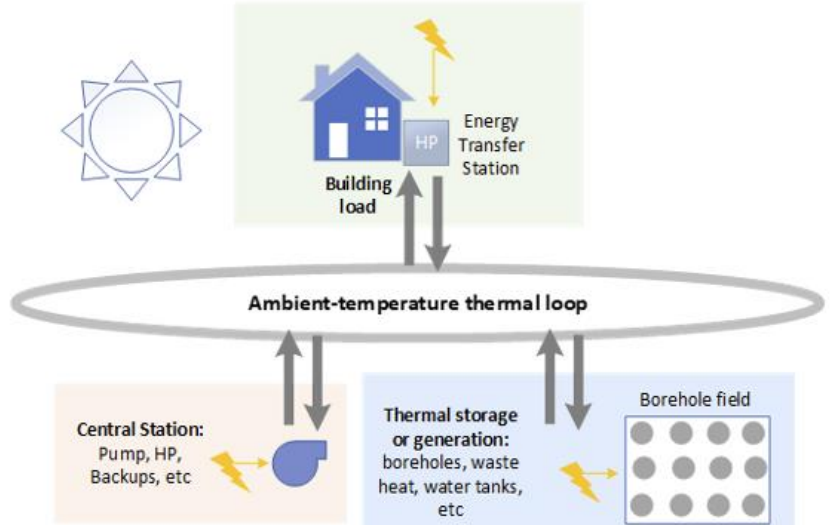
After the shed, the system returns toward the baseline thermal target.

