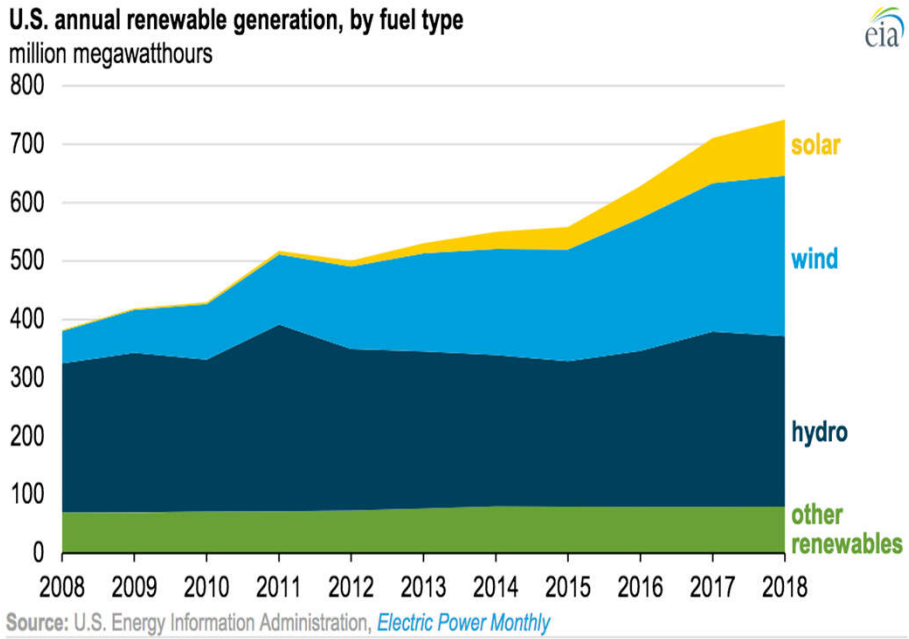
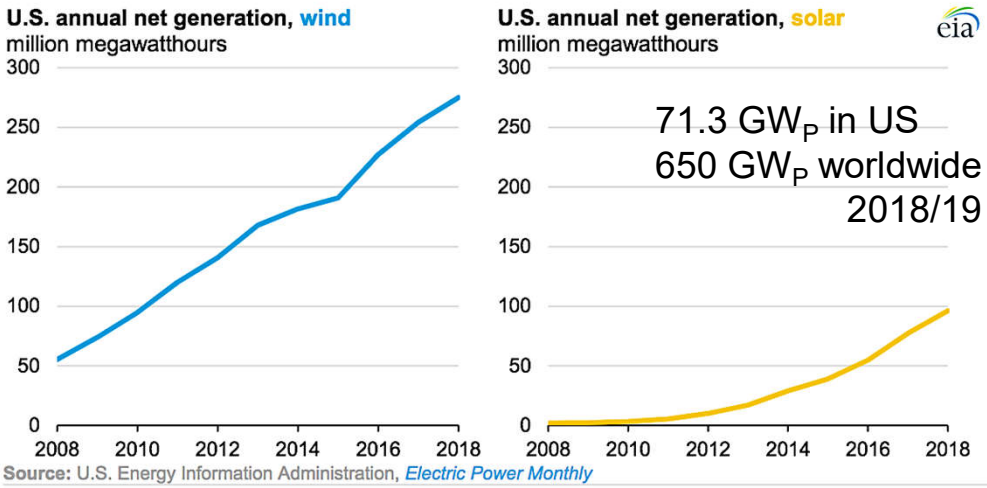
The Good News for CO_2 Free Power

WRIGHT CENTER for PHOTOVOLTAICS INNOVATION AND COMMERCIALIZATION

~18% of US Electricity from Renewables in 2018
~20% from Nuclear



- 90% of growth in wind and solar.
- Sum of hydro and biomass flat (~9%)
- Wind growing linearly (2x in 10 years)
- PV growing exponentially (46x in 10 years)
- If sustained;~83% electricity in next 10 yrs.

