StorageVET® in Action

Storage Value Estimation Tool

Giovanni R. Damato
StorageVET Product Manager

October 18, 2017
CEC EPIC Symposium

Storage Made Easy: StorageVET® Paving the Way

2013 CPUC Cost Effectiveness Study using EPRI's ESVT

StorageVET Live in 2016

Integrated Value + Impact Energy Storage Modeling in 2017

StorageVET Expanded Footprint and Validation

2020 Goal: Make Storage…

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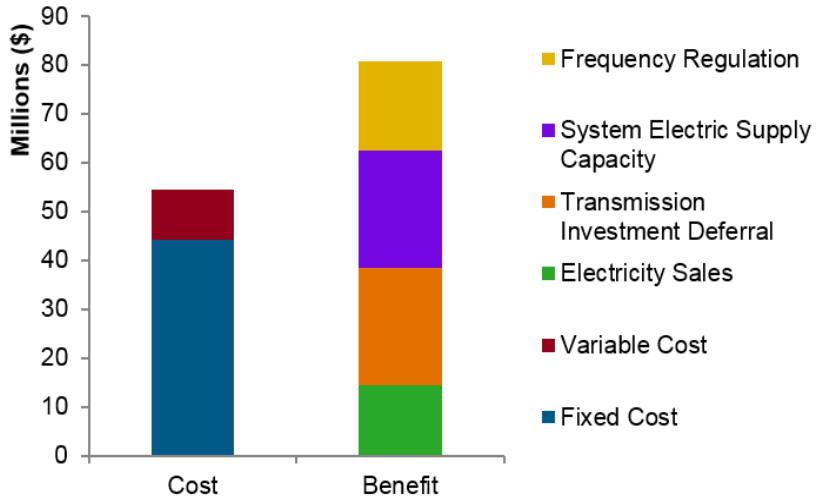
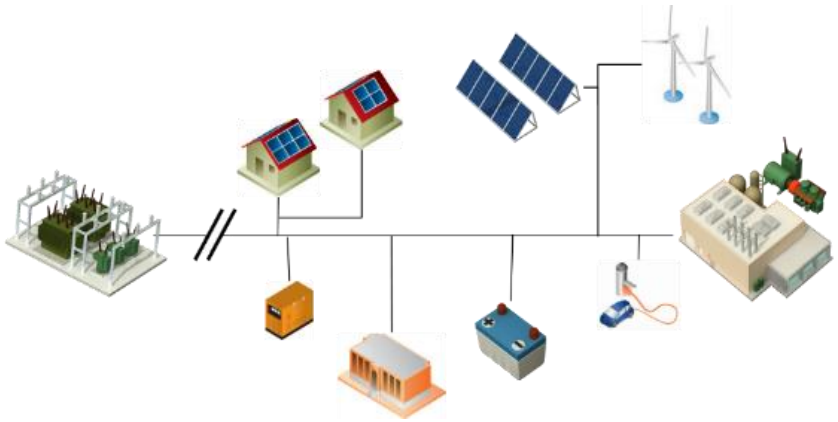
Challenges to Modeling Storage

- Storage and limited energy resources are still not common
- Rules and regulations still are evolving
- Benefit stacking is appealing, but will it be possible
  - More services = more value
  - More services = more requirements → Can they be satisfied?
- Locational value of storage requires site-specific analysis
- Complex optimization between storage degradation and service participation scheduling

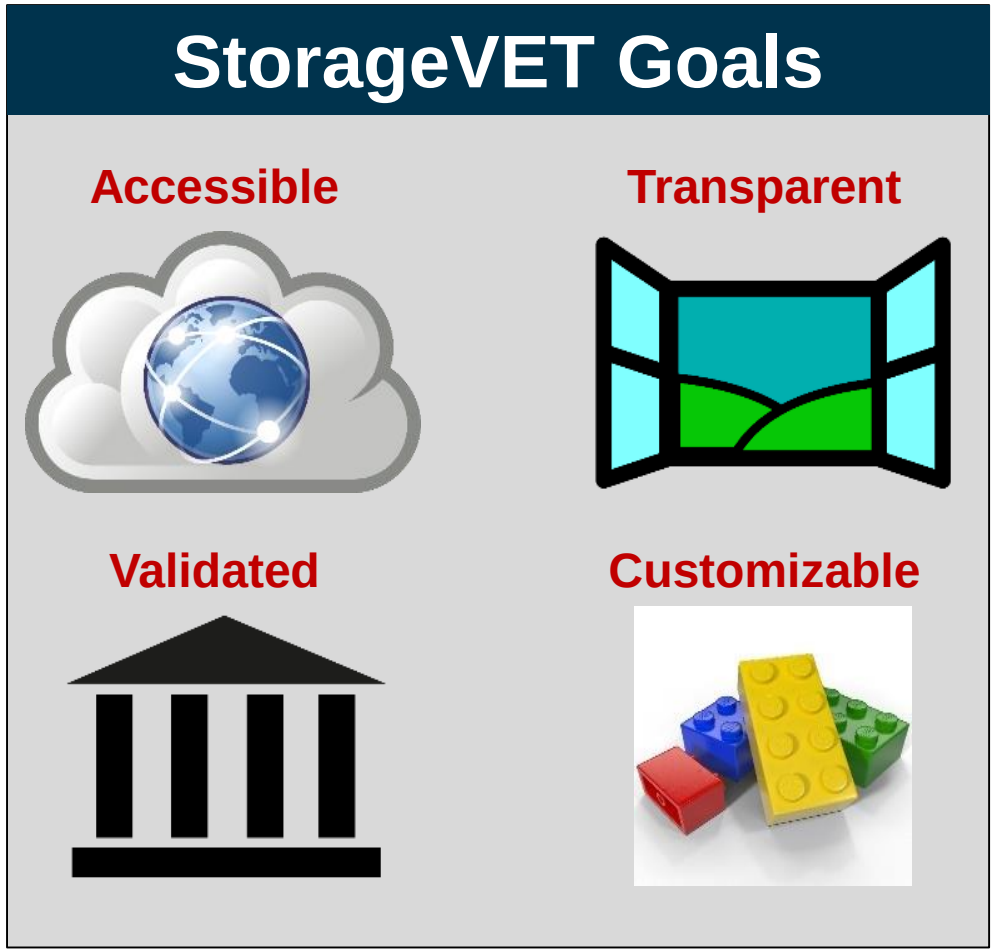




StorageVET ®

Storage Value Estimation Tool: www.storagevet.com

- Web-hosted tool, free to the public
- Project cost-benefit analysis
- Time-series constraints and dispatch optimization simulation
- Multi-services optimization and stacked services
- Customizable for location, technology, sizing, use cases
- Made possible through funding support from the California Energy Commission (CEC)

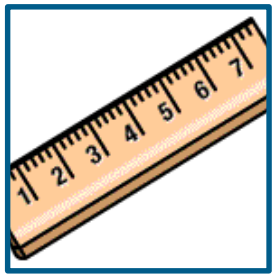


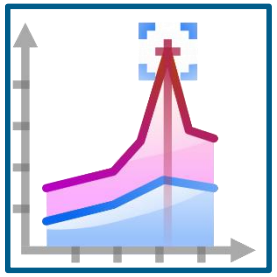
Users of StorageVET® Today

Key Use Cases

Locating & Screening

Sizing/Designing (stacked services)





Operational Strategies (Customer and Grid)

