Who is Eaton?

We are an **intelligent power management** company made up of approximately **85,000 employees**, doing business in more than **175 countries** with annual sales of over **$19 billion USD**.

ELECTRICAL

Power distribution and circuit protection

Power quality, backup power and energy storage

Life safety and security

Structural solutions

Control and automation

Harsh and hazardous environments solutions

INDUSTRIAL

Aerospace

Vehicle

eMobility

F•T•N
Powering Business Worldwide

Outline

Context: Evolution of Control Solutions for BTM DERs

Objective and Problem Statement

Edge and Central Controller Interaction
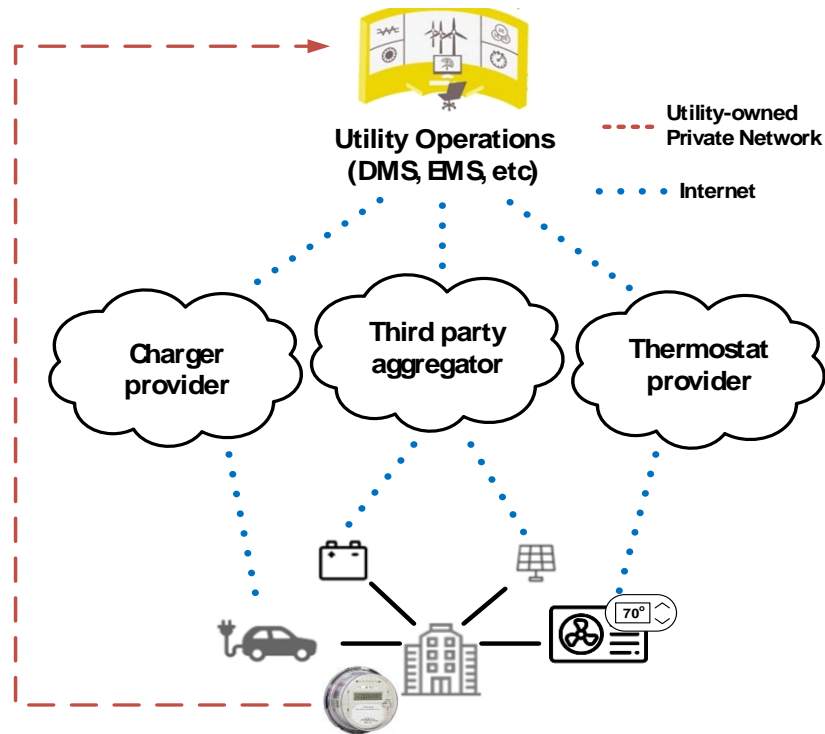
Load Disaggregation and Edge Optimization

Lab Validation and Field Demo
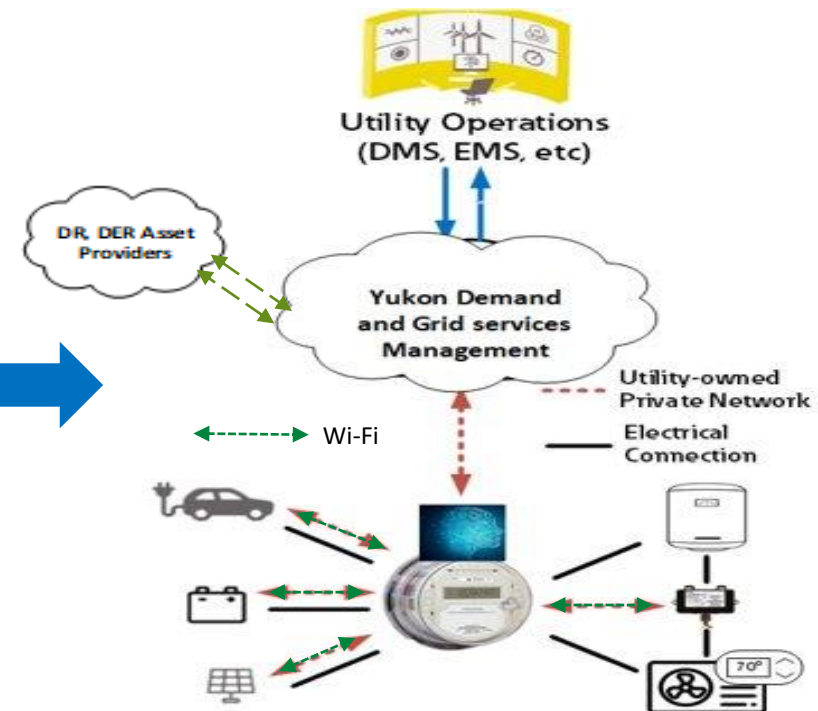
Use Cases and Evaluation Criteria

