Advanced Energy Communities: Grid Integration of Zero Net Energy communities

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LBL Presentation

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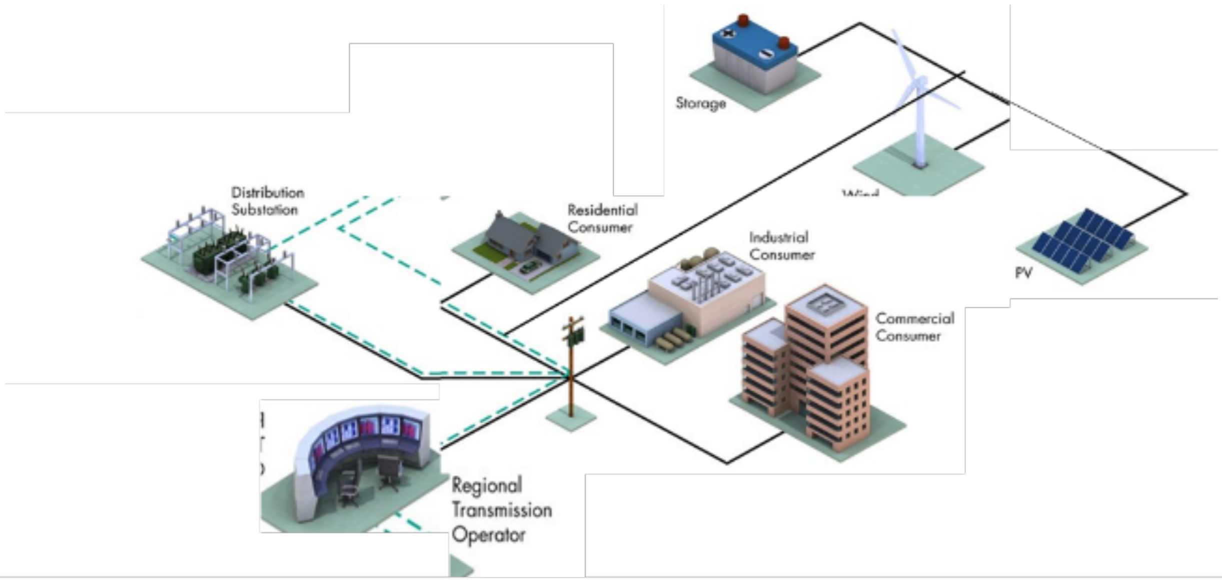
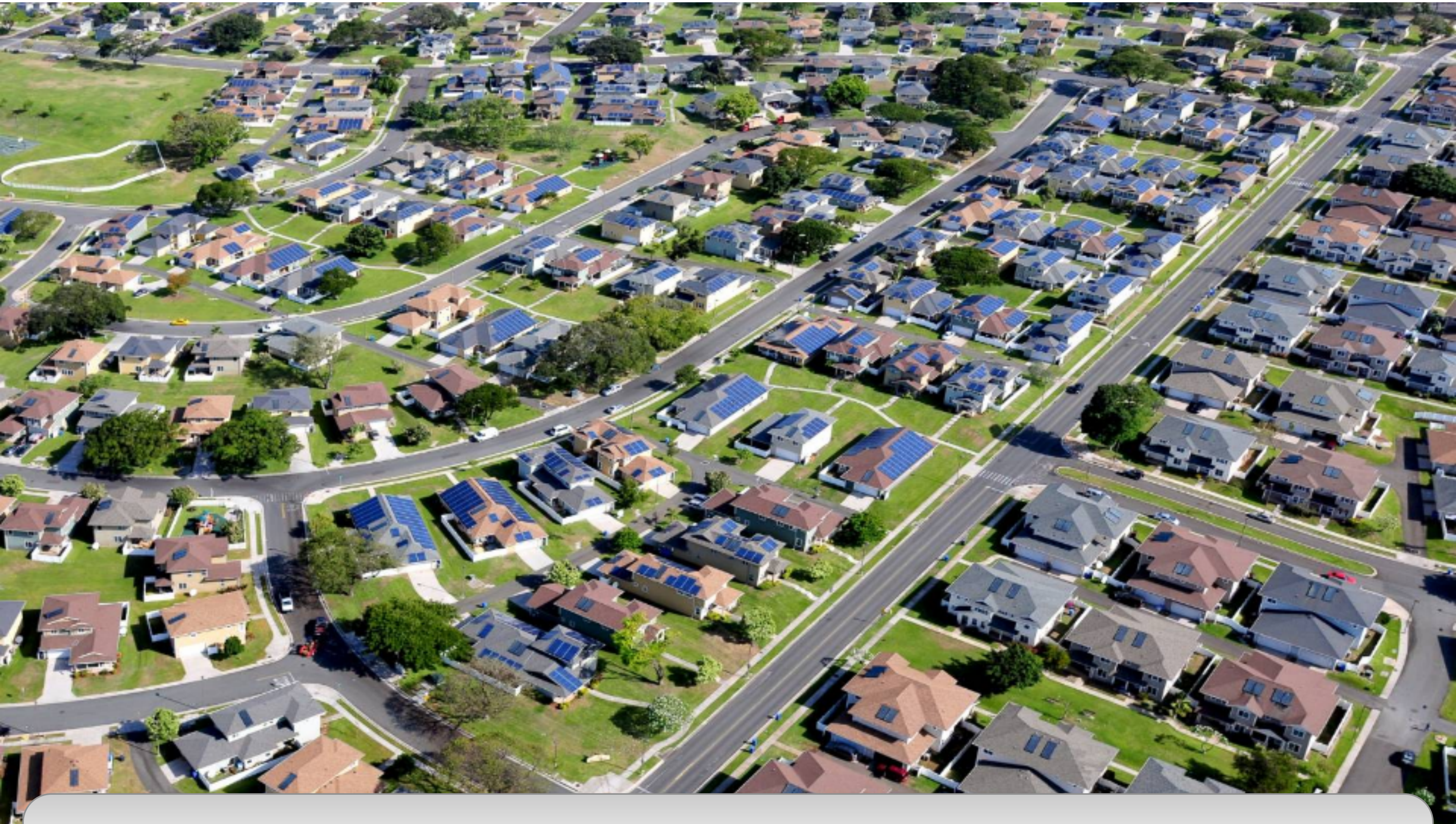
What is an Advanced Energy Community?

Advanced Energy Communities (AEC) are customer focused demonstrations that **integrate multiple customer resources** such as Energy Efficiency, Demand Response, Customer storage, PV (or other local generation), electrification and electric vehicles in an **electrically contiguous area** to achieve larger **utility and societal goals** such as decarbonization, grid hardening and grid support while enabling the utility customers with advanced technologies that **provide comfort, convenience, and cost benefits to the customer**



Advanced Energy Community



Example: A residential new home community that has features including rooftop PV and community scale storage, as well as electrification of end use loads

Example Advanced Energy Communities Initiatives

Vertically Integrated | ISO | Distribution | G&T | Retail Market

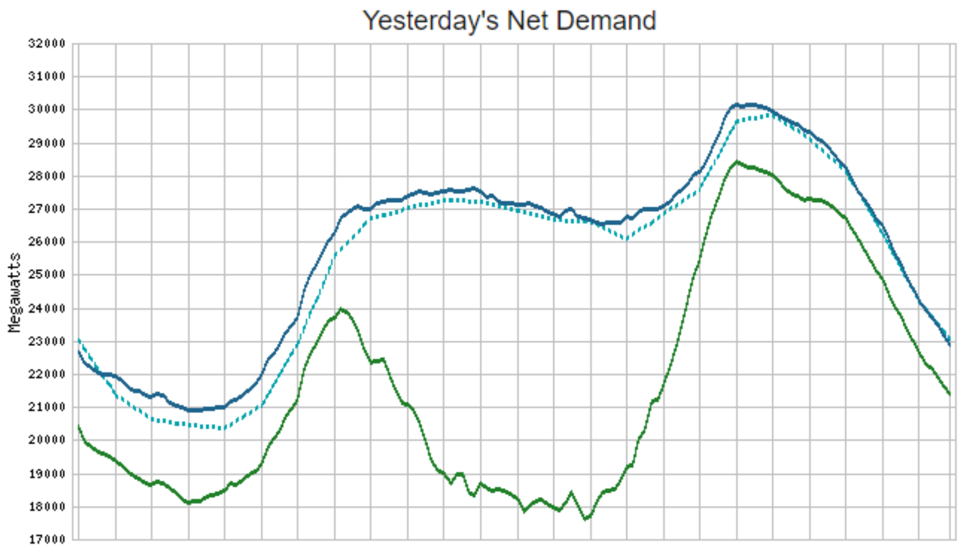
Utility Layer – Abstracts utility program requirements and open standards