Common Communication Platform

- Common Benchmarking Tool

- Screening, Design, Procurement, & Operations

Regulators

Utilities

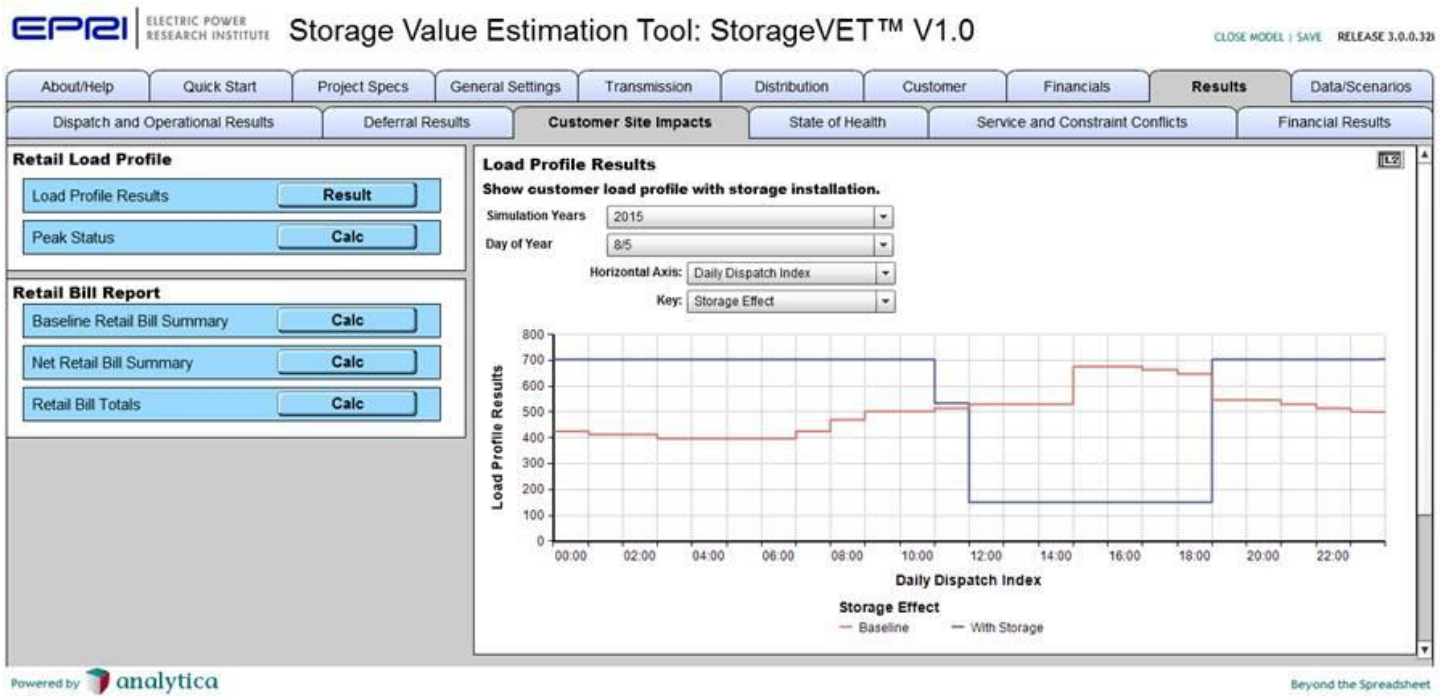
Customers

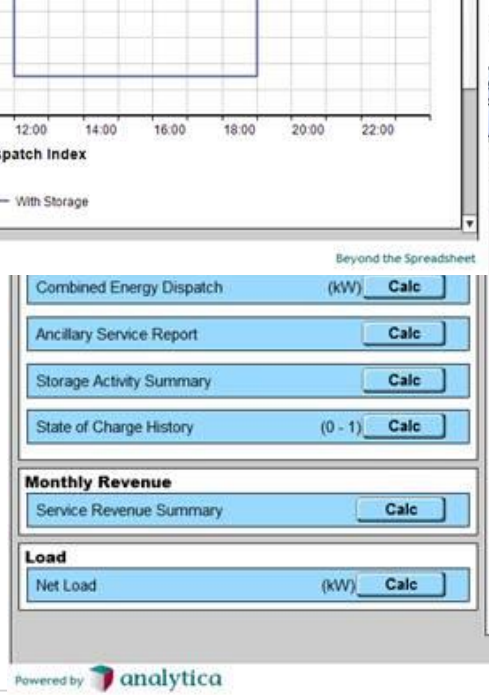
Developers

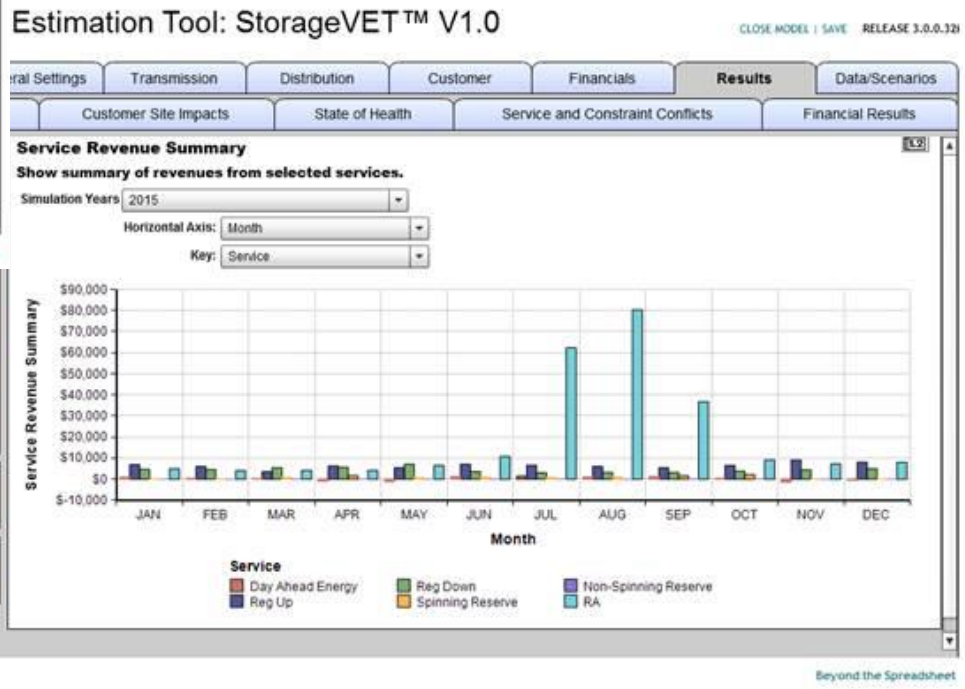
- Bill Savings Assessment
- Product Selection