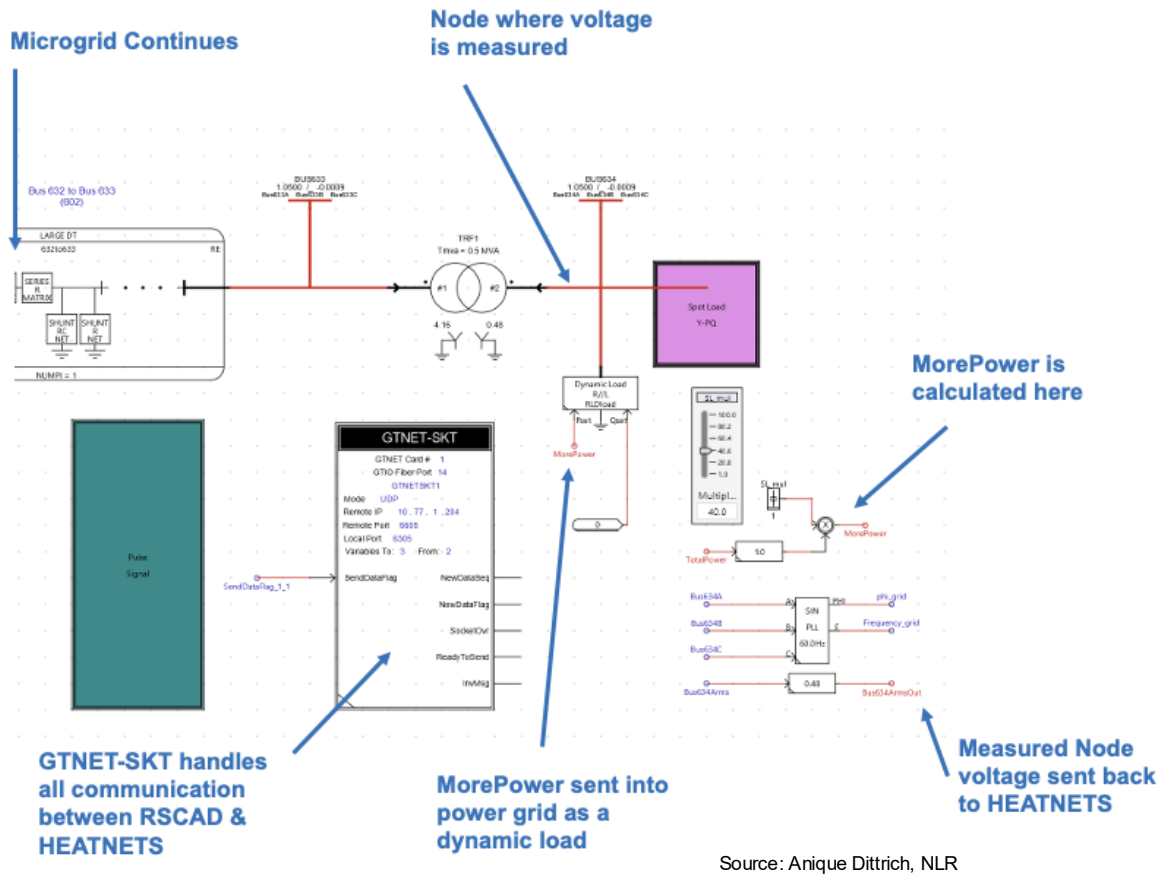



Source: Nischal Guruwacharya, NLR

# 2: TEN + RTDS

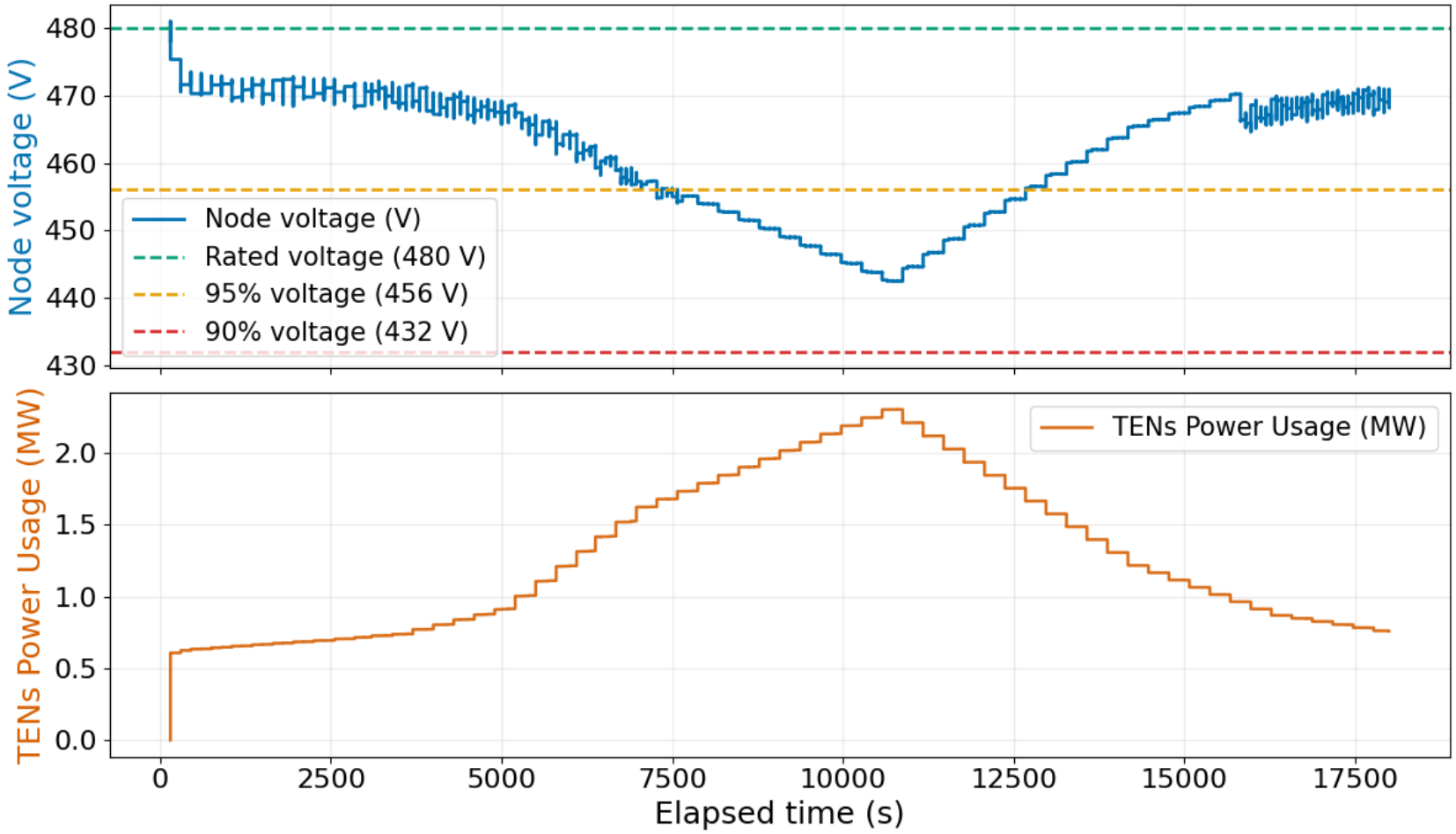
- Representation of Thermal Energy Network & verification on RTDS/RSCAD and RTDS
- HEATnets Microgrid
  - HEat Analysis Tool for NEtworked Thermal Systems), a reduced order and techno-economic model
  - Quasi-steady state
  - Assess power grid voltage and frequency under peak loads (Scale to 4 TENs)
  - Researcher code deployed onto the RTDS




