Coordinated Control of Energy Storage in Networked Microgrids

FREEDM Annual Research Symposium 2026

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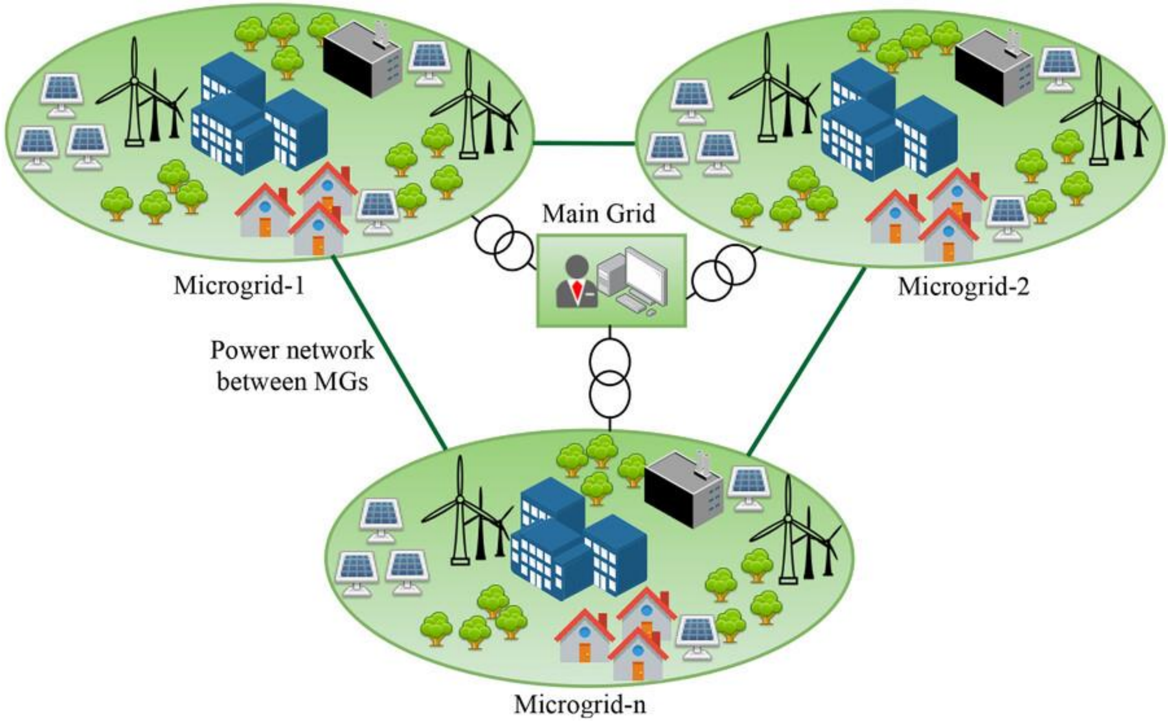
Project Goals

How can grid-tied microgrids *share* each other's energy storage resources via *real-time control and optimization* for coordinated operation during large disturbance events?



