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Distribution Power System Level DR and Detailed Modeling for Electric Water Heaters with CTA-2045 Controls

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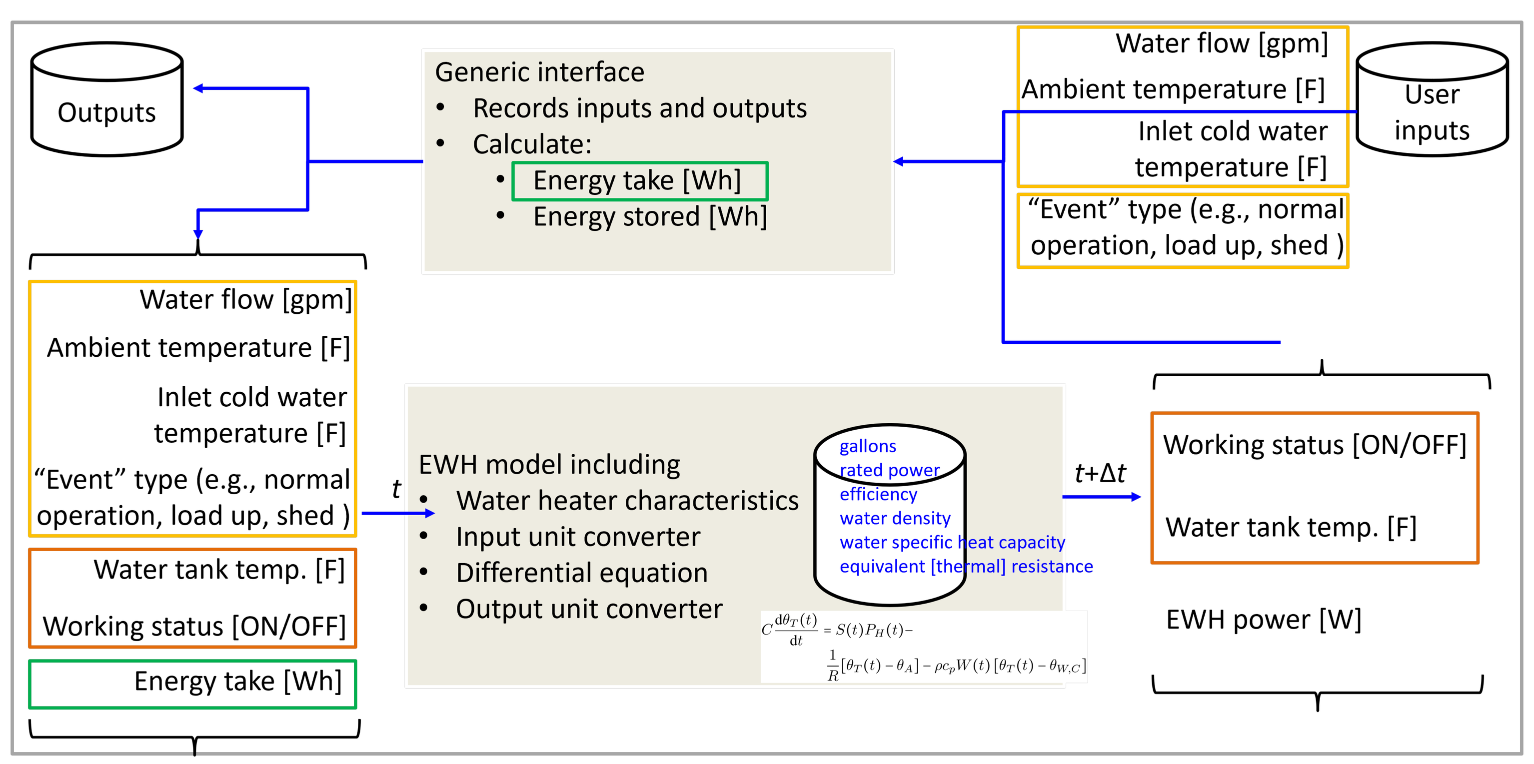
Introduction and Major Contributions

- Verification of EWHs as equivalent energy storage and the evaluation of the energy storage capacity
- A proposed method for batch modeling of individual EWHs based on realistic hot water flow
- Combined dynamic simulation of individual EWHs and a distribution power system with realistic residential loads
- Application of CTA-2045 standard-based DR on EWH at a large scale
- The analysis of EWH DR impact on an example distribution power system, including peak reduction and voltage variation.