Source: Anique Dittrich, NLR

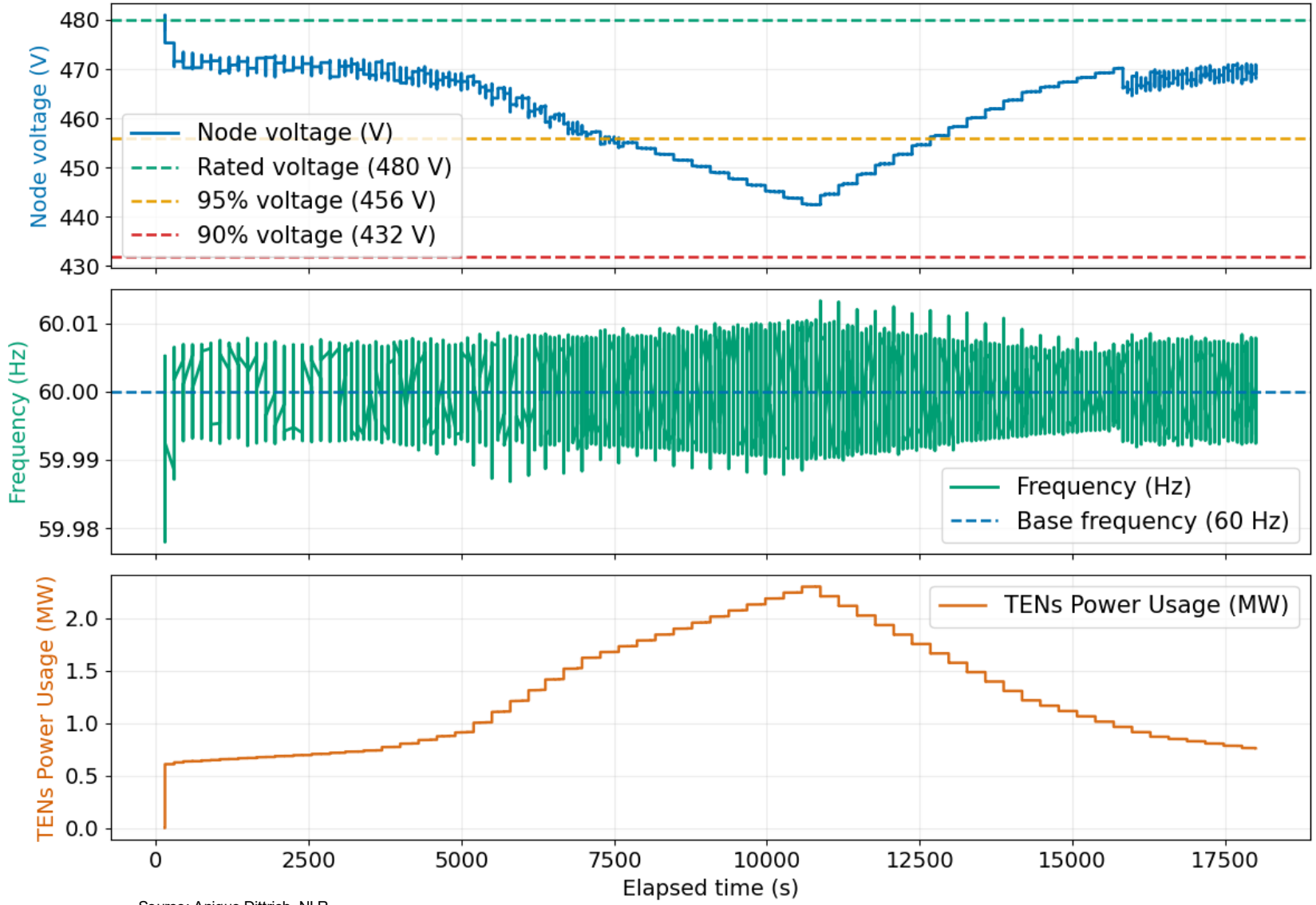
# 2: Impact of 4 TENs Power Usage on Power Grid Node Voltage




