

Real-World Case Studies in the Age of AI from the Center for Microgrid Research

Finland 2026 Symposium on Microgrids

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OUTLINE

Finland 2026 Symposium on Microgrids

15-18 June 2026, Lappeenranta-Tampere

LUT University

INTERNATIONAL Microgrid SYMPOSIUM

Overview of Center for Microgrid Research



Real-World Case Studies with AI data center loads



Controller-Hardware-in-the-loop Real-time Typhoon HIL Case studies

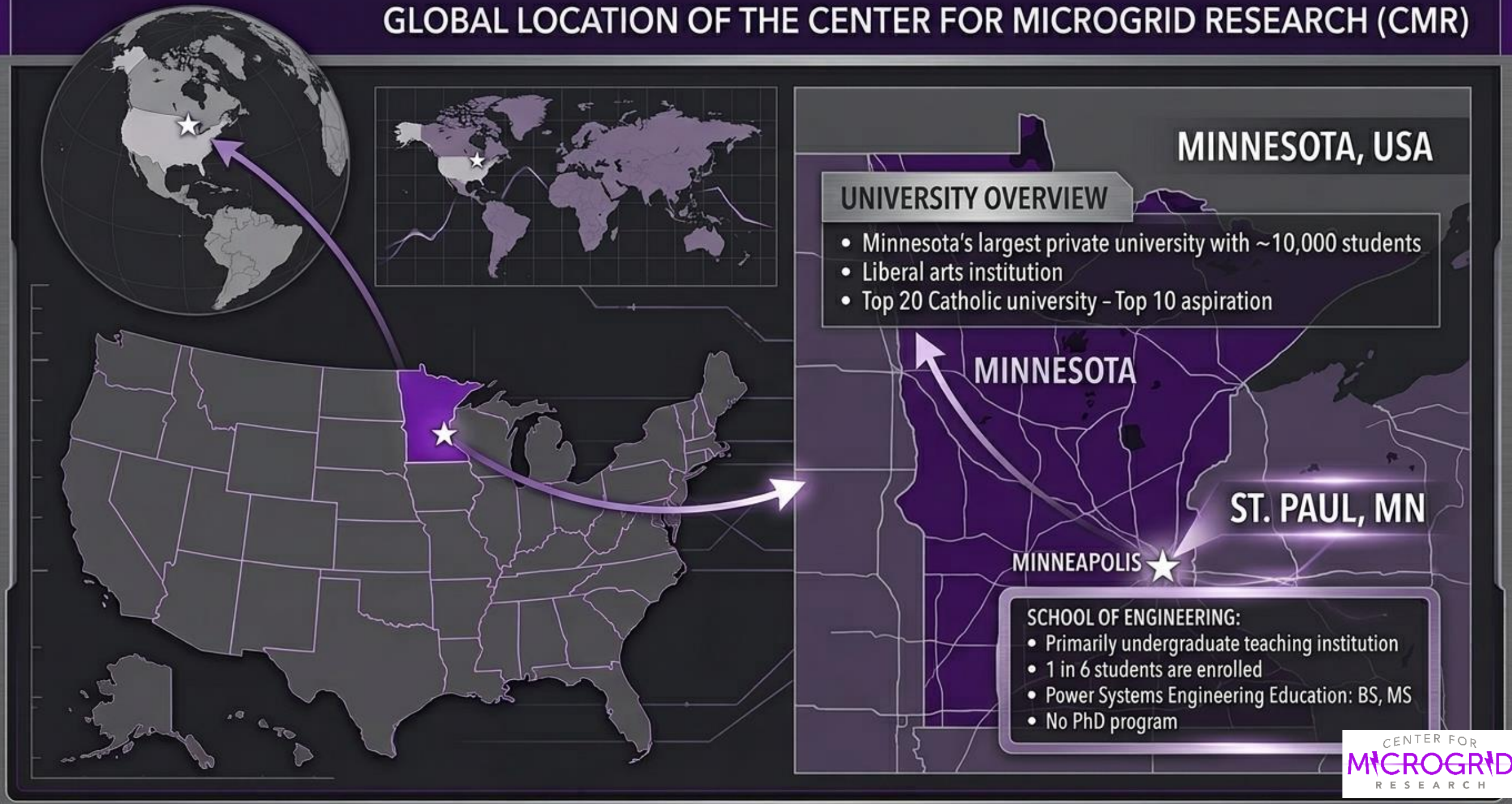


Real-time simulations RTDS Case studies



CENTER FOR MICROGRID RESEARCH

GLOBAL LOCATION OF THE CENTER FOR MICROGRID RESEARCH (CMR)



CENTER FOR MICROGRID RESEARCH

Center for Microgrid Research: Who We Are

OUR VISION

To be one of the premier applied engineering research centers in the area of distributed energy resources and microgrids enabling a secure, resilient and carbon-free electric grid for the 21st century.

OUR MISSION

Be a resource to the energy community to transition to carbon free electricity and train innovative engineers and technology leaders for the 21st century.

Simulation and Modeling Powerhouse

Real-Time Digital Simulator (RTDS)



REAL-TIME GRID SIMULATION

REAL-TIME GRID SIMULATION

CONTROLLER HARDWARE-IN-THE-LOOP (CHIL)

Typhoon HIL Testbed



POWER HARDWARE-IN-THE-LOOP (PHIL)

One of the largest university-based real-time simulation testbeds in the world

Innovation Hub

Utility-Scale Infrastructure for Real-World Research

Deployed Systems Testing & Validation



Microgrid 1



INTEGRATED CONCEPT TO DEPLOYMENT

DER Integration & Performance Testing



Microgrid 2



UTILITY-SCALE OPERATIONS

A 10,000+ square-foot R&D facility anchored by more than 2.9+ MW of real-world power infrastructure

OUR TEAM



OUR TEAM

THE FOUNDATION: A WORLD-CLASS R&D ENGINEERING TEAM

A dynamic, multi-disciplinary team of experts and researchers, driving innovation and excellence in microgrid technology, DER integration, and grid modernization.

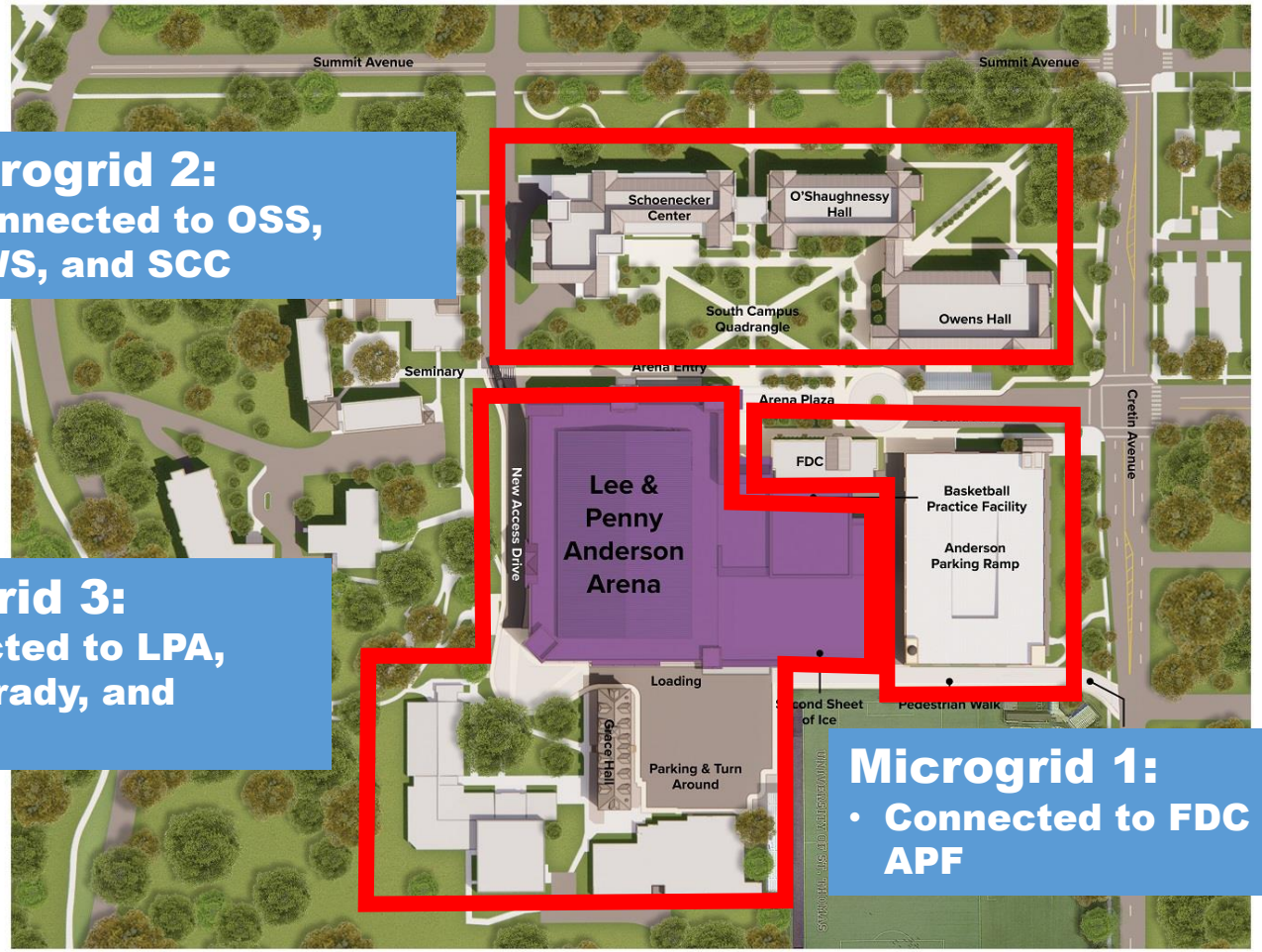
Collaborative ● Tenacious ● Intrepid ● Results-Oriented



Innovation-Focused, Safety-First

Academic Excellence and National Visibility: An Expanding World-Class Facility

Construction of a 6,400 SF Facility to house expanded Center for Microgrid Research including 1.5MW of generation capacity, 13.8kV power distribution, 13.8kV testbay, grid-scale energy storage, south campus and Xcel grid tie-ins, DC Fast Chargers, and large scale-electric vehicle connections



Microgrid 2:
- Connected to OSS, OWS, and SCC

Microgrid 3:
- Connected to LPA, Binz, Brady, and others

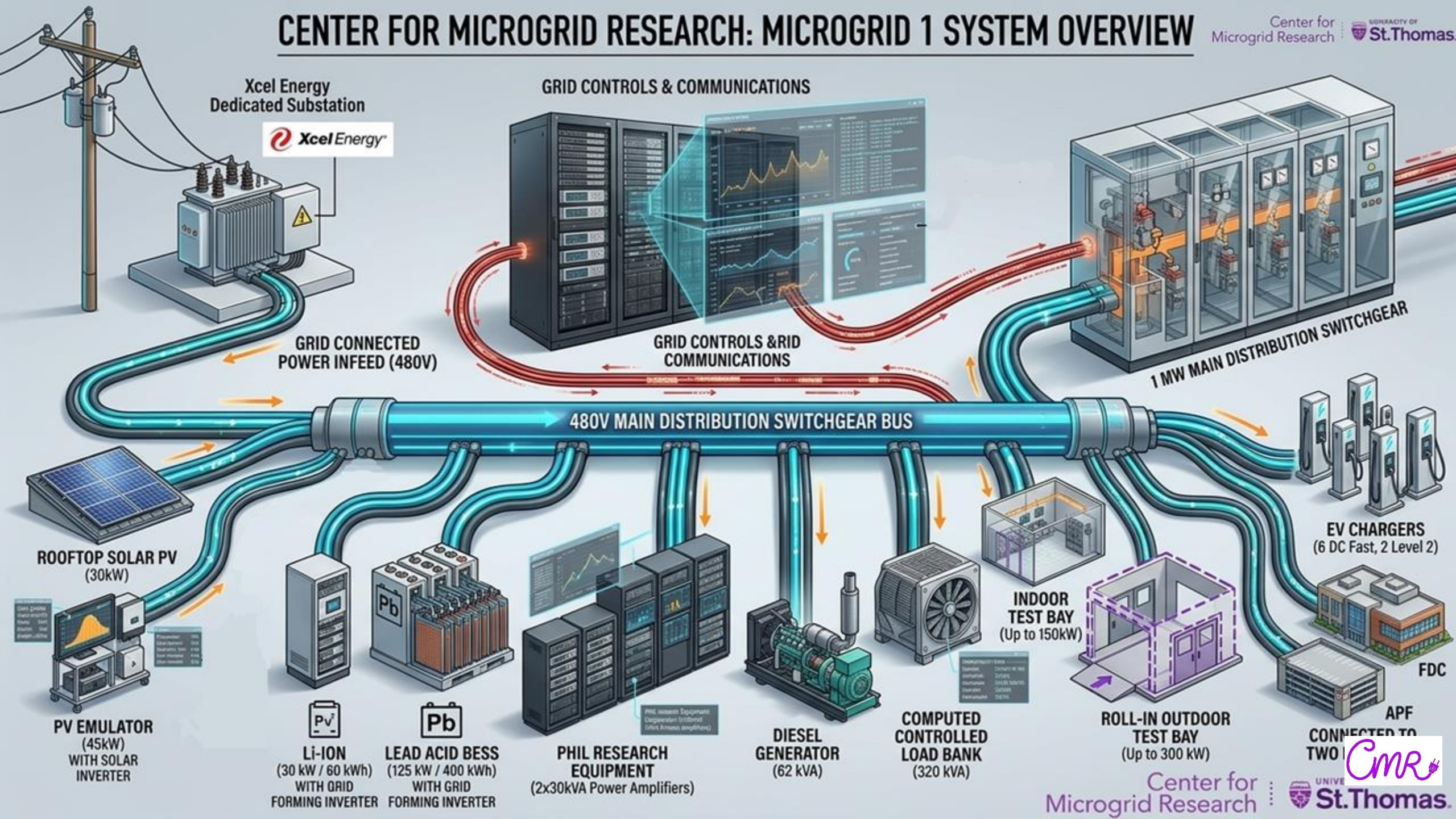
Microgrid 1:
- Connected to FDC and APF





CENTER FOR MICROGRID RESEARCH: MICROGRID 1 SYSTEM OVERVIEW

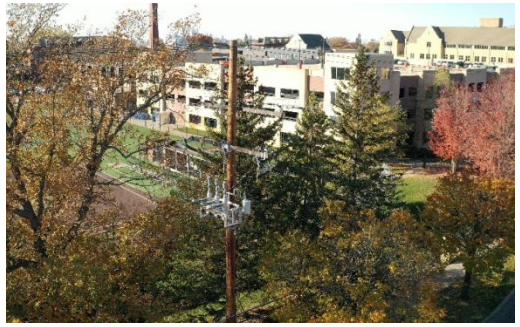
Center for Microgrid Research | St.Thomas