Data Module – Warehouse and analytics | Controls Module – Algorithms

Product Layer – Manages all Connections using API and open standards

Echo | SMA | ecobee | E-Gear | Lutron

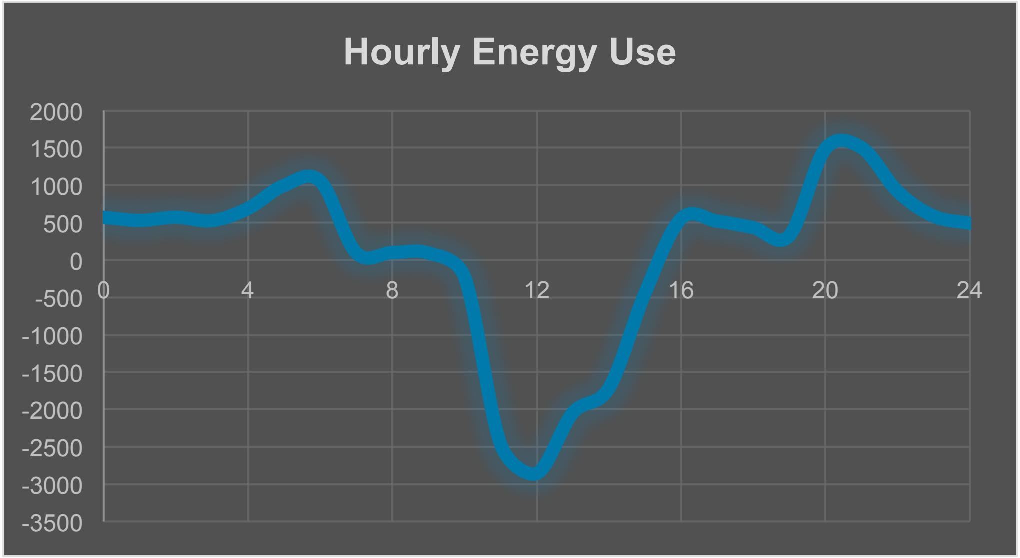
Supply – Demand balance needs rising at all levels….



California ISO Demand Curve for Feb 7, 2017

Net Demand for Advanced Energy home, Feb 1, 2017

Customer technology evolution driving load shape changes, and increasing balancing needs from grid edge to the ISO



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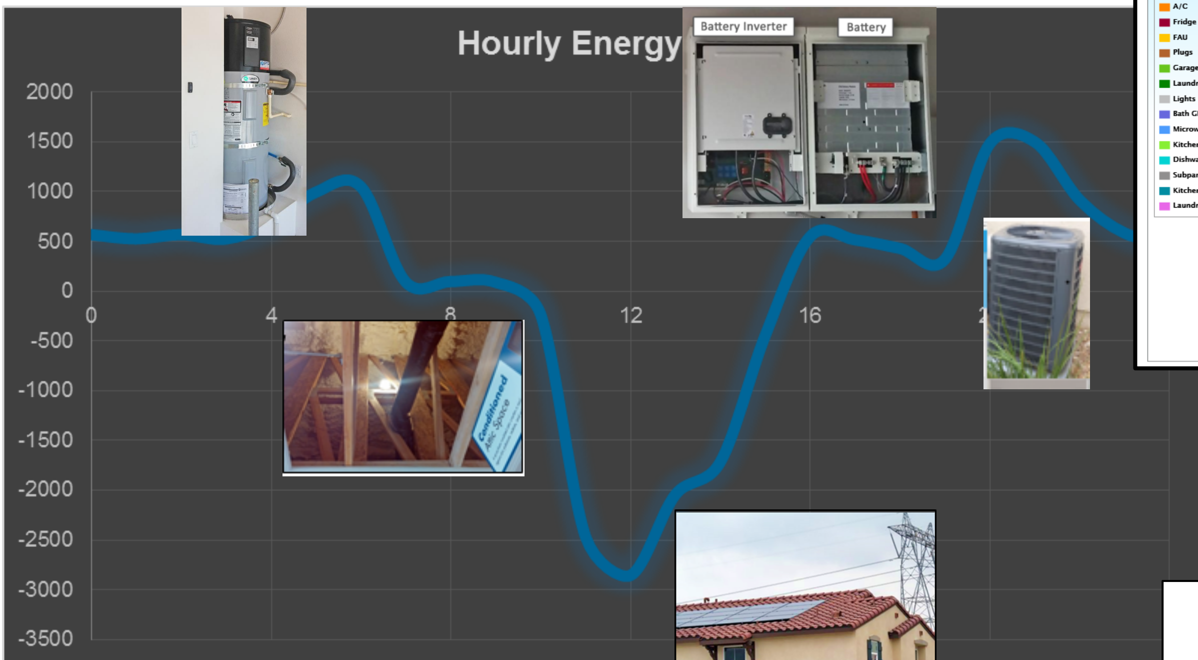
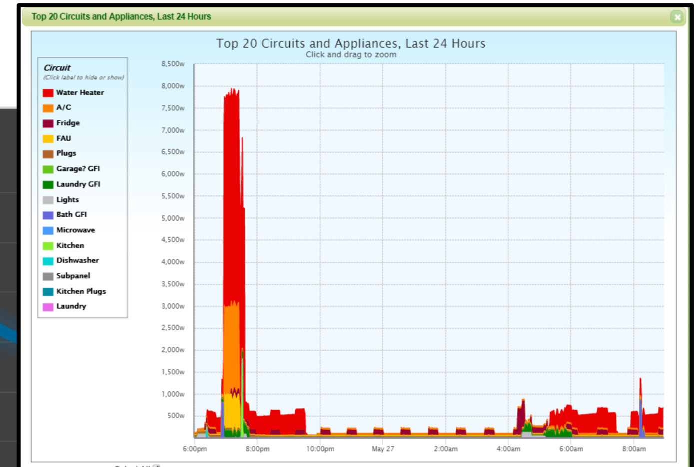
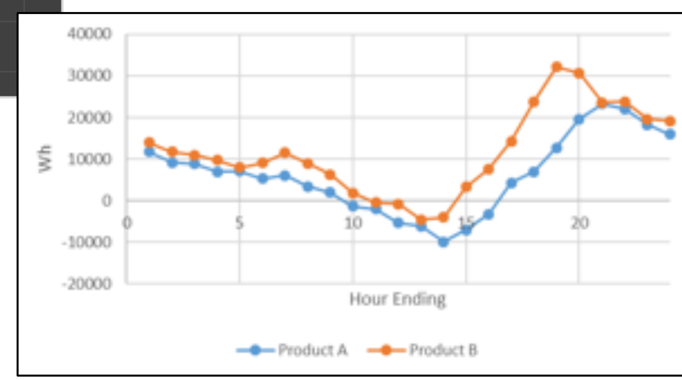
Example Lessons learned from Advanced Energy Community





"Duck Curve" at transformer

Storage shifts peak by 2 hrs



Interactive and competing impacts from electrification, energy efficient construction, solar PV, battery storage

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Fontana ZNE Community: California's first ZNE neighborhood

Highlights

- First production builder ZNE neighborhood
- First time homebuyer community priced below LA area average
- Net cost less PV less than $1,000 per home

- Average PV size 4 kW due to EE (TDV ZNE)
- Electric heating and water heating
- Smart Home features

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Project Goals

Evaluate impact of ZNE communities on electrical grid and technology strategies to enhance grid benefit

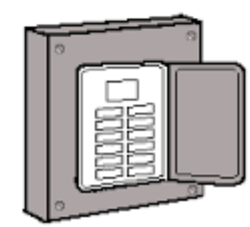
- Demonstrate new technologies and strategies that enable cost effective Zero Net Energy homes and resulting high PV adoption
- Measure the impact of concentrations of ZNE homes on electrical distribution
- Demonstrate how residential Energy Management systems can balance PV with loads and support power system needs
- Evaluate and demonstrate optimal location of Energy Storage in ZNE communities (residential vs. neighborhood)
- Develop integrated modeling approach to integrate building and distribution models

Inside the Smart, Connected, Controllable Home

Smart Thermostat

Solar & Storage

Smart Heat Pump Water Heater



Controllable Loads

Annual Energy Use and PV sizing

	Annual Energy Usage			PV Sizing	
Home	Modeled Annual Energy Used (kWh)	kWh Needed for ZNE (kWh)	kWh/sq. ft	Base Case PV	Integrated EE PV
6	6,923	6,099	2.59	6.1kW	4.5kW
7	7,485	6,518	2.57	6.4kW	4.5kW
8	6,882	6,199	2.57	5.5kW	4.0kW
9	7,485	6,518	2.63	6.4kW	4.5kW
10	6,882	6,445	2.36	5.7kW	4.0kW
11	6,923	6,208	2.44	5.3kW	4.0kW
12	7,518	7,213	2.58	5.5kW	4.0kW
13	6,926	5,956	2.44	5.5kW	4.0kW
14	7,512	7,213	3.24	5.5kW	4.0kW
15	6,902	5,961	3.16	5.5kW	4.0kW
16	6,773	5,768	3.5	5.5kW	4.0kW
121	6,331	5,801	2.73	5.5kW	4.0kW
122	6,550	5,800	3	4.6kW	3.5kW
123	6,143	5,021	3.17	5.0kW	3.8kW
124	6,521	5,759	2.99	5.3kW	4.0kW
125	6,559	5,560	3.01	4.7kW	3.5kW
126	6,521	5,568	2.99	5.0kW	3.8kW
127	6,035	5,798	3.12	5.5kW	4.0kW
128	6,451	5,800	2.96	5.0kW	3.8kW
129	6,451	5,800	2.96	5.0kW	3.8kW
AVG.	**6,789 kWh**	**6,050kWh**	**2.85**	**5.4kW**	**4.0kW**