Model-in-the-loop of Electric Water Heater Model with CTA 2045 Functionalities

- The EWH model has CTA 2045 functionalities
- Hot water draw profiles are from CBECC-Res
- Models are already implemented in C# and Python class.



Schematic of the Model-In-the-Loop (MIL) for an EWH.

EWH as Alternative Energy Storage

Current available energy storage capacity

$$E_{C,B}(t) = \overline{E_{B,R}} \cdot (SOC_{B,max} - SOC_B(t))$$

Energy content of the stored water

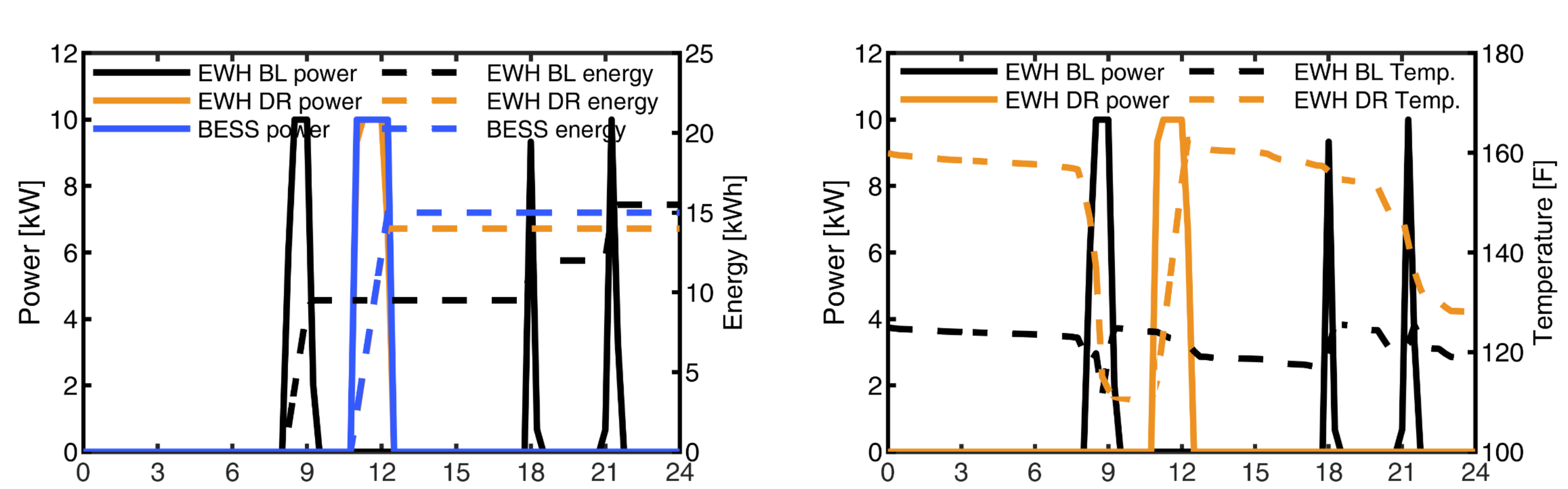
$$E_W(t) = V\rho c_p \theta_T(t)$$

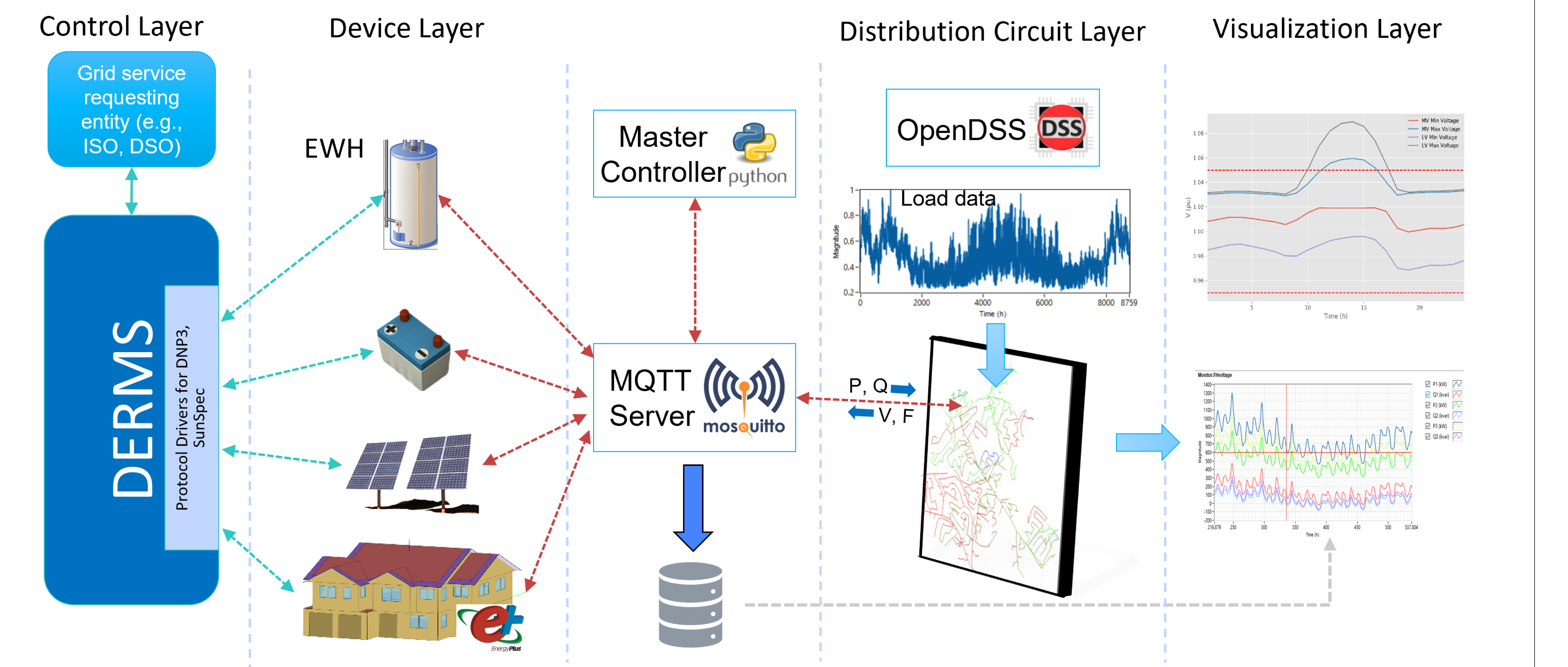
Current available energy storage capacity