Center for Microgrid Research | St.Thomas

Center for Microgrid Research: Microgrid 1

Xcel Energy Grid-Tie 13.8 kV





Solar PV System



Dedicated Substation





50 kW Diesel Genset



320 kVA Load Bank





Protection System

1MW Switchgear

125 kW/400 kWh Lead Acid Energy Storage System

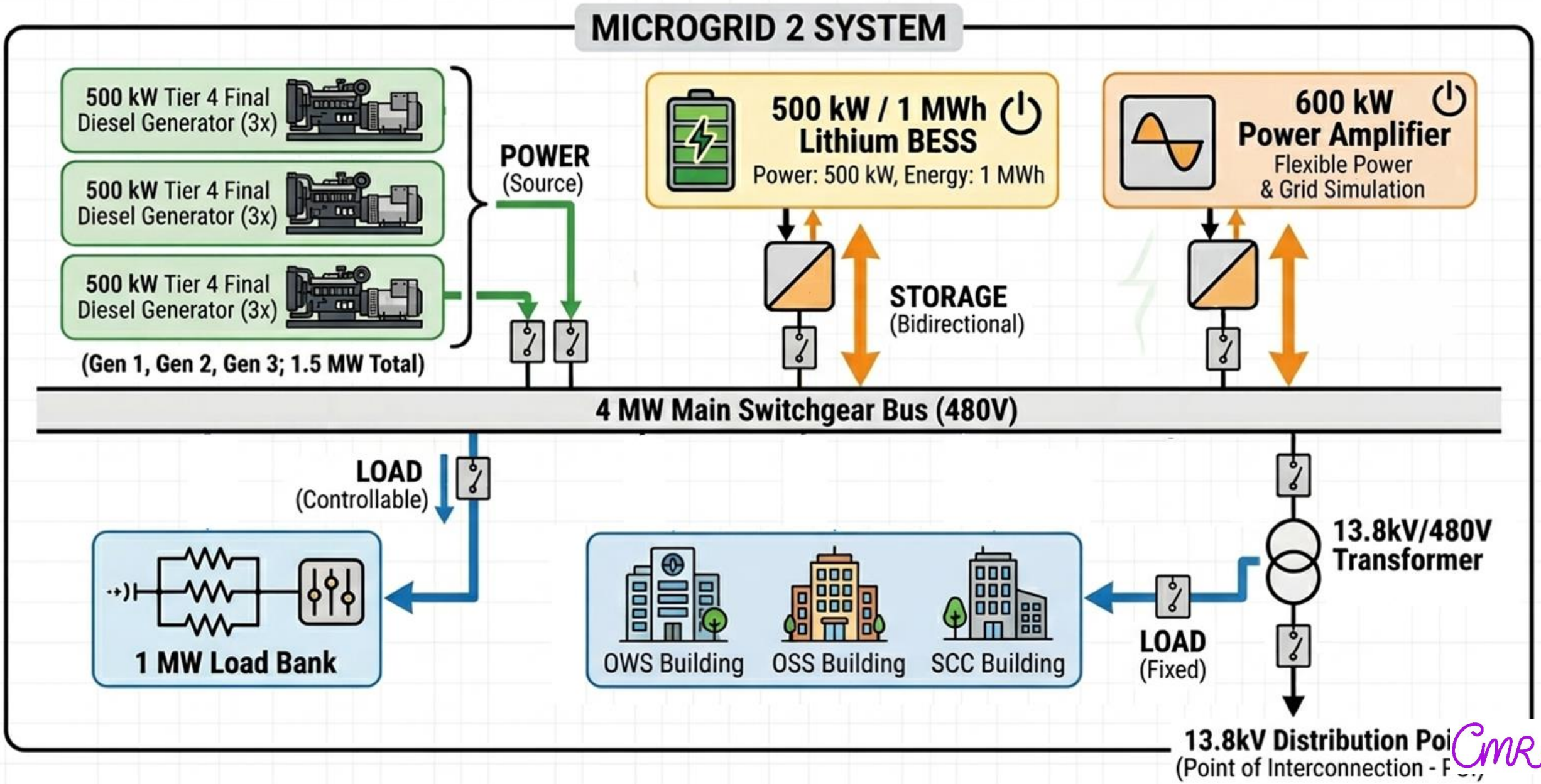
30kW/60kWh Lithium-Ion Energy Storage System

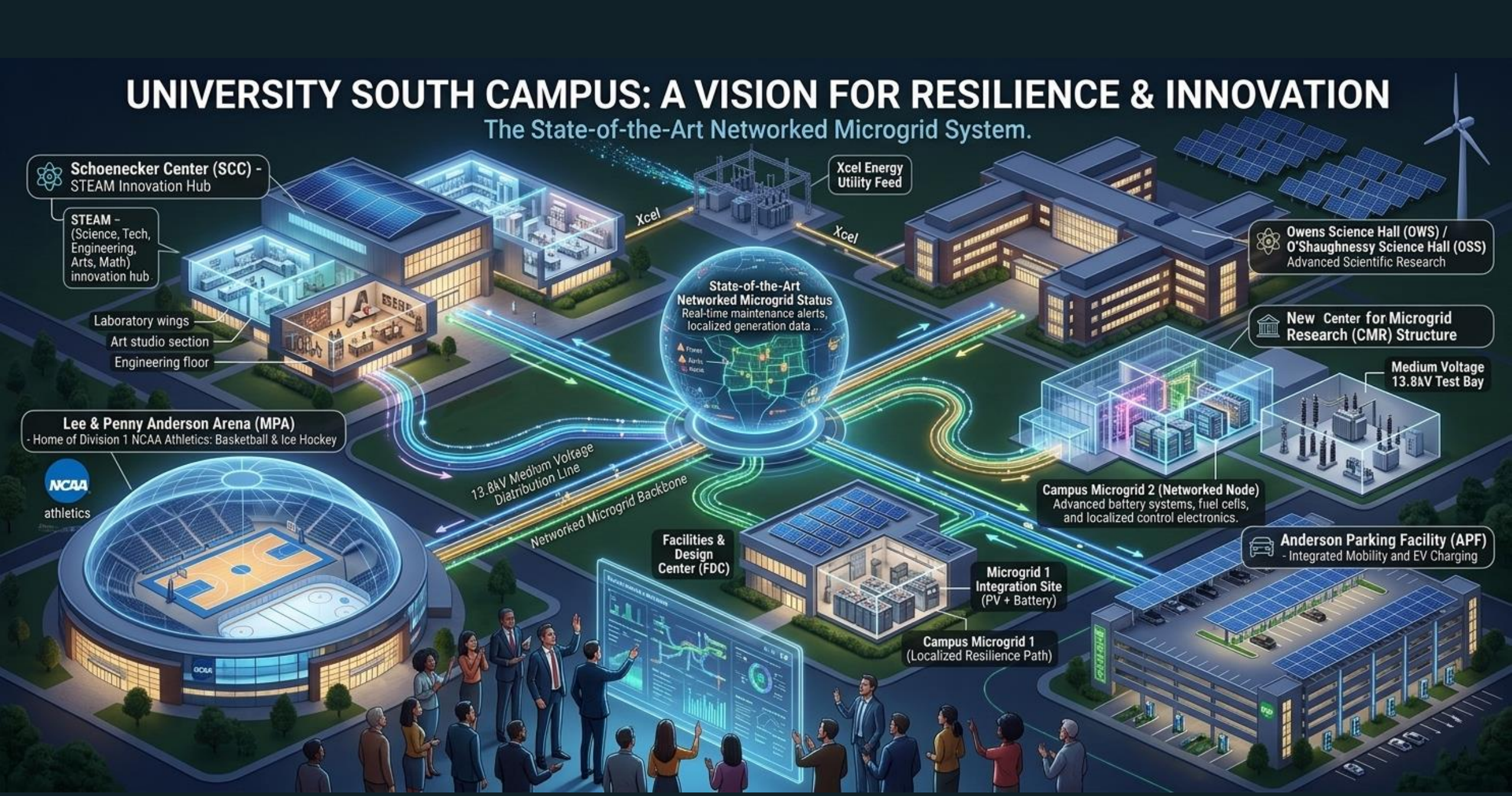




CENTER FOR MICROGRID RESEARCH

MICROGRID 2 SYSTEM SCHEMATIC (Islanded and Controllable Configuration)





LUT Group Confidential - Other information (3Y)

Construction and Build-Out of Expanded National-Level Facility



Construction and Build-Out of Expanded National-Level Facility

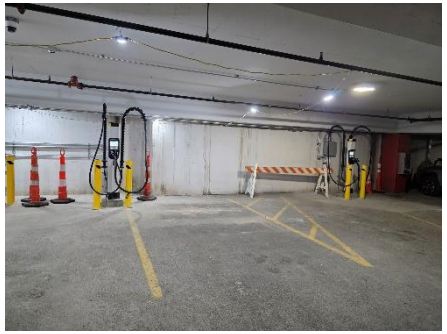
Construction of a 6,400 SF Facility to house expanded Center for Microgrid Research including 1.5MW of generation capacity, 13.8kV power distribution, grid-scale energy storage, south campus and Xcel grid tie-ins, DC Fast Chargers, and large scale-electric vehicle connections



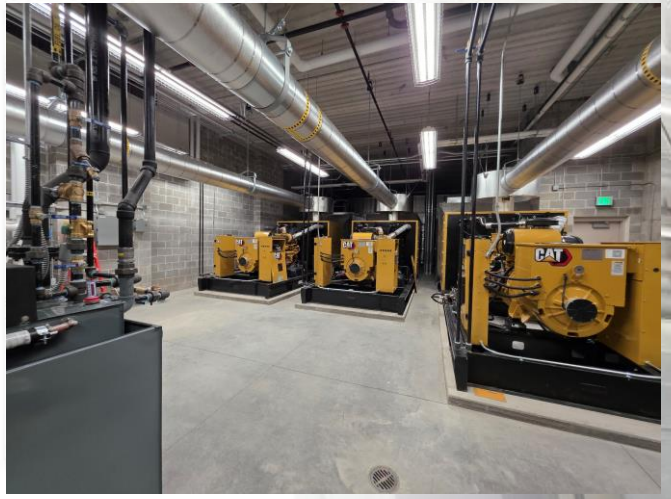






BASEMENT: DIESEL GENERATORS (3x500kW CAT)



MAIN LAB BAY (VIEW FROM GRAND AVE. GARAGE)

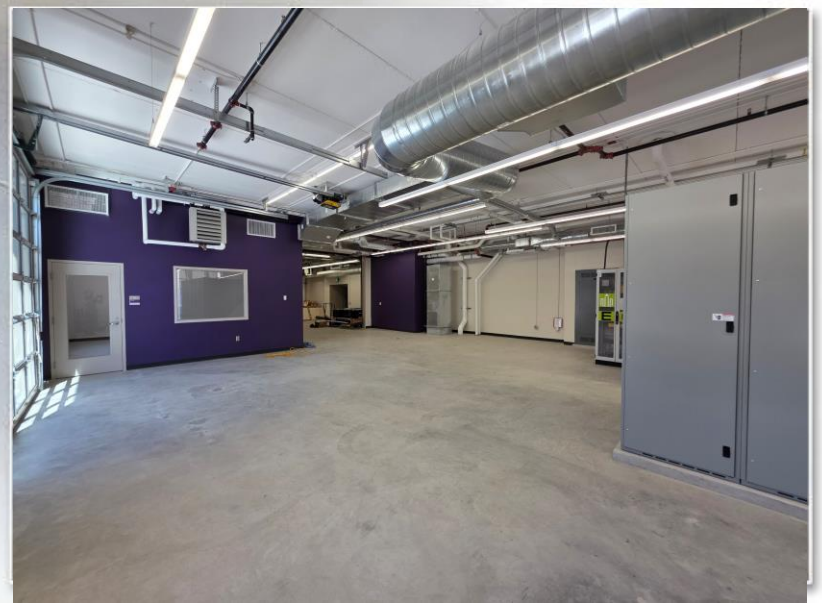
BUILDING EXTERIOR & SITE SIGNAGE



MEDIUM VOLTAGE TESTBAY (PURPLE BAY)