Comparing PV Sizing – With and Without EE Measures

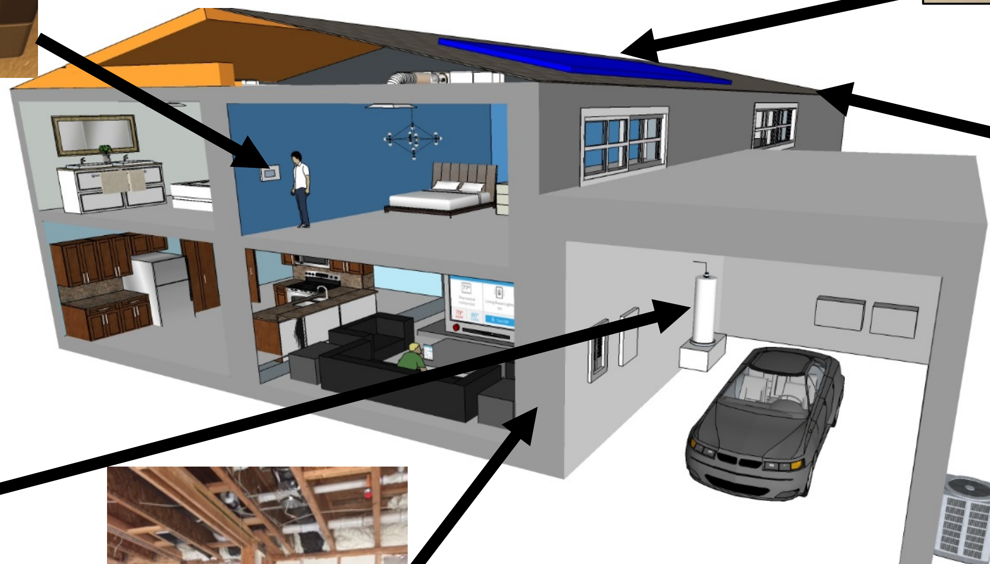
- Energy Efficiency measures result in reduced PV size of 1.4kW/home (~$5000)
- Evening peak load reduction of 1.6 kW
- Approx. $17,000 incremental cost to attain Zero Net Energy
- With CA NEM rules:
  - annual energy cost to customer is around $350 (electric + gas)
  - Electrification of water heating helps offset net annual generation

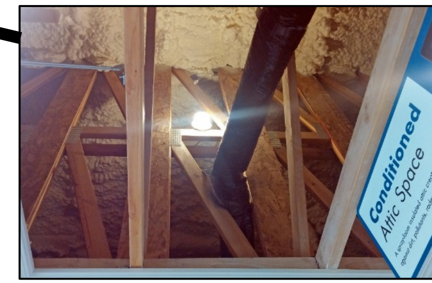
Implemented ZNE Measures

Nexia Thermostats/HEMS

All LED lighting

3.5 – 4.5 kW PV





High Performance Envelope

Electric Heating and Water Heating

Foam Insulation

<u>Plus:</u>

- Plug load controllers
- Circuit-level monitoring

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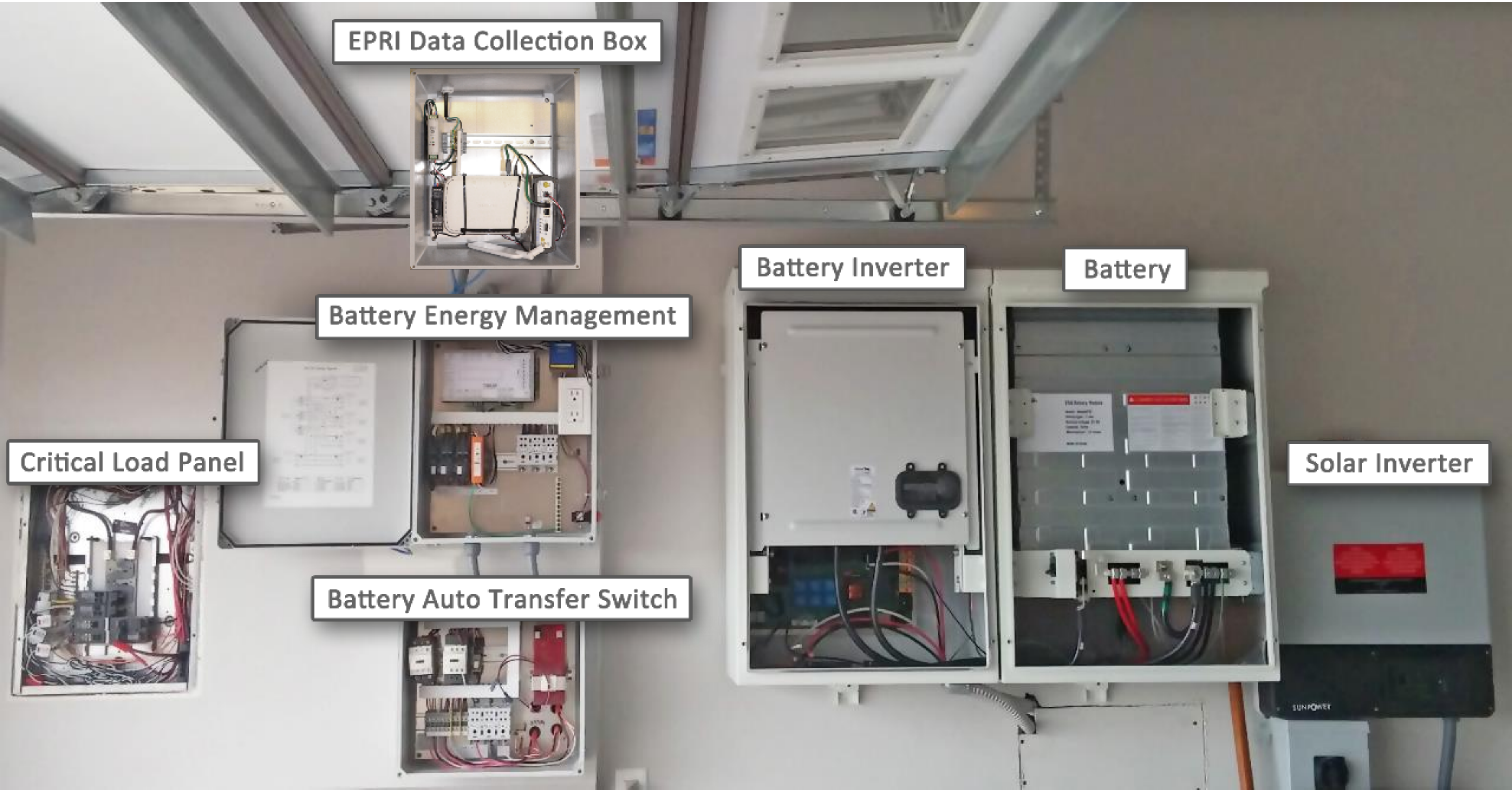
Home Integrated Battery Storage System



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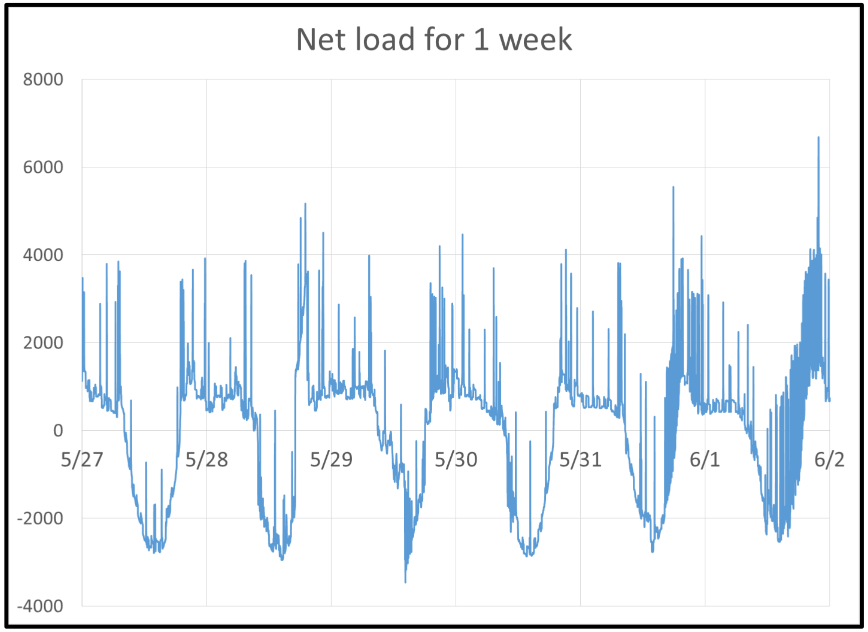
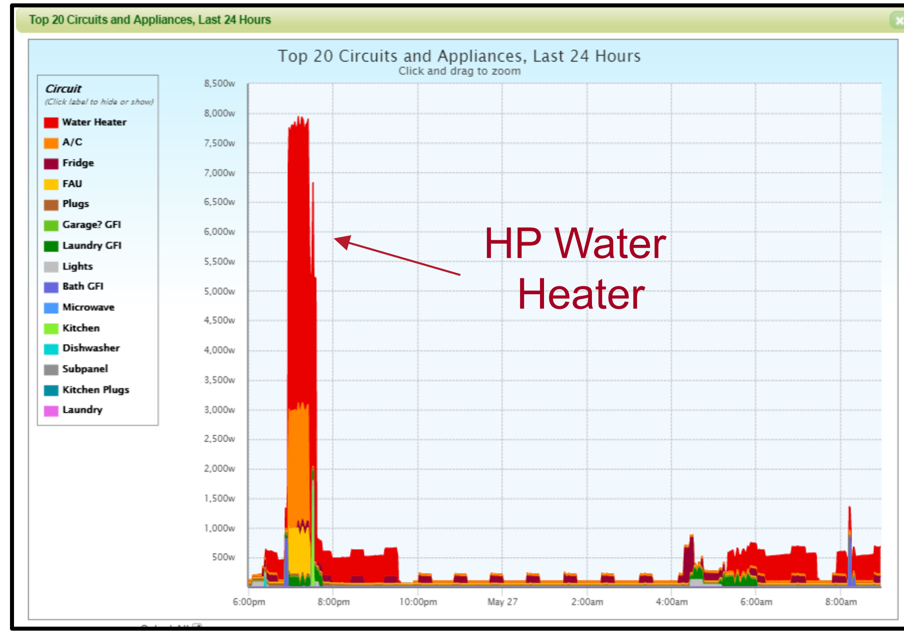
How Are These Homes Performing?