Current Challenges

Evolution of Control Solutions for BTM DERs

Current Solution

Utility Operations (DMS, EMS, etc)

- - - Utility-owned Private Network
.... Internet

Charger provider

Third party aggregator

Thermostat provider

- Uni-directional data transfer for monitoring
- Access residential devices thru public access points for individual appliances and DERs
- No control on residential devices

Proposed solution

Utility Operations (DMS, EMS, etc)

DR, DER Asset Providers

Yukon Demand and Grid services Management

Wi-Fi

- - - Utility-owned Private Network

——— Electrical Connection

- Bidirectional data exchange between Central- and premise Meter-controller
- Single layer for observability and controllability
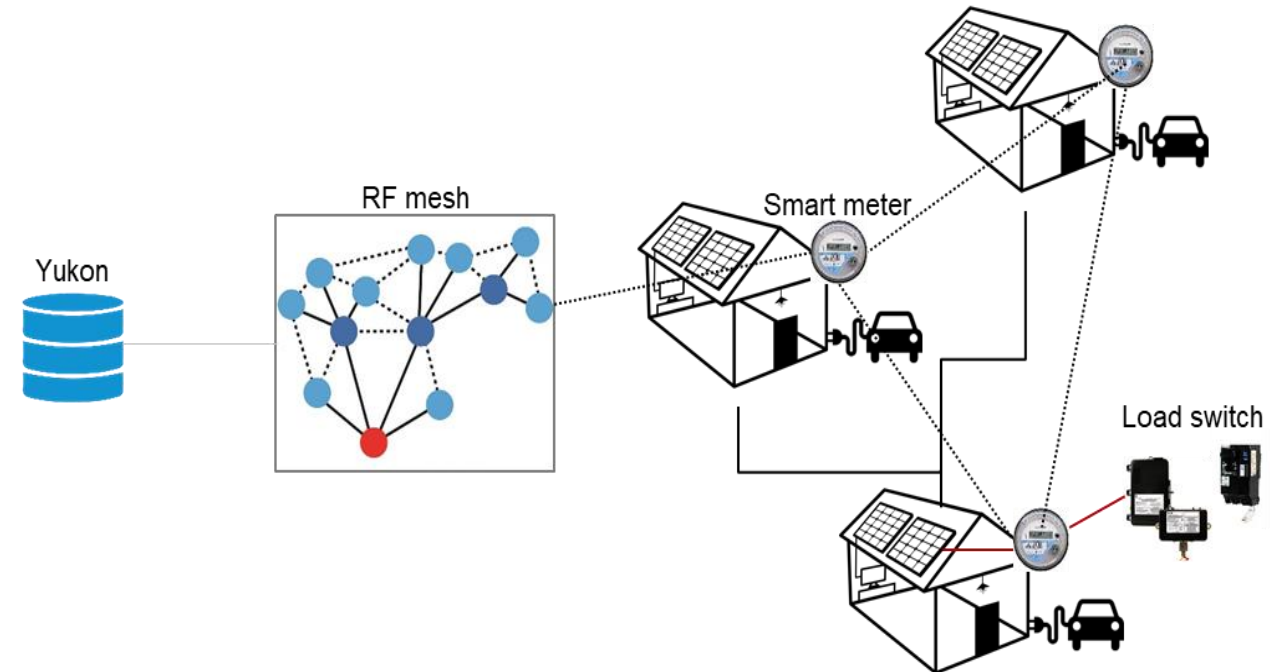- Meter-controller via local and cloud connectivity access is the focus of premise-customized control
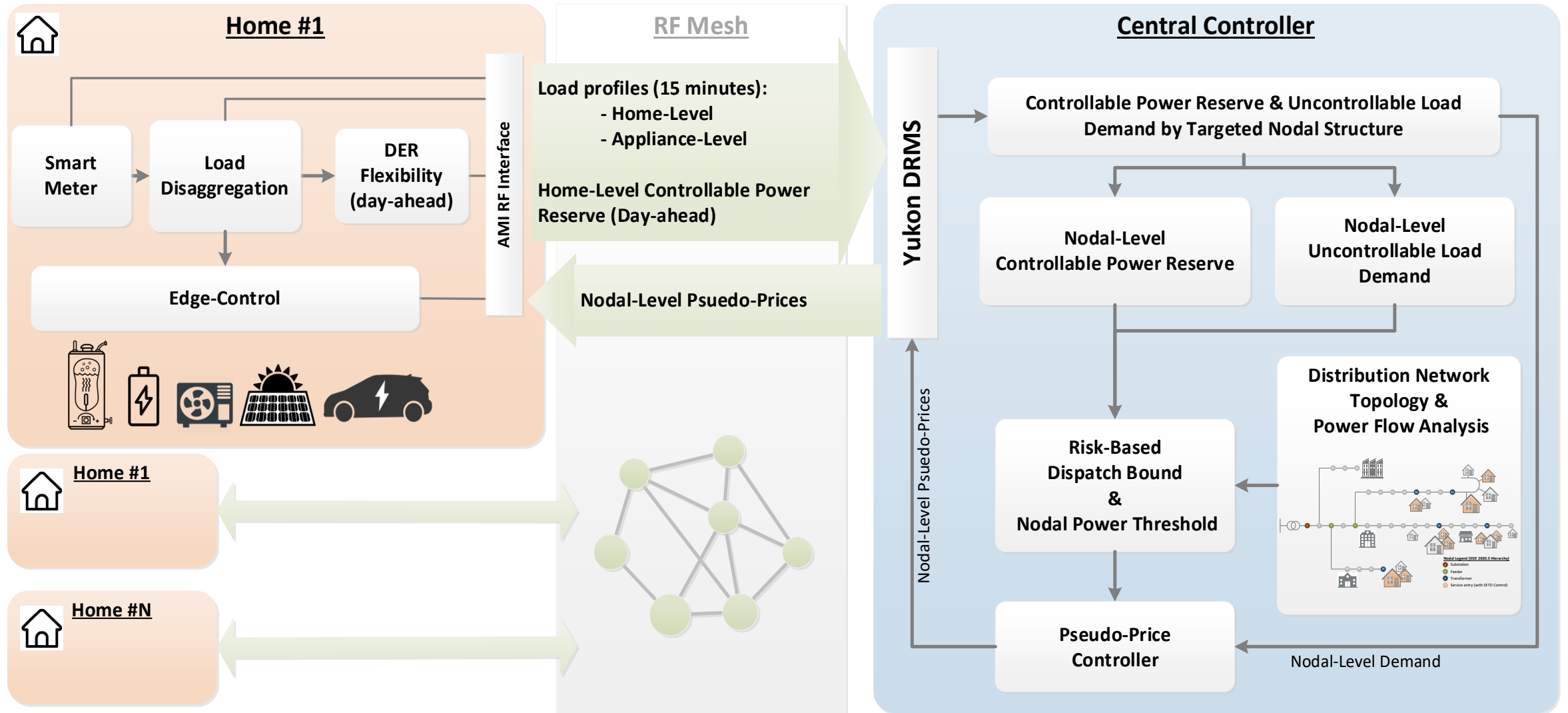
Advanced DER Control for Grid Management

Objective

- Develop and field-validate a first-of-its-kind TRL 6 control technology

Problem Statement

- How to manage a more dynamic, decentralized and bi-directional grid driven by increasing penetration of behind-the-meter (BTM) DERs?

- How to provide assured delivery of grid services from solar and synergistic DERs to improve grid reliability and encourage further solar adoption?

- How to improve observability and controllability of BTM DERs for utility operators by leveraging existing and evolving AMI infrastructure?