ALTERNATIVE LAB VIEW (CORNER BAY)



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CENTER FOR MICROGRID RESEARCH

AI TRAINING: A NEW GRID CHALLENGE

The Problem – AI Training as a New Grid Challenge

SCALE & IMPACT

MASSIVE DATACENTER SCALE



- **Power Stabilization for AI Training Datacenters** (Microsoft, OpenAI, NVIDIA)
- Large AI training jobs can span **tens to hundreds of thousands of GPUs** operating synchronously.
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- Th **po hu**
- Ca lo



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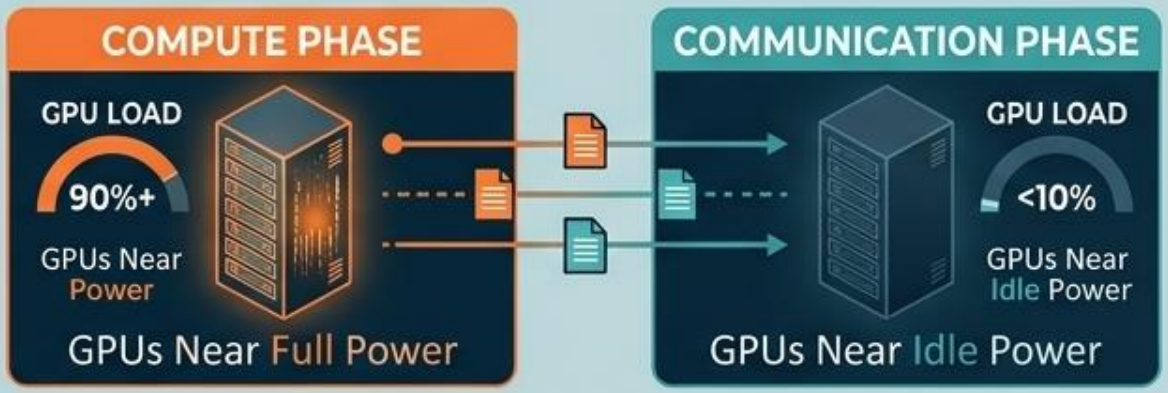
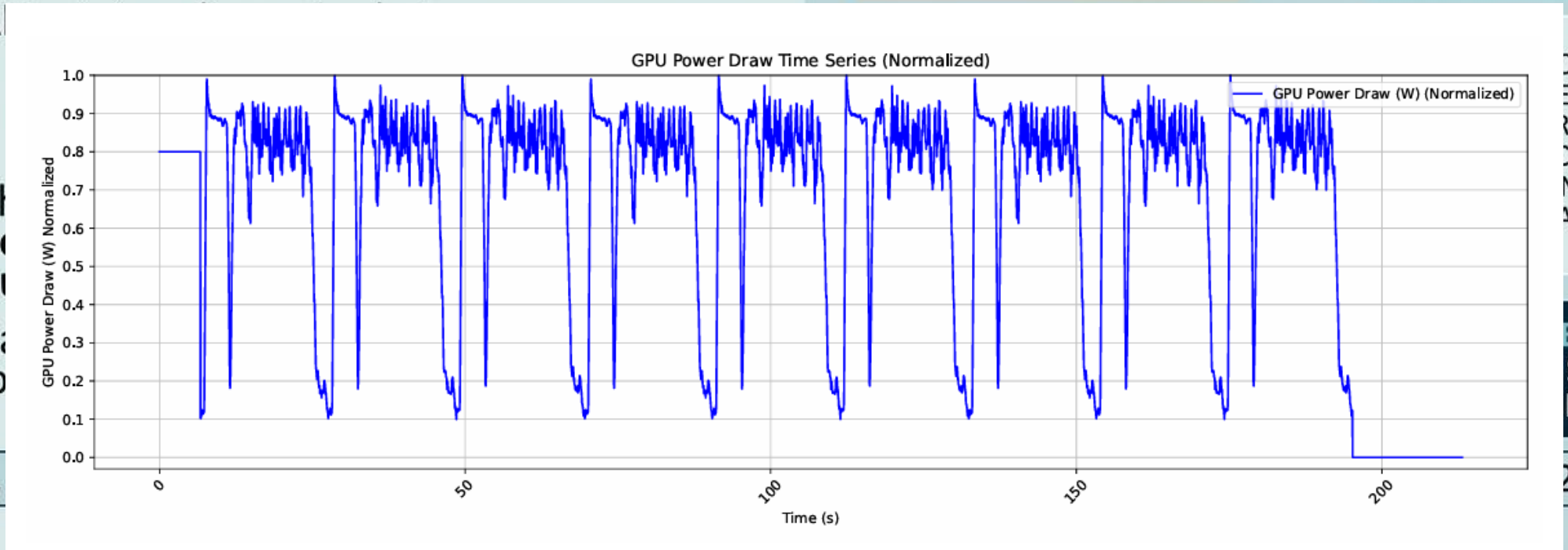
PHASE DYNAMICS





OWER
EADINGS
ROM AN AT-
CALE TRAINING
N DGX-H100
ACKS.

ENGE:
SUPPORT
NG LOADS?

2025).