Energy Usage in Watts (1 min interval)

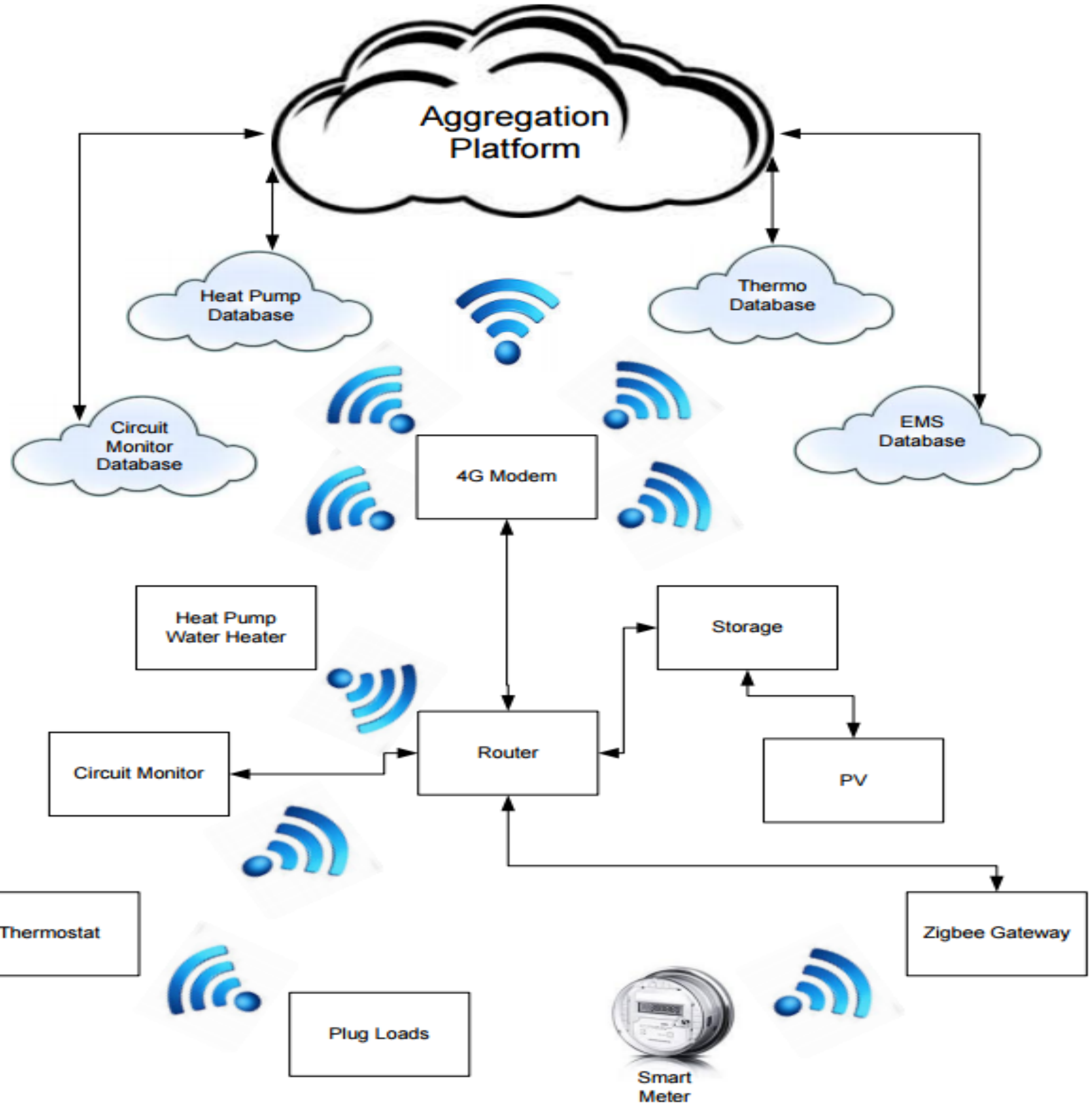


Disaggregated load profile

- These ZNE homes are occupied by first time home buyers, not energy enthusiasts
  - Anecdotal - $25 July bill with electric dryer, $0.64 bill in April
- Very erratic load shape with HPWH and appliance driven peaks
- Models: average loads/time-step; actually discrete, intermittent loads
- Intermittent loads coincident → large, unanticipated peaks

What Does This Mean to the Grid?

Single Home Device Aggregation & Control



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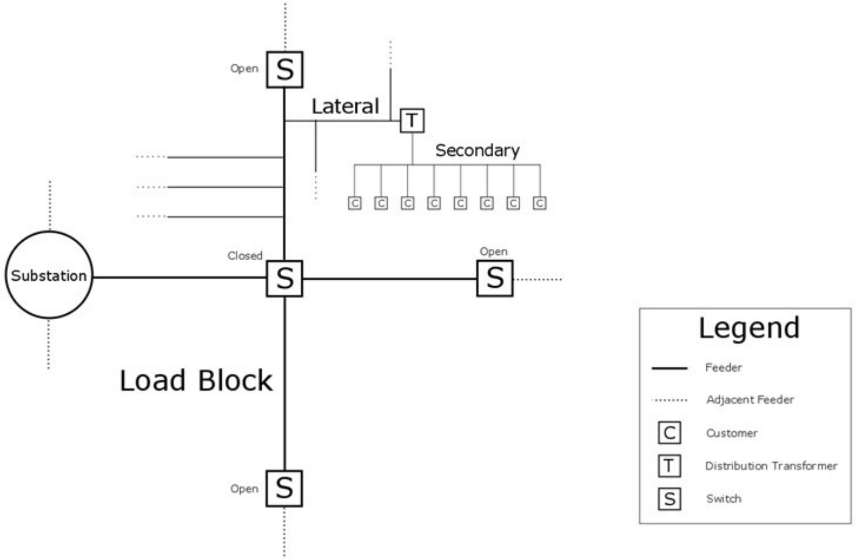
Current Distribution planning and operations practices and Concerns

- Distribution systems might not be designed for electrification of end loads, from either planning or operations viewpoint
- Distribution planning process fundamental assumption: HVAC systems are the largest loads
- ZNE homes will be more efficient and provide improved thermal envelopes.
- Electrification of gas loads within ZNE homes could create some new challenges to planning
- Need better customer models for planning and controls for operation