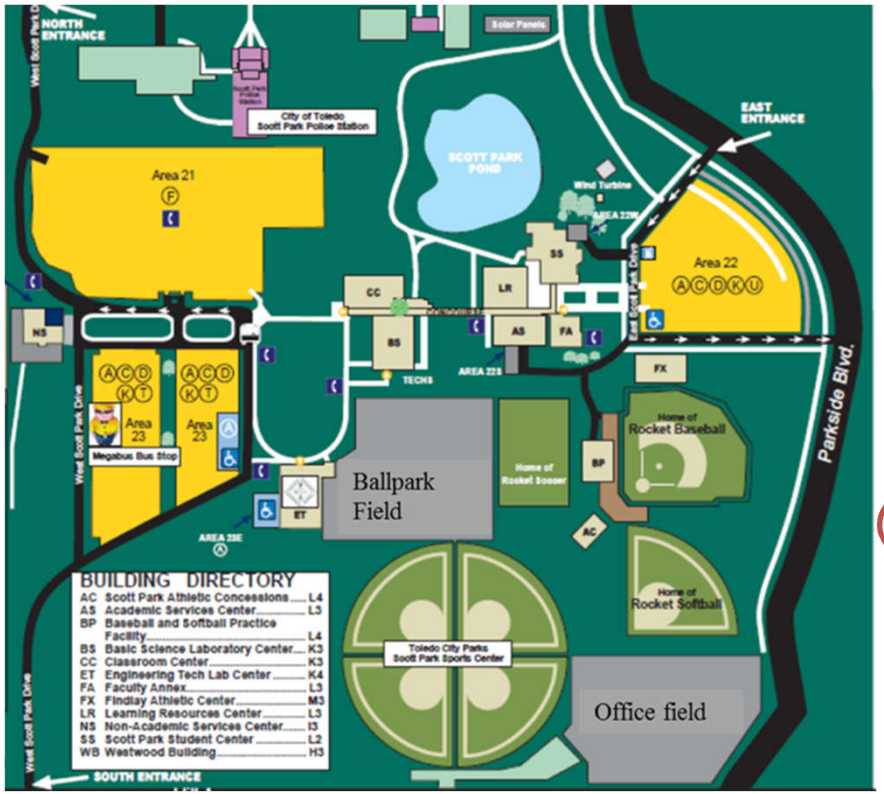


THE UNIVERSITY OF TOLEDO 1872

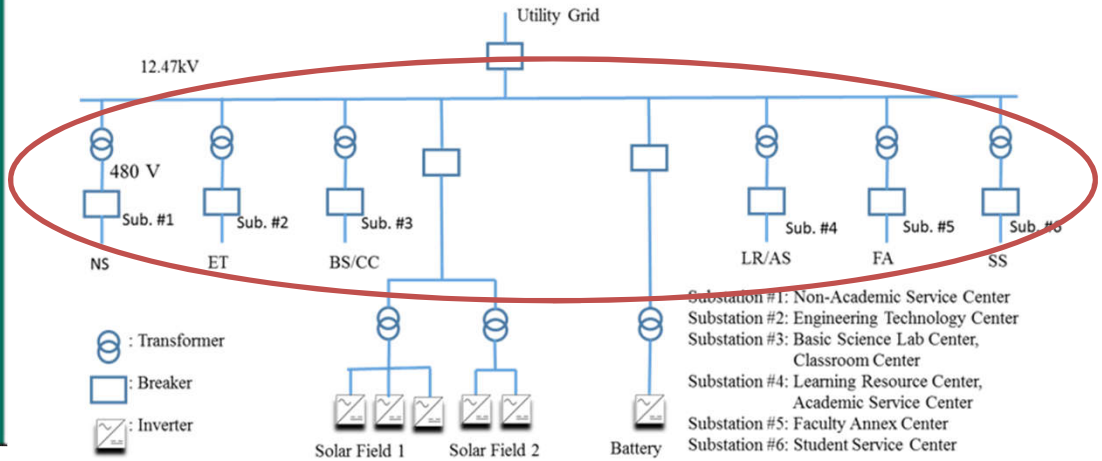
Scott Park Transactive Campus Demonstration

- Since January 2017
- How can more renewables be accommodated?
- Integrated PV and storage systems with buildings on Scott Park Campus
- Testing control strategies for transactive energy.
- Consider “Actors” and Their “Needs”.