- Sales, Marketing, RFP Response

StorageVET® Live: www.storagevet.com







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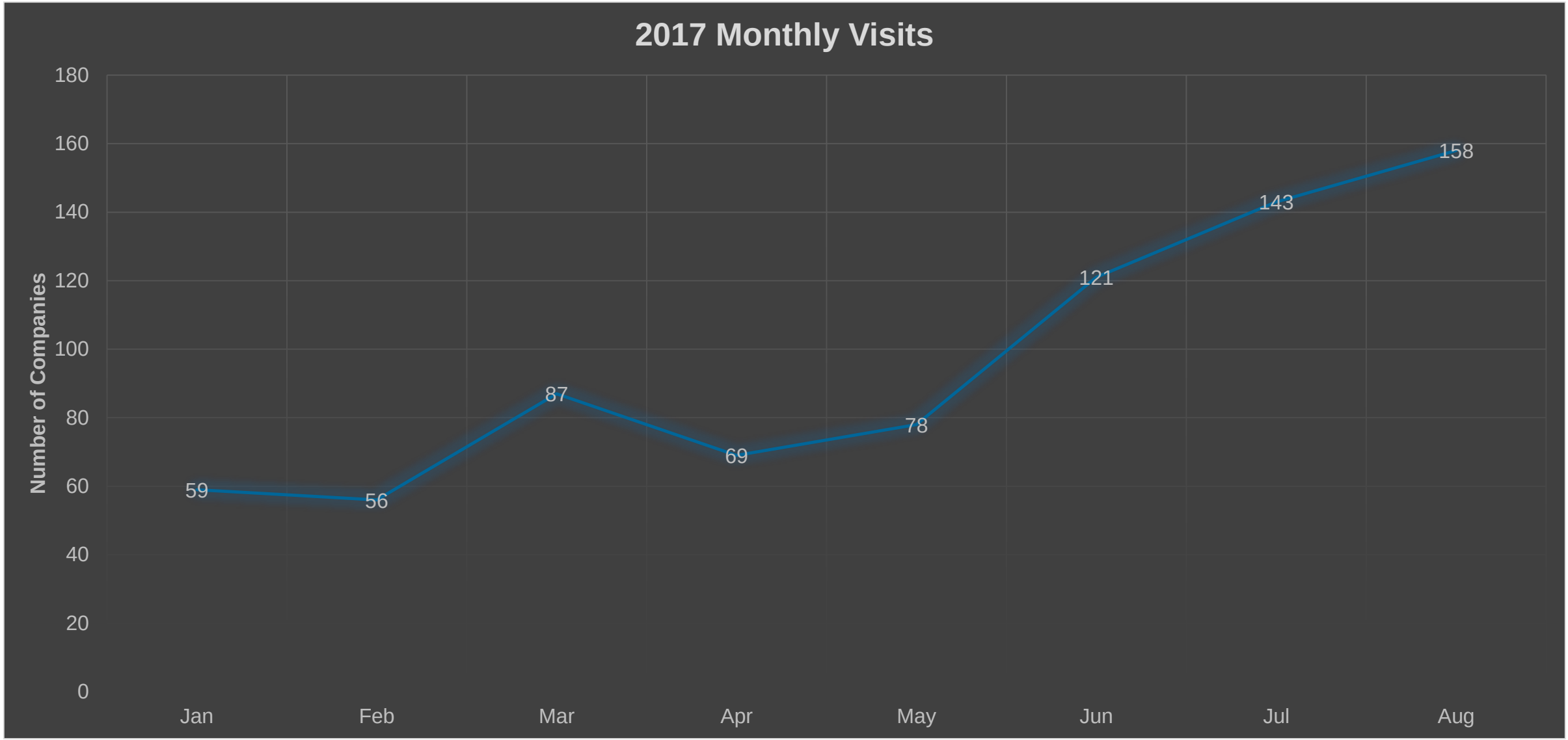
485 StorageVET® Users Across 170 Organizations



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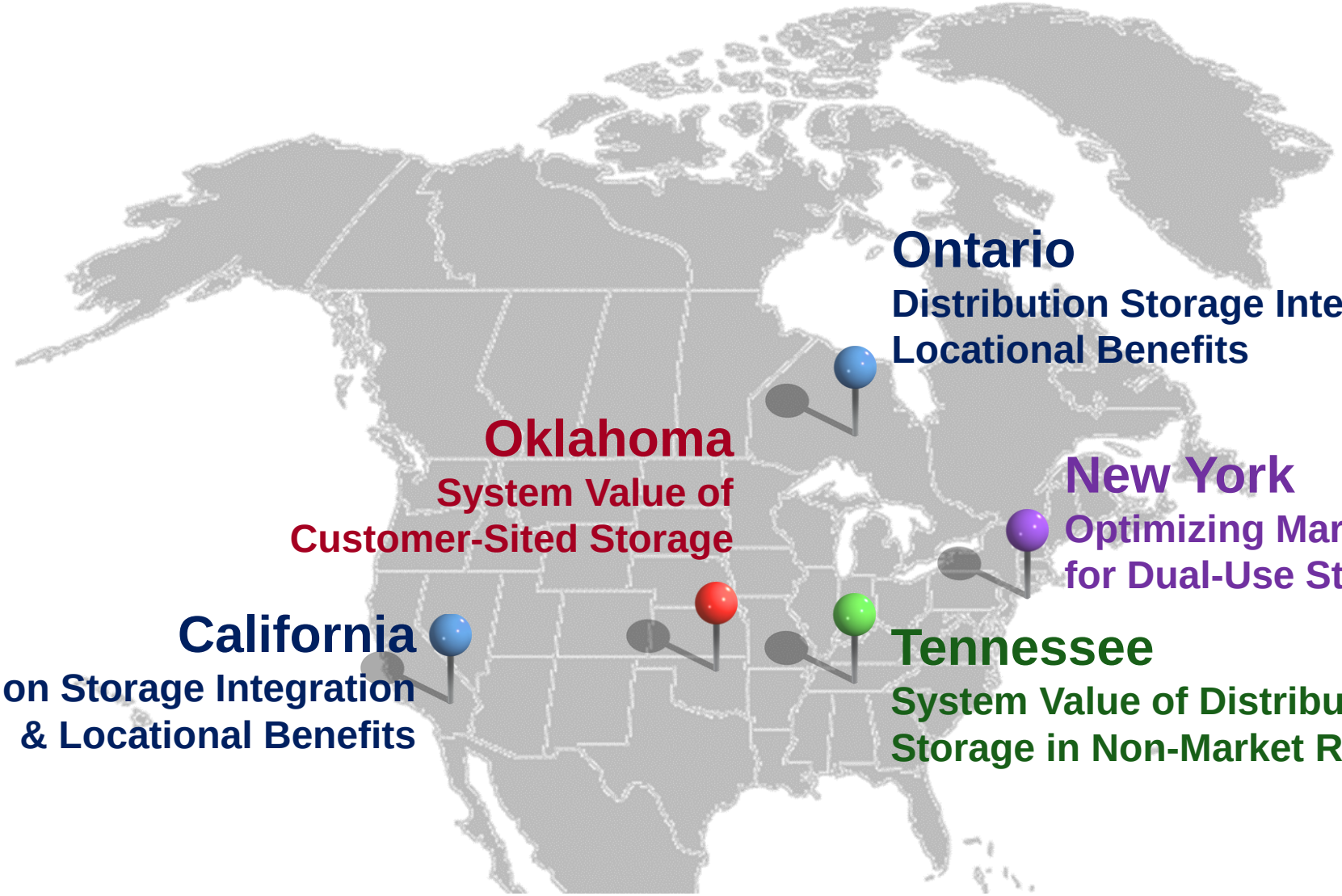
Current StorageVET Validation and Research



Ontario
Distribution Storage Integration & Locational Benefits

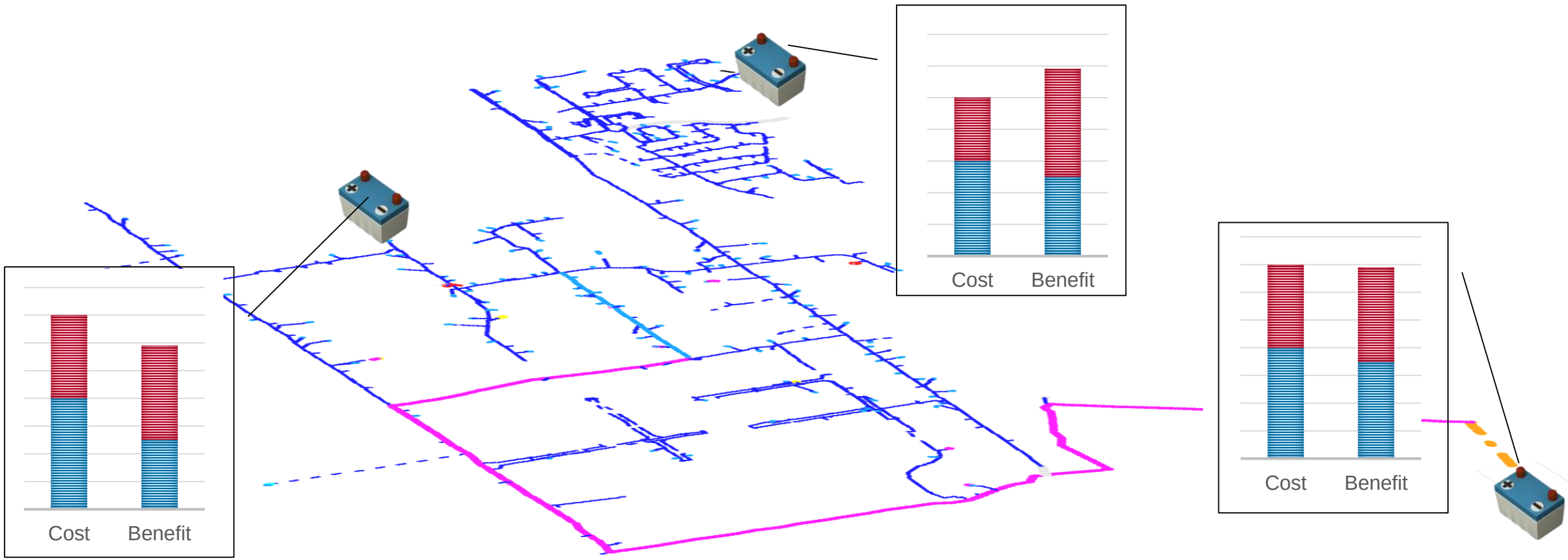
Oklahoma
System Value of Customer-Sited Storage