Source: Anique Dittrich, NLR

- Voltage should be within +- 5% its rated value (utility standard)
- Voltage not to go past +-10% its rated value b/c it causes issues with connected systems

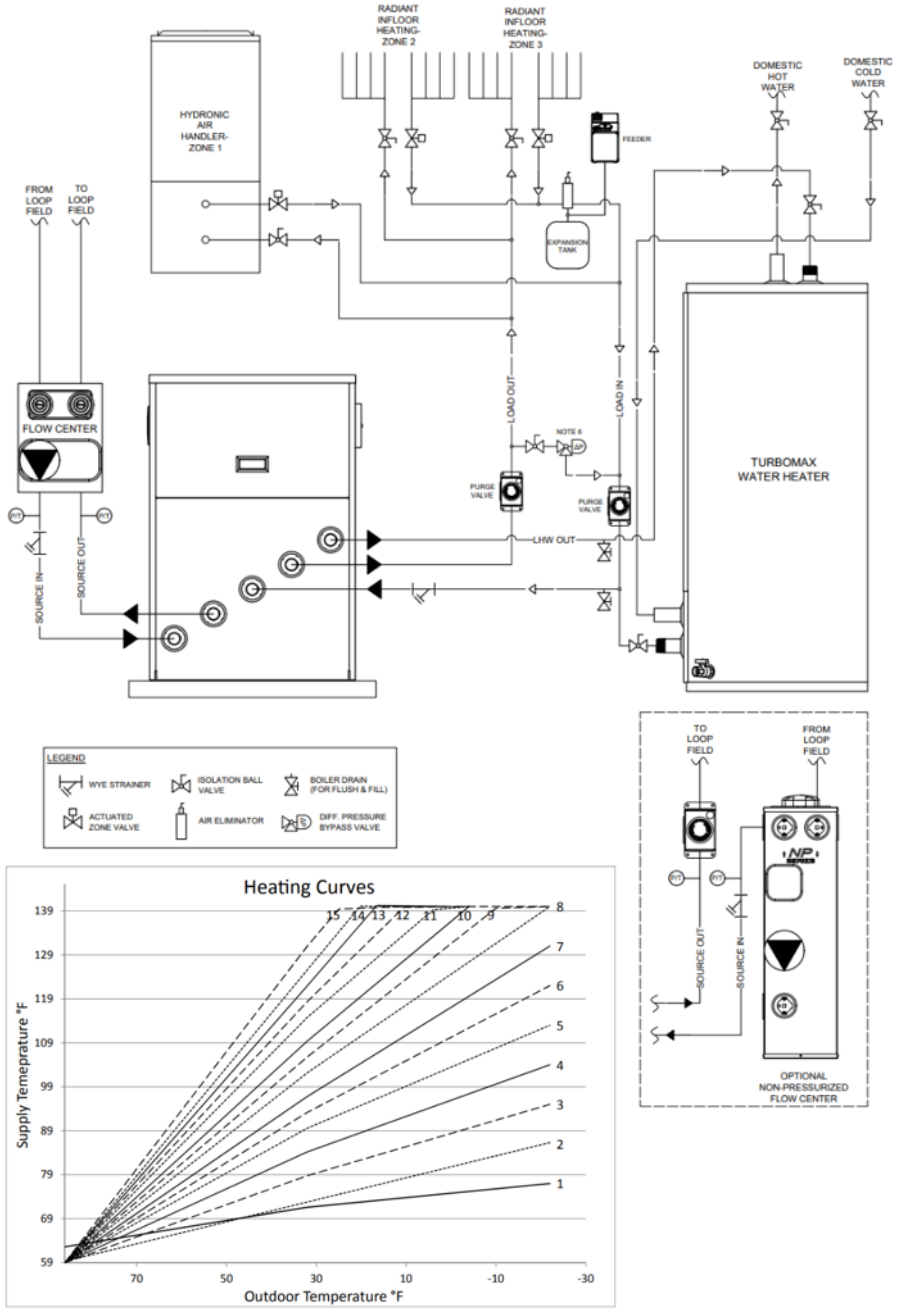
# 2: Ideal Power Source Frequency Response