Advancing DOE SETO office's primary goal of increasing the affordability, reliability, and performance of solar technologies while maintaining a reliable and resilient power grid
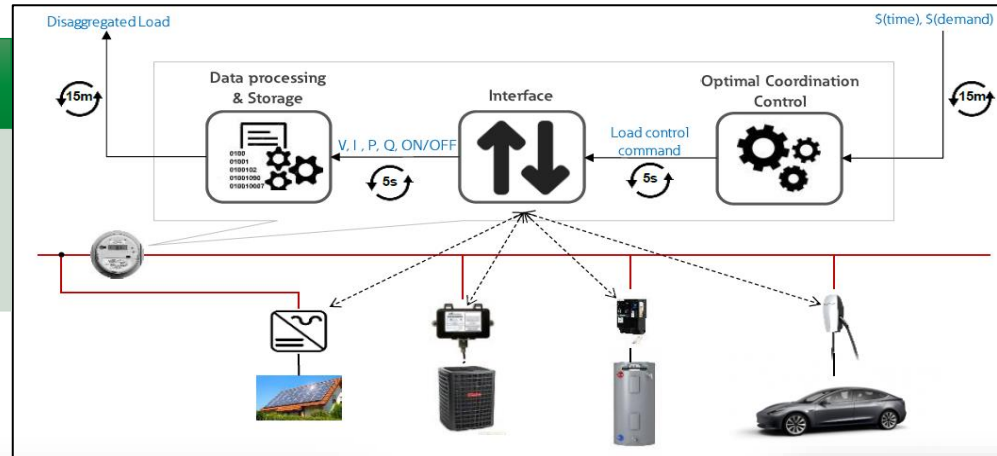
Edge and Central Controller Interaction
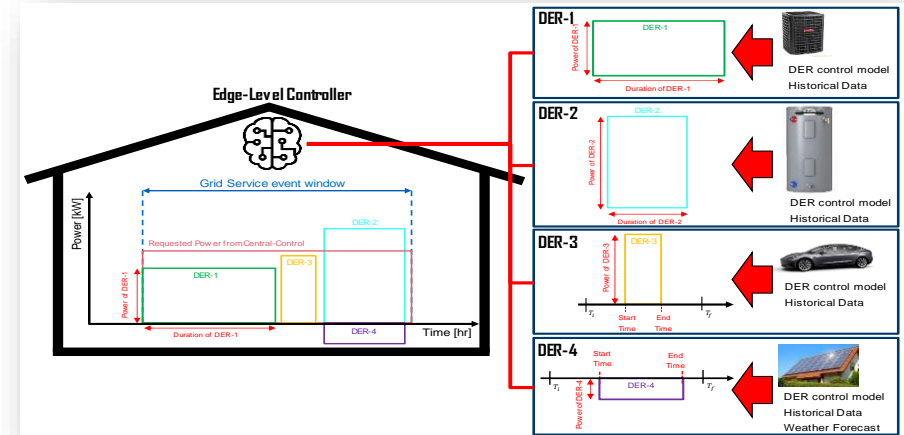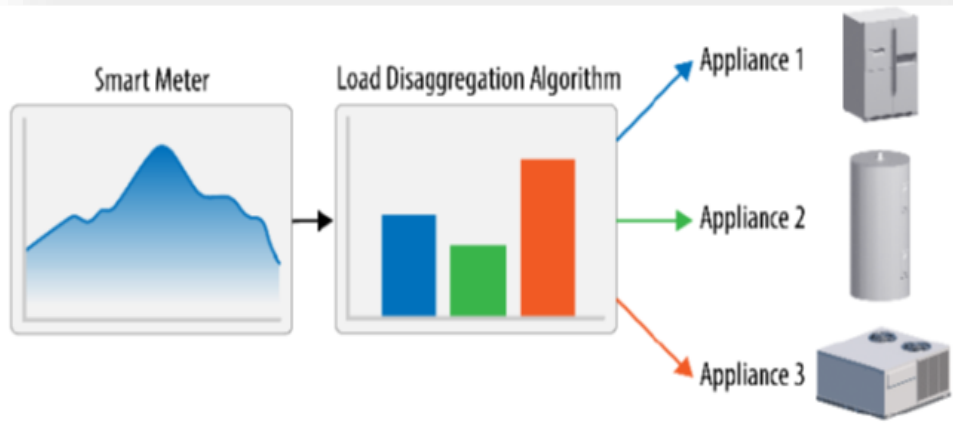
Meter-Based-Edge Control

