Intelligent Efficiency Conference

Track A: Integrating Distributed Resources

3A Integrating Nanogrids and Microgrids into the Modern Grid

Raymond Kaiser, Amzur Technologies

Opening Remarks

American Council for an Energy-Efficient Economy

Intelligent Efficiency Conference

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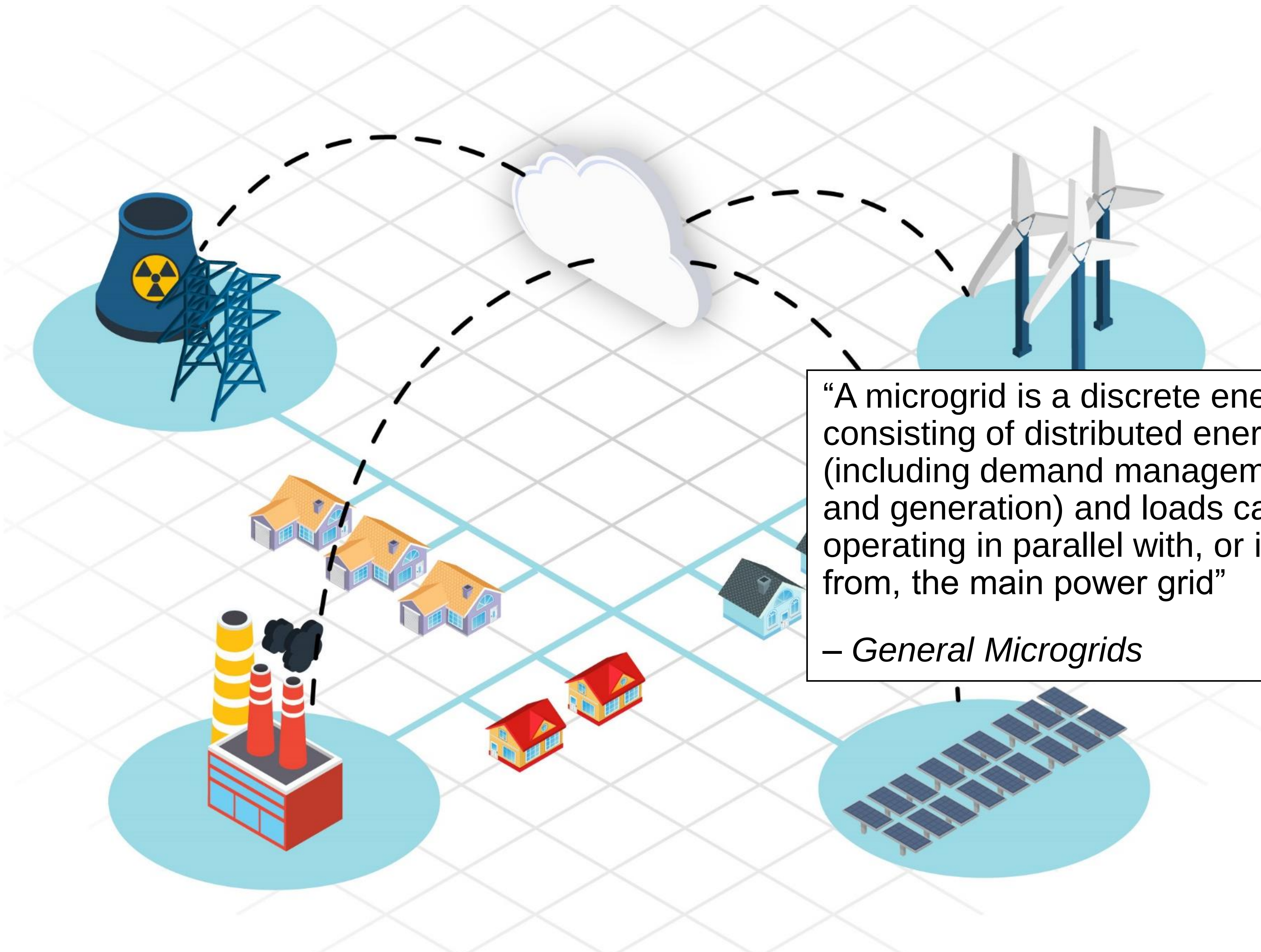
Michael R. Starke, PhD, Oak Ridge National Laboratory

Microgrid Research

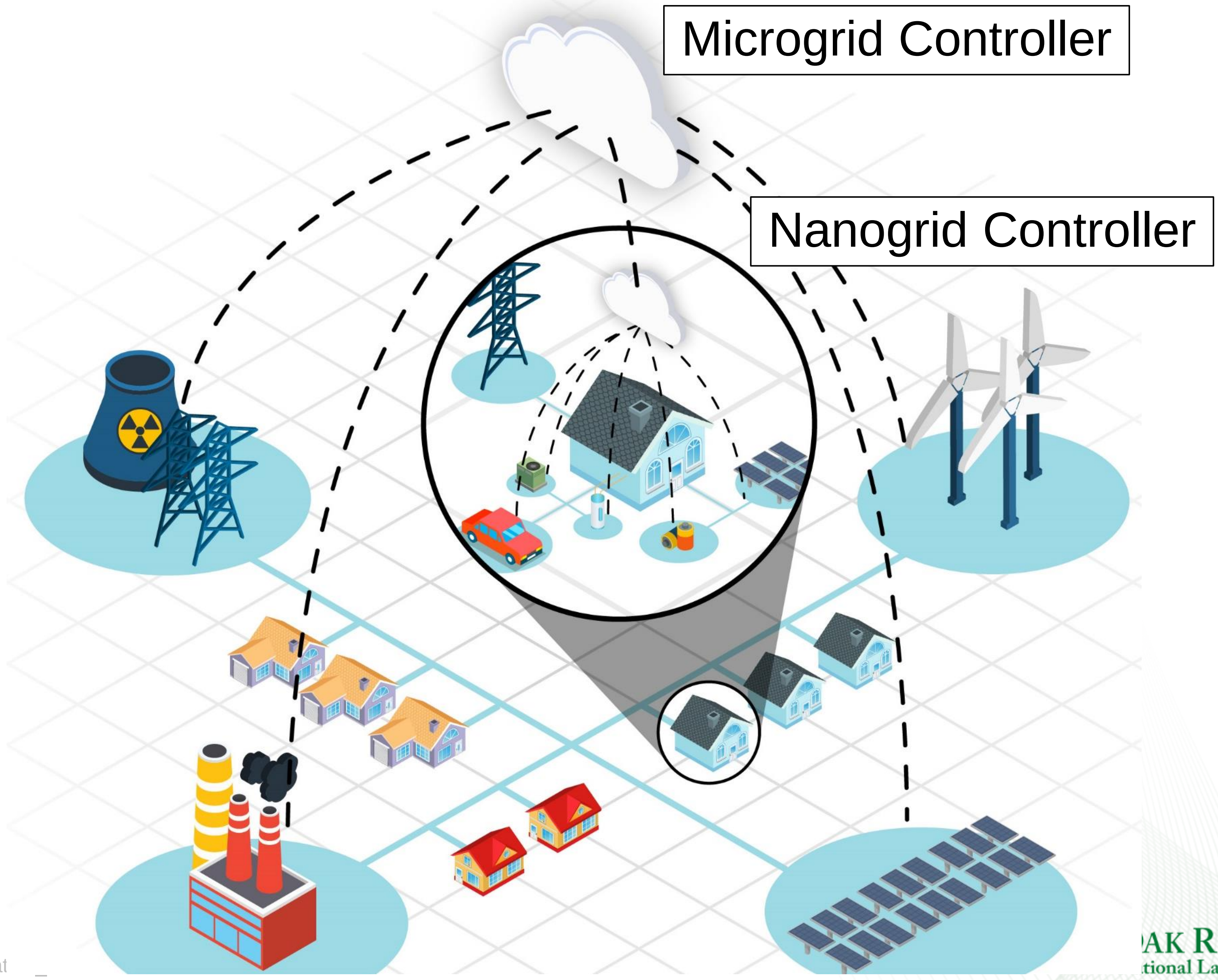
What is a microgrid? – State of the Art



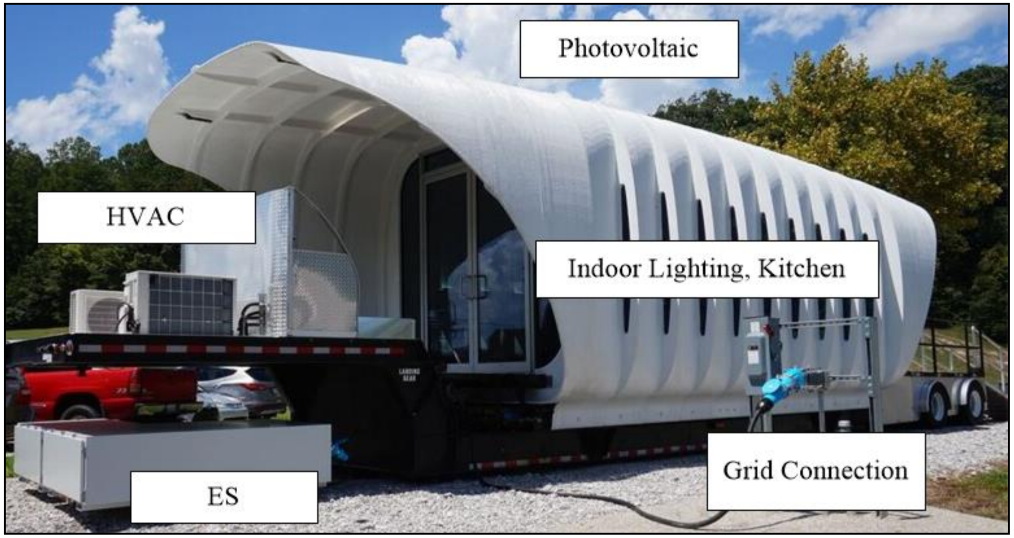
"A microgrid is a discrete energy system consisting of distributed energy sources (including demand management, storage, and generation) and loads capable of operating in parallel with, or independently from, the main power grid"