Buildings at Scott Park Campus

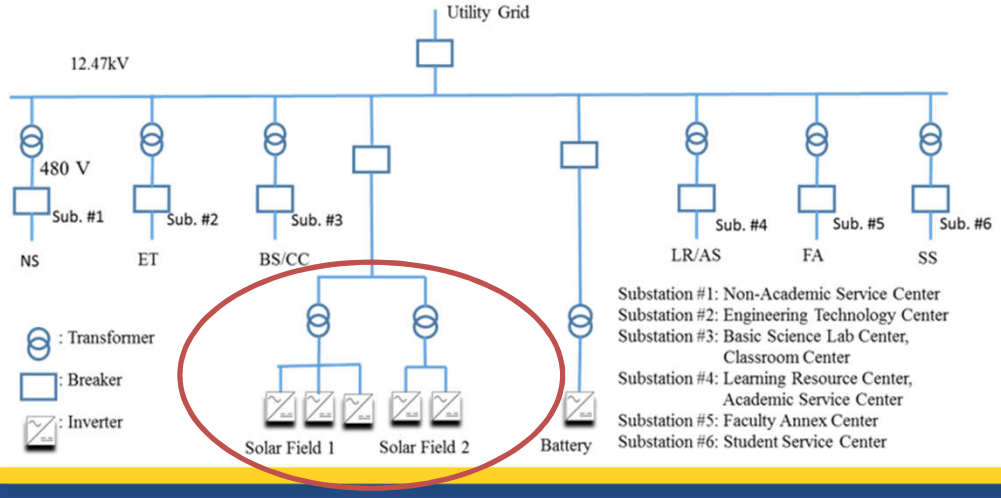


- 8 buildings:
  - 4.6 MW of controllable loads
- 1 MW photovoltaic generation:
  - Ball park field – 360kW, and Office field- 640 kW
- Battery energy storage system (BESS):
  - 130kWh and 125kW



PV at Scott Park Campus

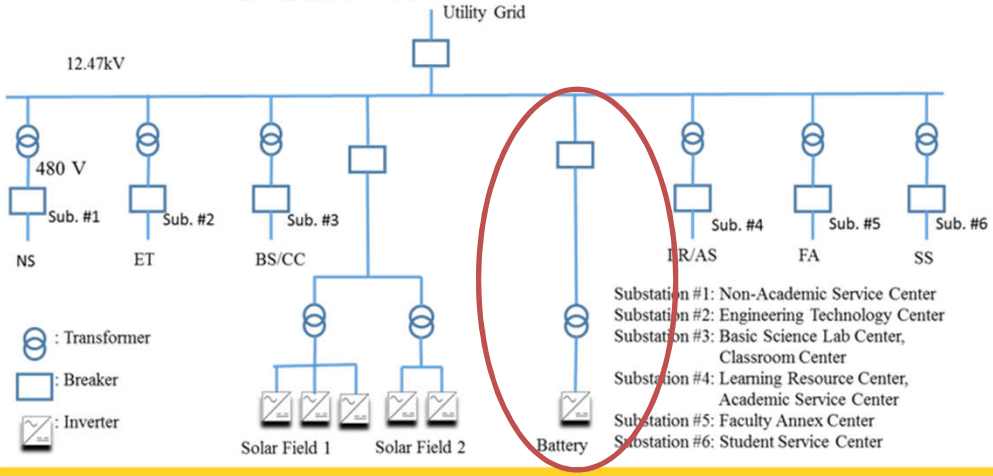
- 8 buildings:
  - 4.6 MW of controllable loads
- 1 MW photovoltaic generation:
  - Ball park field – 360kW, and Office field- 640 kW
- Battery energy storage system (BESS):
  - 130kWh and 125kW