Load Disaggregation

- Site/edge-level estimation of power/energy data for individual load components in the absence of dedicated sensors
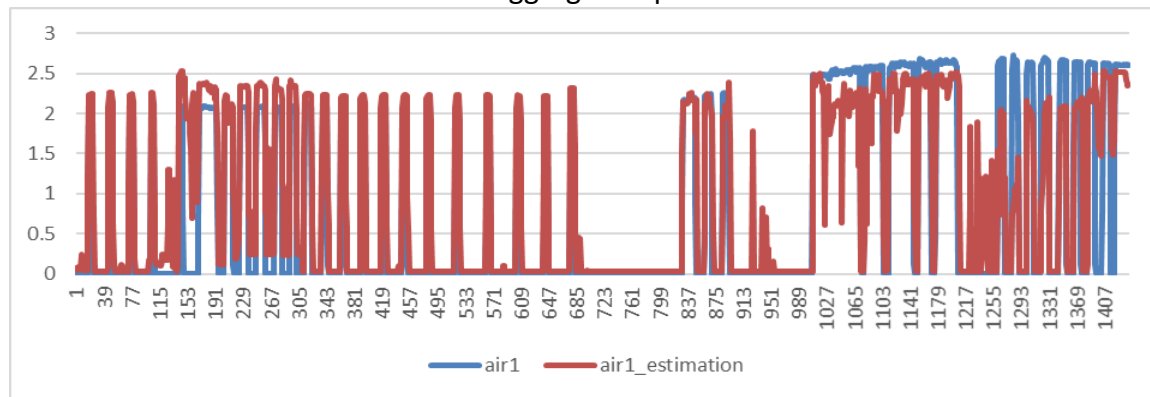
Edge Optimal Control

- Receives central control command and finds out the optimal control of DERs and flexible loads

Testing in the HW

AC load disaggregation plot

air1   air1_estimation

Error Analysis

Error Matrix	AC	EV	PV
MAE	0.32	0.23	0.42
MAPE (%)	10.94	6.81	9.72

Edge-level controller execution time

Optimization Process	Time (s)
DERs Flex Bound	93.9
DERs Schedule	3246.4
Total	3340.3

Optimization time can be decreased based on applications:
- Utilize (faster) commercial solver
- Reduce optimization time-window
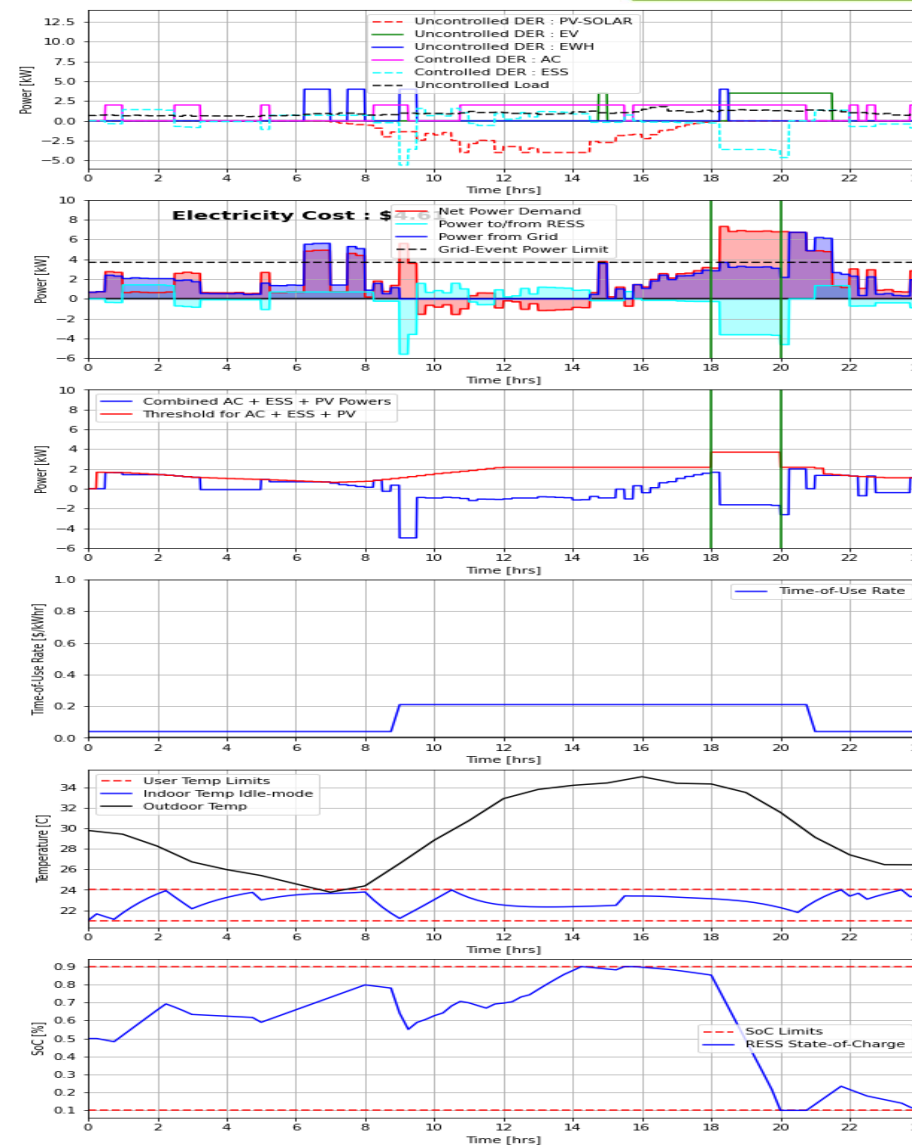
Lab and Field Demo