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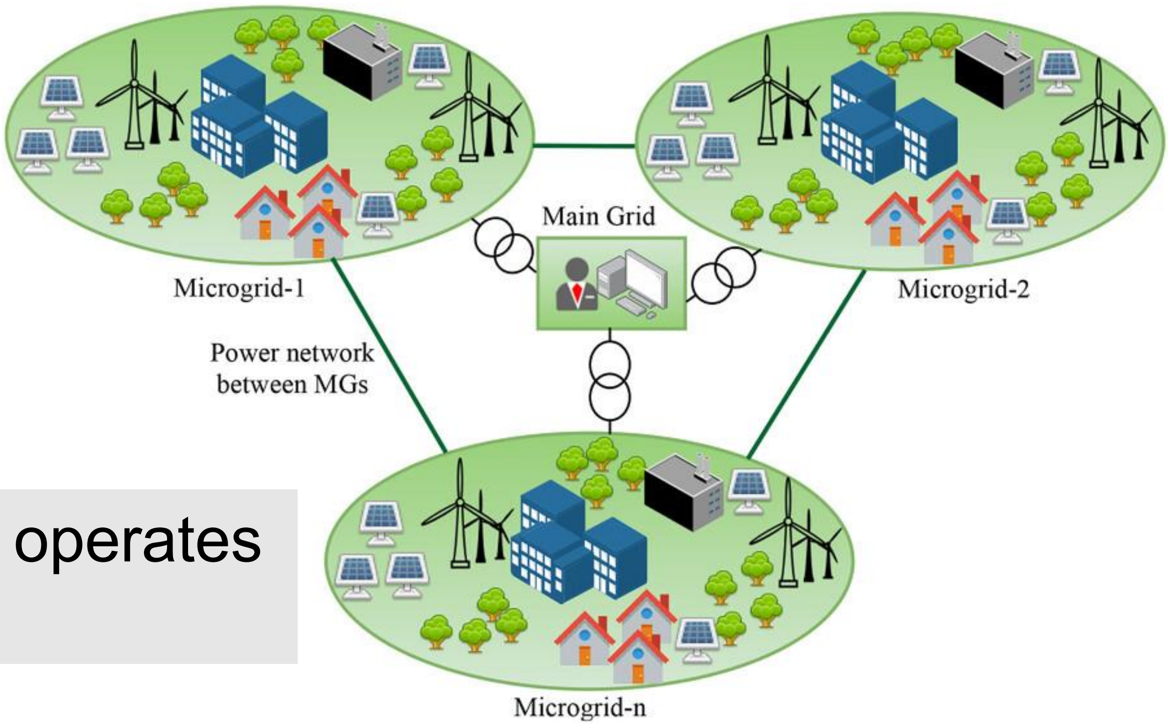

Current state-of-the-art: Every microgrid operates using only *local, myopic controls*

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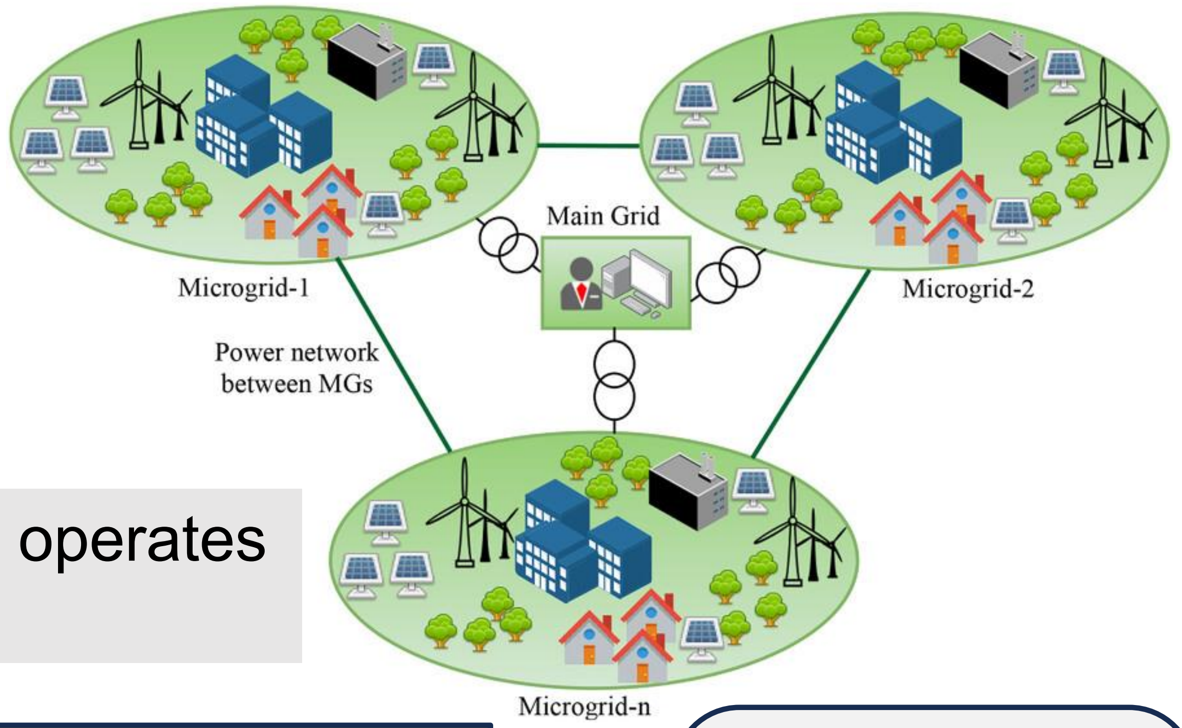