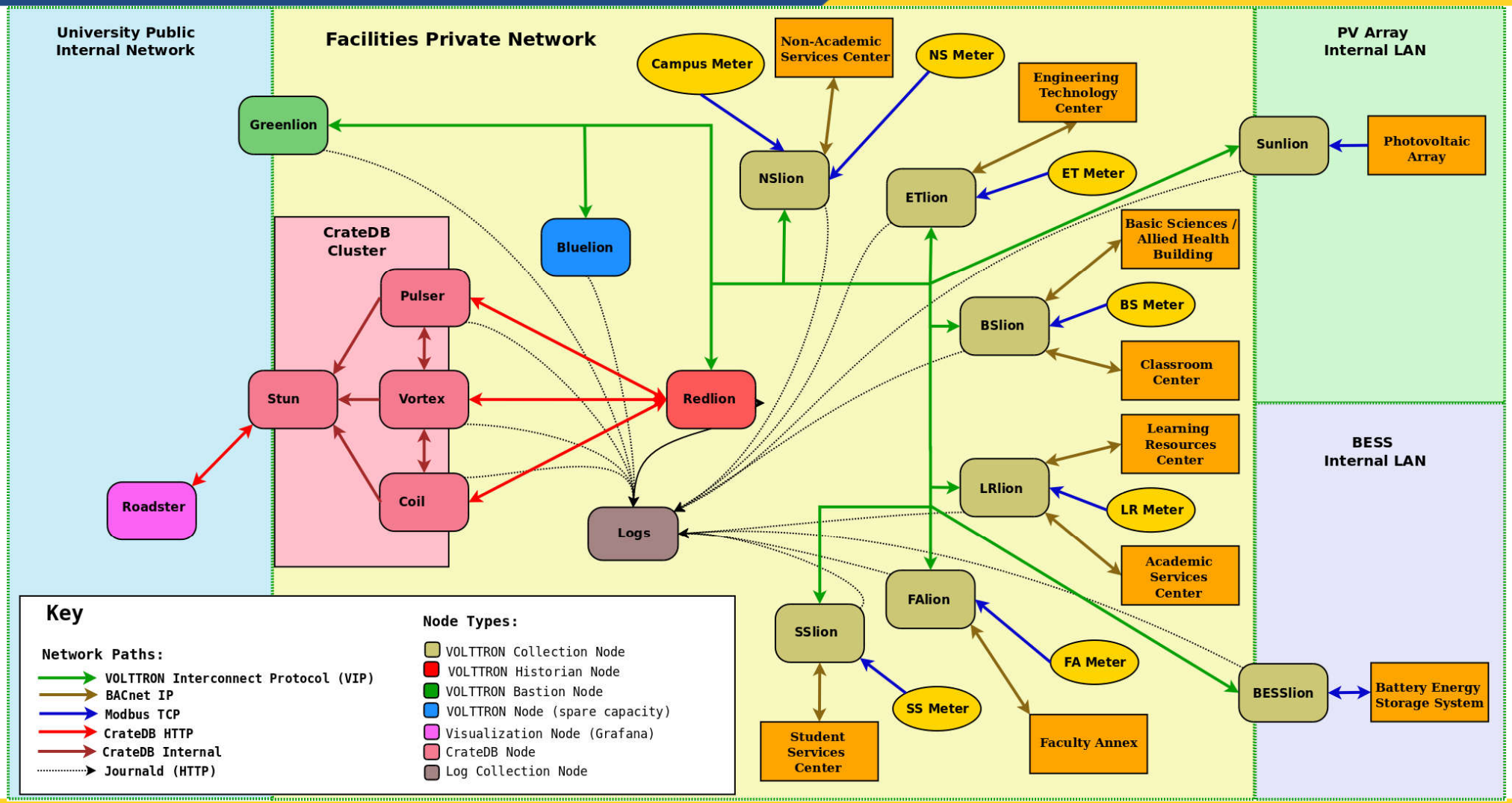


Battery Energy Storage at Scott Park Campus

Acquired with 50% Cost Share by UT

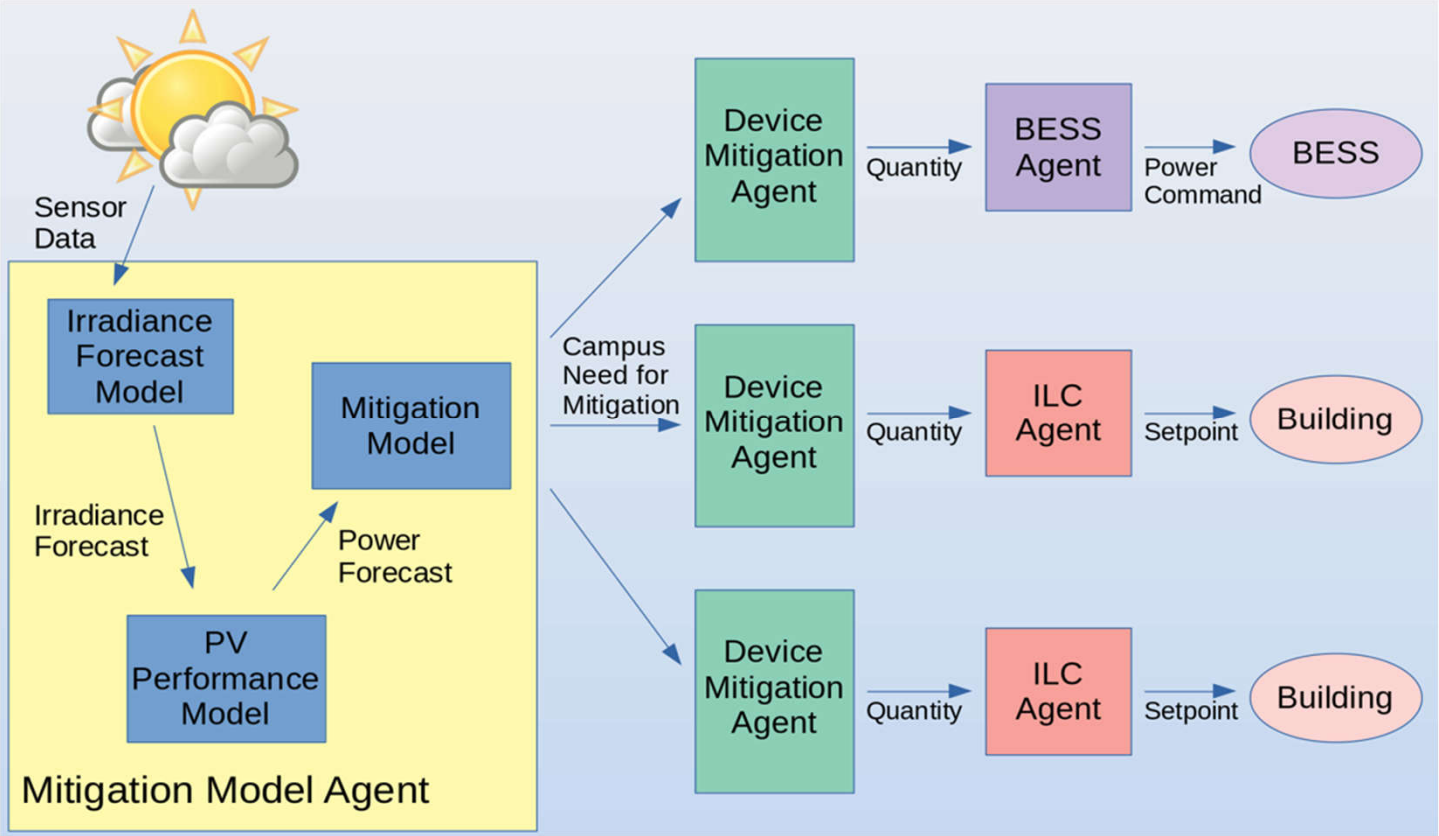
- 8 buildings:
  - 4.6 MW of controllable loads
- 1 MW photovoltaic generation:
  - Ball park field – 360kW, and Office field- 640 kW
- Battery energy storage system (BESS):
  - 130kWh and 125kW