- Up to 25 homes will participate in the field demo

- Participants will have at least one DER (controllable/uncontrollable) and one controllable load (e.g., HVAC, Electric Water Heater)

- Homes will be connected thru local RF Gateway Network and DEC AMI System to Eaton-hosted DR-DER Central controller

- Demonstration will be held during a predefined grid service event and coincidental peak can also be considered

- Prior to field demo, a validation testbed is being conducted at NREL
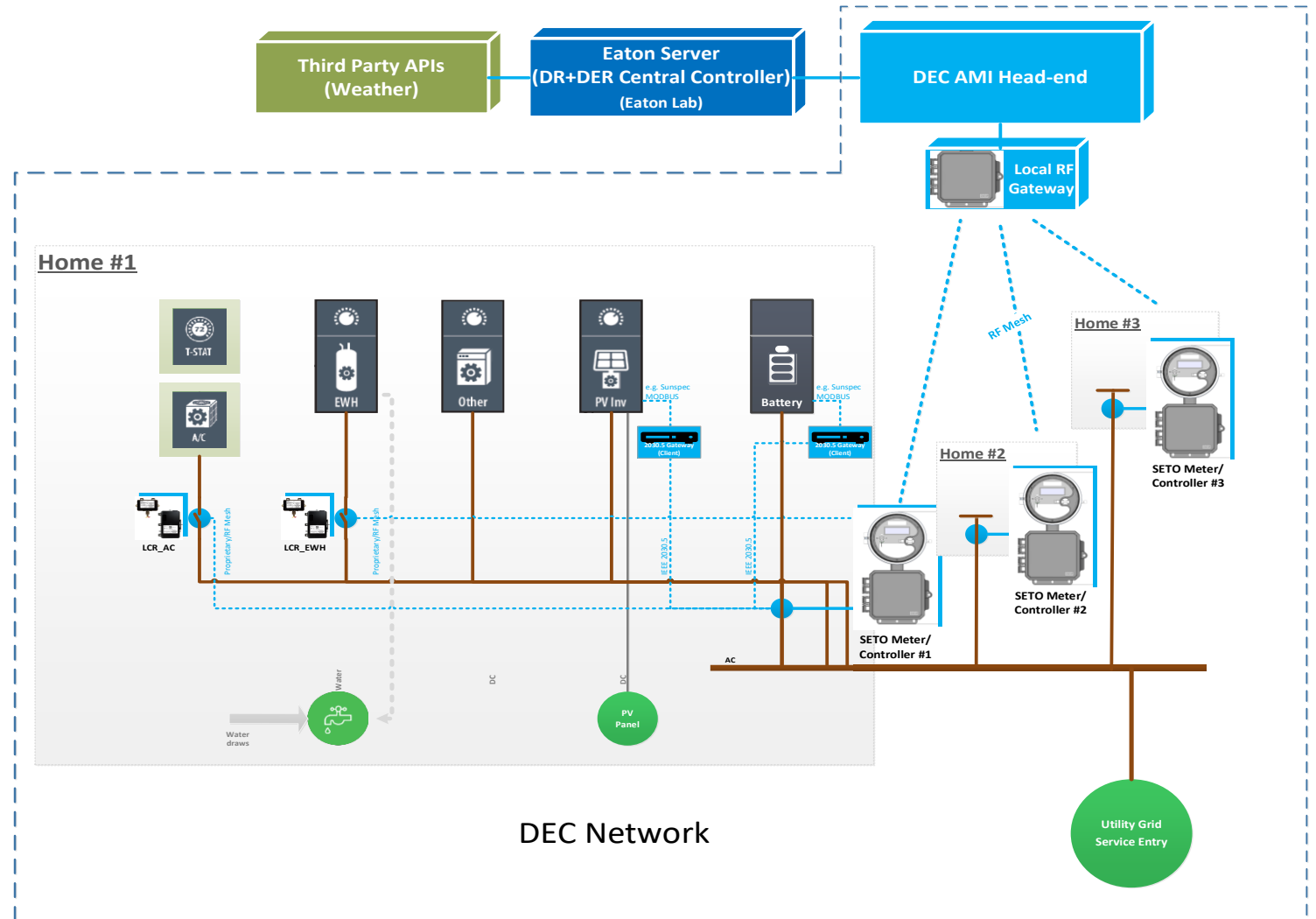
Use Cases and Evaluation Criteria