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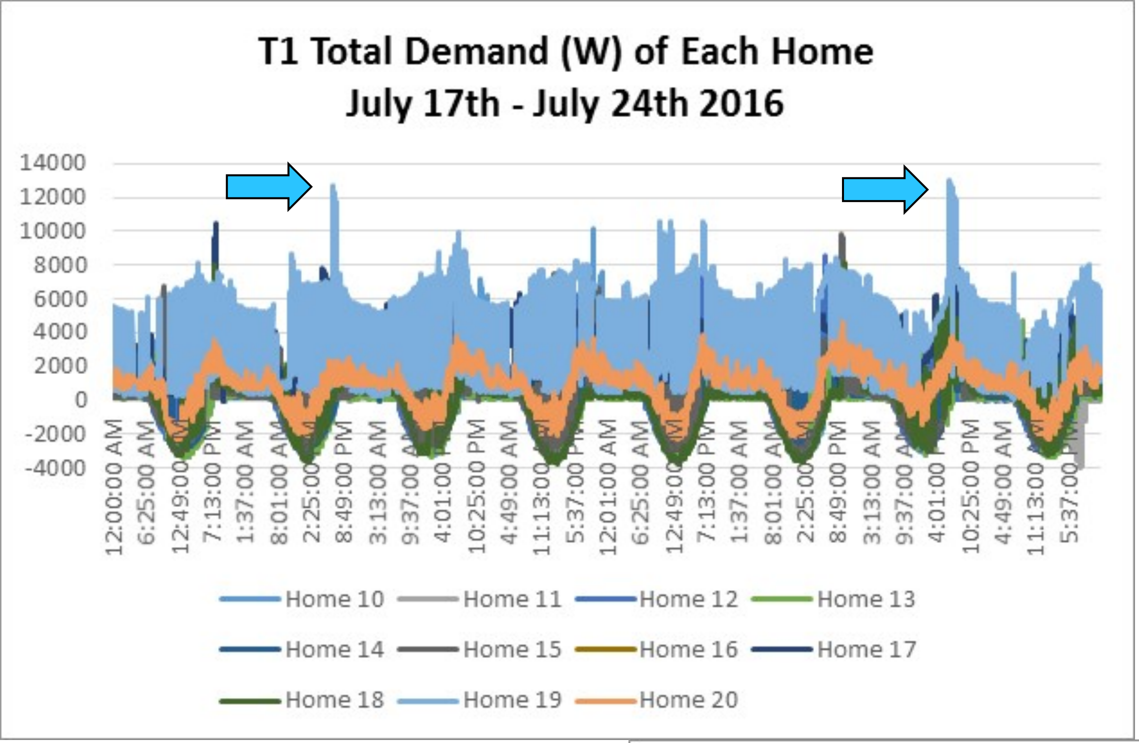
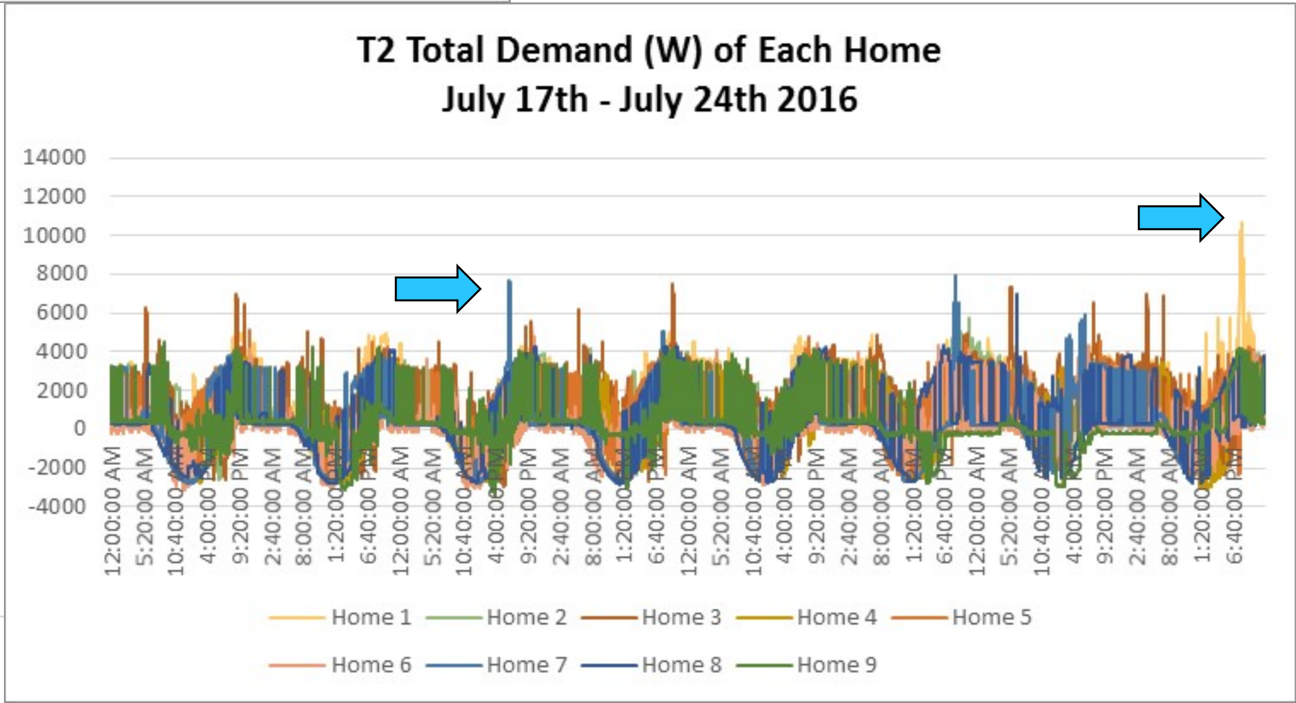


Electric Heating ZNE Homes

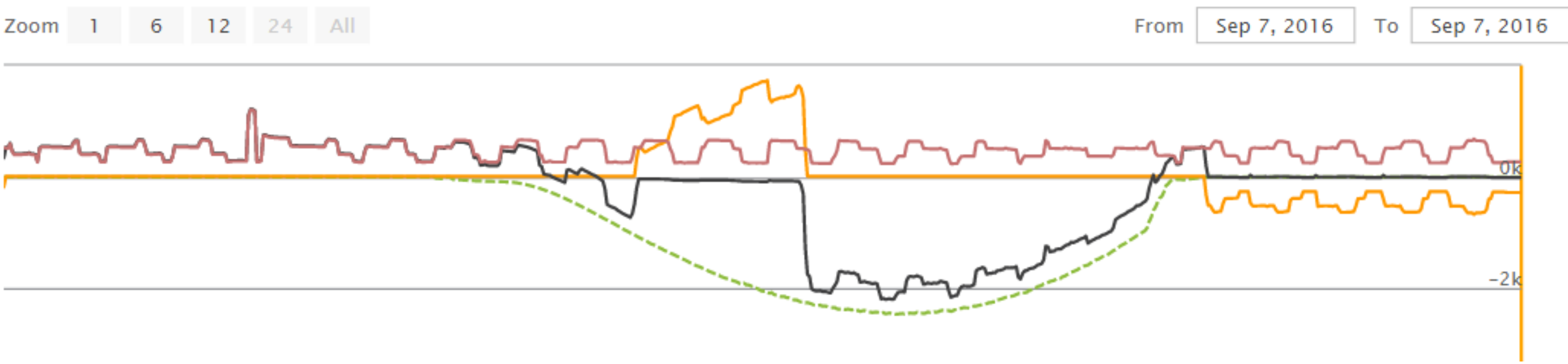
Actual Measurements

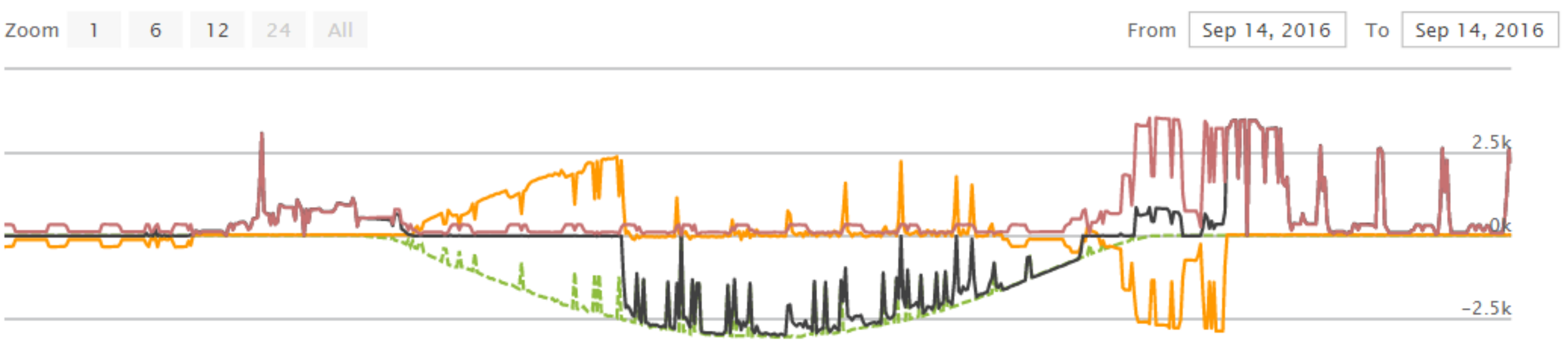
- Measurement data from homes built in Fontana



Performance with battery storage, EE and solar

- Batteries can operate in different control modes - self-consumption, Time of Use, Utility Aggregation
- Tested in self consumption and 2 different ToU modes