$$E_{C,W}(t) = \overline{E_{W,S}} - E_W(t)$$

Energy take

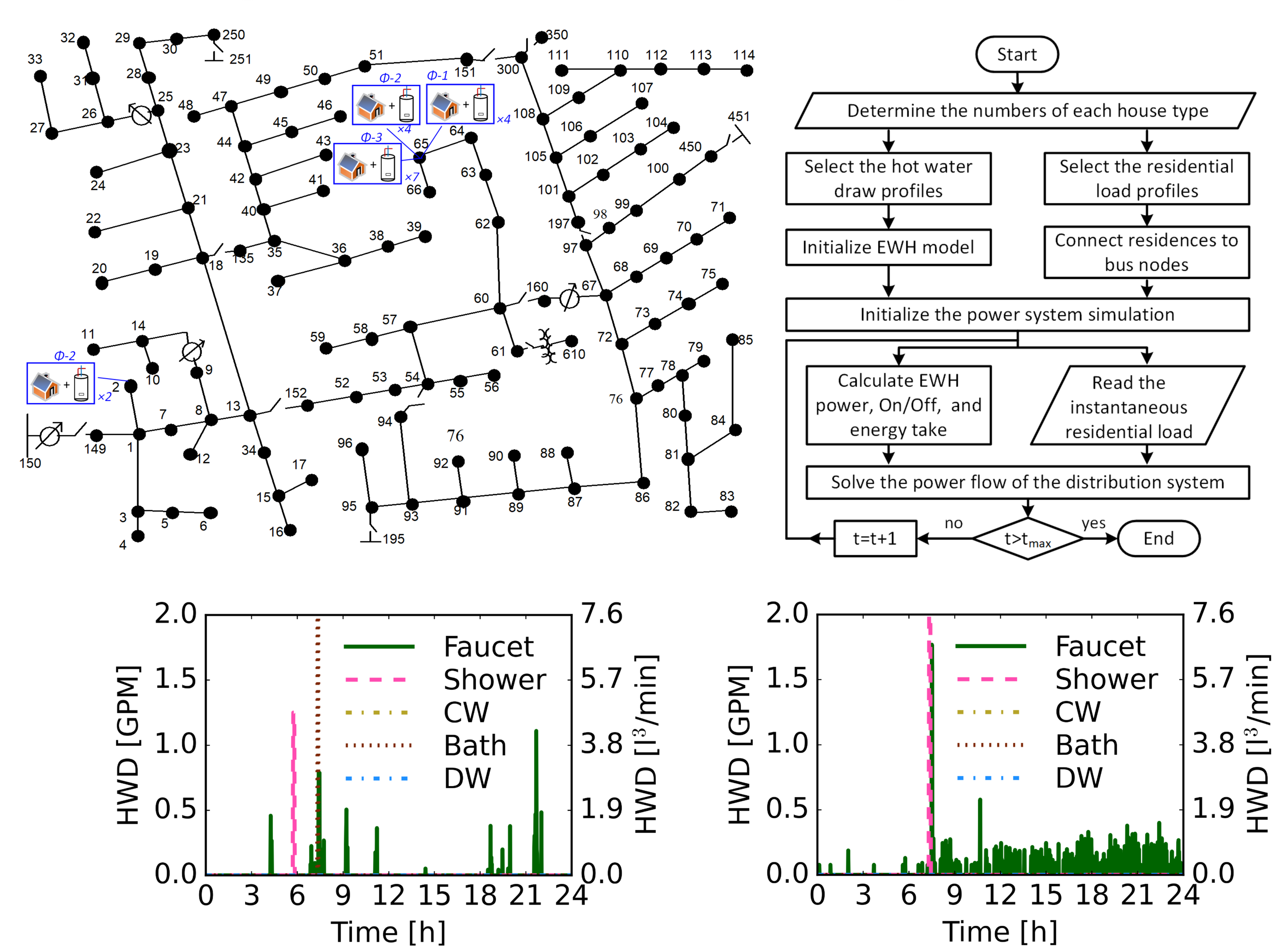
$$E_{T,W}(t_2 - t_1) = E_W(t_2) - E_W(t_1)$$





The architecture of EPRI's DER integration testbed currently under further development through the DOE ENGAGE project.