Base Case

No Control

Flat Rate

Edge Control

Manage the premise devices without the coordination with Central

Supports economic operations at any time except grid service events

Flat rate or TOU

Edge + Central Control

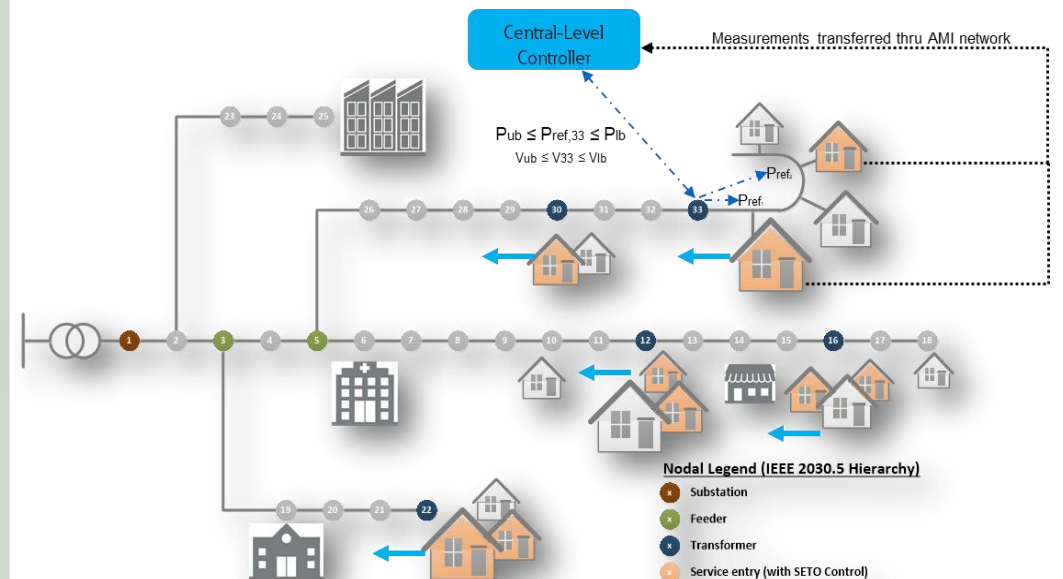Coordinated control between central and Edge Controller