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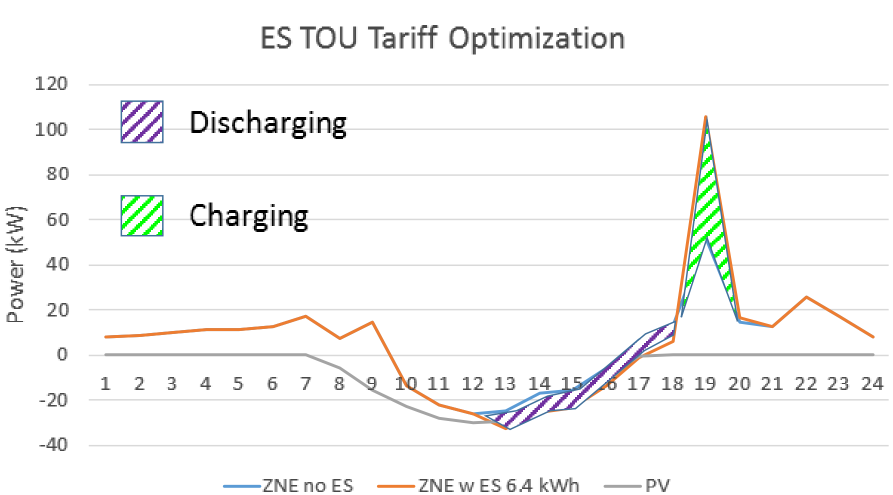
Could Energy storage Provide a Potential Solution

Controls are key

Operation based on ToU rates Optimization

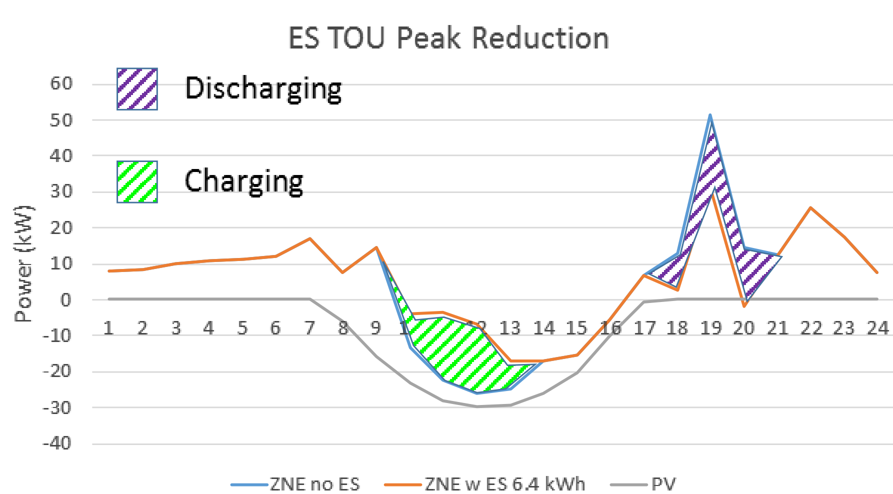
- Energy storage is operated to optimize for current ToU rates
  - Peak is Noon – 6 PM (ES discharge)
  - Off-peak is 6 PM – 6 AM (ES charge)
- 100% SOC maintained overnight



The ES TOU tariff optimization control scheme could potentially cause adverse impacts.

Operation based on ToU Peak Reduction

- Energy storage systems operated with “simulated peak and off-peak”
  - Peak is 5 PM – 8 PM (ES discharge)
  - Off-peak is 9 AM – 12 PM (ES charge)
- 25% SOC maintained overnight



The ES TOU grid balancing control scheme could be beneficial.

Lessons learned – Planning, Operation, and Design

1. Minimize the size of PV arrays for multiple benefits:
   - Neighborhood planning, lot fits, lower costs
   - Reduce peak backflow, and reduce late evening ramps
2. Energy efficiency has more capacity benefits than PV
3. PV and load peaks (8 PM – 12 AM) are not coincident
4. Energy storage controls optimized for grid benefits (tuned to duck curve) can help distribution grid
5. End to end models integrating building and distribution models are achievable and can enable better grid operations
   - Models need to be more granular, not averages

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Aggregation Platform for Smart End Devices

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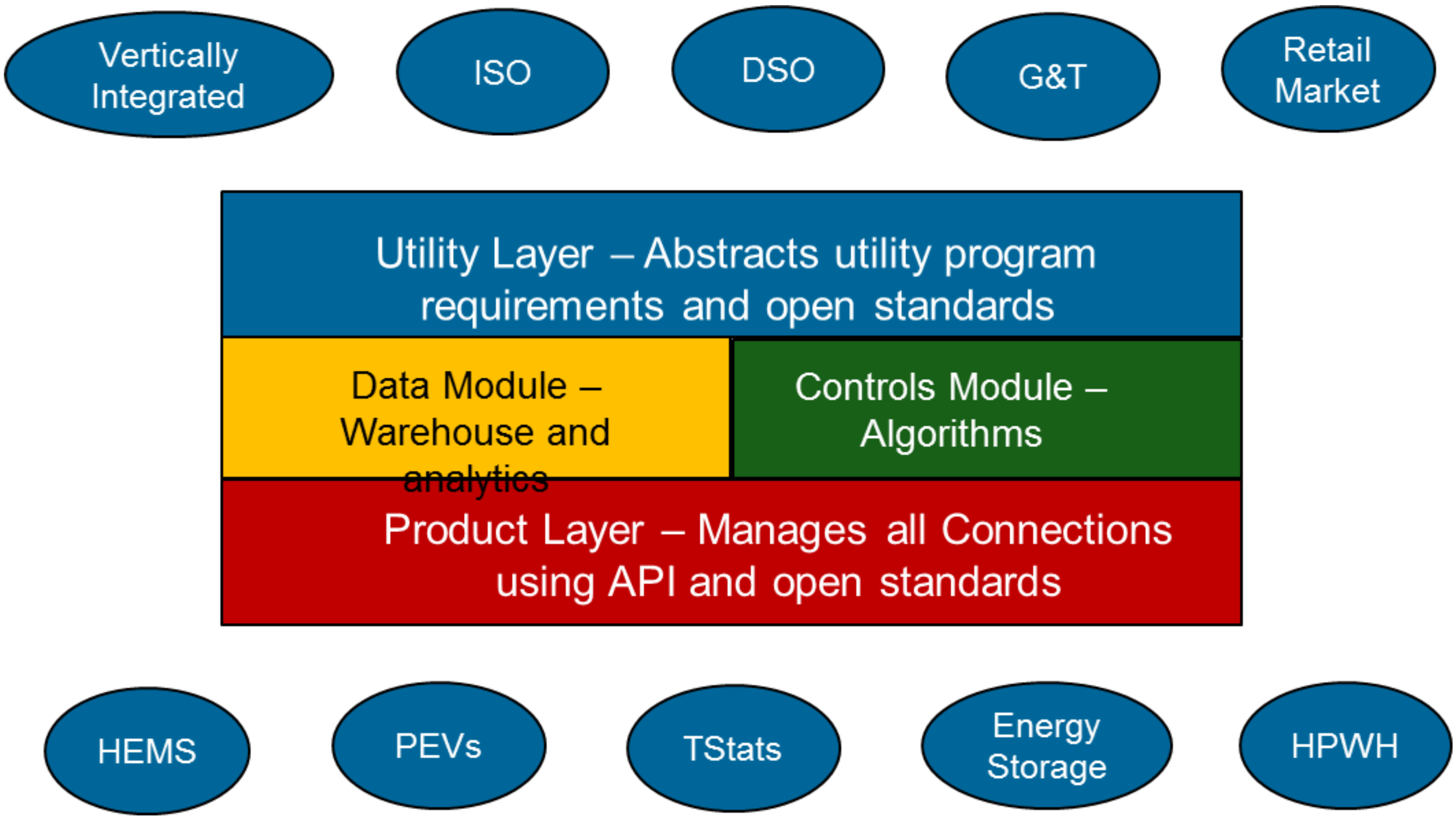
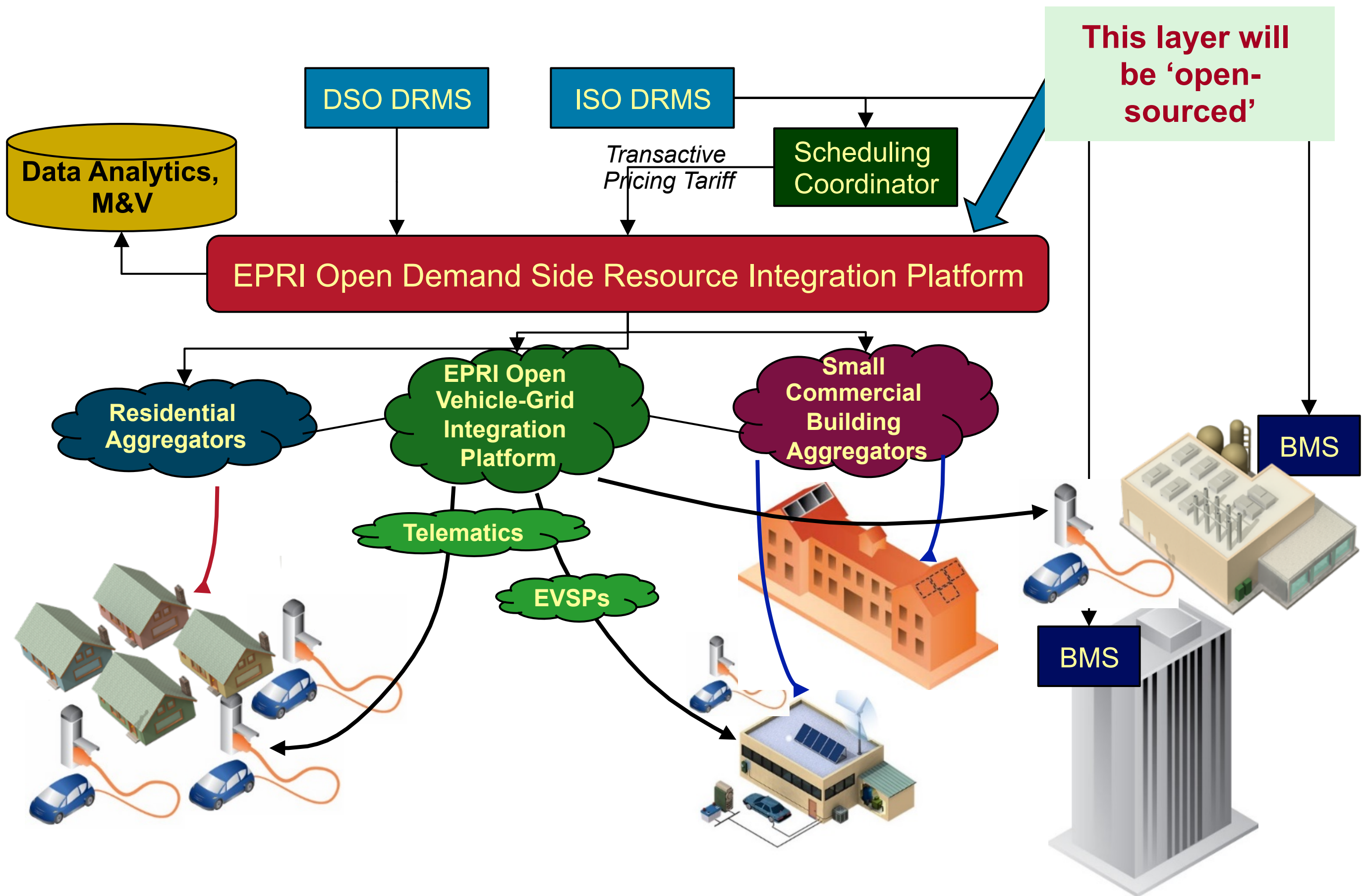
The need for aggregation and path forward – Conceptual View