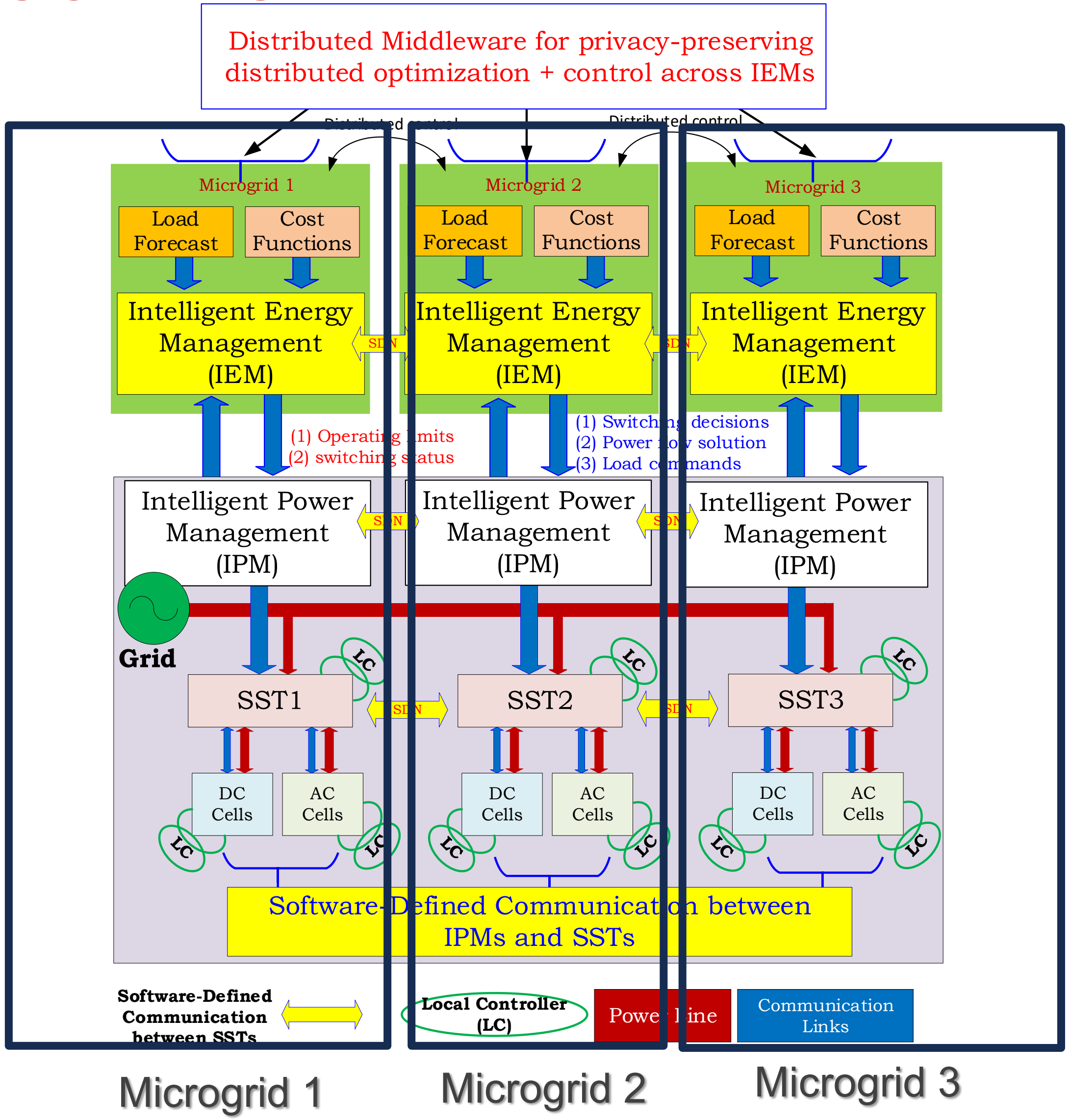
Current state-of-the-art: Every microgrid operates using only *local, myopic controls*

Coordinated control can:

(1) save operational costs by using shared storage
(2) batteries act as shock absorbers saving neighboring microgrids
(3) better stability margins
(4) better resilience

(1) Stabilize power compensation,
(2) Control ramp rates
(3) Mitigate large step changes