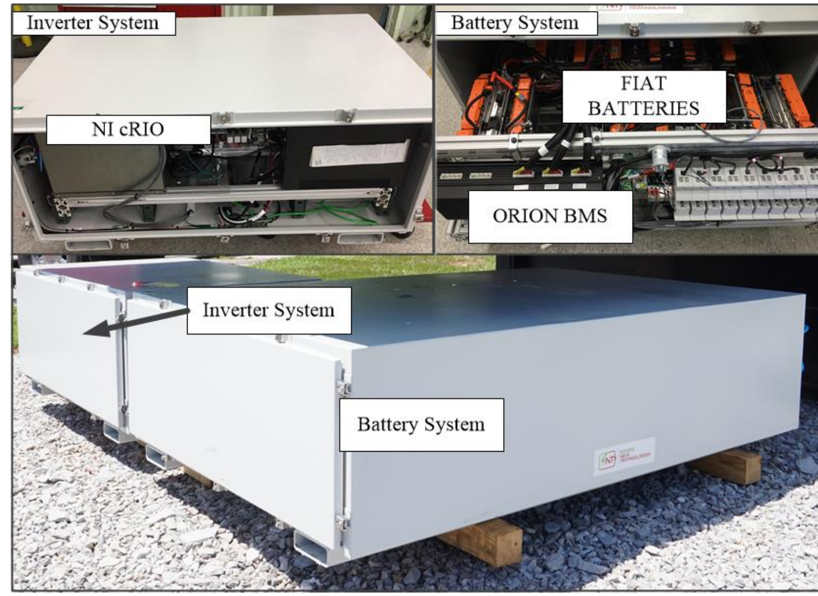
– *General Microgrids*

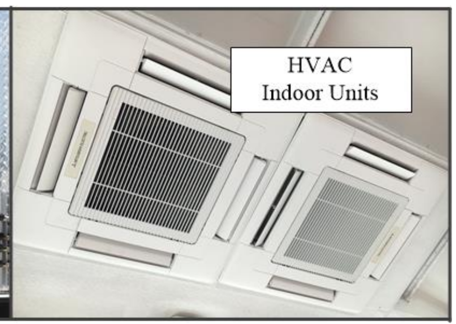
Micro/Nano Grids – More Recent

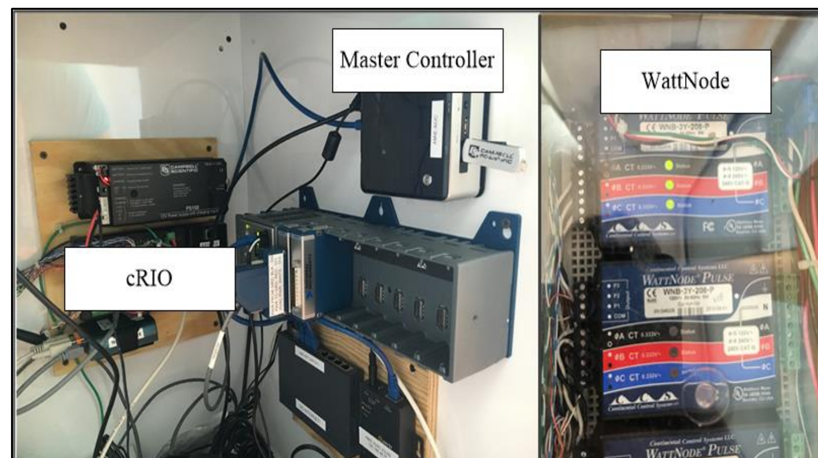


Example of Nanogrid

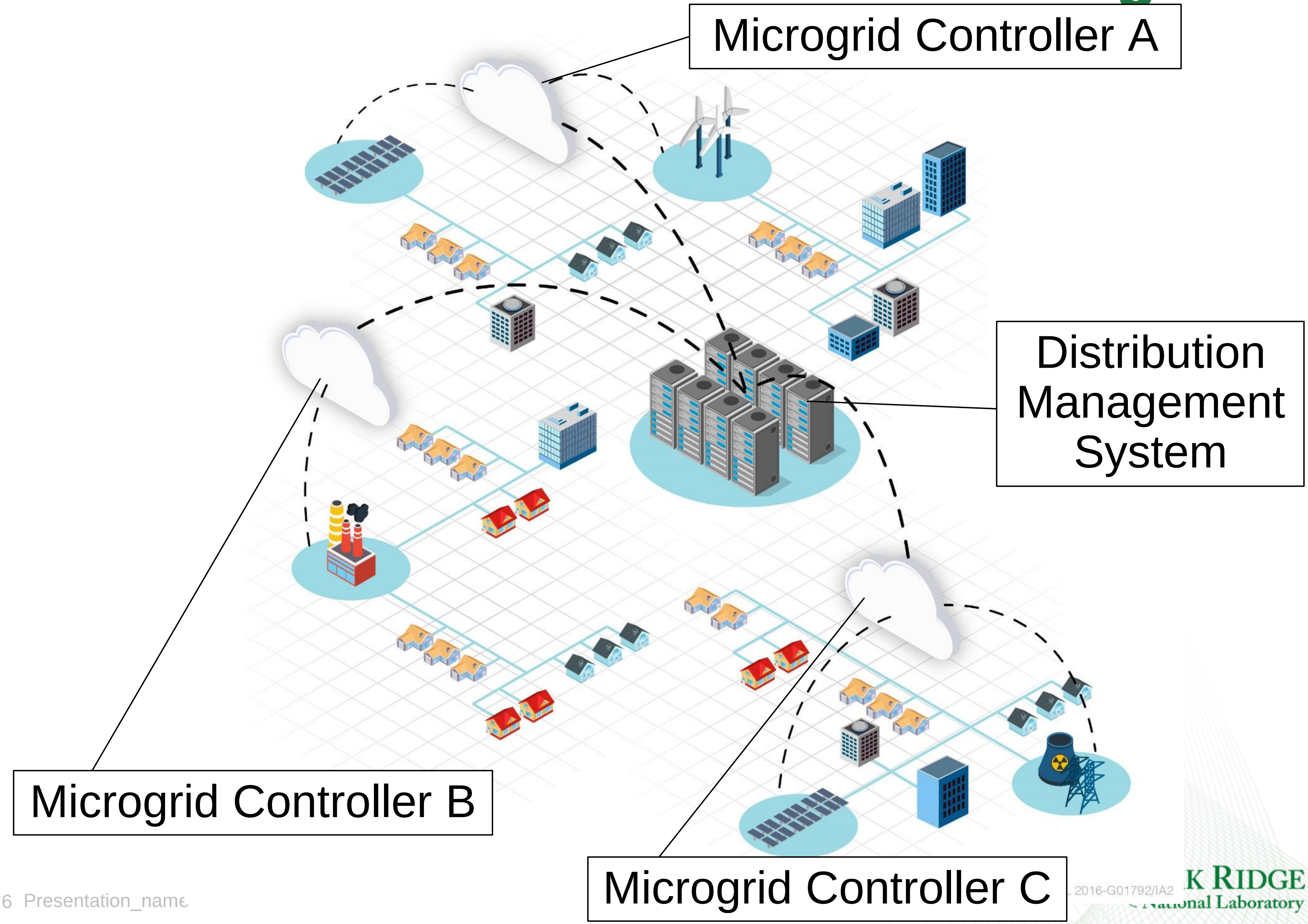








Next Generation: Networked Microgrids



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Kurt Roth, Fraunhofer Center for Sustainable Energy Systems
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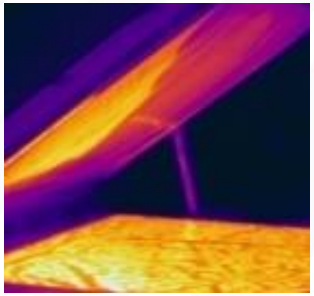
An Integrated SHINES System Enabling High Penetration Feeder-Level PV

Kurt Roth, Ph.D.