New York
Optimizing Market Participation for Dual-Use Storage

California
Distribution Storage Integration & Locational Benefits

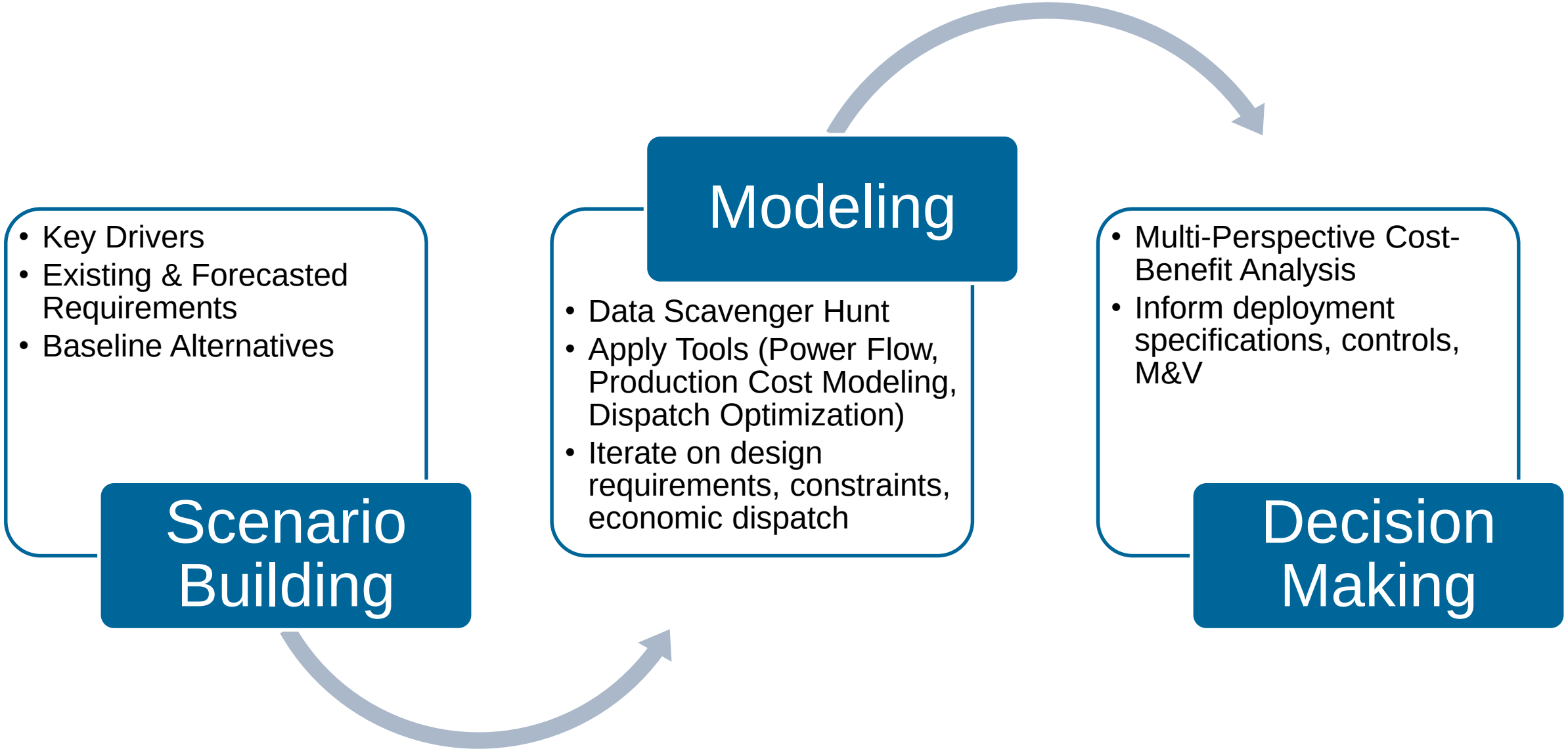
Tennessee
System Value of Distribution & Bulk Storage in Non-Market Regions

Integrated Energy Storage Modeling Vision



Streamlined and informed decision making…
…just as easy to model storage for deployment as a familiar transformer upgrade

The Framework



What's Next?

- Progress towards a cohesive valuation research portfolio to make storage…

- StorageVET validation and integration:
  - Model Validation Effort Through ESIC
  - Expand Regional Footprint
  - Integrated Energy Storage Modeling Supplemental
    - Impact + Value
    - Host + Participant Collaborative Multi-Year Project
  - StorageVET User Group

Together…Shaping the Future of Electricity

Additional Material

www.storagevet.com

StorageVET Access

www.storagevet.com

Access to StorageVET

- Model is publicly available, but requires registration and log-in (process takes a few days)
- Interested users should first enroll
- Follow instructions at www.storagevet.com
- Join ESIC StorageVET Subgroup (bi-weekly) to engage in stakeholder collaboration to test and improve the tool

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Energy Commission Smart Inverter Projects

EPIC Fall Symposium

Angie Gould

Overview

- Projects' Description
- Projects' Status
- Projects' Benefits
- Lessons Learned

Projects' Description

- Five projects testing, verifying, and demonstrating smart inverter autonomous (SIWG Phase I) and communications (SIWG Phase II) functions
- All five projects are from the 2012-2014 EPIC Investment Plan
- $6,395,533 in EPIC funds across the five projects
- $3,587,839 in total match funding

Projects' Status

- Three projects started mid-2015; two started mid-2016. All scheduled to complete March 2019
- Projects primarily performing laboratory testing and updating protocols and testing procedures to meet updated IEEE 1547 and Rule 21 updates. Field testing will follow
- Recipients are participating in meetings of the Smart Inverter Working Group and DNP3 User Group, as well as in the development of Rule 21, IEEE 1547, and IEEE 2030.5

Projects' Status, continued

- When projects are complete, will have:
  - Open source software clients for both DNP3 and IEEE 2030.5 communications standards
  - Standardized communications across inverter manufacturers
  - Optimized grid support from inverters, DERs, and consumer devices working together

Projects' Benefits

- Improved power quality and reliability, increased renewable penetration
- Reduced interconnection time and costs for PV and storage
- Optimized coordination of smart inverters with customer-side devices (e.g., smart thermostats), EV charging, and storage to enable high penetration PV
- Freely available software to test for compliance with communications standards

Lessons Learned

- Standards have been updated more slowly than anticipated, delaying some aspects of the projects
- Other areas, like controllable loads, have developed more quickly than anticipated, allowing projects to procure equipment at lower than expected costs