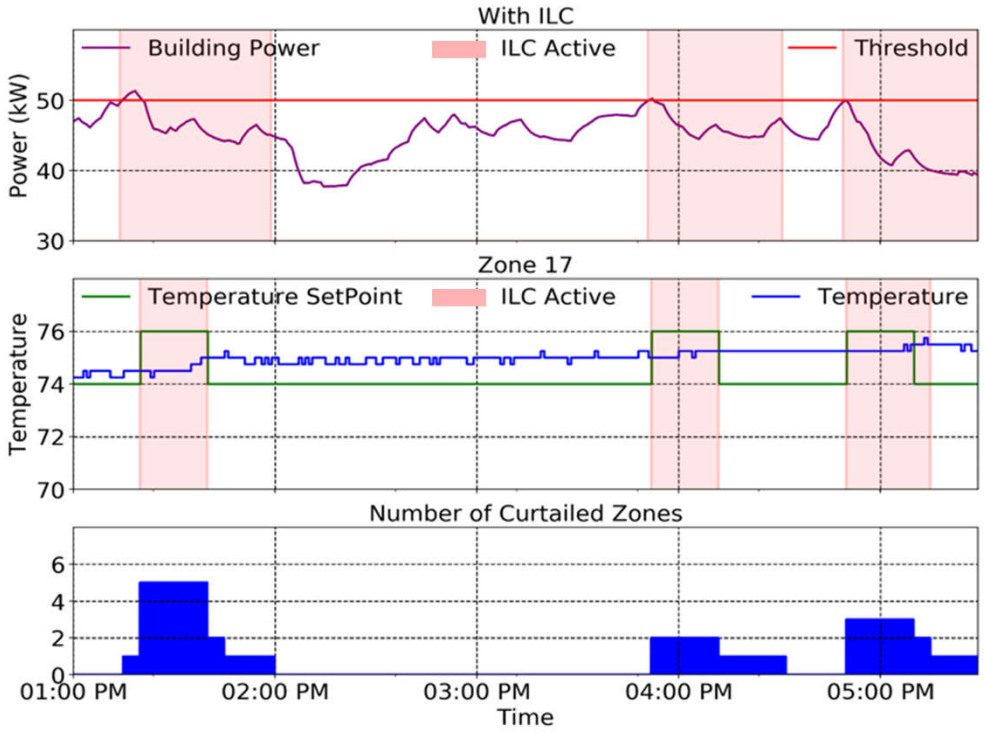


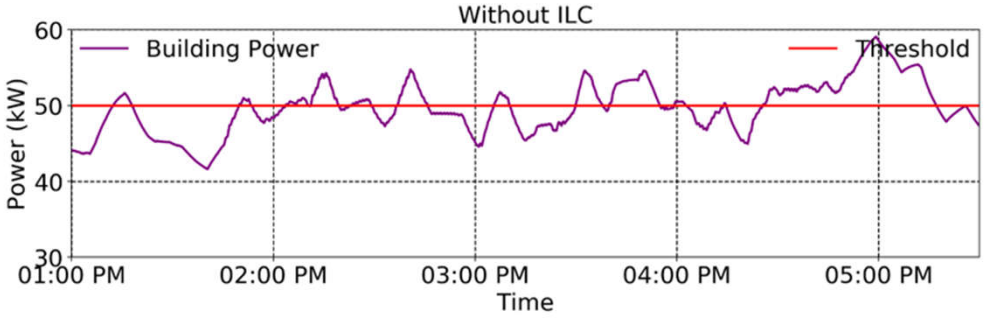
VOLTTRON™ Network Integration with Cluster DB – 1 min Resolution