ACEEE Intelligent Energy Conference
December 6, 2016

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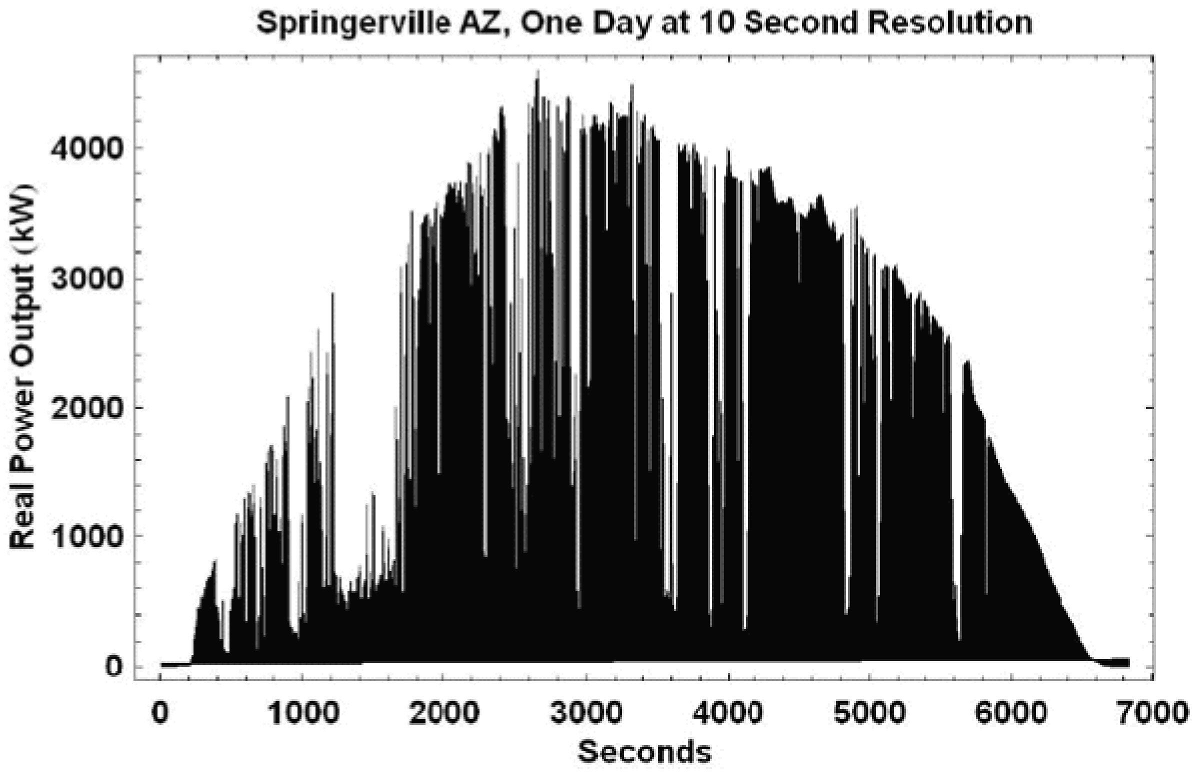
High Penetration PV is:

Rated PV Power = Peak Facility Loads

Sources: Steward Health Care, Thermofab, Wikimedia Commons.

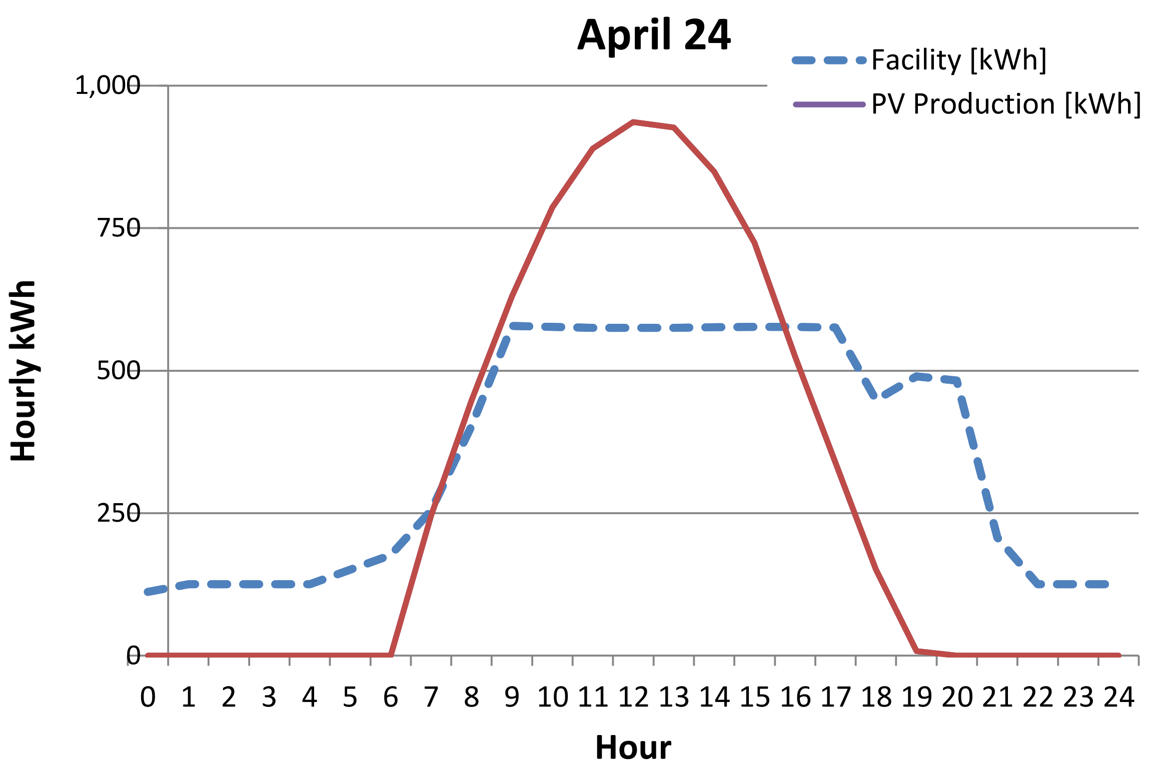
Challenge: PV Intermittency

Power ramps up to 50% of peak output in one minute



Source: Curtright and Apt (2008).

Challenge: Solar Surplus on Sunny Spring Days



- Worcester, MA climate
- "Typical" April 24th
- Big Box Retail (simulated)
- PV = 1,000 kW
- Building Peak = 1,000 kW
- T_{high} = 73°F

Sources: DOE/OpenEI, Fraunhofer calculations.

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The Solution: Storage + Integrated optimized system control

- 1MW of PV Solar
- **0.5/1.0MWh of storage**

- 1MW of **Managed Loads**

Sources: National Grid, Steward Health Care, Wikimedia Commons.

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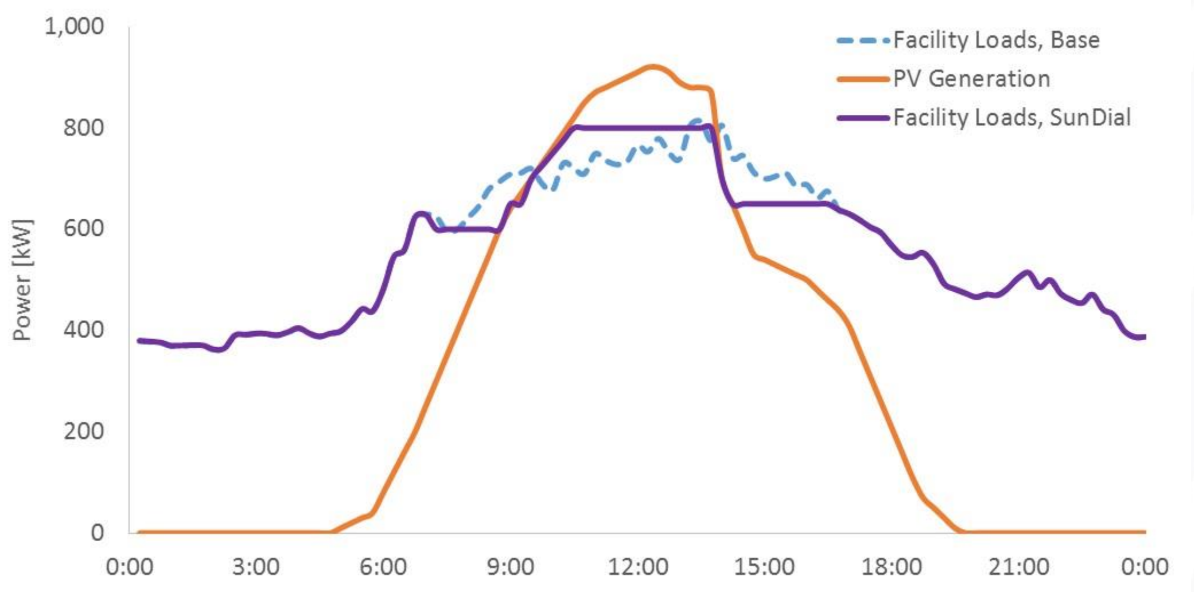
Solution: Mitigate Solar Surplus



- Mix of C&I facilities
- PV = 1,000 kW
- Building Peak = 1,000 kW
- July 21, 2015

Sources: DOE/OpenEI, Fraunhofer calculations.