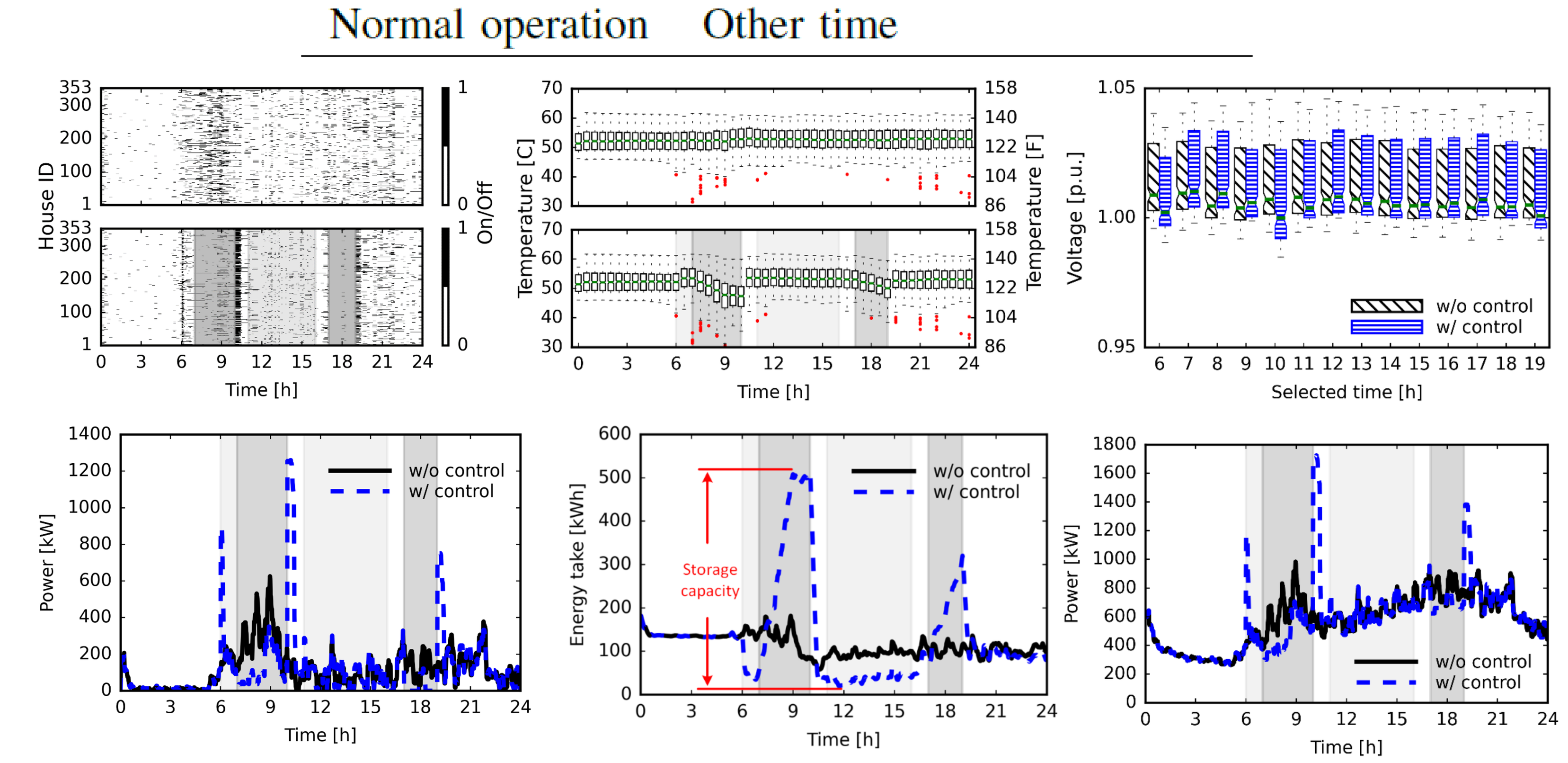
Modeling of Residential Community



- IEEE 123-bus system was used for the residential community
- Each 10kW of the original loads was replaced by a residence; 353 houses total
- One of US's largest rural smart grid demonstrator, the Smart Energy Technology Project, in Glasgow, KY.

Case Studies

Event	Duration
Shed	[7:00,10:00) ∪ [17:00,19:00)
Load up	[6:00,7:00) ∪ [11:00,16:00)
Normal operation	Other time



- Bus voltage were kept with 5% variation; peak power reduced by 28%
- EWH had 1,388Wh energy storage in average
- Occupant comfort was maintained via CTA 2045 control, according to ASHRAE standards.

Acknowledgement

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