System Architecture



Field data from M.C. Dean, NREL databases, EIA grid monitor

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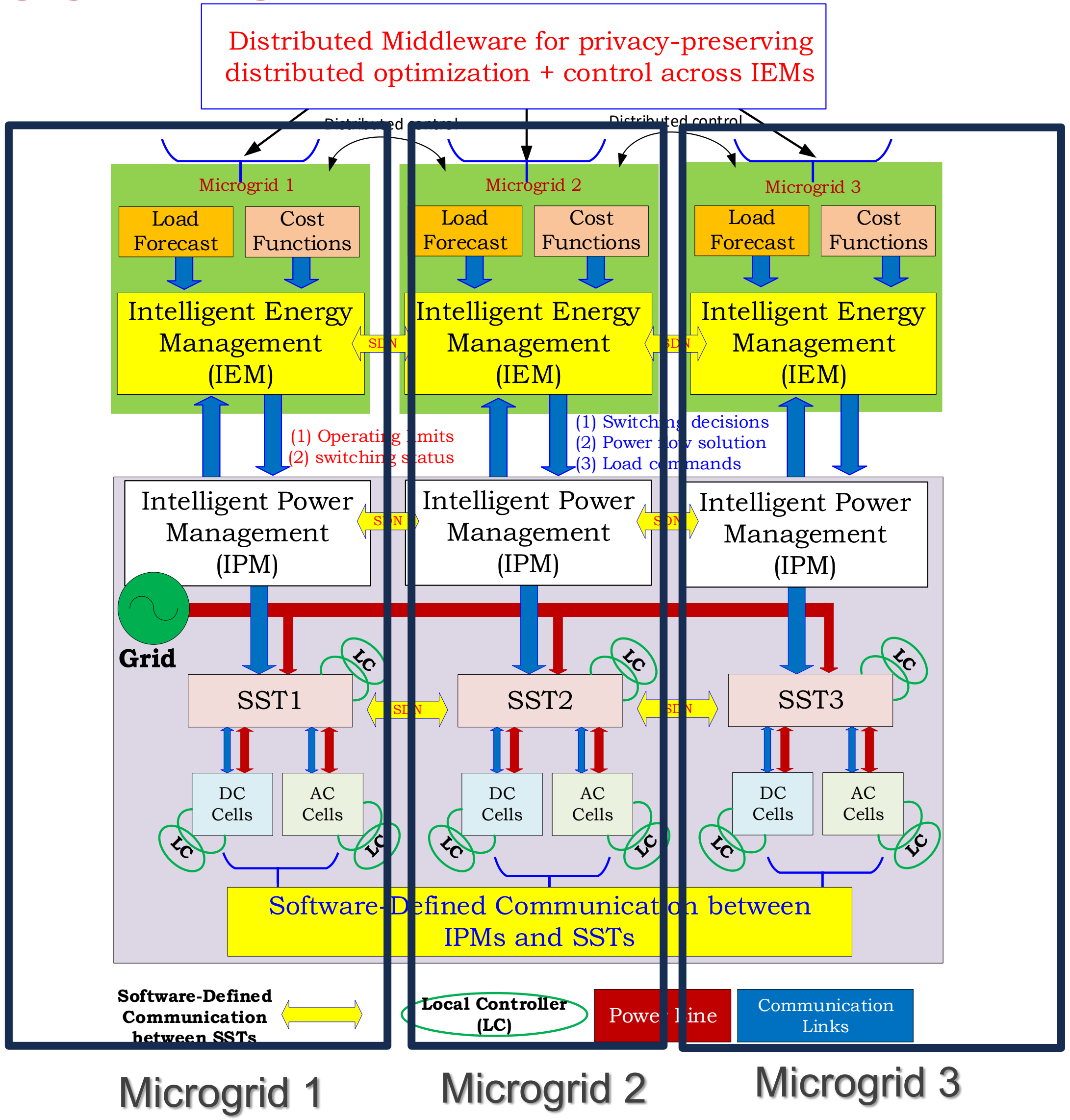
System Architecture

Intelligent Energy Management (IEM)