Open Aggregation Platform as the DRP Enabler



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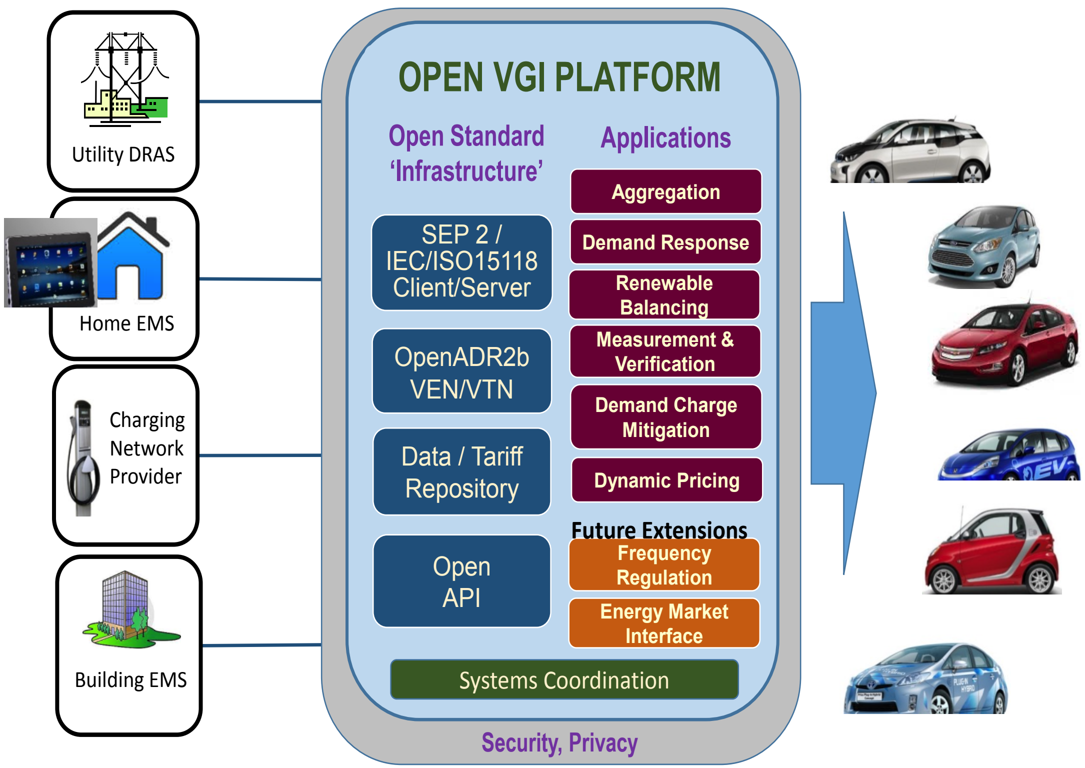
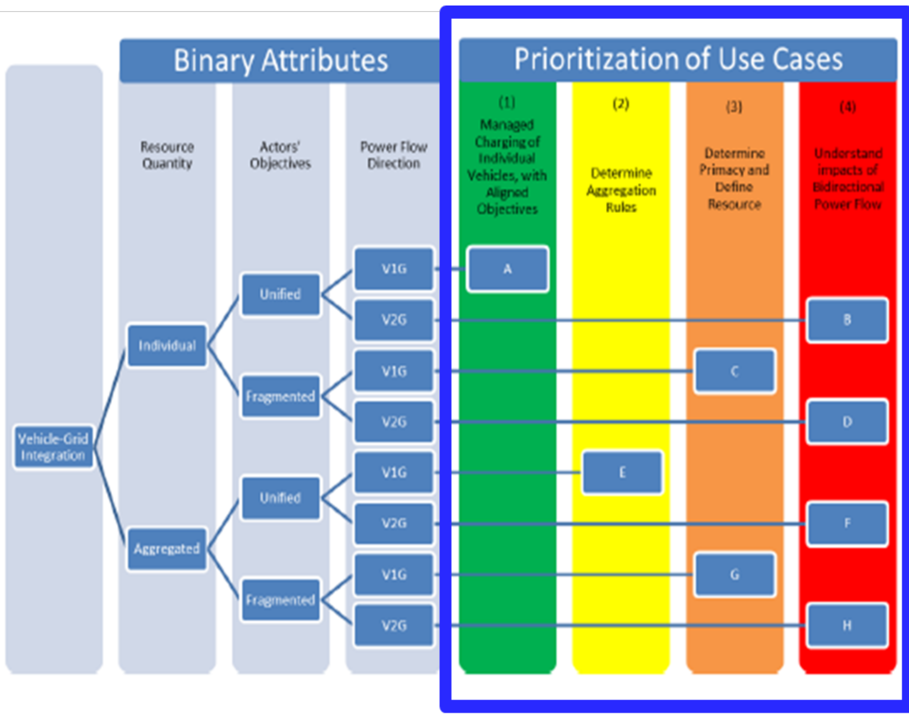
Interactive Interface between PEVs and Stakeholders



- Unified open interface platform
- Single interface to utility and 3rd party DRMS
- Engages all stakeholders in the VGI ecosystem
- Engages stakeholder diversity and innovation through interoperable interface and communications protocols / standards
- Automated PEV Customer interactions
- Interactive communications and data gathering through PEV telematics
- Interoperability is key to enable compatibility, extensibility, innovation, and adaptability