Real-World Case Studies: Case Study 1

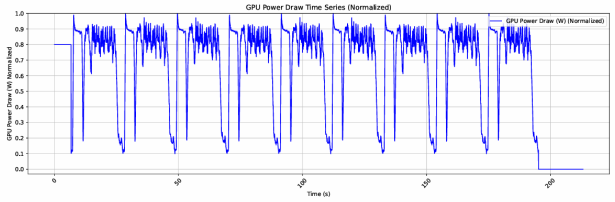
Island-mode

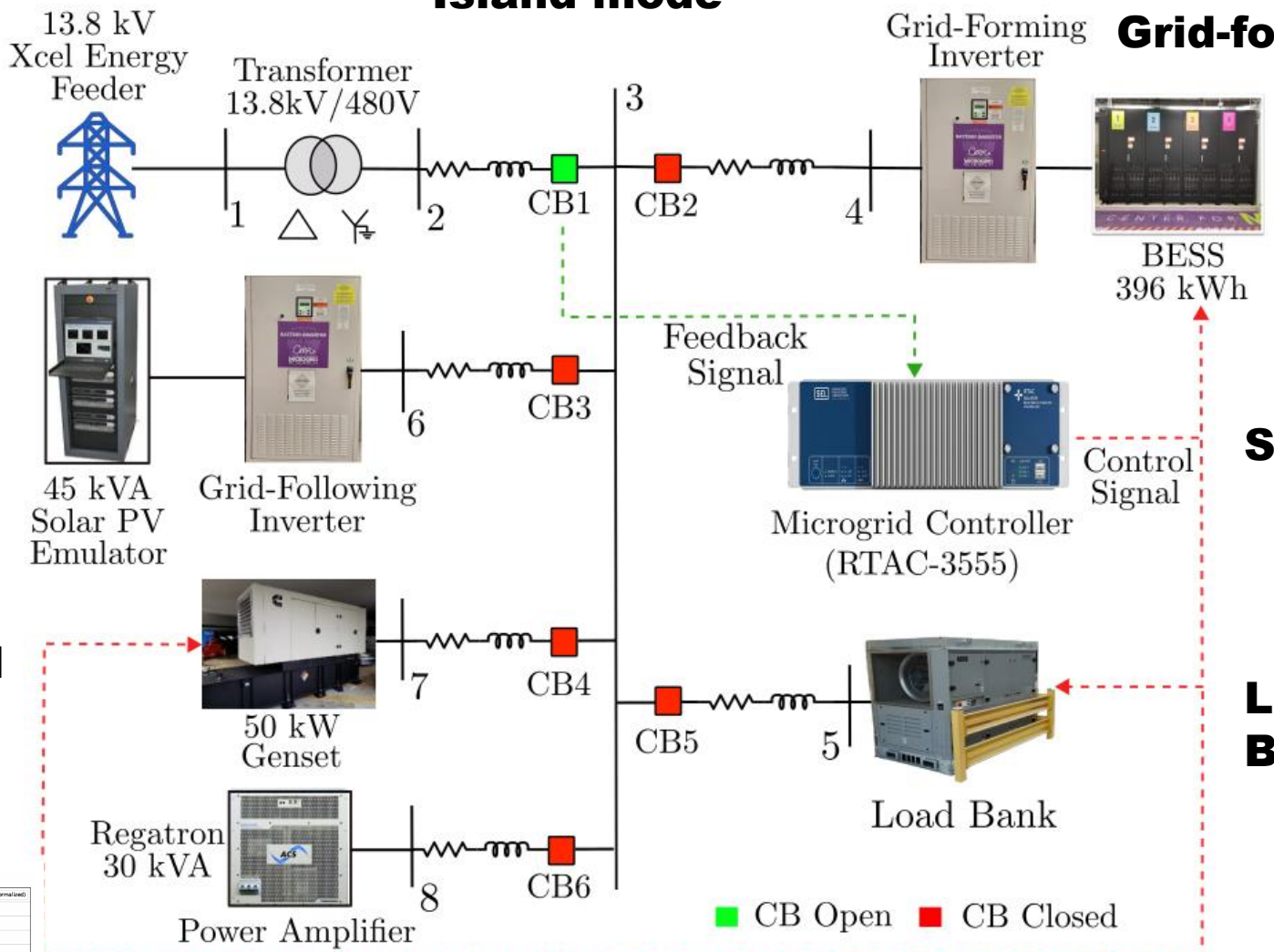
Grid-forming Droop control

PV Emulator: Constant 10 kW

Diesel Gen: Grid-forming Droop control

AI data center load 1-20 kW

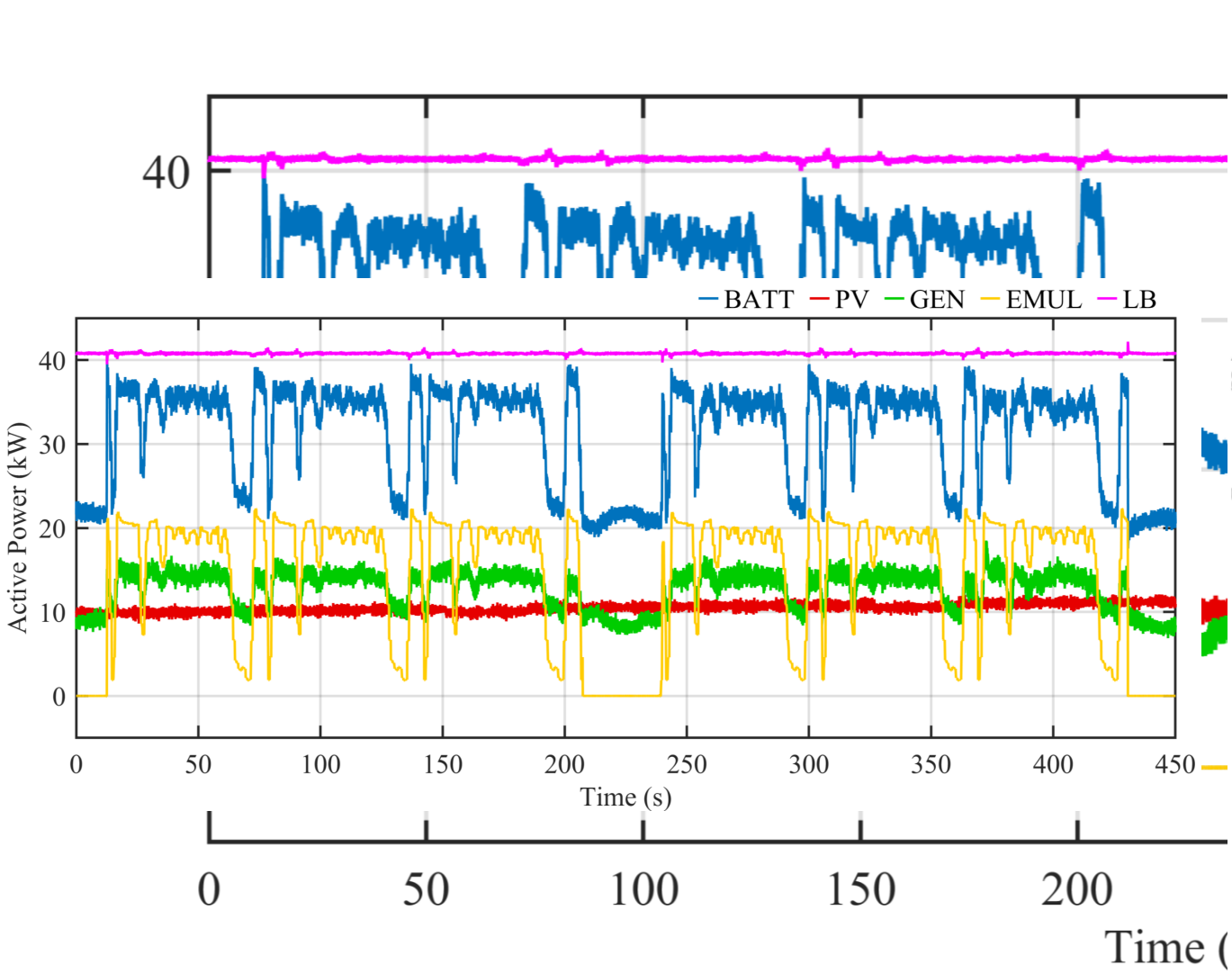


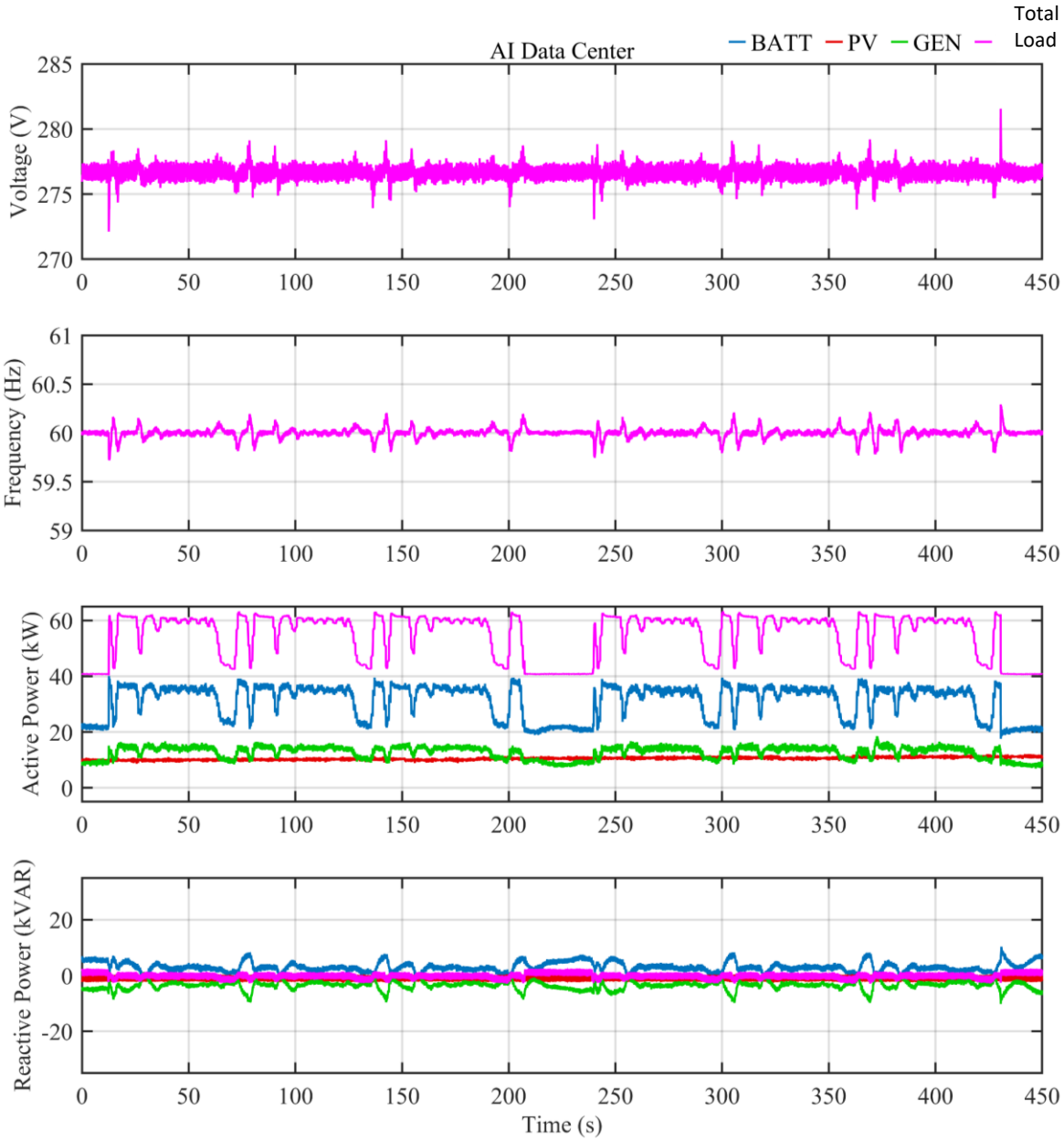


Secondary V/f control

Load bank: Baseload 40kW

Real-World Case Studies: Case Study 1





LUT Group Confidential - Other information (3Y)