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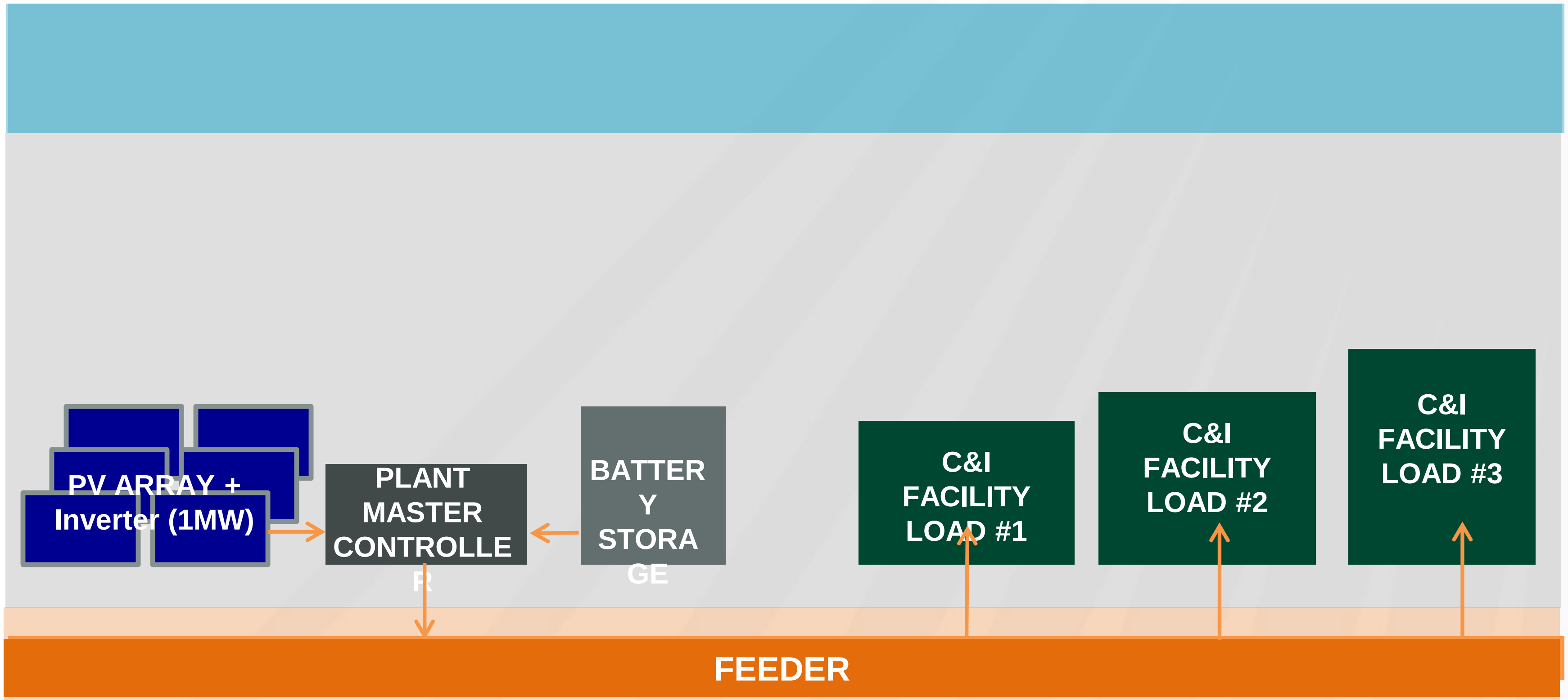
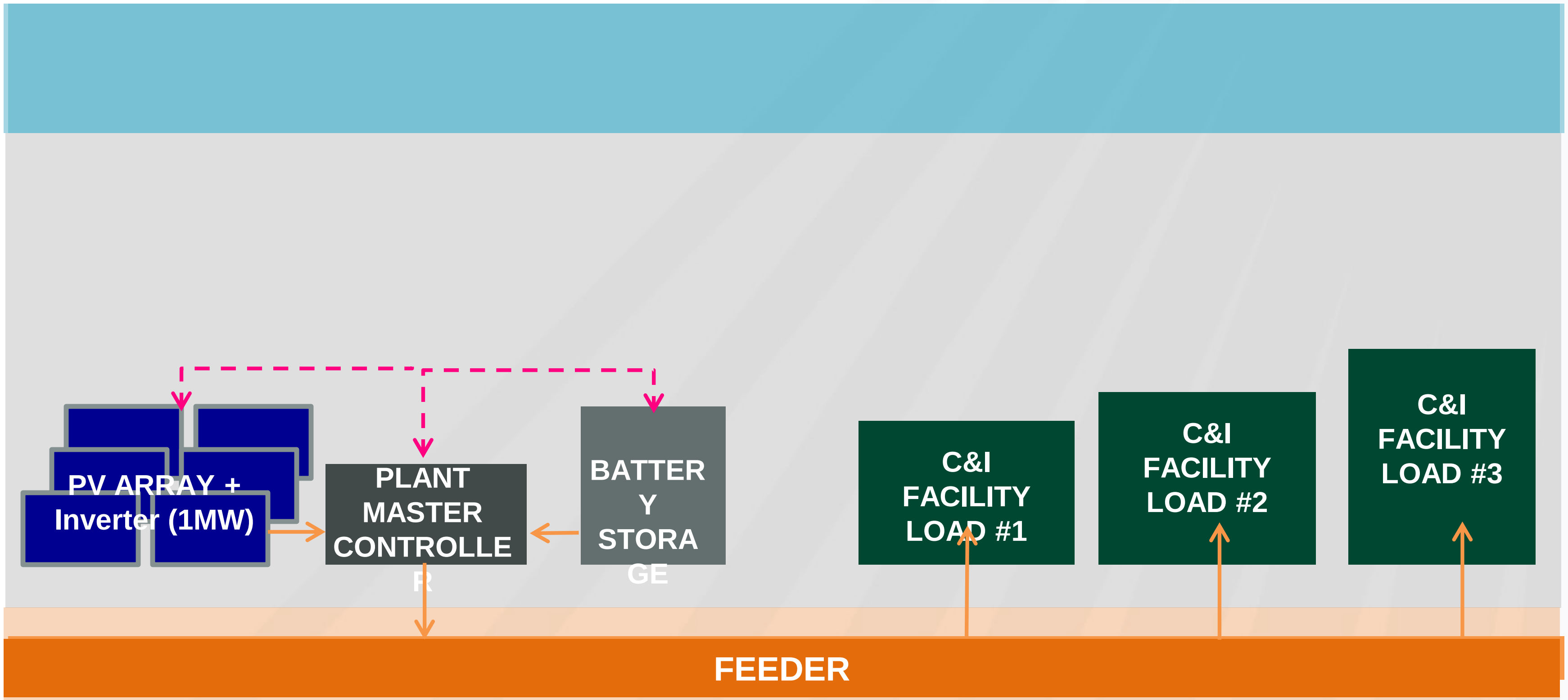
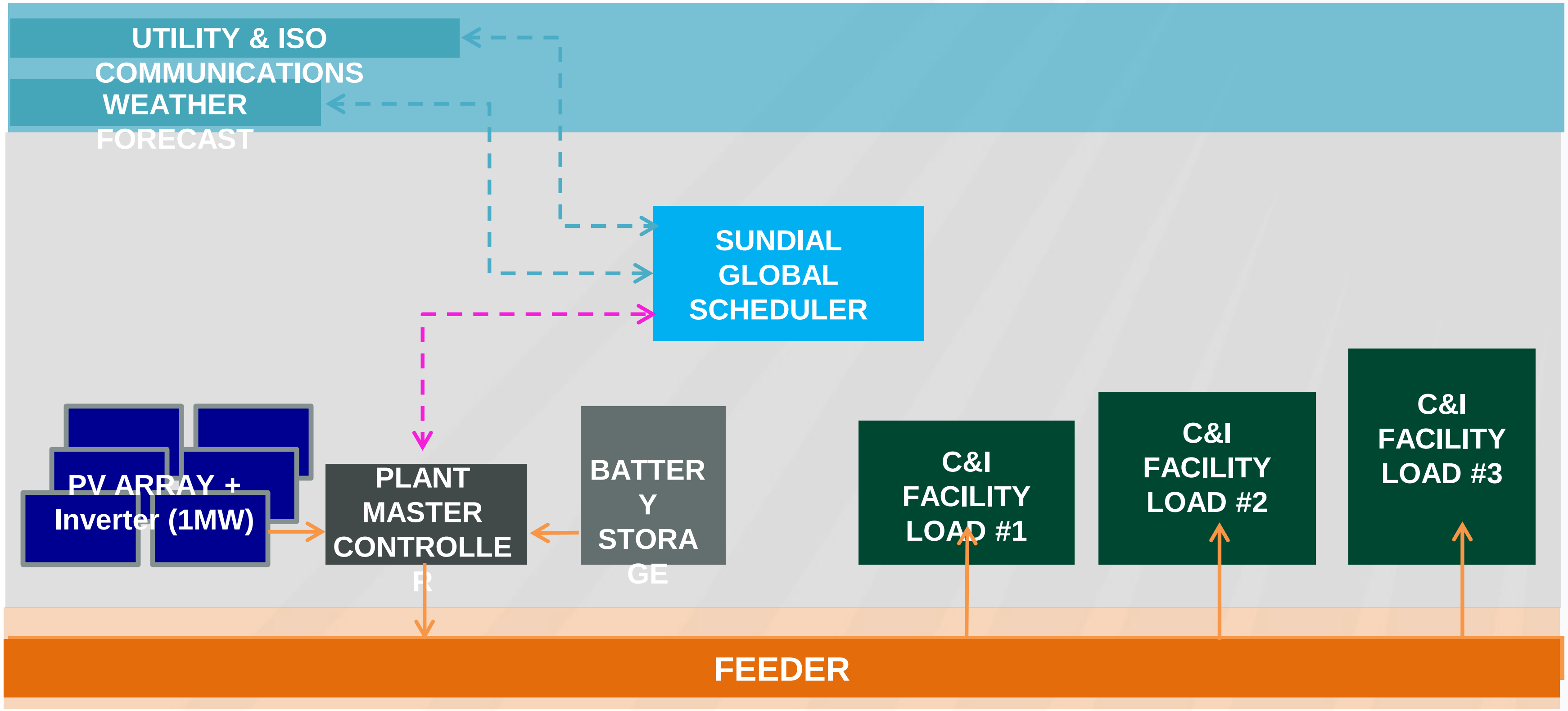
Architecture – Major Components