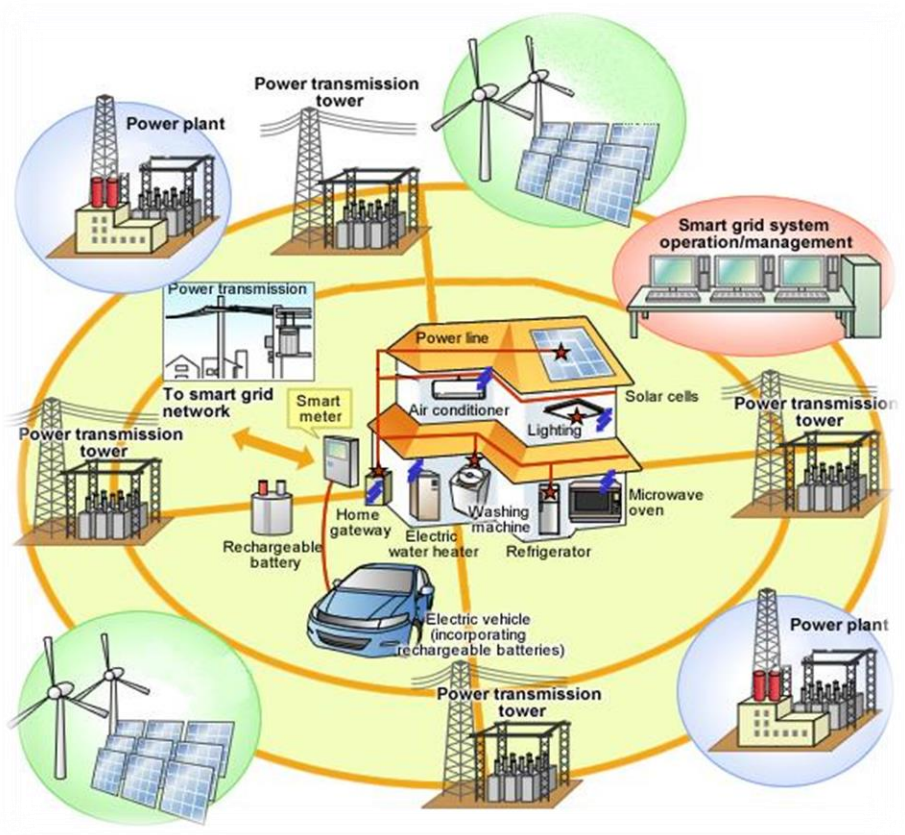
Q&A

ornia Edison

Extra Slide

Policy Drives Innovation

- Increase RPS to 50% by 2030
- Reduce GHG to 40% below 1990 levels by 2030
- 1.3 GW of storage by 2020



- Double energy efficiency savings by 50%
- 1.5 million ZEVs by 2025
- Increase access to clean energy in disadvantaged communities

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South Coast Air Quality Management District Advanced Smart Inverter Project

EPIC Fall Symposium

October 18, 2017

Pam Seidenman

Director, Public-Private Partnerships

Advanced Microgrid Solutions

Overview

- Project Description
- Project Status
- Project Benefits
- Procurement Summary
- Lessons Learned

EPIC Triennial Investment Plan

Solicitation: Solar +: Taking the Next Steps to Enable Solar as a Distribution Asset

Project: South Coast Air Quality Management District Advanced Smart Inverter Project

- **Program Area:** Applied Research and Development
  - **Funding Initiative S3.2:** Develop Integrated and Hybrid Photovoltaic Technologies and Strategies to Reduce Costs and Advance Zero-Net Energy Buildings
  - **Funding Initiative S4.2:** Develop Innovative Tools and Strategies to Increase Predictability and Reliability of Wind and Solar Generation
  - **Funding Initiative S6.1:** Develop Smart Inverter Capabilities to Improve Grid Operations
- **Program Area:** Technology Demonstration and Deployment
- **Funding Initiative S15.1:** Demonstrate Advanced Energy Storage Interconnection Technologies and Systems in Transmission, Distribution, and

Project Description and Goals

- Project: Solar + Storage + Smart Inverter + Warm Bridge at South Coast AQMD
- Goals: Advance the deployment and grid integration of distributed solar resources through decreased cost; increased circuit hosting capacity; and enhanced value.
- Advance the capabilities of smart solar inverters to manage SIWG Phase III functions and high penetrations of PV
- Demonstrate and measure system pe
  - Scenario A - solar power only
  - Scenario B - solar + storage.

Procurement Summary

EPIC Funding - $2,729,943

Match Funding - $2,173,382

Total Project - $4,903,325

Total Solicitation Funding - $22,768,717

- Prime is Certified CA Small Business - Advanced Microgrid Solutions (AMS)

System Specs

- 500kW high efficiency solar
- 750 kW/1500 kWh energy s
- Uninterruptable power supp

Project Objectives

- Demonstrate the value of a technology-agnostic aggregated DER implementation (solar and storage) with SIWG Phase III solar inverter to:
  - Improve power quality (reduced voltage swings)
  - Provide additional SIWG Phase III functionality
  - Increase hosting capacity by 25%
  - Increase solar while dramatically reducing curtailment
  - Measure and validate data to determine fair levels of compensation for solar curtailment to support grid functionality
  - Provide recommendations for cybersecurity

Project Status

Milestone	Date	Status
Start Date	9/29/17	Complete
South Coast AQMD Board Approval	10/10/17	Complete
Develop Detailed Project Plan	12/8/17	
Solar Design, Engineering, and Installation	8/17/18	
Storage Design, Engineering, and Installation	8/31/18	
Communications Enablement and Bench Testing	7/27/18	
Field Demonstration	7/19/19	
Data Analysis and Recommendations	10/19/19	
Evaluation of Project Benefits	2/24/20	
Technology/Knowledge Transfer Activities	1/17/20	
End Date	3/20/20	

Project Benefits

- Demonstrate a system that provides powerful, flexible distribution-level grid support
  - Can be replicated on any circuit
  - Compatible with a wide range of DERs
    - New and existing solar, fuel cells, wind, building management systems, and others
    - Accelerate the deployment of renewables and achieve the state's energy goals, including AB 32, SB 32, SB 350, AB 1637, AB 2868, and CPUC proceedings

  Renewables integration services:
    - Renewables intermittency firming
    - Flex ramping
    - Absorbing reverse power flows
    - Renewables capacity increase
- Contribute to identified areas of EPIC Triennial Plan

Project Benefits Continued

Safety

- Decrease the likelihood of blackouts and brownouts
- Absorb dangerous reverse power flows caused by high solar penetration

Reliability

- Provide a more flexible, rapid response to SIWG Phase III functions
- Increase the pool of resources capable of providing grid support
  - Reduce peak energy demand at the host site by 16%
  - Reduce total energy usage by > 10%
  - Increase solar PV DER capacity on the Boothill feeder by 1.25 MW