Real-World Case Studies: Case Study 2

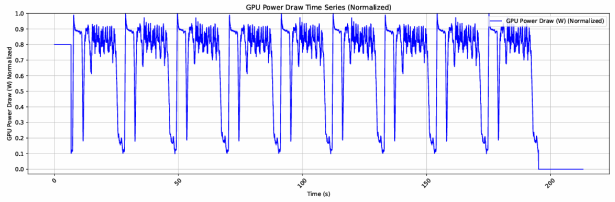
Island-mode

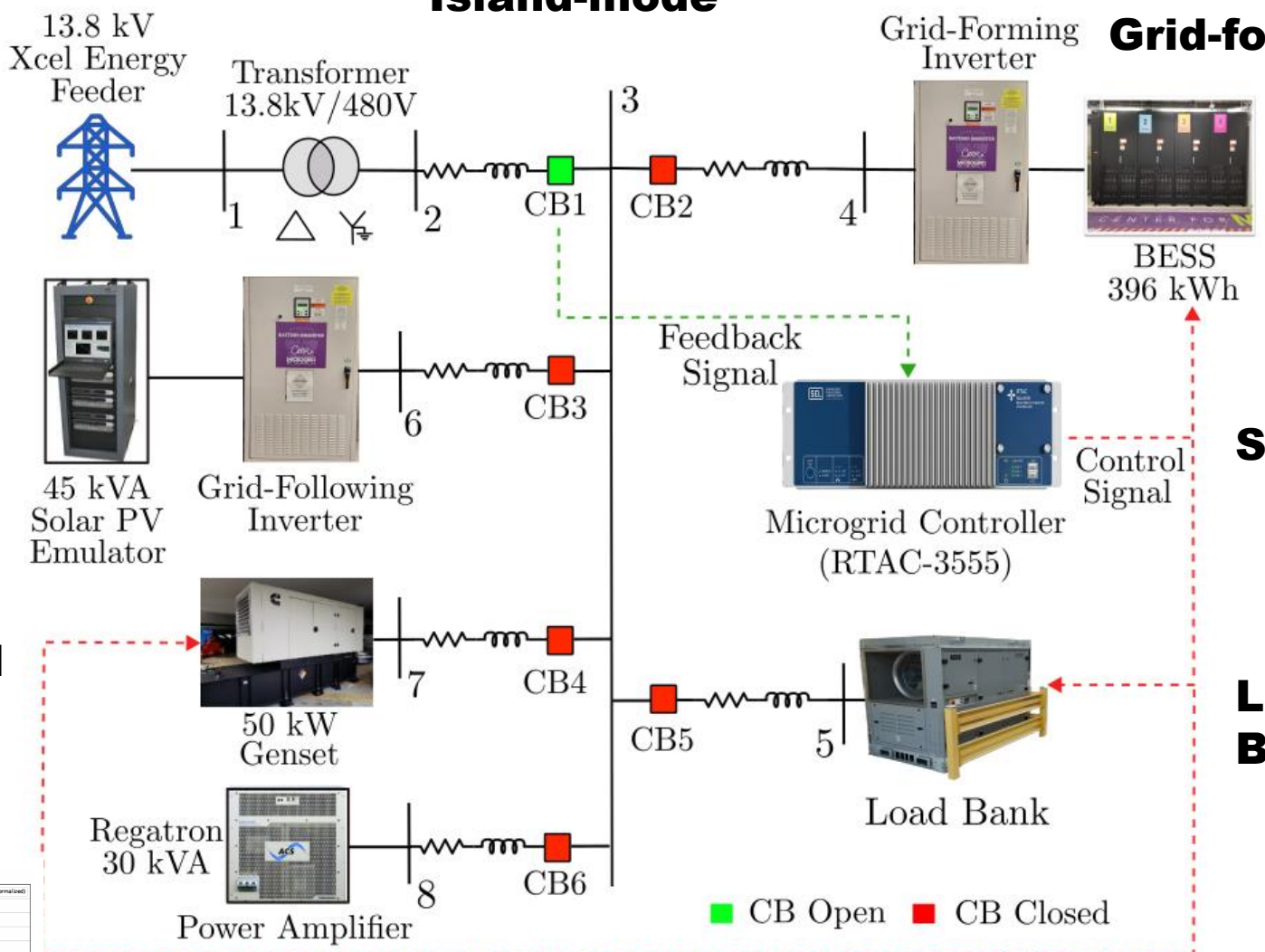
Grid-forming Droop control

PV Emulator: Triangular PV Curve 5-30 kW repeating each 10 seconds

Diesel Gen: Grid-forming Droop control

AI data center load 1-20 kW

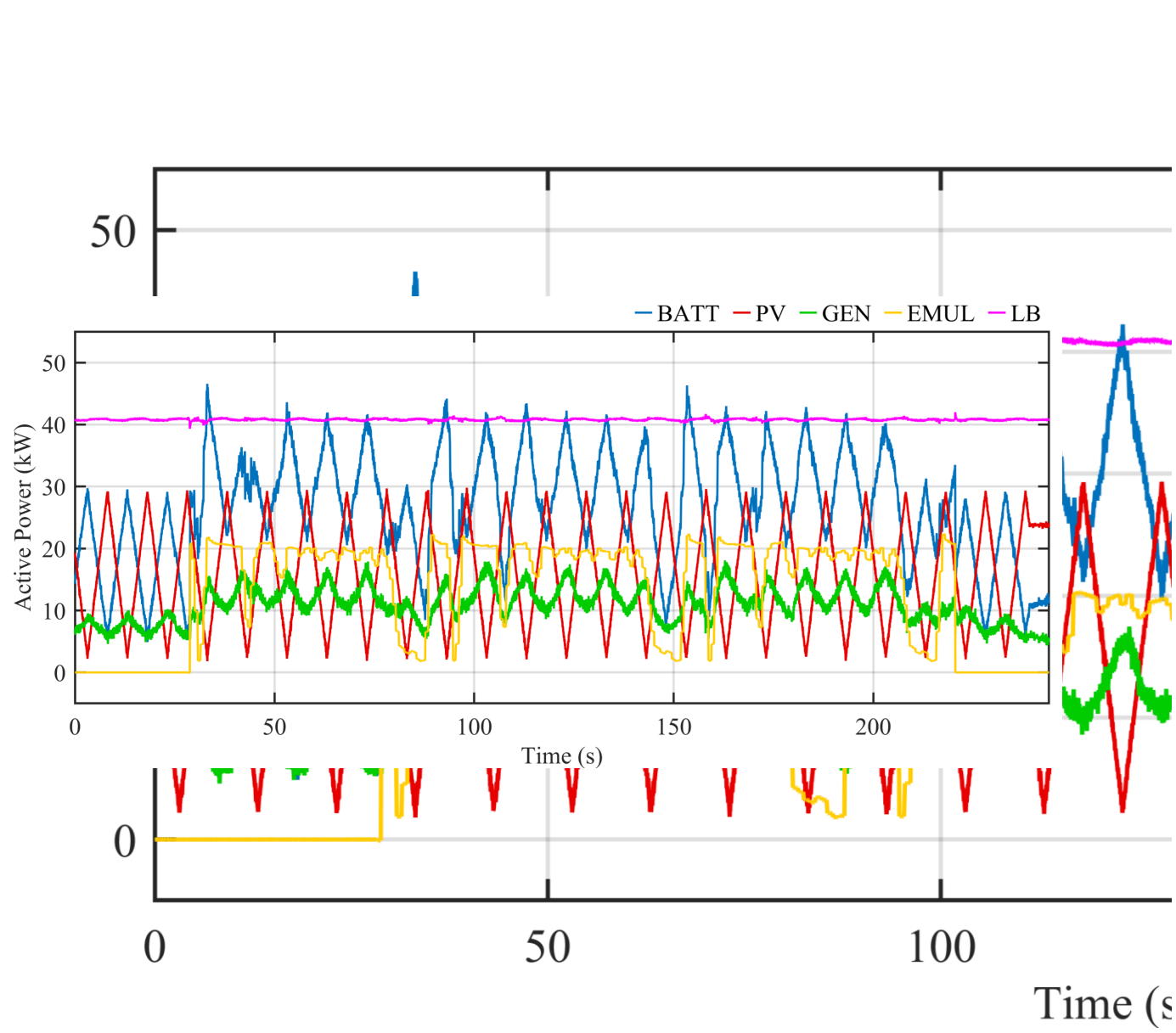


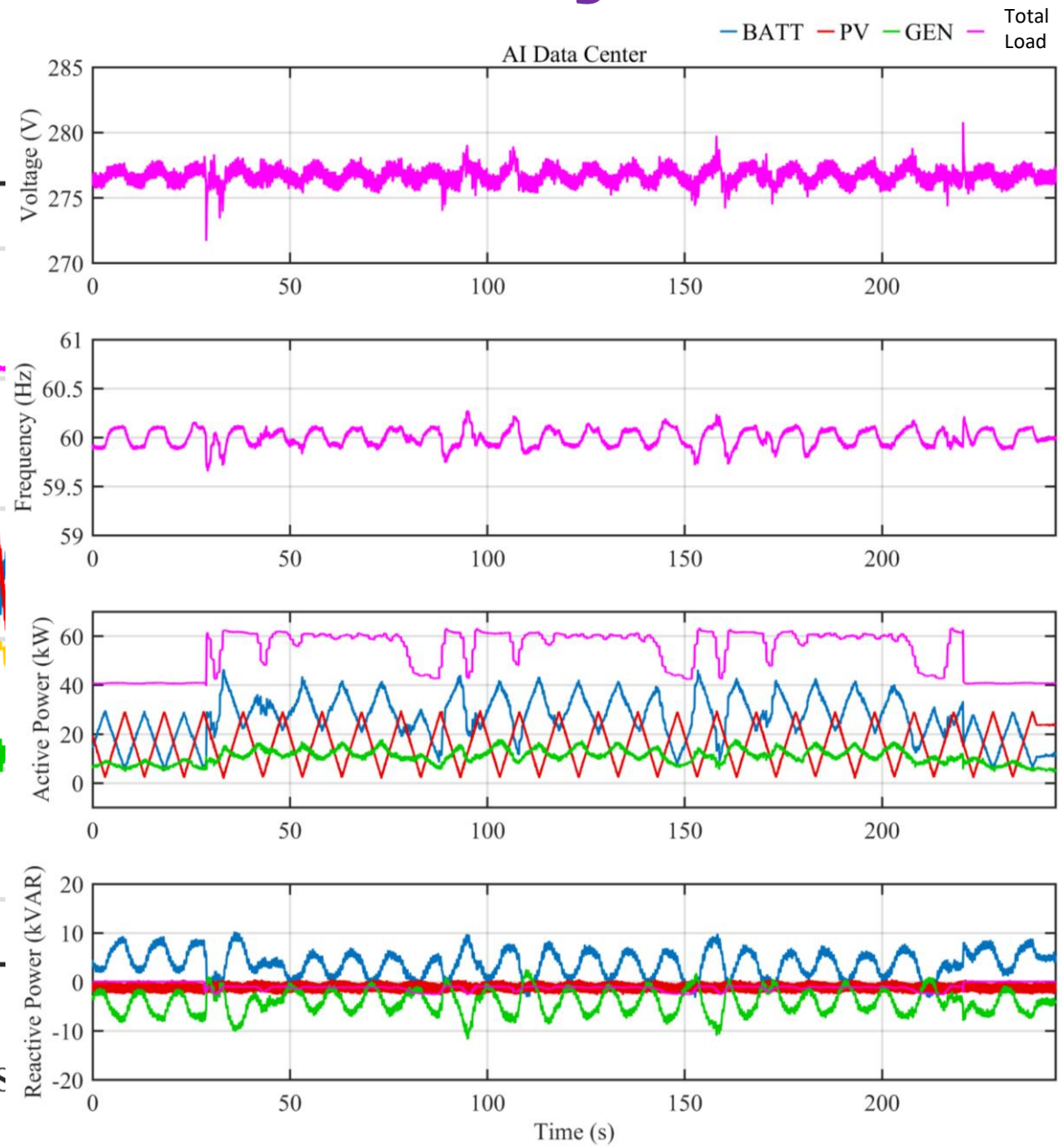


Secondary V/f control

Load bank: Baseload 40kW

Real-World Case Studies: Case Study 2





LUT Group Confidential - Other information (3Y)