Supports grid service events such as, peak load reduction

Day-ahead peak prediction

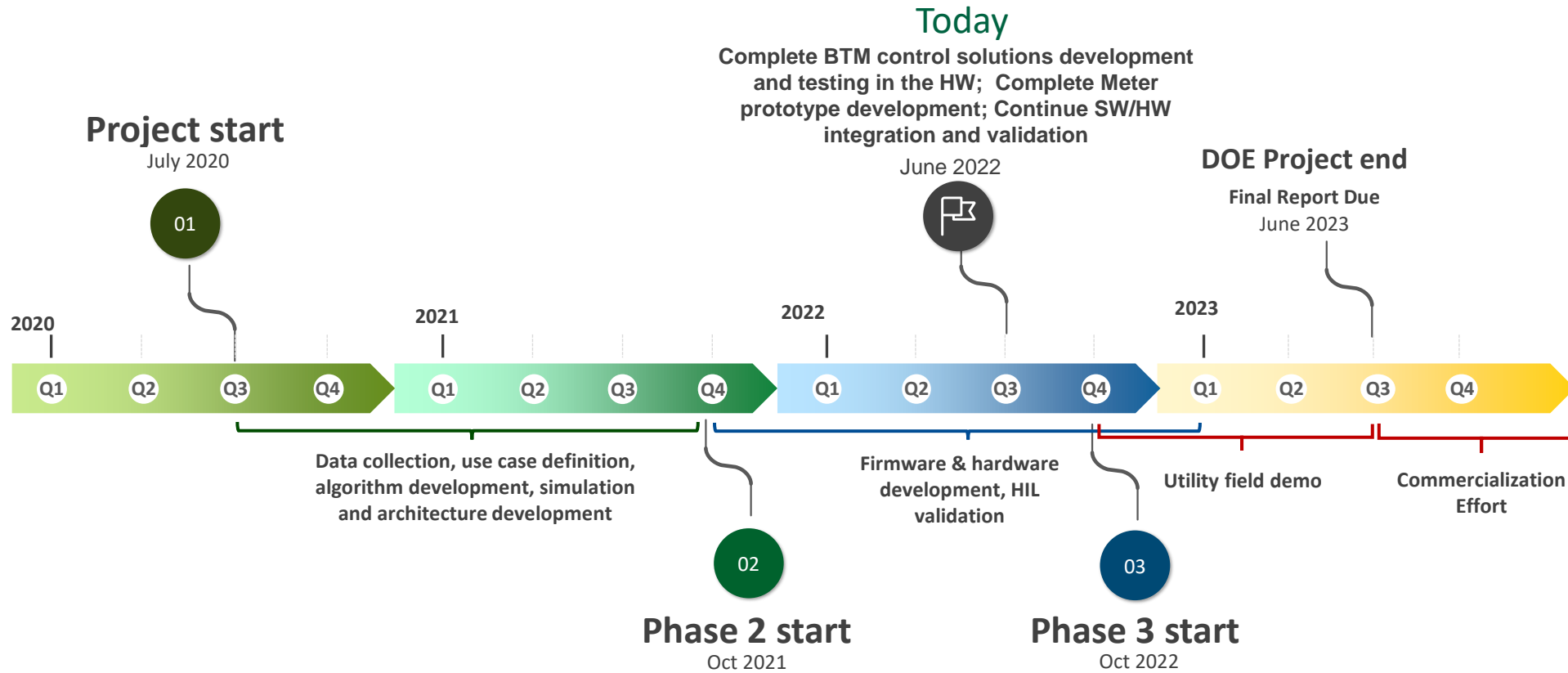4h-ahead peak prediction (PJM CP)

Flat rate or TOU

- Edge level SETO controller will be evaluated based on the reduction in customer energy usage and bill compared to base case
- Central controller will be evaluated based on satisfying the reference power set point threshold, nodal voltage bounds, and estimated load control savings for coincidental peak reduction
- Maintain QoS at the customer premise

Accomplishments and Next Steps

Today
Complete BTM control solutions development and testing in the HW; Complete Meter prototype development; Continue SW/HW integration and validation
June 2022

Project start
July 2020

01

DOE Project end
Final Report Due
June 2023

2020

2021

2022

2023

Q1 Q2 Q3 Q4 | Q1 Q2 Q3 Q4 | Q1 Q2 Q3 Q4 | Q1 Q2 Q3 Q4

Data collection, use case definition, algorithm development, simulation and architecture development

Firmware & hardware development, HIL validation

Utility field demo

Commercialization Effort

02
Phase 2 start
Oct 2021

03
Phase 3 start
Oct 2022

Thank You