Cost

- Reduce demand charges at the host site by 28% and overall electric bill by

Lessons Learned

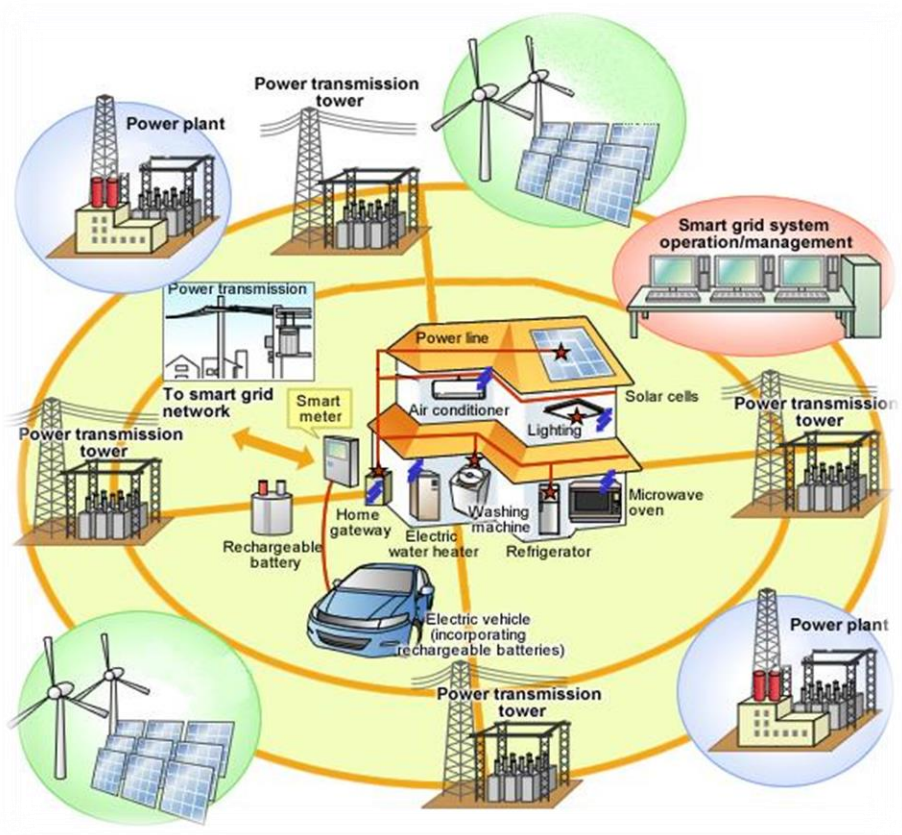
- Useful to have a backup vendor
- CEC has been a critical SME and implementation partner
  - CEC alerted us that the PI for the M&V vendor had left and suggested alternatives
  - Helped to file the CEQA

Contracting

- Reclassified a subcontractor as a vendor
  - Reduced administrative burden for all involved, including the CEC
  - Enables more direct cost control and fiscal surety

Policy Drives Innovation

- Increase RPS to 50% by 2030
- Reduce GHGs to 40% below 1990 levels by 2030
- 1.3 GW of storage by 2020



- Double energy efficiency savings by 50%
- 1.5 million ZEVs by 2025
- Increase access to clean energy in disadvantaged communities

Thank You and Q&A

Distribution System Constrained Vehicle to Grid Services for Improved Grid Stability and Reliability

EPIC Fall Symposium

Sunil M. Chhaya, PhD

Electric Power Research Institute

Overview

- Project Description
- Project Status
- Project Benefits
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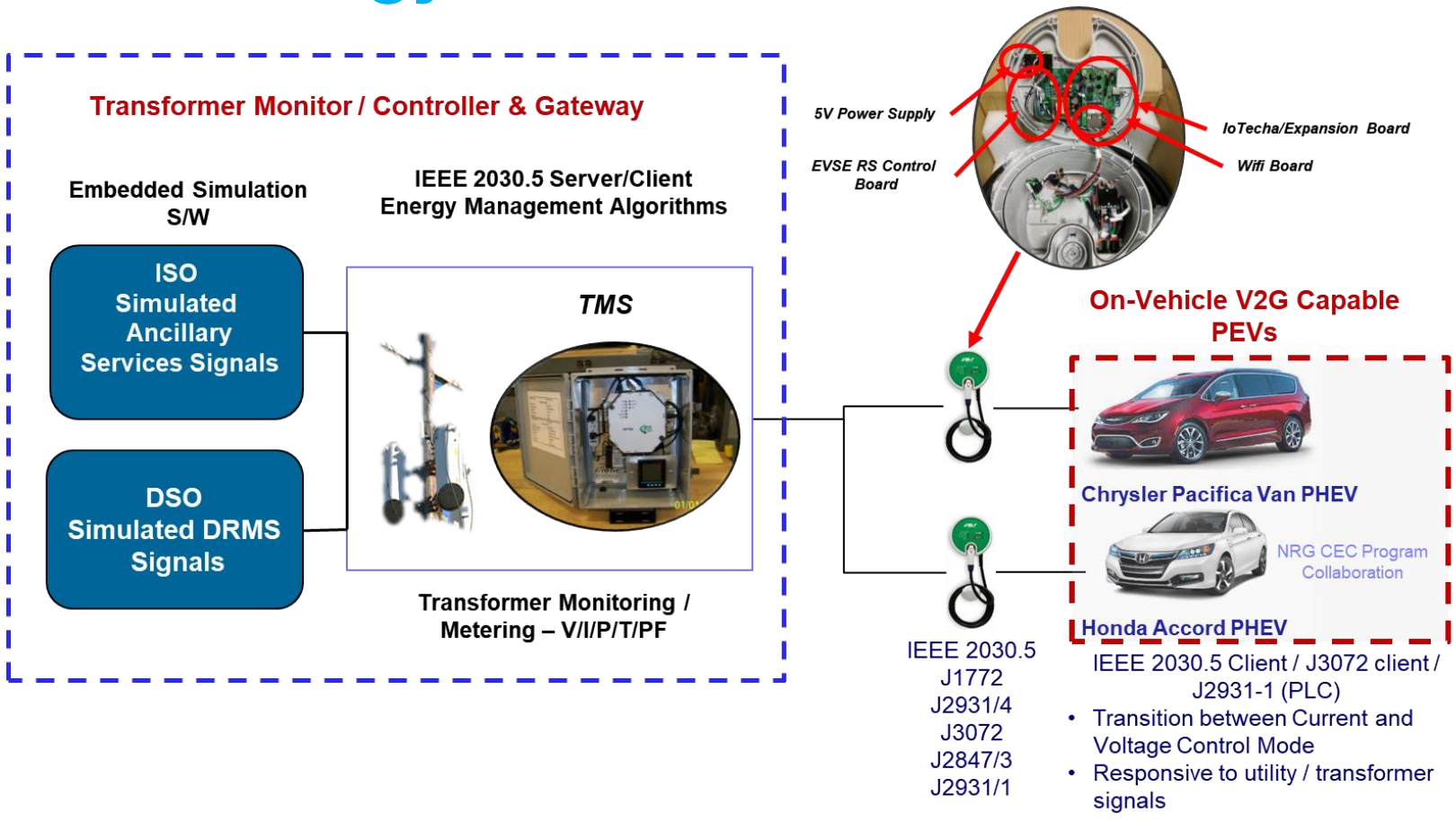
Project Description

- Transformer level V2G services management for residential or commercial scenarios
  - Transformer Management and Monitoring System as a DA edge of the grid node
  - Charge and discharge scheduling for fleet
  - DER integration
  - Mobility-prioritized implementation
  - ‘End to end’ cybersecurity
- Open standards (IEEE, SAE) based implementation
- Partners: Fiat Chrysler Group, Honda R&D America, Kitu Systems, AeroVironment

- EPIC Wave 1 based investment addressing S9.2
- Advances PEV adoption through enabling vehicle-to-grid services and reduction in GHG emissions