Real-World Case Studies: Case Study 3

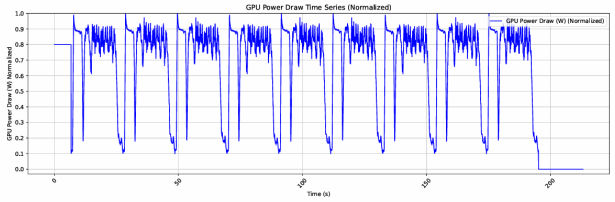
Island-mode

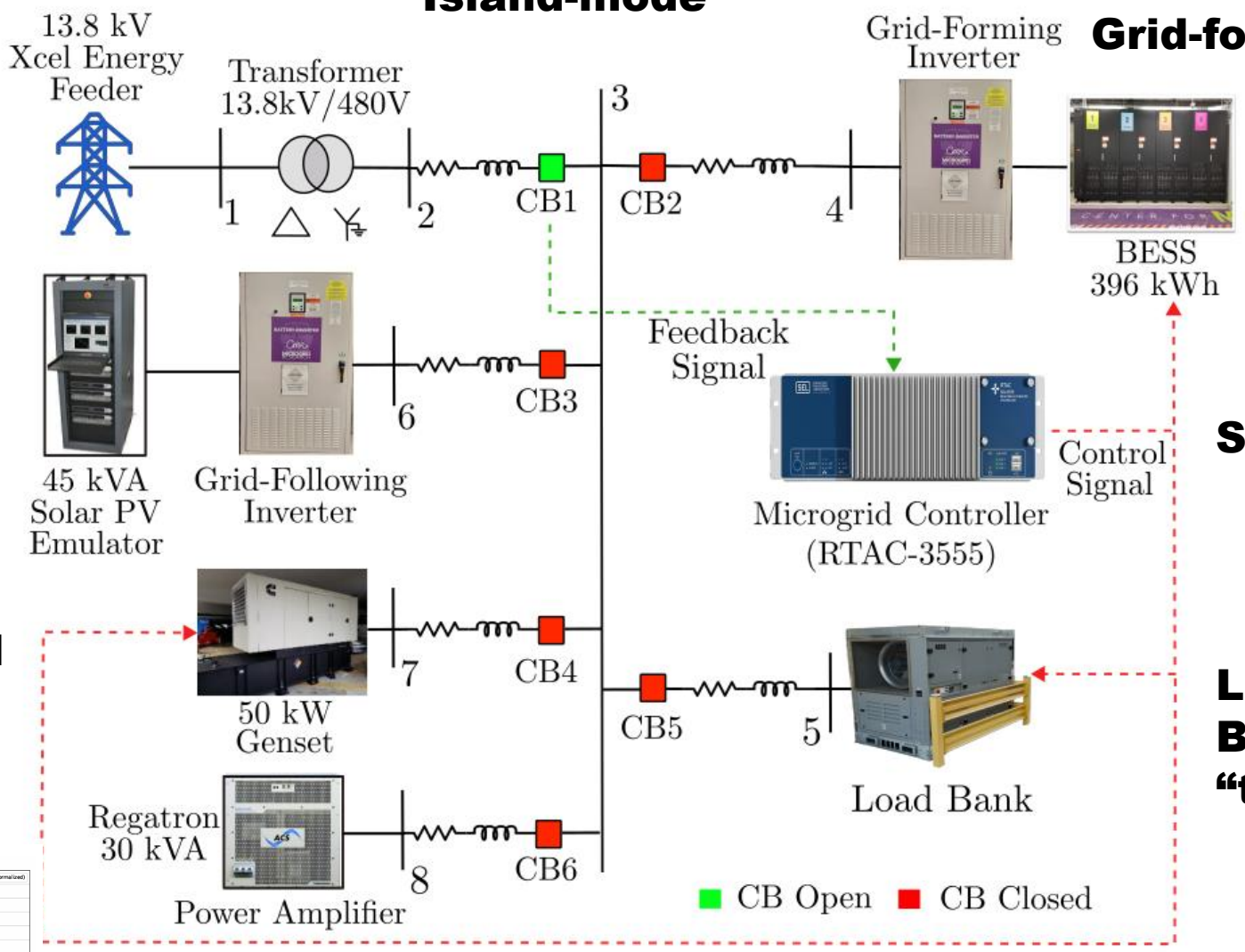
Grid-forming Droop control

PV Emulator: Triangular PV Curve 5-30 kW repeating each 4 seconds

Diesel Gen: Grid-forming Droop control

AI data center load 1-20 kW

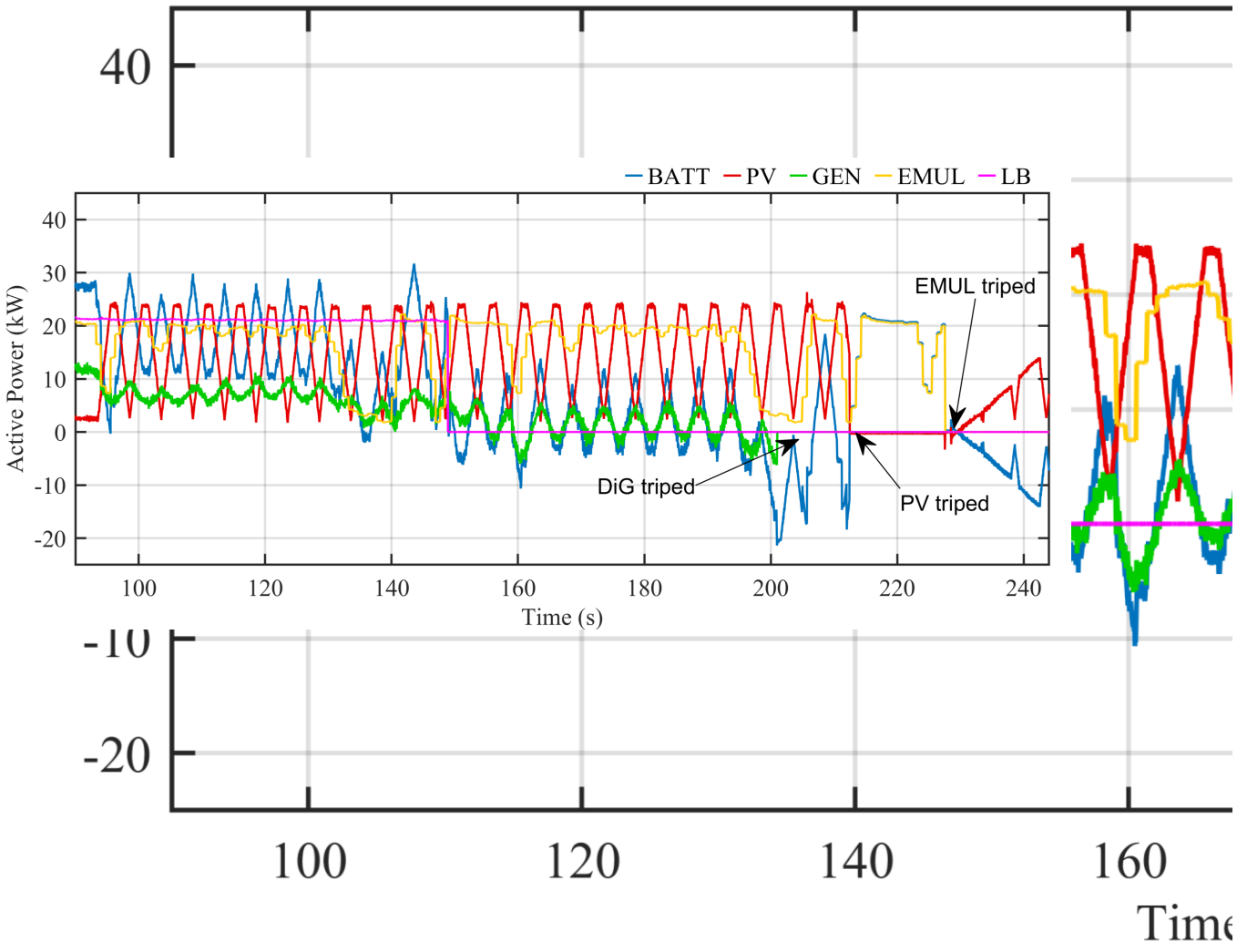


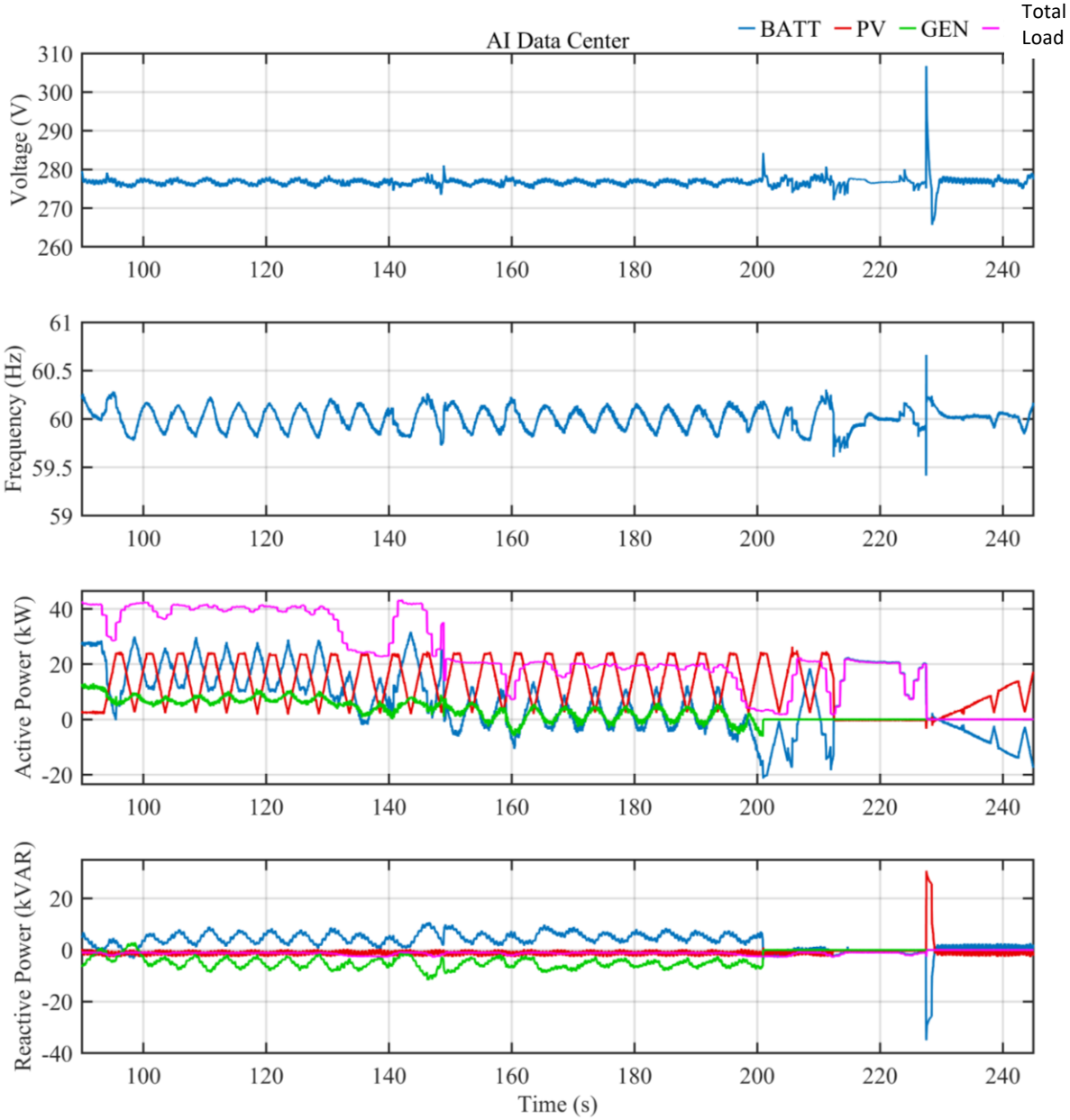


Secondary V/f control

Load bank: Baseload 40kW “tripped” at 150 sec

Real-World Case Studies: Case Study 3





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Real-time simulations RTDS Case studies



CENTER FOR MICROGRID RESEARCH

Typhoon HIL Testbed CHIL Case Study

Overview & Scale

Largest within Typhoon HIL's global network (over 600 partners)

(Matt Baker, Typhoon HIL, Inc.)

Typhoon multi-CHIL model with 20 real-time industrial controllers

Component Breakdown

	5*	Typhoon HIL 606 real-time simulators
	8*	HIL modular units for I/O mapping
	7*	Woodward EasyGen 3500 DiG controllers
	4*	EPC Power inverter controllers
SEL	6*	SEL-751 protection relays
	2*	ASCO 5310 ATSs
	1*	Eaton CB-8000 capacitor bank

Physical Testbed



CENTER FOR MICROGRID RESEARCH

R. S. Patekar, M. Kabalan, M. M. Z. Moustafa, M. Almeida, M. Baker, I. Celanovic, and T. Bozada, "Demonstration of 17 industry-grade controllers and relays in a Typhoon hardware-in-the-loop testbed for microgrid and grid modernization applications: A case study," Accepted for publication in IEEE PES GM, 2026.

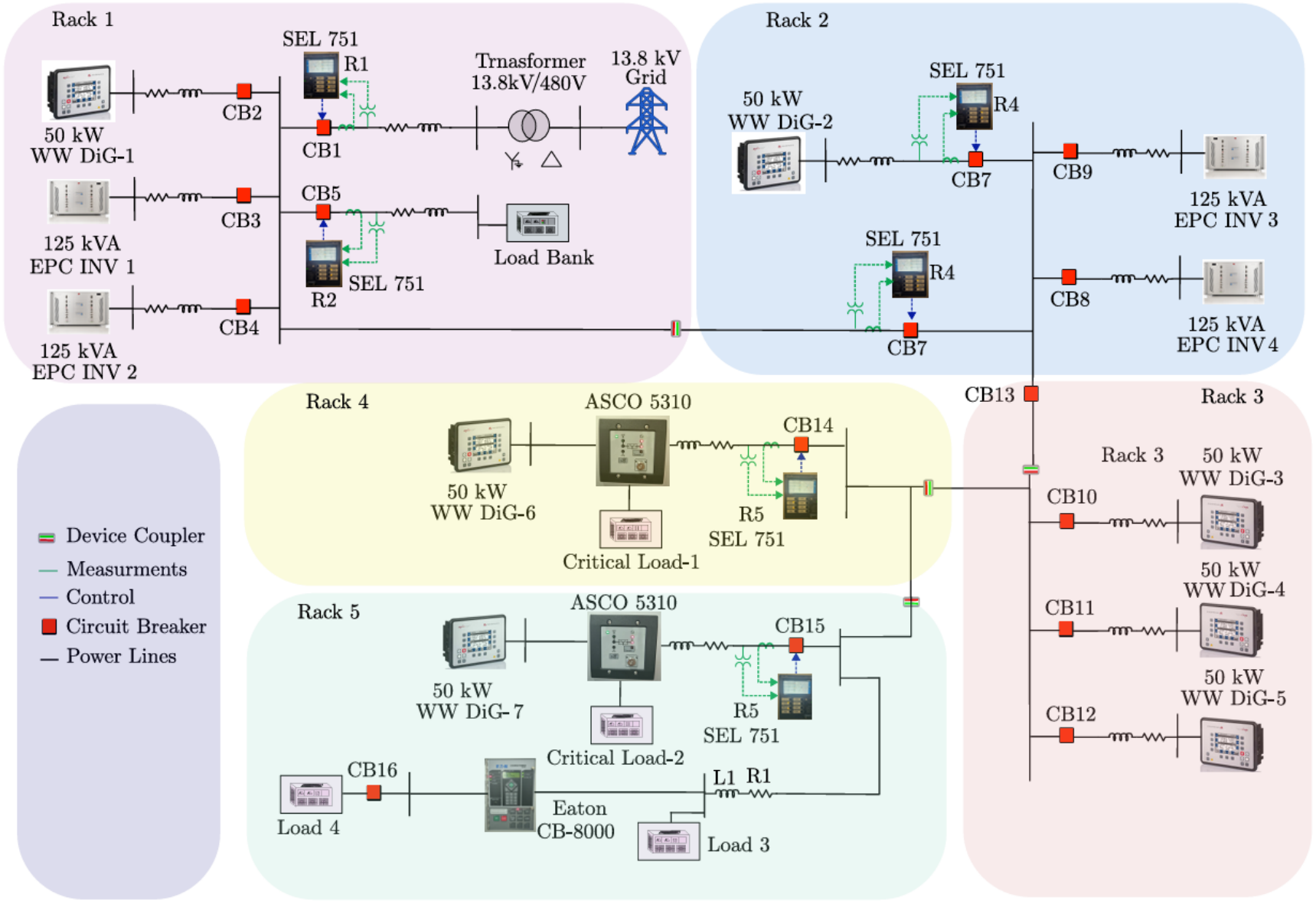
R.S. Paterka, et al, ""Demonstration of 20 Industry-Grade Controllers in a Typhoon Hardware-in-the-Loop Testbed: Case Studies for Microgrid," Accepted for publication 2026 ECCE.a

Typhoon HIL Testbed CHIL Case Study

Source	Rating
DiG 1	62.5 kVA
DiG 2	62.5 kVA
DiG 3	62.5 kVA
DiG 4	62.5 kVA
DiG 5	62.5 kVA
DiG 6	62.5 kVA
DiG 7	62.5 kVA
Load Bank	750 kVA

Source	Rating
Critical load-1	20 kW
Critical load-2	20 kW
Load 4	30 kW
Load 3	15 kW
Capacitor Bank	100 kVAR
Transformer	1 MVA
X_T	0.06 (p.u)
X_{Line}	0.03 (p.u)

Source	Rating
ESS 1	125 kVA
ESS 2	125 kVA
ESS 3	125 kVA
ESS 4	125 kVA
Utility Grid	480 V/13.8 kV
R_T	0 (p.u.)
R_{Line}	0.01 (p.u)
Relay	SEL 751



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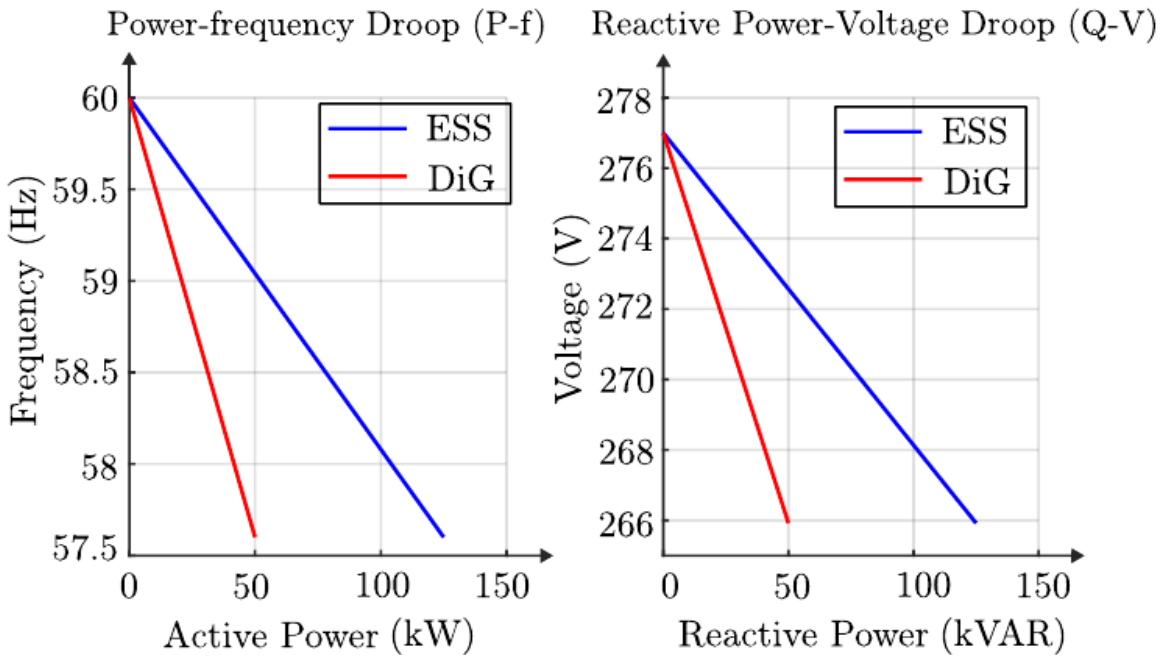
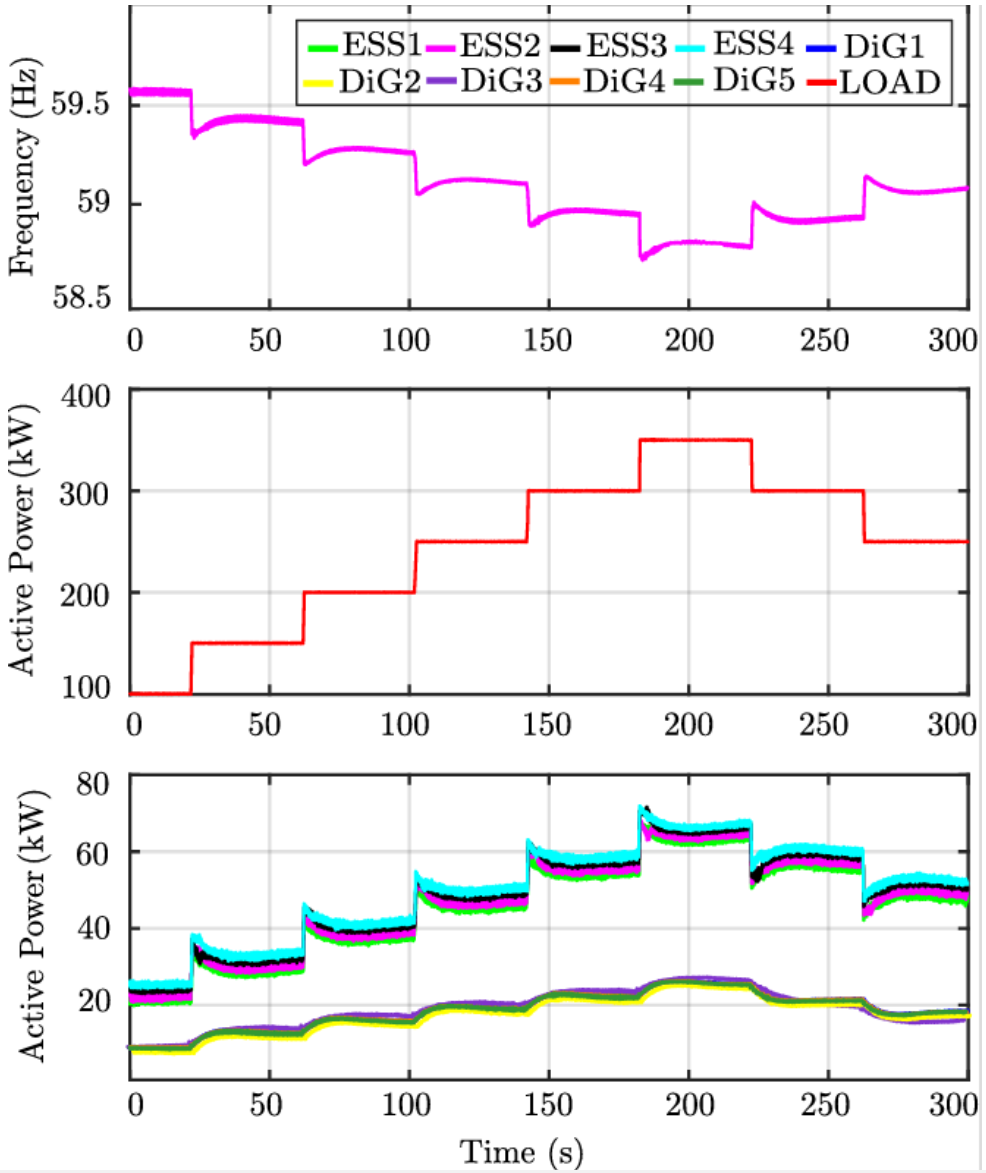
Typhoon HIL Testbed CHIL Case Study 1