Source: Anique Dittrich, NLR

# Next Steps

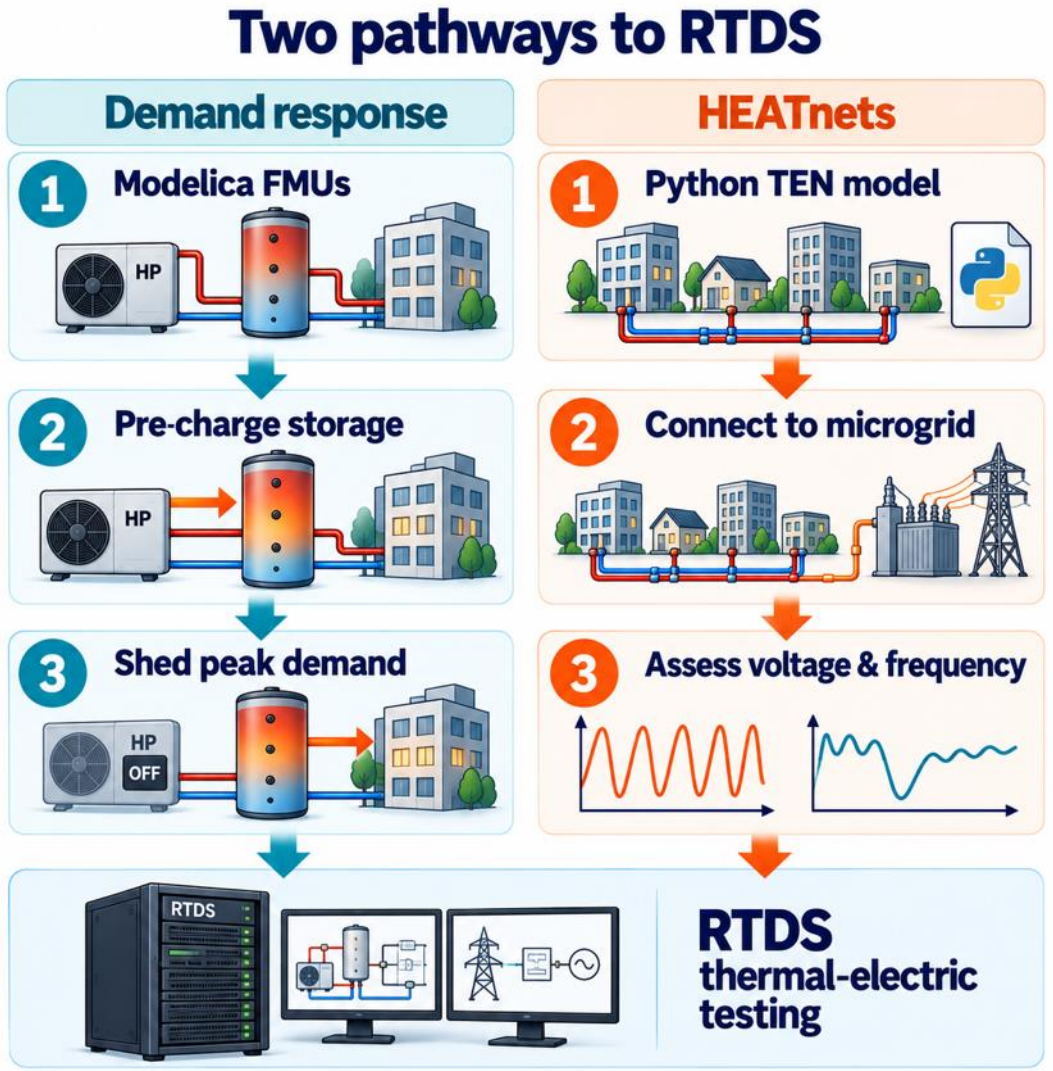
- Model validation using observed system data
- CHIL to demonstrate rapid model integration of physical thermal equipment at NLR
  - 6 – 5 ton Hydron Heat Pumps
  - Research borehole field
- Control development
  - Physical bi-direction flows for TEN
  - Reinforcement control/AI-assisted control
- Leverage Alfalfa/Pacer for holding FMUs in state
- Run the same sim in not real time (accelerated timesteps) to check if the results the same?
- Change ideal power source to physical controllable grid interface (CGI) to test impacts




Source: Hydron Cutsheet

# Conclusions

- Real-time system hardware has been historically focused on electrical analysis, need to combine thermal and electrical
- Two RTDS and FMU-based approached were evaluated on ease of deployment
- Thermal storage enables peak shedding by pre-charging before the peak and serving the building from stored heat while the heat pump is off
- The implementation establishes a reusable thermal-electric RTDS building block for future controller and CHIL studies




Source: Codex

Insert the words "in part" if this work includes non-NLR authors.

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# Thank you!

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