Technology Architecture

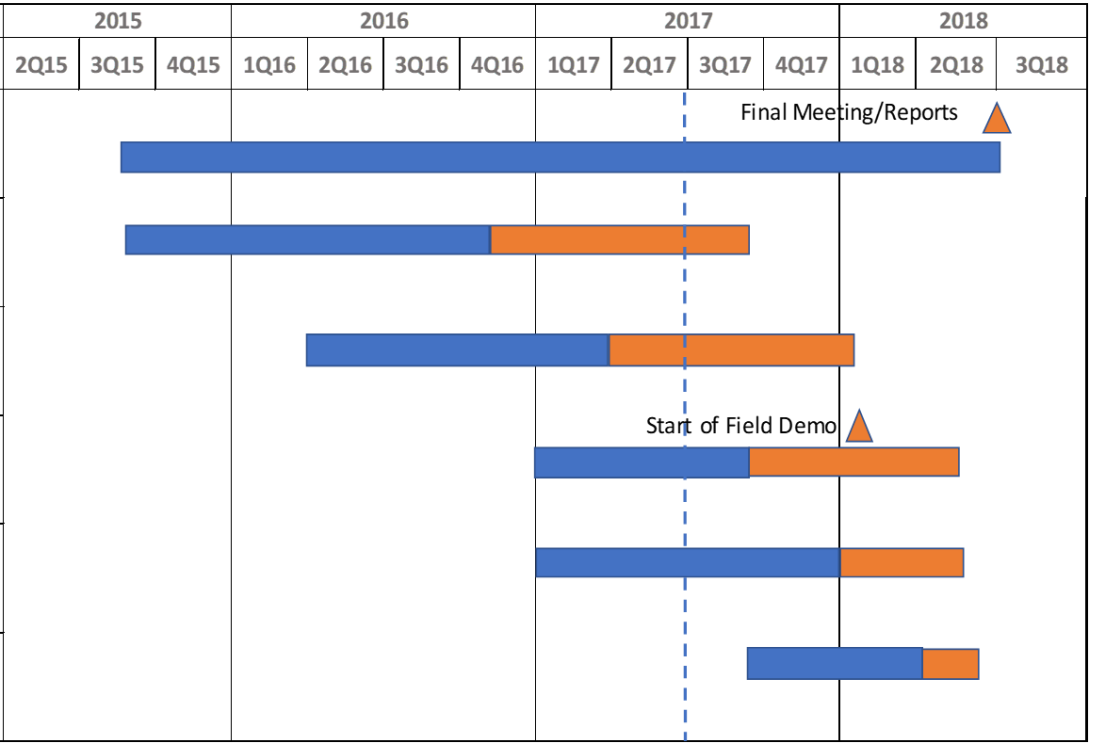


Project Goals

- Develop/demonstrate V2G capable PEVs and communication technologies and open standard interfaces
- Develop / demonstrate an end to end integrated system capable to offer distribution and ISO grid services
- Prove technical feasibility by testing the system under a variety of use cases
- Validate the cost/benefit for ratepayers and PEV owners
- Transfer technology to relevant stakeholders

Project Status

Task	Task Name	Start	Finish
1	Project Management	8/17/2015	6/30/2018
2	Requirements Architecture Design	8/17/2015	9/20/2017
3	Technology Development	3/31/2016	1/17/2018
4	Deployment Test Data Acquisition	12/15/2016	4/30/2018
5	Evaluation of Project Benefits	1/2/2017	4/30/2018
6	Technology Transfer	1/2/2018	5/30/2018



- What happens when the project is complete
  - Project is addressing two key challenges: **Demonstrable Value and Clarification of Interconnection Requirements**
  - Technology has Potential for increased level of deployments
  - Adoption by customers – dependent on anticipated consumer value net of incentives

Project Benefits

- Greater Reliability – Directly managing resources at the transformer level
- Lower costs – open standards, vehicle-integrated V2G and scalable implementation
- Increased safety – Interconnection capable with ‘Rule 21-equivalent’ functionality (IEEE2030.5 DER)
- Advances V2G services to accelerate PEV adoption
- Intelligently leverages PEV storage capabilities

Procurement Summary

- EPIC Solicitation PON-14-310
  - $6.7M grant solicitation
  - $1.5M grant award for EPC-14-086
  - 1 of 5 awarded projects
  - No DVBE requirement for grants

EPRI Transformer Management System: HW

Transformer Power Measurement Unit

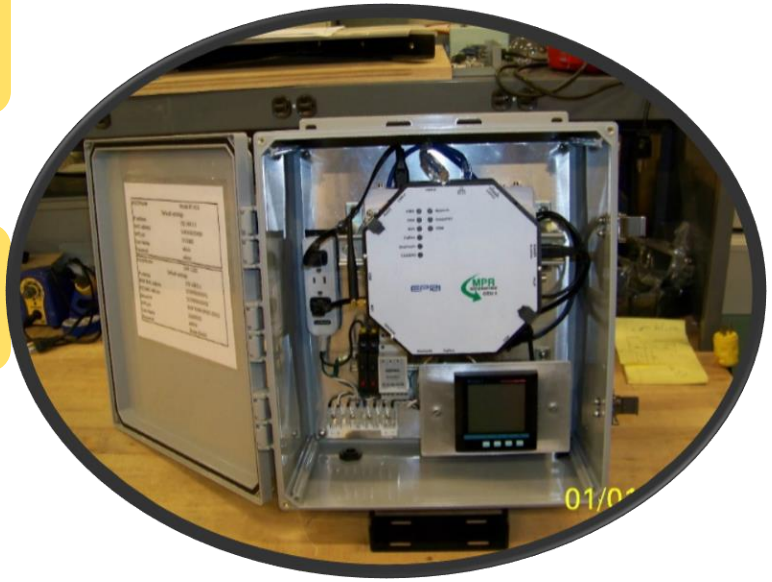
- Measures Voltage, Current and Phase
- RS485 Communications Interface to the TC

Transformer Controller (TC)

- Linux based open Router Platform
- RS485 Communications Interface to the TPMU
- Communications to each EVSE(s) and PEV (s) via HomePlug AV Adaptor
- Performs Energy Management Algorithm

HomePlug AV Ethernet Adaptor

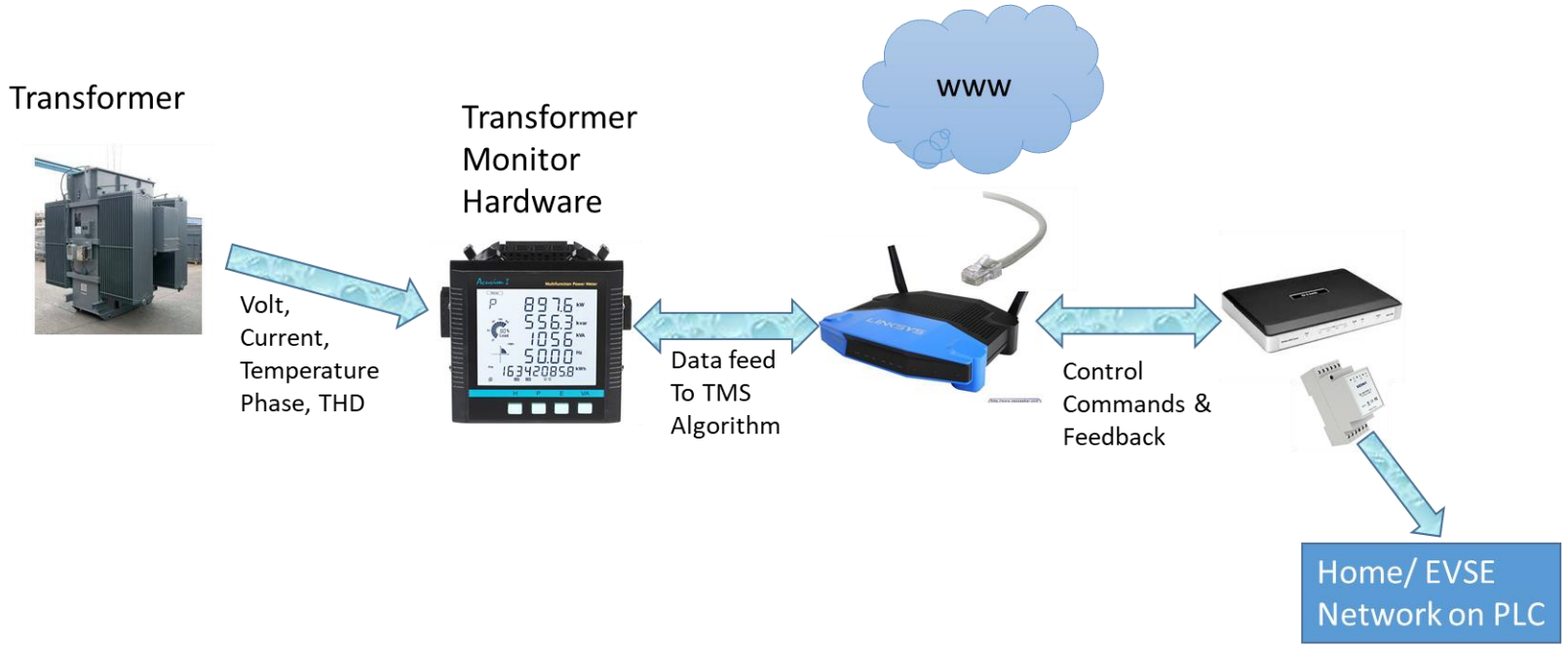
- Ethernet connected to the Transformer Controller
- Communicates to all connected Gateways via the premise drop