Flow Chart for Mitigating Variability



Intelligent Load Control (ILC)

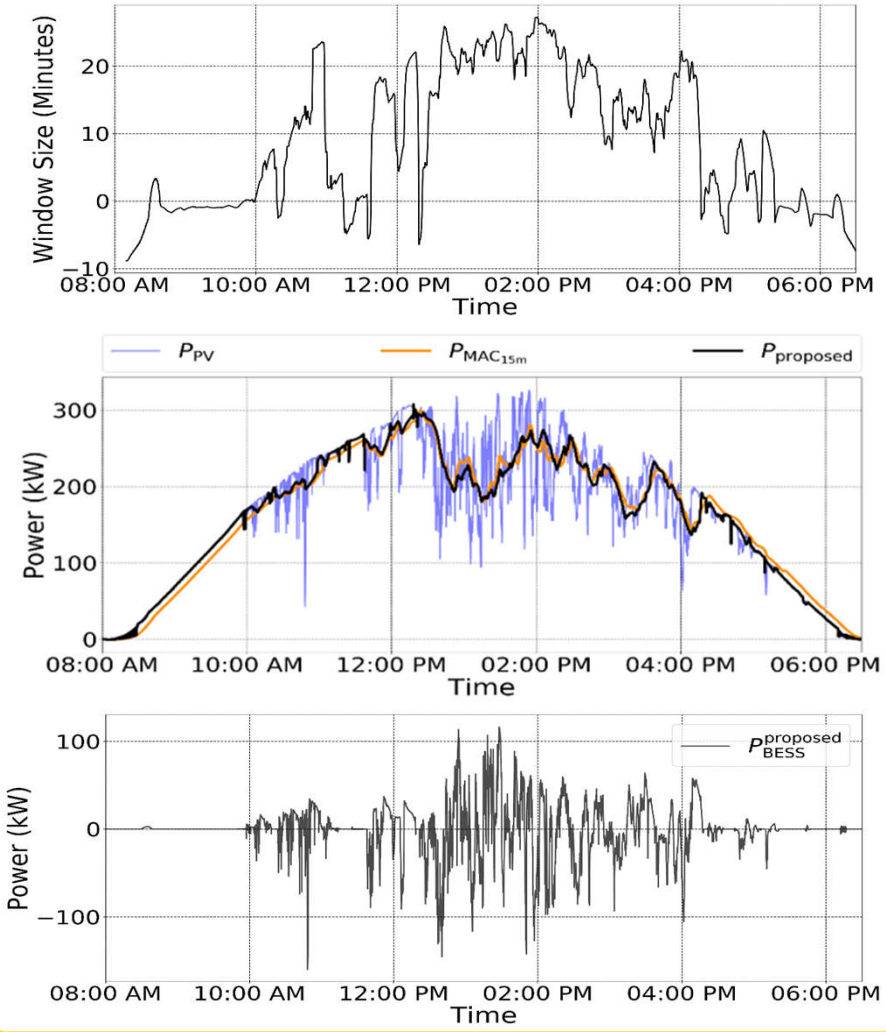




- Developed by PNNL.
- Has been tested with eight buildings.
- Worked with PNNL to test dynamic threshold targets and bi-directional operation.
- Allows capacity bidding, incentive response, curtailment and augmentation, and transactive applications.

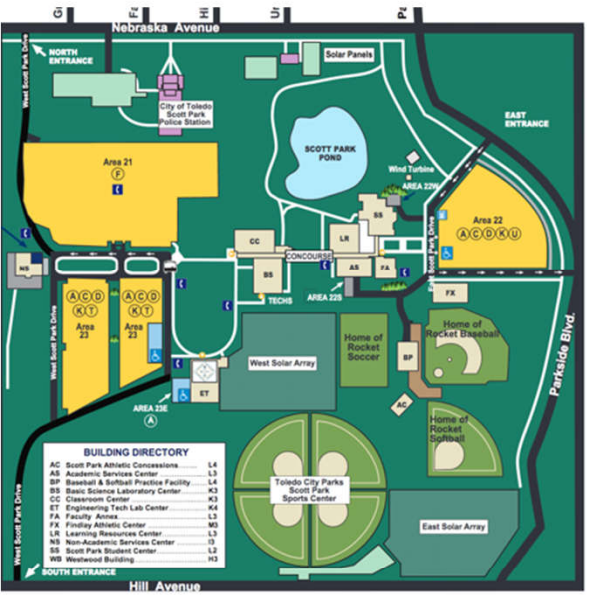
Mitigating Variability

- Economic algorithmic-driven transactions.
- Adaptive moving average can achieve:
  - Better trade-off between battery utilization and degree of smoothness
  - No memory effect
  - Require lower capacity of battery