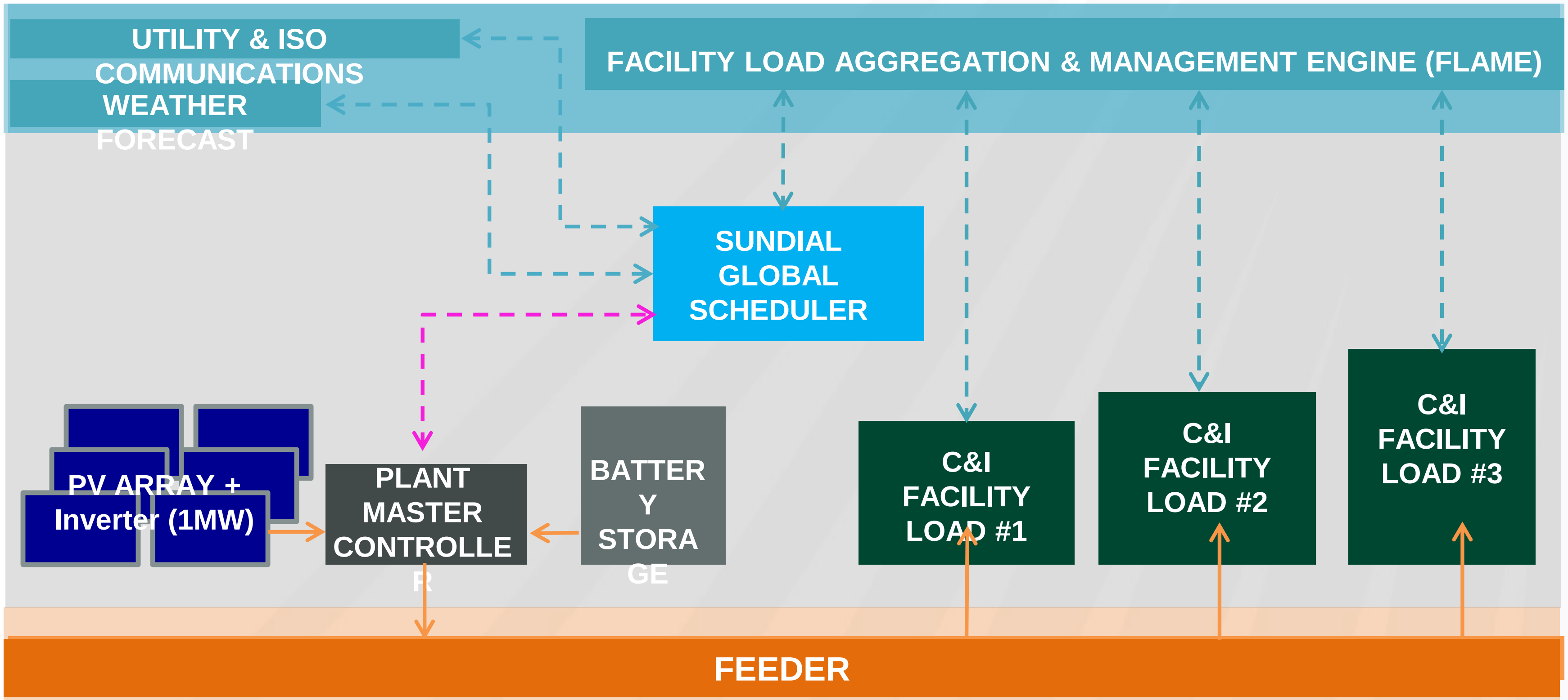
Architecture – Major Components



Architecture – Major Components



Architecture – Major Components



SunDial: A Vision for Integrating Hundreds of GW of Solar

SunDial Objectives

- Create extensible framework to readily integrate loads, storage, and PV
- Test and pilot business models and market mechanisms to enable high PV penetration

Market Transformation: *A transparent, low-friction market for storage / solar integration on the feeder level*

- Flexible with respect to markets: multiple use cases, vendors, and business models
  - Potential T&D deferral
  - Avoided system upgrades
  - Virtual Power Plant , etc.
- Flexible with respect to asset location, ownership, and type

Year-long Demonstration Project

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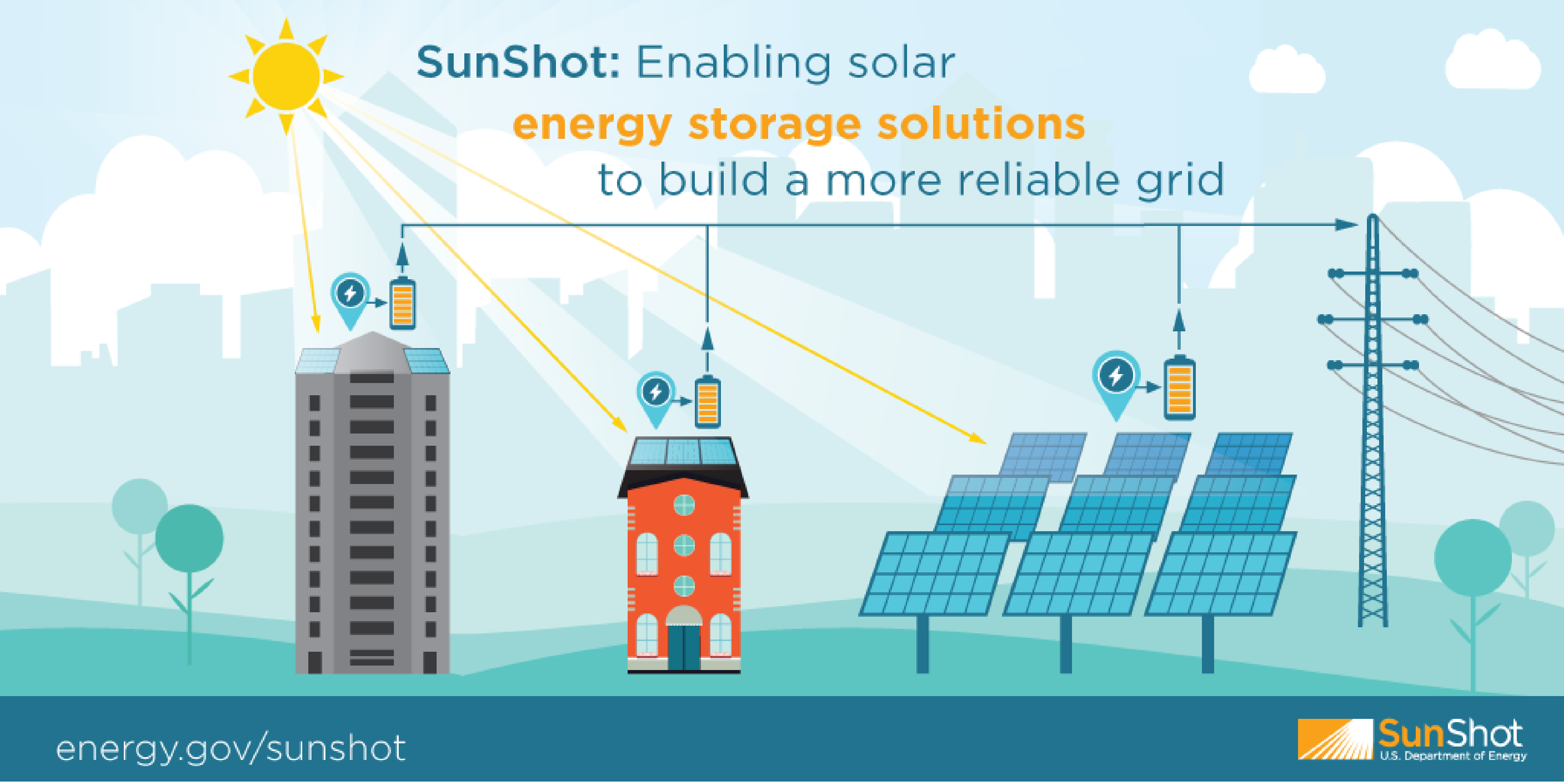
Lisa Martin, Austin Energy
Austin SHINES