Island – mode operation

Droop Based power sharing between ESSs and DiGs

No secondary V/f control





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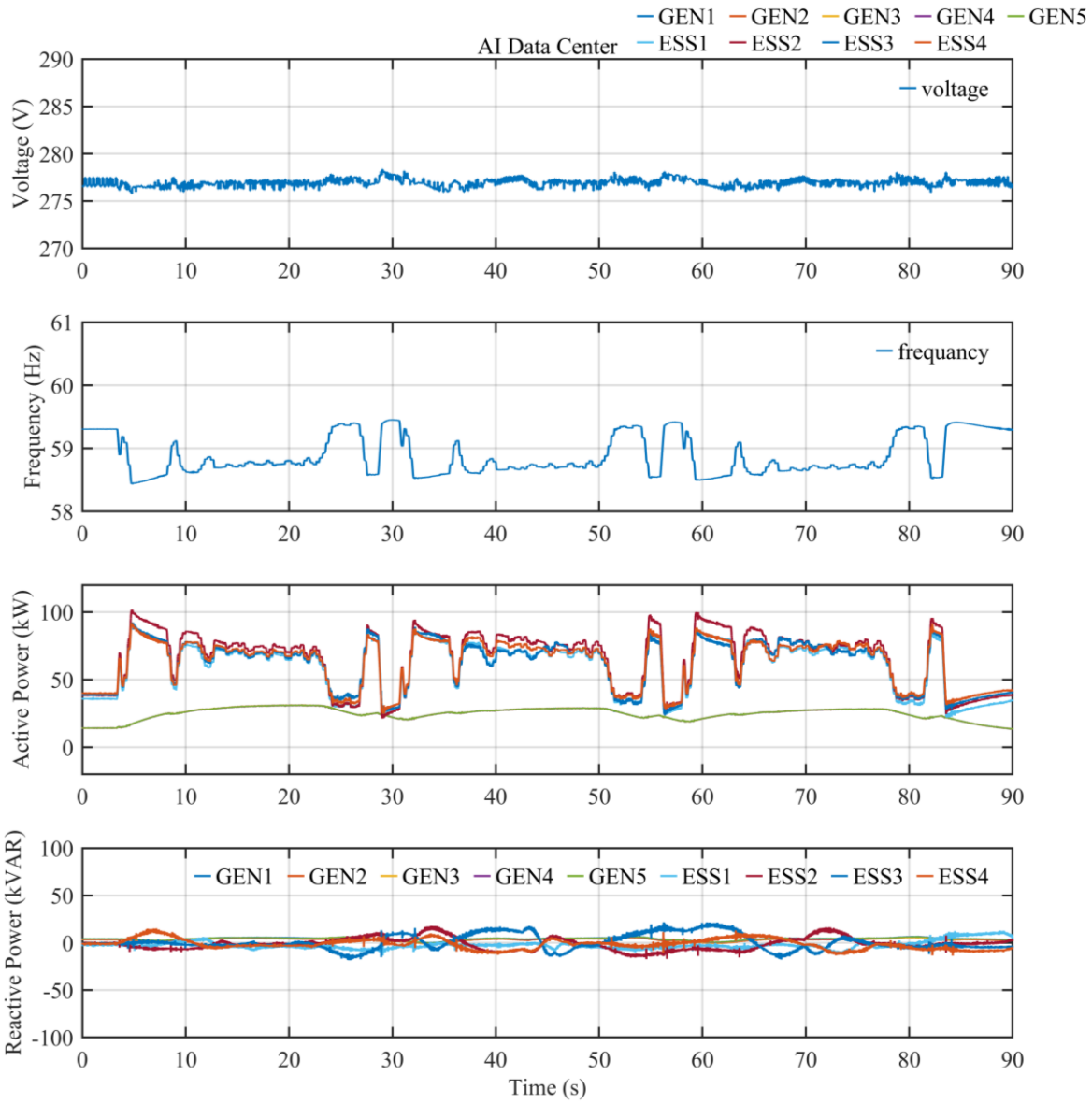
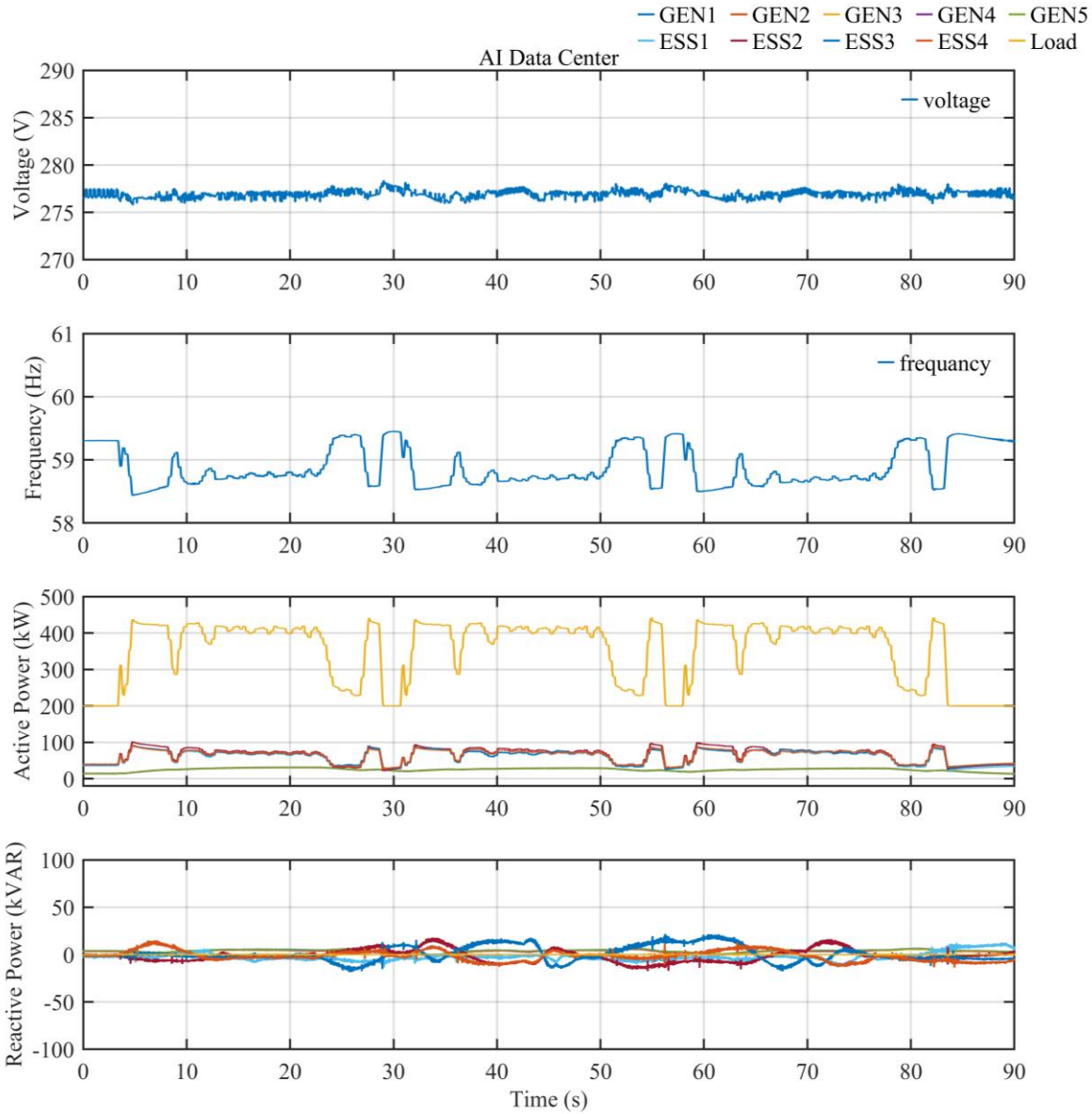
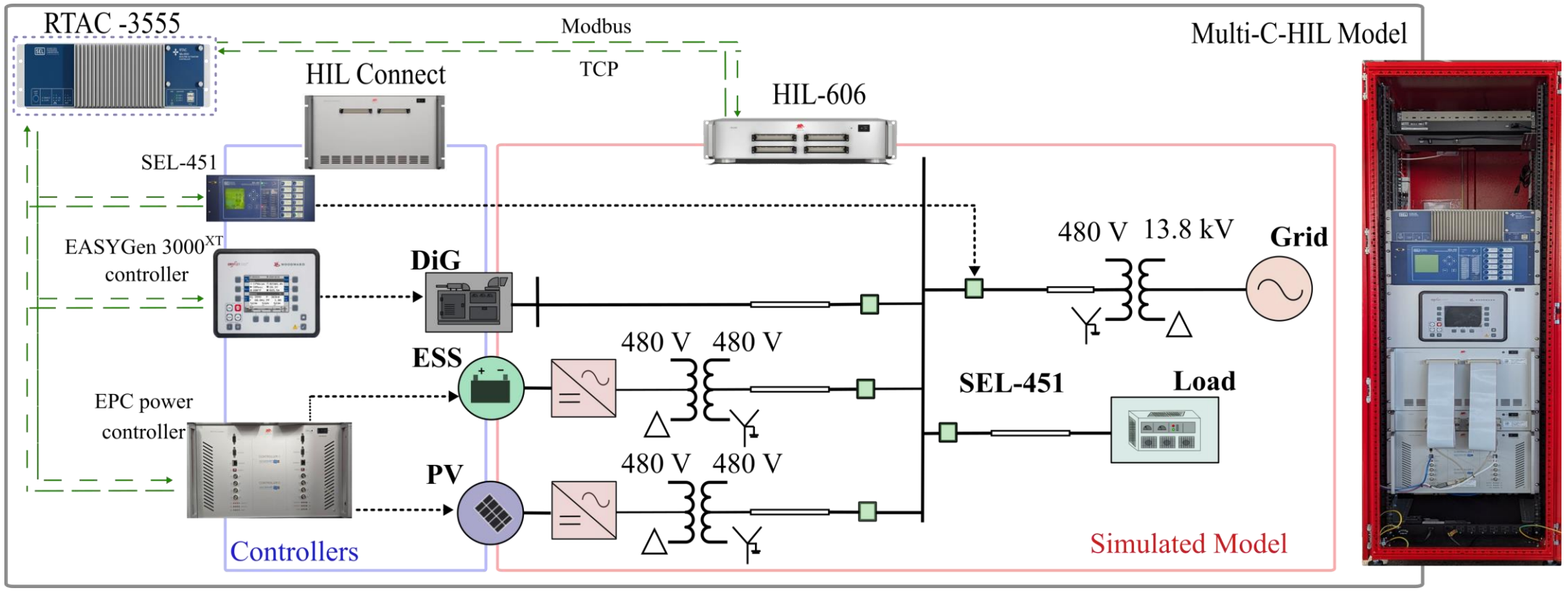
Typhoon HIL Testbed CHIL Case Study 2





LUT Group Confidential - Other Information (01)

Typhoon HIL Testbed CHIL Case Study 3
Replicating Real-World Performance of Microgrid 1