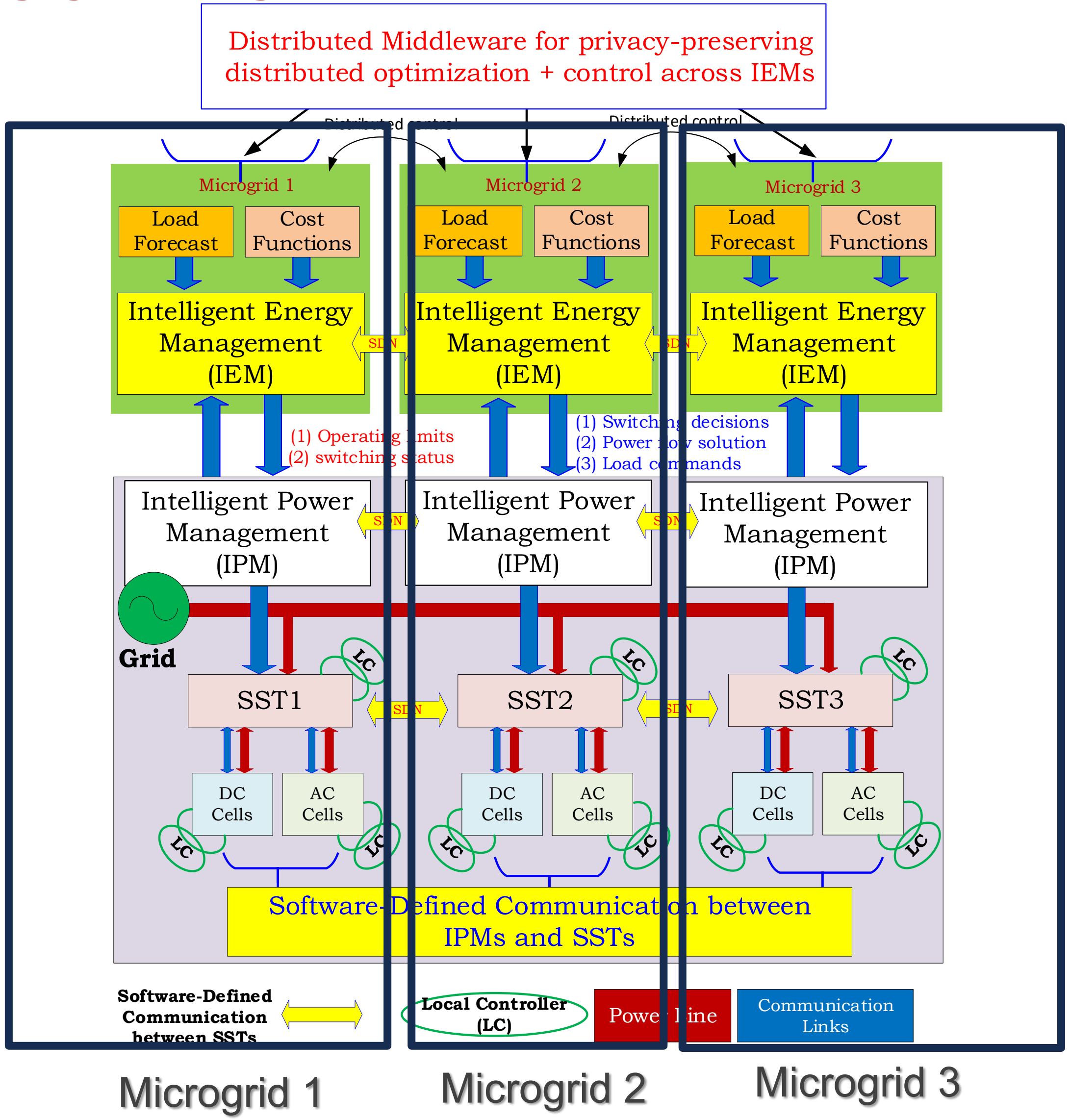


Optimization (Dispatch, OPF, Load Forecasting)

System Architecture

Intelligent Energy Management (IEM)

Intelligent Power Management (IPM)



Optimization
(Dispatch, OPF, Load Forecasting)

Distributed Control
(Power flow damping, DC-link voltage regulation, Voltage Stability)

Two Primary Challenges to Overcome

1. Lack of Exact Model Information:
   - Use Machine Learning Methods for both IEM and IPM
   - IEM: SDDP, MCMC, DL
   - IPM: Reinforcement Learning

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2. Battery SST models make the grid dynamics nonlinear
   - Linear feedback control may no longer work
   - Nonlinear distributed control is a hard problem
   - IPM: Lifting-based control

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We are doing "global" IEM/IPM, not local

Rely as little on the complex system model as we can

Nonlinear SST dynamics from BESS and Data Center loads

Technical merit: Scalability + Model-free + Nonlinearity

Timeline

Year 1:

- Develop Scalable ML based optimization (IEM)
- Develop Scalable ML based nonlinear control (IPM)
- Extensive testing on IEEE prototype models

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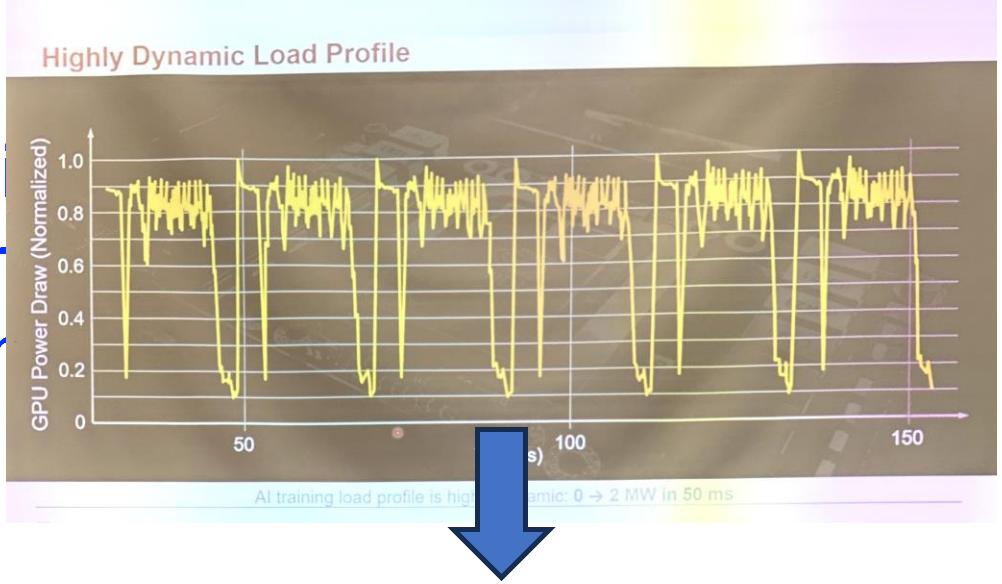

Year 2:

- Integrate Data Center load models from parallel M.C Dean projects
- How does “erratic” data center demands change IEM and IPM?

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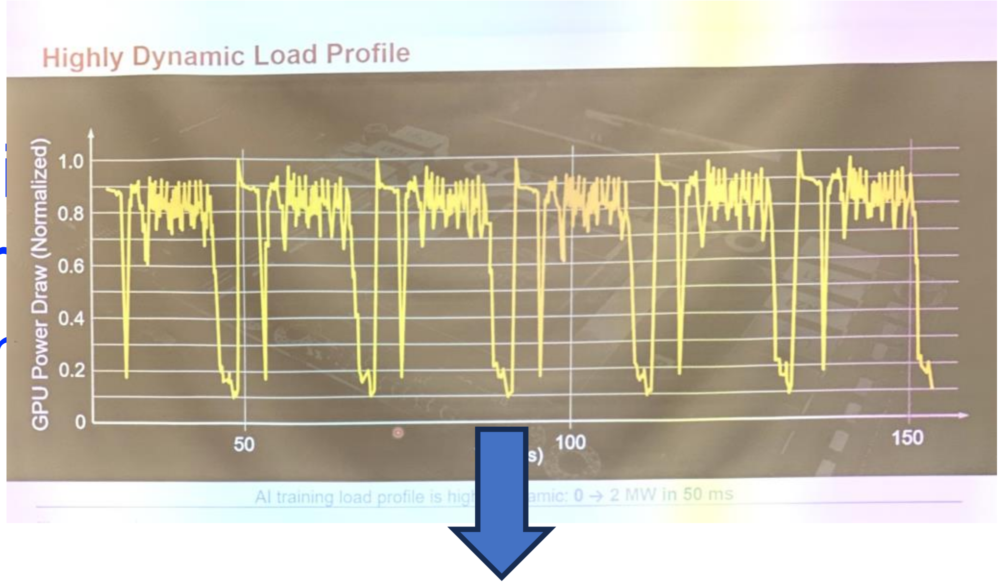
Timeline



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Year 3:
- Further use of advanced ML for IEM (using weather data)
- Coordinated GFM control for data center BESS

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Project Team

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ECE and FREEDM
Power Electronics