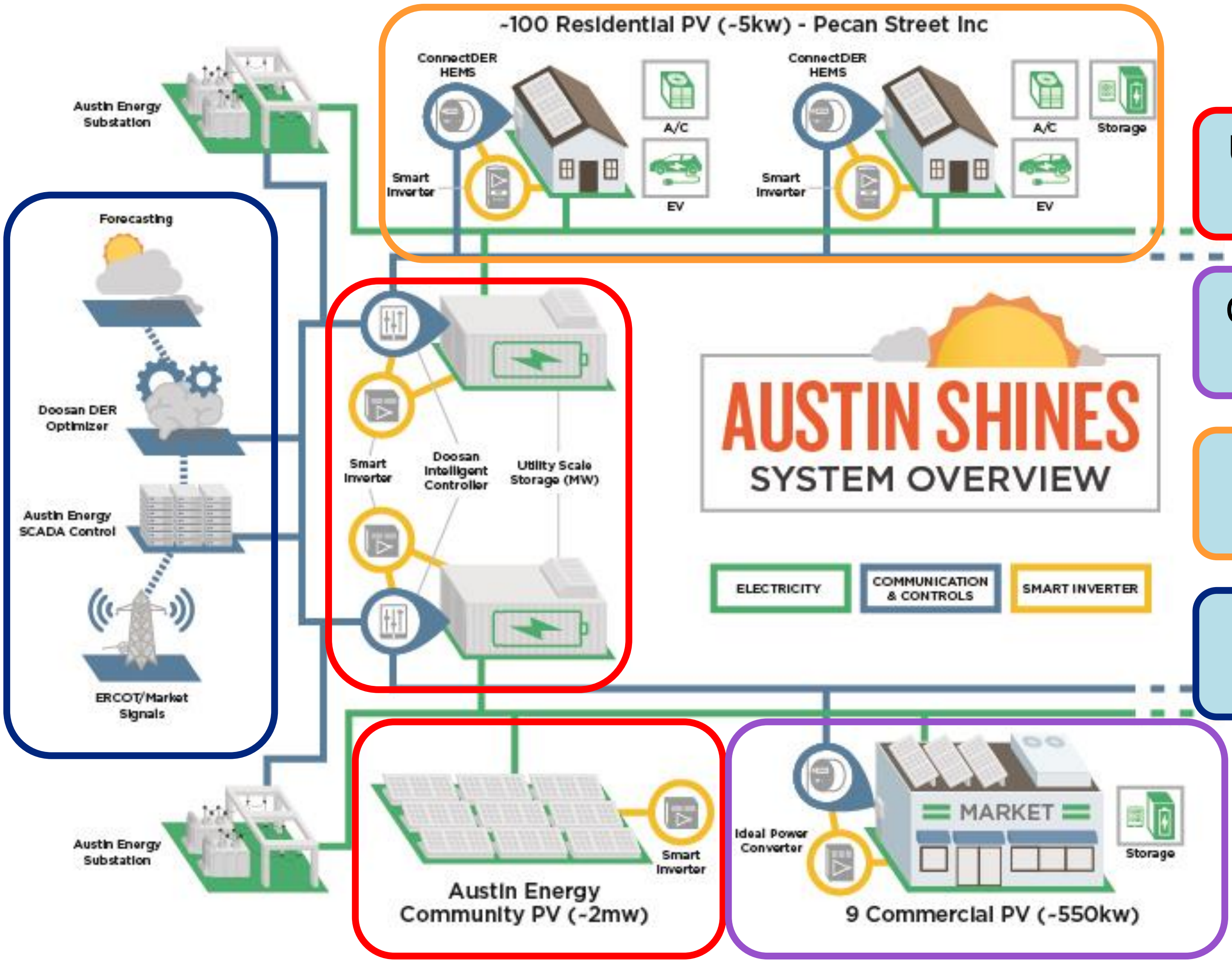
A bit about Austin Energy

DOE SunShot & SHINES Vision



The projects will work to dramatically ***increase solar-generated electricity*** *that can be dispatched at any time – day or night – to meet* ***consumer electricity needs*** *while ensuring the* ***reliability*** *of the nation's electricity grid*

SHINES Conceptual Architecture



Utility Scale Energy Storage + PV

Commercial Energy Storage + PV

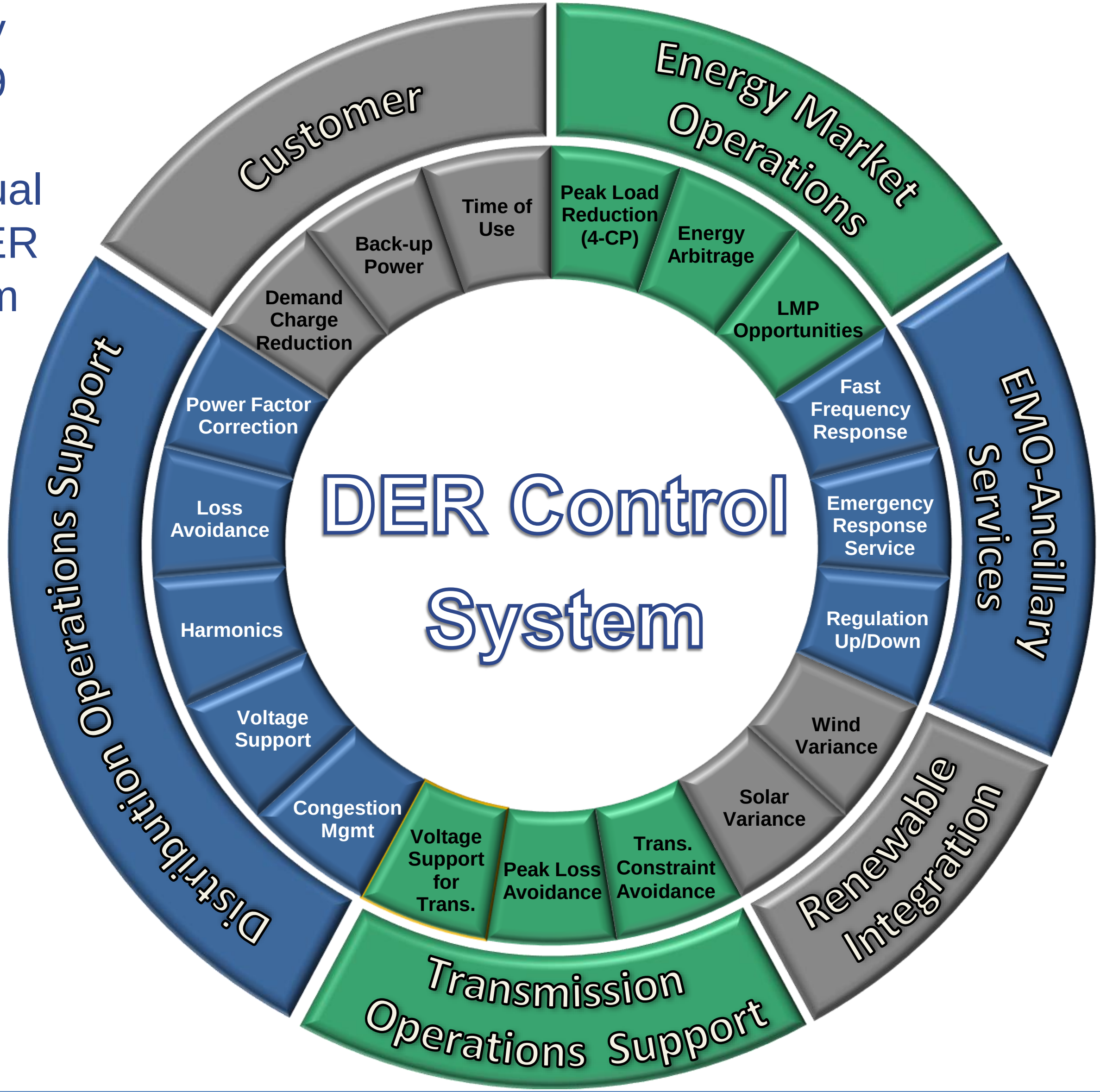
Residential Energy Storage + PV

DER Management Platform

Illustrative

Potential DER Control System Applications

Austin Energy considered 19 applications during conceptual design of its DER Control System



Thank you

Lisa Martin

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Thank you!