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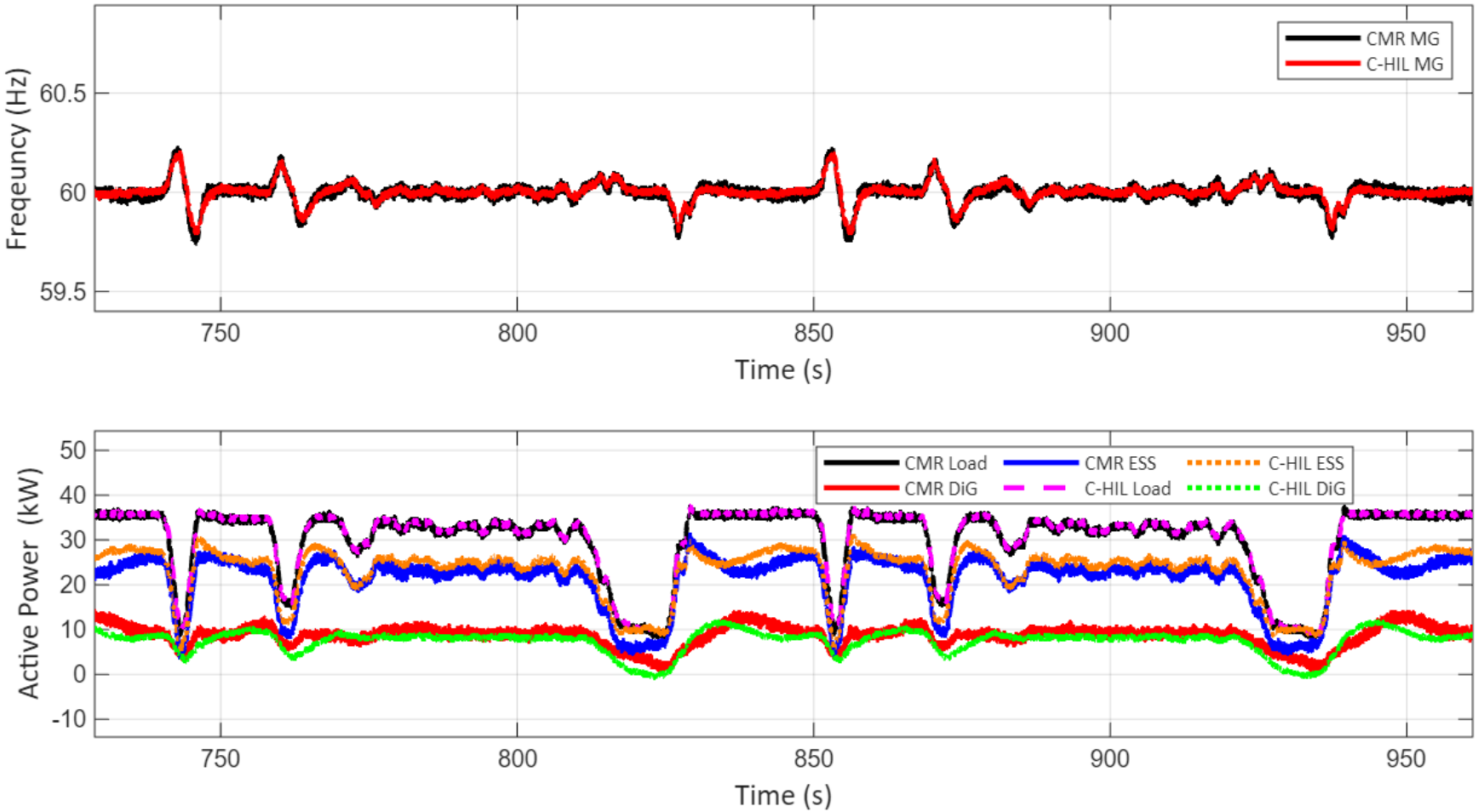

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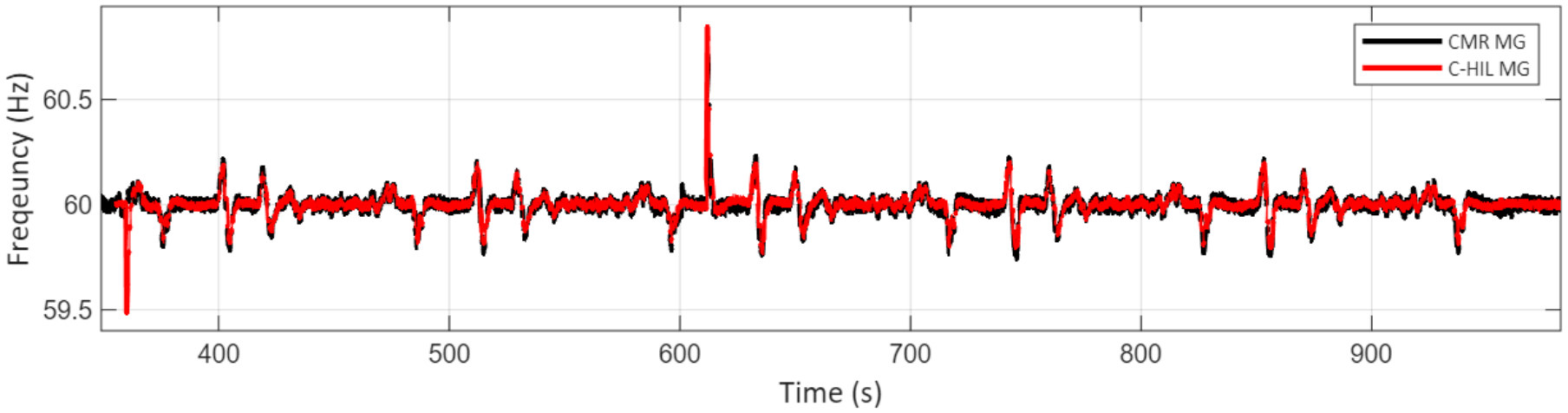

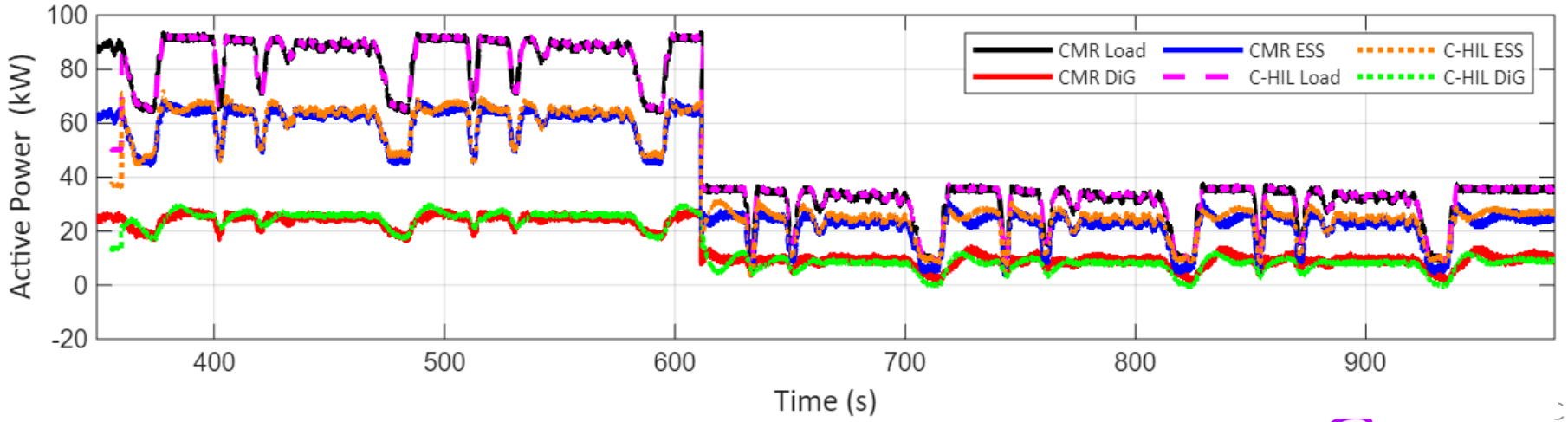

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CMR RTDS Real-Time Testbed

Key Milestones

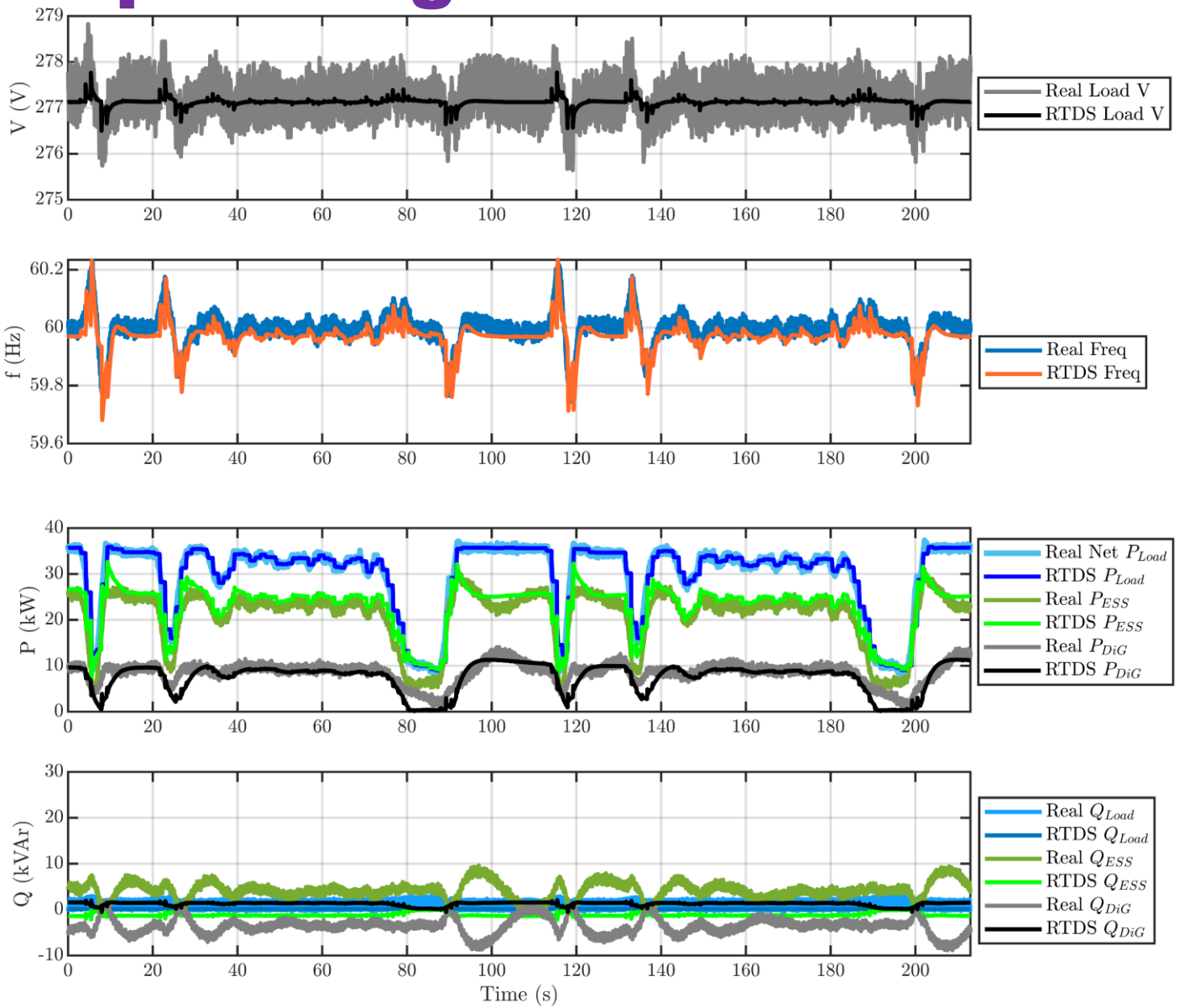
- ***largest* installation of the newest generation of RTDS real-time processing hardware**
  - US Academic Institution
  - Second Worldwide out of 240 institutions

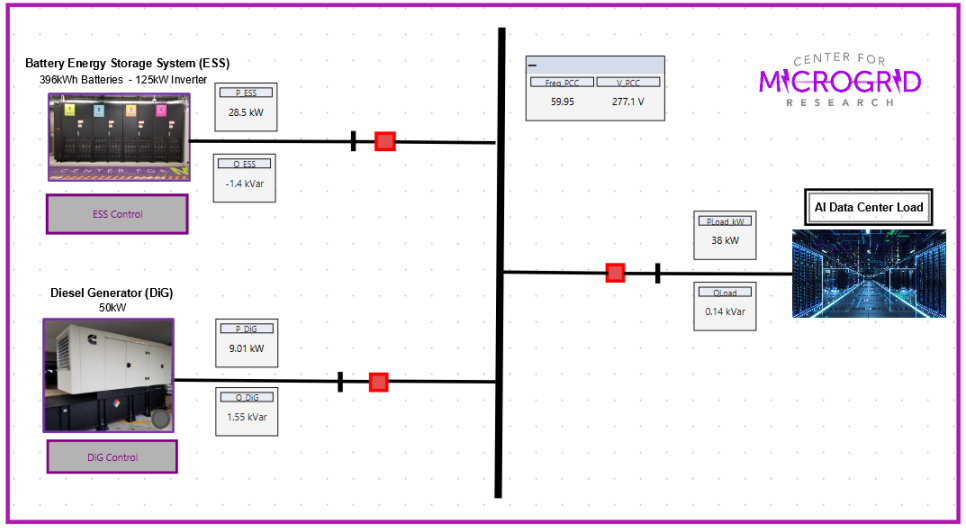
*as of 2025



CMR CENTER FOR MICROGRID RESEARCH

RTDS Testbed Case Study
Replicating Real-World Performance of Microgrid 1







Center for Microgrid Research Sample of Ongoing R&D Efforts

Microgrid design, implementation, and commissioning	**Microgrid control and operation AI-Powered and Real-world demonstrated Algorithms**	**Enabling true plug-and-play of power devices using the Tactical Microgrid Standard**	**Demonstrating some of the world's most complex Hardware-in-the-loop Studies**
Demonstrating Mobile and versatile Microgrids-On-Wheels	**Workforce development and training on microgrids, cyber security, and operations**	**Demonstrating Cyber Security Challenges and Protection**	**Large signal stability and mathematical modeling**

Center for Microgrid Research

UNIVERSITY OF St.Thomas

LUT Group Confidential - Other information (3Y)

THANK YOU on Behalf of the CMR team! Questions?

Reach out for collaborations, data, visits, or questions. Hiring students and postdocs



kaba8087@stthomas.edu

Connect with me on LinkedIn

engineering

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