OVGIP Use Cases Directly Address VGI Roadmap Priorities

VGI Use Case Priorities



OVGIP Use Cases

1 Automated Utility Electricity Rate Tariff Processing

2 Locational Demand Response; Balancing Resource

3 Interface with Home Energy Management System / ESI

4 Interface with Building Energy Management System

5 Pricing Signal Events

6 Interface with EVSE Network Provider

7 Optimized Load Management (ISO/IEC 15118)

8 Vehicle Roaming

9 EVSE Networking Functionality

10 Metering and Data Exchange

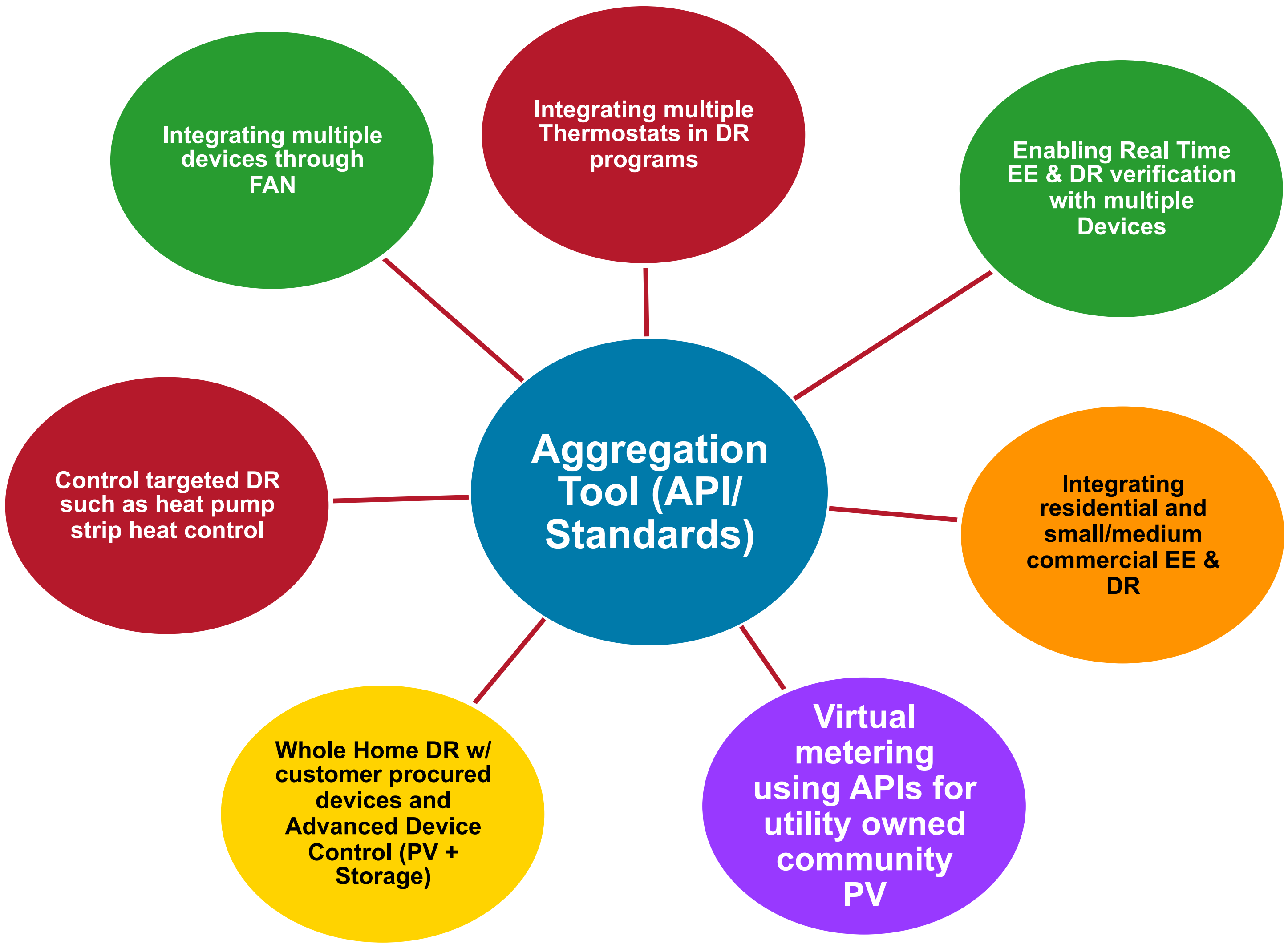
11 Customer Enrollment and Administration

The Road Map for VGI Communications

V1G Load Capacity Aggregation	DSM Localized Load Control	DER – V1G Load Control Integration	V2G - Reverse Power Flow Integration	Interactive DER Management and Control
Ability to respond to aggregated regional DR load control signals	Customer ability to control PEV load through interface with local energy management systems	Integration of PEV load control with Utility and ISO DER management systems and energy market processes – ancillary services and frequency regulation	Introduction and integration of PEV V2G capable technology and communications standards	Integration of V2G dynamic interactive control with Utility and local Smart Inverter DER management systems.

Applied systems integration development approach – graduated phase development methodology – use cases build on each other

Aggregation of Mass Market Systems – Enabling Multiple Use cases with a single tool



The Future? … with Advanced Energy Communities

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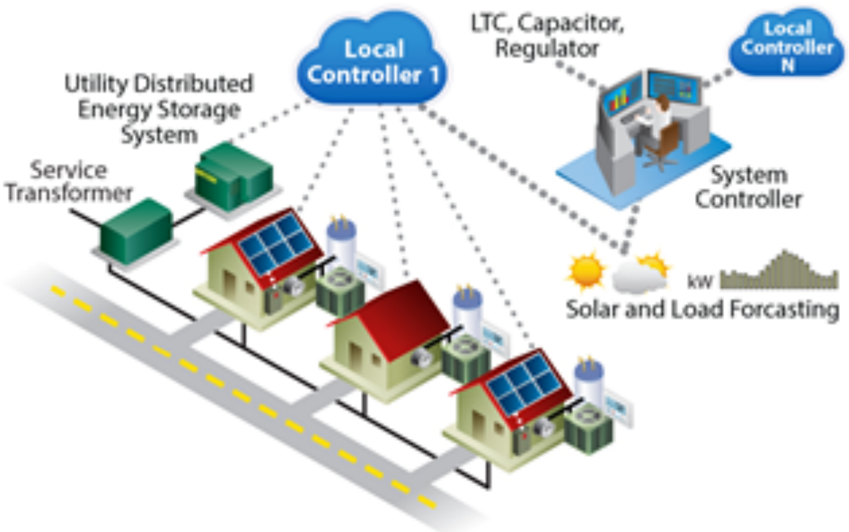
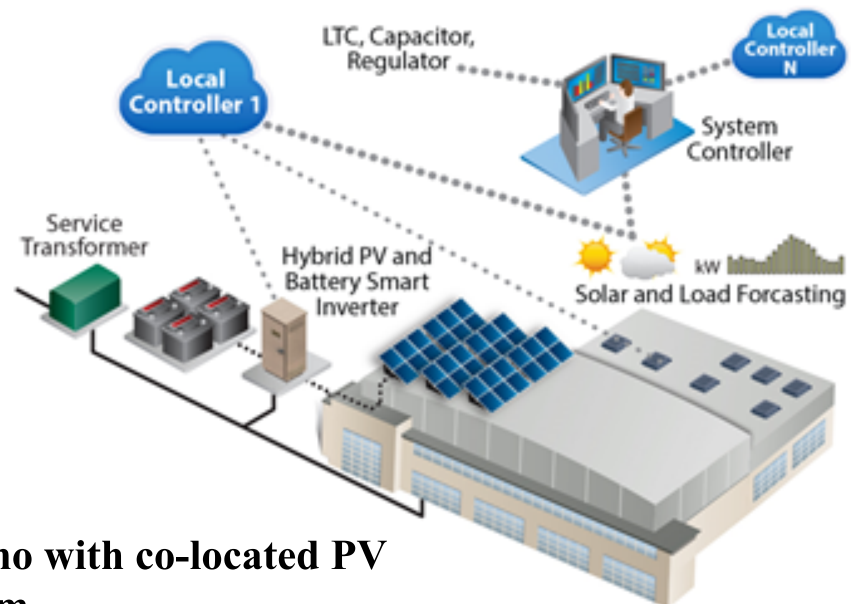
Integrated Solutions are key to access full range of DER Benefits



- **Planned residential demo with multiple roof-top PV and a single storage system**

- Need to develop ***integrated*** control and management systems for distribution systems
- Address high penetrations of interconnected DER



- **Planned commercial demo with co-located PV and energy storage system**

AEC requires coordination of many stakeholders

Need to work with builder constraints

Manage multiple subcontractors and AHJ

Customer centric connectivity architectures

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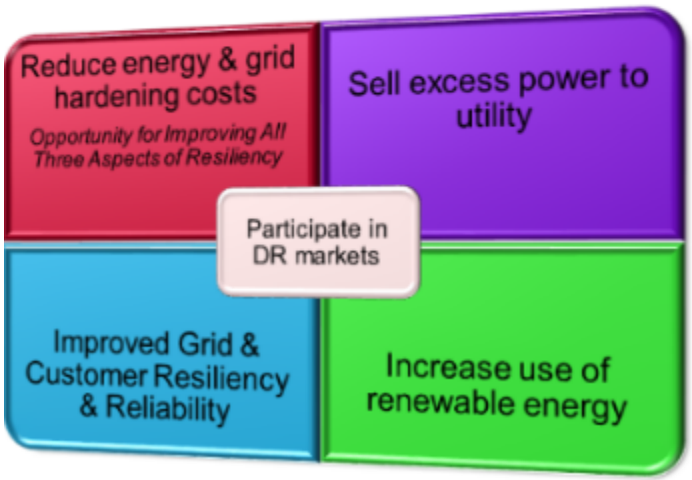
Consistent Approaches to Enable Adoption

- Understanding of technologies: strengths, weaknesses, costs, benefits, challenges
- Develop framework and tools
- Facilitate integration and operation of "grid-ready" solutions through engineering studies, and demonstrations



*Micrograds and AEC can make sense - **if** - the technical and economic advantages add up and can be valued by both end-user and in the power system benefits*

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What does it take to build an AEC?

- Find thought leaders and partners in industries that have been resistant to change (e.g., builders)
- Understand builder constraints and what they will and will not do
- Understanding how different building systems interact with each other and systems optimization
- Understanding of how buildings interact with the grid
- Being able to work with multiple trades
- Understanding of solar purchasing and installing solar
- Understanding of optimizing buildings for solar performance
- Controls architectures to integrate customer resources
  - Need to work with products customers (consumers & builders) want
- Energy storage – what, where and how?

Together…Shaping the Future of Electricity

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