Scott Park Campus

- 8 buildings
- virtually unpopulated

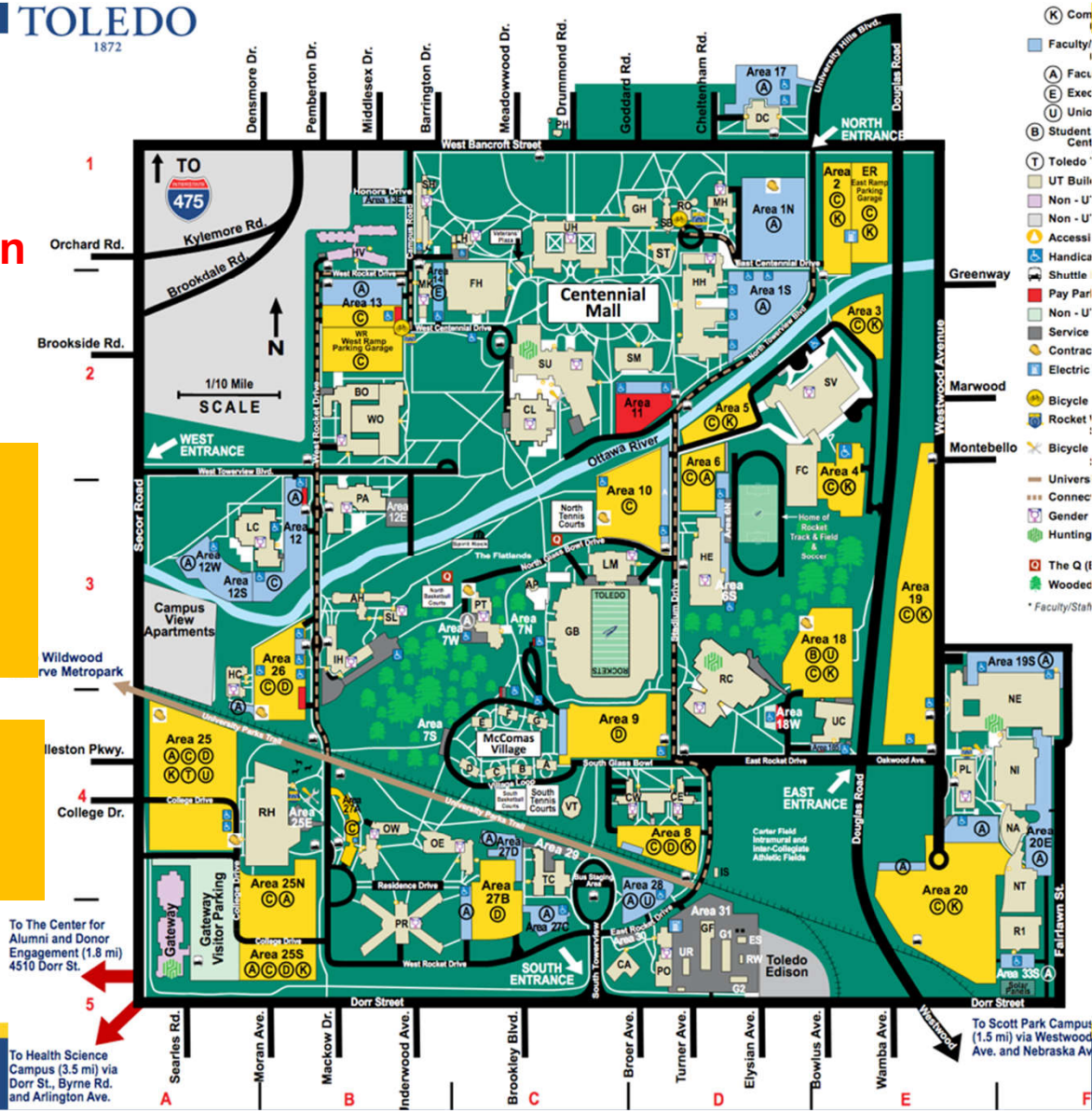


Move to Main Campus

> 10x:
- **# of Bldgs**
- **Complexity**
- **Power**

Contracts and bidding in PJM

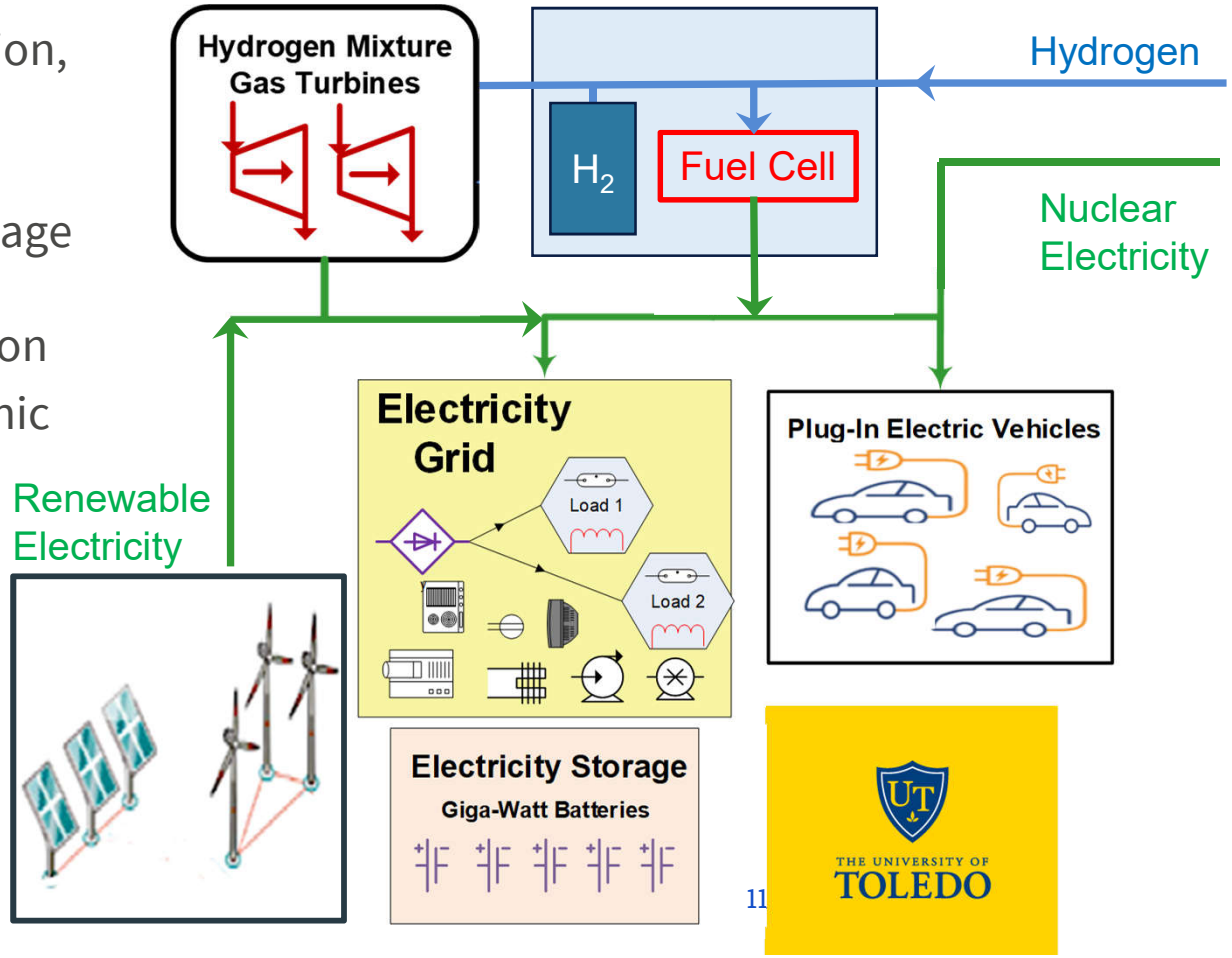
Incorporation of H_2 ?



DAVIS – BESSE HUB

- Renewable power and DER integration, grid stability
- Transactive energy and control
- Battery storage integration and voltage equalization technology
- Hydrogen storage/fuel cell integration
- Reduction in high frequency harmonic input to the grid

Randy Ellingson
Mike Heben
Raghav Khanna
Sandrine Mubenga
Tom Stuart



U.S. DEPARTMENT OF ENERGY

- Funding from US DOE:
  - Office of Electricity
  - Office of EERE, Building Technologies Office
- Collaboration with First Energy.
- Recent Follow-on Funding:
  - Digital Twin Reinforcement Learning (Grid Security)

Lawrence Livermore National Laboratory

Scott Park Transactive Campus

- Randy Ellingson, Professor of Physics
- Michael Heben, Professor of Physics (PI)
- Michael Green, Director, Energy Management
- Raghav Khanna, Professor of Electrical Engineering
- Roshan Kini, Graduate Researcher
- Roan Martin-Hayden, Undergraduate Researcher
- Bill McCreary and Team, Director of IT and Cyber Security
- David Raker, Graduate Researcher
- Tom Stuart, Professor of Electrical Engineering (Emeritus)