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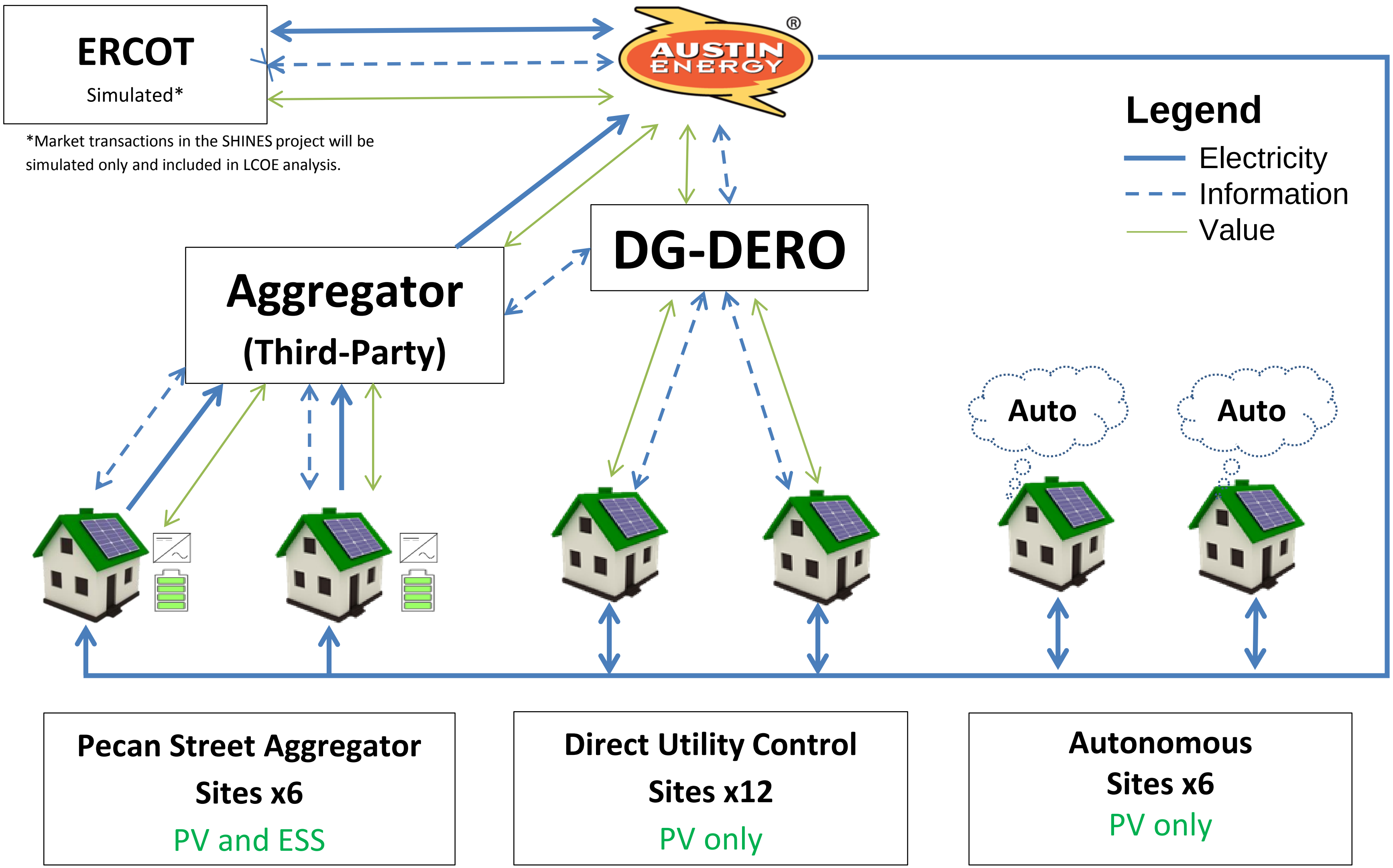
Visit ACEEE on the Web:

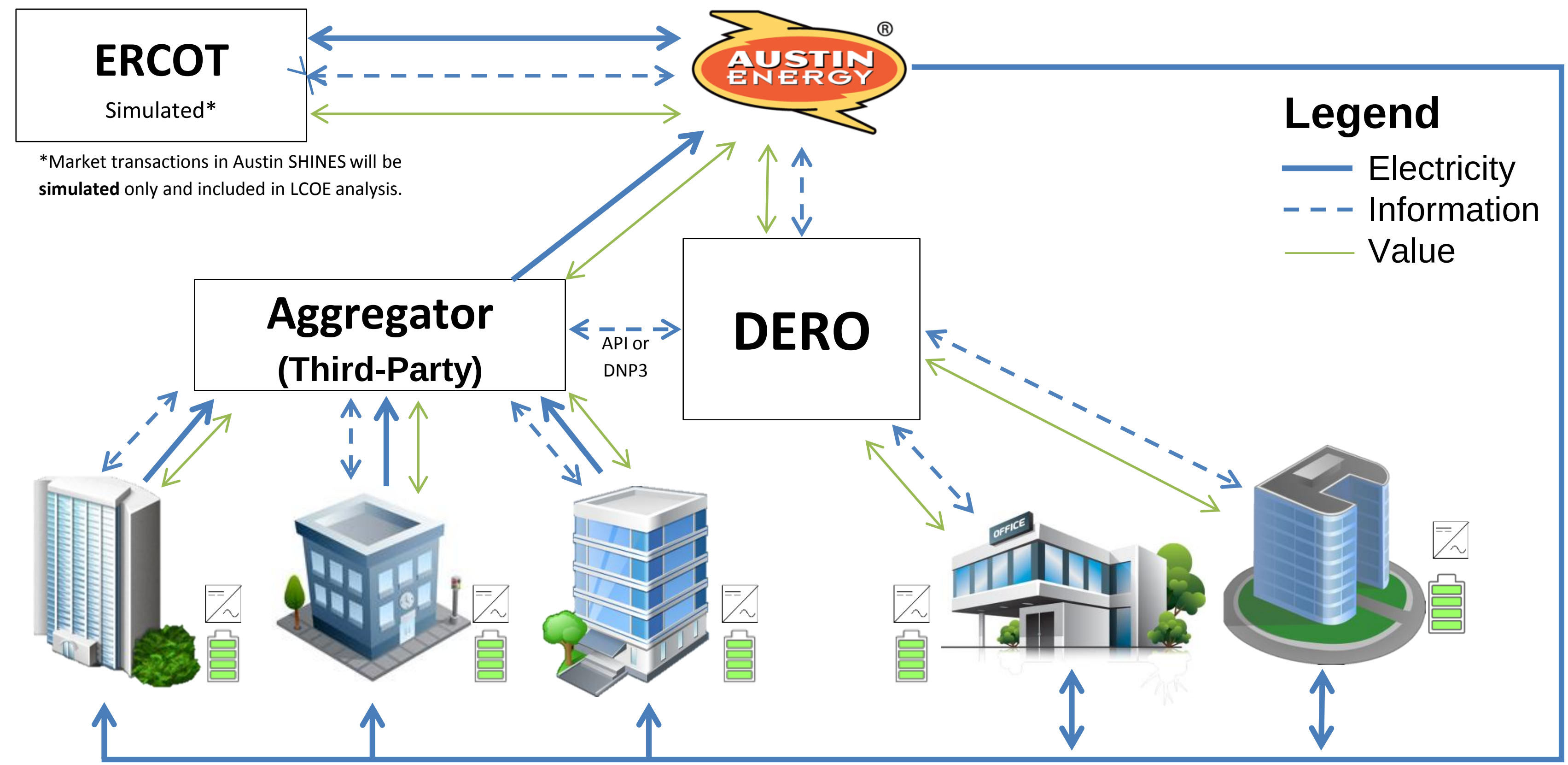
www.aceee.org

ACEEE American Council for an Energy-Efficient Economy

Residential Components



Commercial Components



3rd Party Aggregator Sites – 400kW

5x – 30kW

2x – 125kW

Dispatch Priority: Customer value propositions

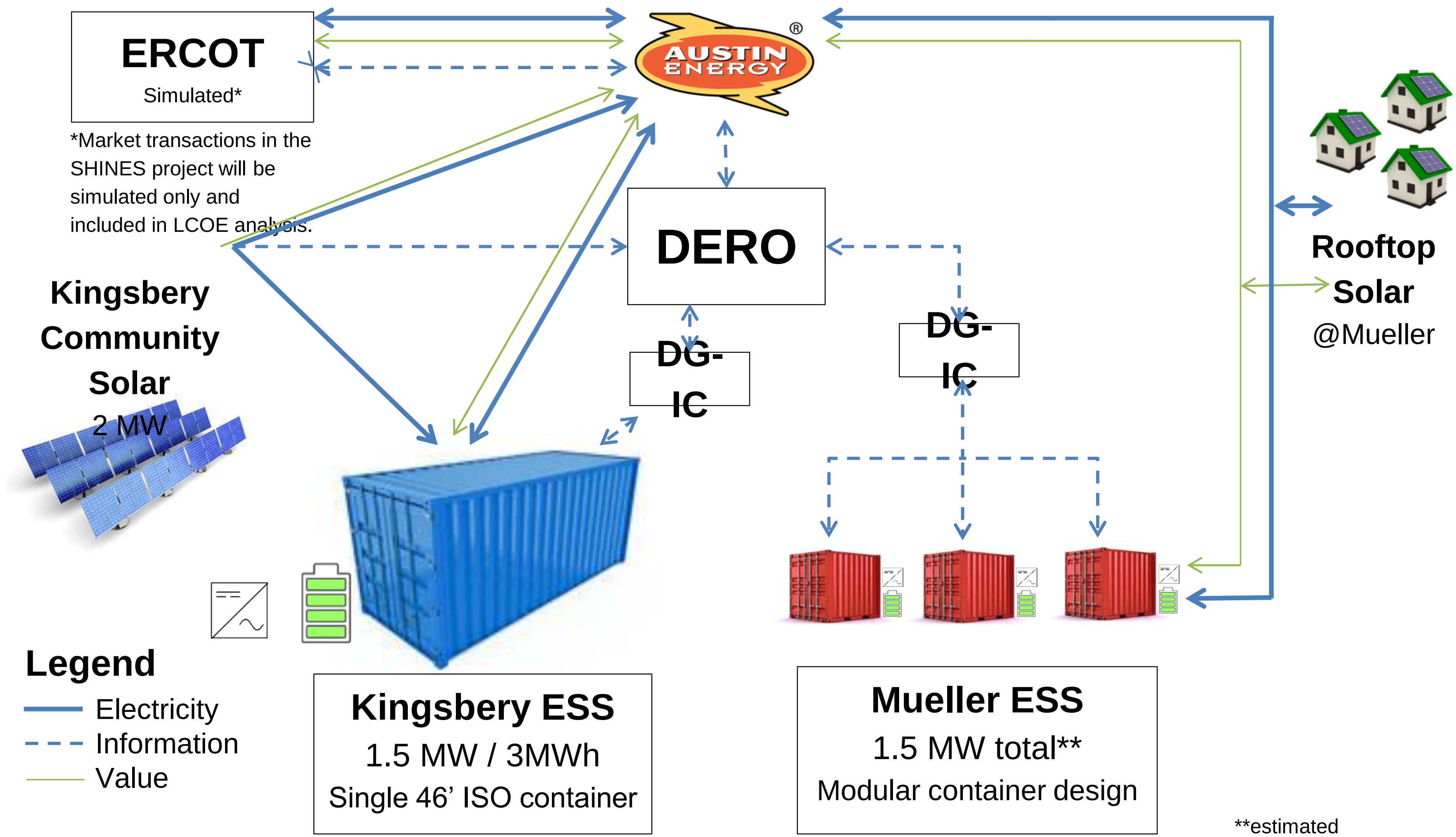
Direct Utility Control Sites – 155kW

1x – 30kW

1x – 125kW

Dispatch Priority: Utility reliability needs

Utility-scale Components



A Market for Aggregated, Feeder-Scale Demand-Side PV Support

Multiple *potential* business models accessible to multiple participants

- Potential T&D deferral
- Avoided system upgrades for storage- and load-aggregated PV
- Virtual Power Plant
  - Robust alternative to net metering
  - Multiple markets: day ahead, real time, demand response, capacity
  - Bid into markets as a single controllable aggregated resource
  - Future localized market for grid support

SunDial enables assets…

…from different owners…

…at different locations…

…to engage in cooperative business models

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Different Use Cases

Illustrative Examples

Use Case	Goal	Battery Storage	FLAME
PV Intermittency	Limit max. rate of change to <10%/min	Seconds to minutes	~5-15 minutes (fans, pumps, lighting)
Feeder-scale Load Shaping	Limit net power flow and morning/evening ramps	15 min to 4+ hours	15 min to 4 hours (pre-cooling, HVAC)
Peak Load Shaving / Demand charge reduction	Match generation and loads	15 min to 4+ hours	15 min to 4 hours (pre-cooling, HVAC)
Volt-Var	Optimize voltage	Real/Reactive power	n/a

The Concept

Physically decouple storage, PV, and load management

- **Global Scheduler:** Feeder-scale global optimization engine
  - Optimization over varying timescales and use cases
  - Leveraging PV, storage, AND aggregated load management resources
- **FLAME:** Facility load aggregation and management engine
  - Based on an existing, proven demand response aggregation business model
- **Plant Master Controller:** Local, fast, site-level control of PV and storage
  - Utilizing standard utility-scale PV/Storage control and integration capability
- Newly developed **interoperability interfaces**

Enables a transparent, broadly scalable mechanism to achieve and simplify feeder-scale integration of PV, loads, and battery storage

SunDial Global Scheduler

Works for Different Use Cases

- PV intermittency mitigation
- Load Shaping
- Peak Load Reduction
- And more…

Determines System State (Current & Predicted Future)

- Solar resource
- Battery
- Loads and Load Sink/Shed Potentials
- Grid Constraints, Pricing

Performs Optimization

- Minimize cost based on objective function defined by the current use case
- Shrinking horizon scheduling approach
- Updated according to new information at subsequent scheduling steps.

Generates Control Signals

- PMC, FLAME, Battery

Implemented as an extension of, e.g., PNNL's VOLTTRON distributed control and sensing platform

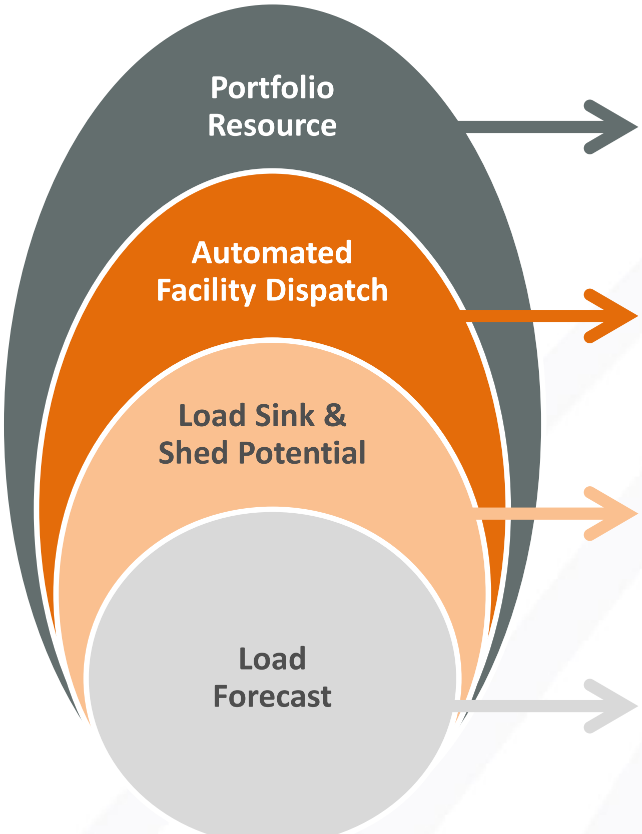
Meeting SHINES FOA Technical Targets

- **LCOE:** \$0.14/kWh with \$1.55/W solar; \$0.10/kWh with \$1.00/W solar in MA
- **Efficiency:** 90% RT efficiency achievable
  - Displace ~25% of electrochemical storage throughput with load management
    - approaches or exceeds 100% RT efficiency
  - Co-located storage on the primary side of the MV transformer
- **Component lifetimes:**
  - Limit cycling on battery through load management
  - Account for replacement in lifetime LCOE calculations

Project Outcomes

- Standardized interoperability interface for integration of aggregated loads with DG
- Develop new, low-friction market mechanism for localized PV support services
- Leverage aggregated resources to reduce interconnection complexity
- Commercial implementation of distribution-scale DSM aggregation engine for integration with solar
- Demonstrate technical and commercial feasibility of scalable approach for decoupled solar, storage, and load management

Facility Load Aggregation & Management Engine (FLAME)



Statistical representation of expected portfolio loads and shed/sink potentials and their costs, over time

Curtailment script within customer acceptance parameters

Building model calibrated with prior load control events

Predicted loads based on historic building data and exogenous weather factors