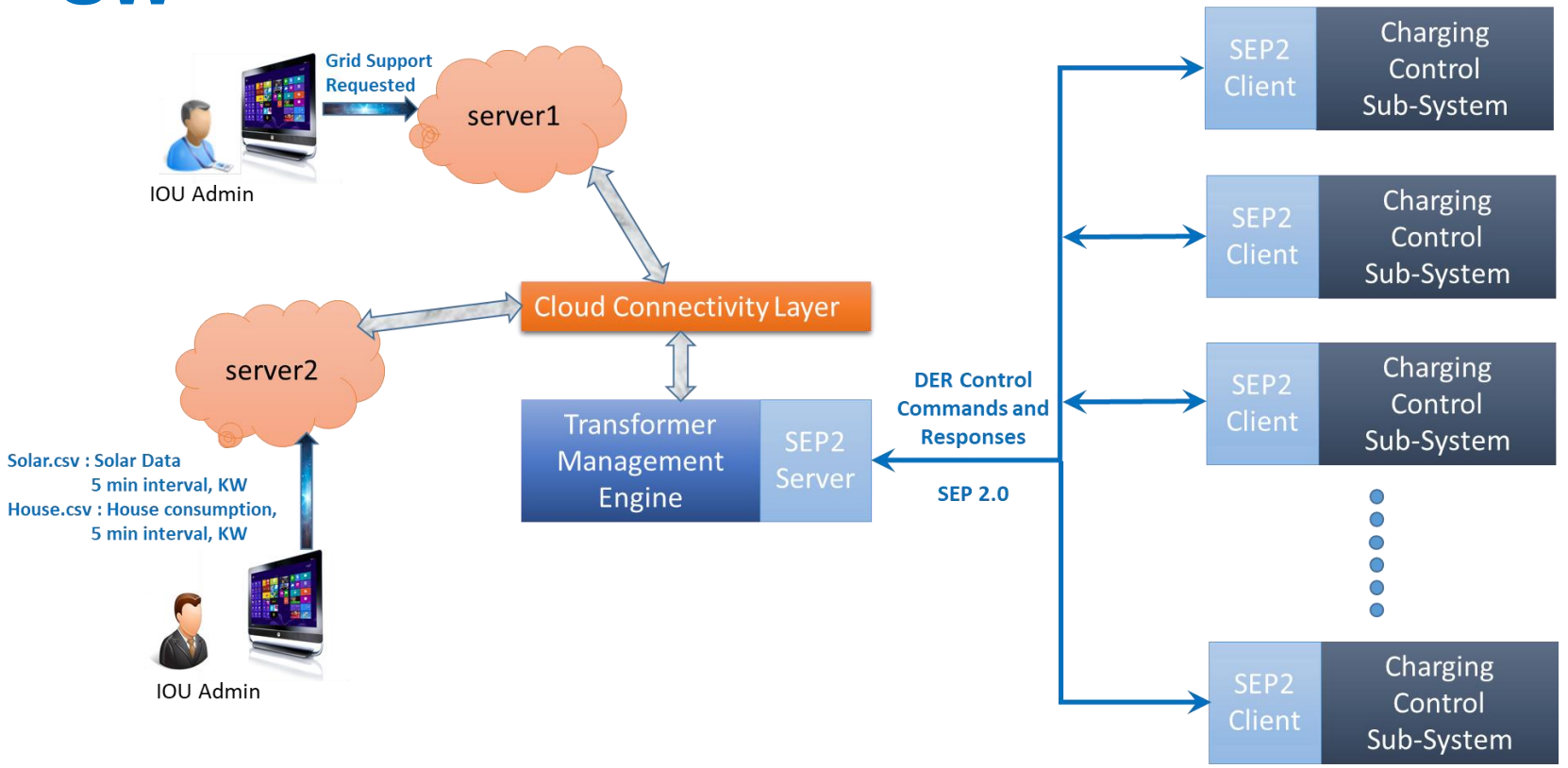
TMS Enclosure NEMA 3R

Outdoor Mounted to L2 Charging Island 30KVA Transformer

EPRI Transformer Management System: HW

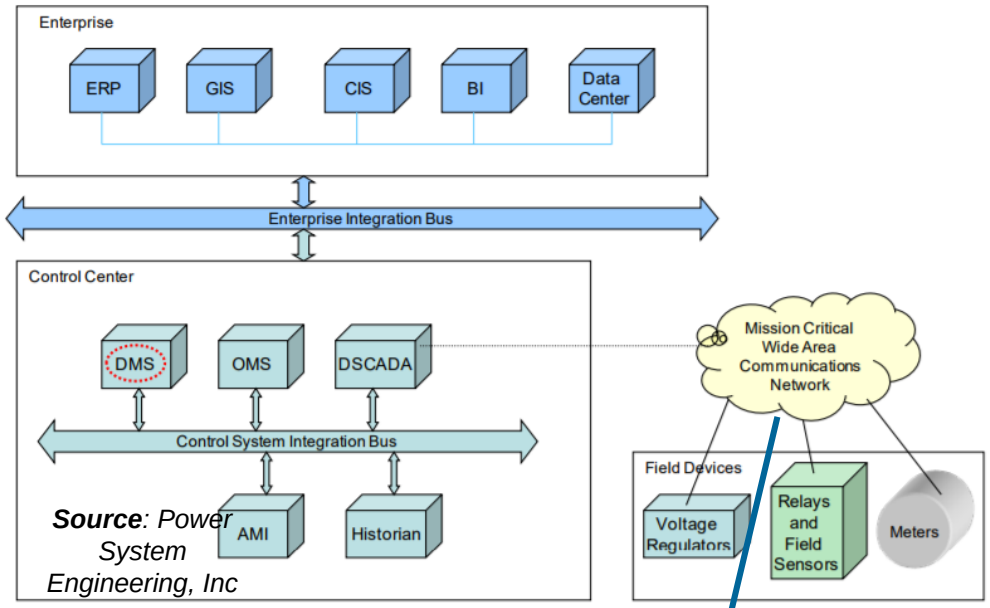


EPRI Transformer Management System: SW



Transformer Management System – as the Edge of the Grid Link to DA Svstem

- Node in the Distribution System Automatior by linking up with D-SCADA, DERMS and ADMS
- Streams critical distribution system endpoir data upstream to DERMS, ADMS and to T&D automation via D-SCADA,
- Applications:
  - Visualization,
  - Real-time hotspot identification etc.
- Disaggregation / control node for DMS /ADMS for DERs
  - EVs
  - PV
  - Storage
  - Demand Management including Demand Charges
- Responds in real time to localized distribution system conditions.



***Source**: Power System Engineering, Inc*

UCSD 14-086 Project Site Equipped with EPRI TMS, interacting with PV, Storage and EVs

Southern California Edison

Lessons Learned

- Technology
  - On-vehicle: Grid-tied Bidirectional Power Converter / smart inverter – relatively modest risk (Gen 2)
  - On-EVSE: Much lower risk, UL-capable EVSE w/ J3072/IEEE2030.5 can be UL1741 compliant
- Maturity of marketplace
  - For V2G capable vehicles, selling them as 'storage replacement' would be possible – help maximize self-consumption either at home or workplace
  - No marketplace exists today because these have not been commercially introduced (except Nissan's recent announcement)
  - Key barrier is demonstrated value
- New Capabilities / Opportunities: Transformer Management System

Policy Drives Innovation

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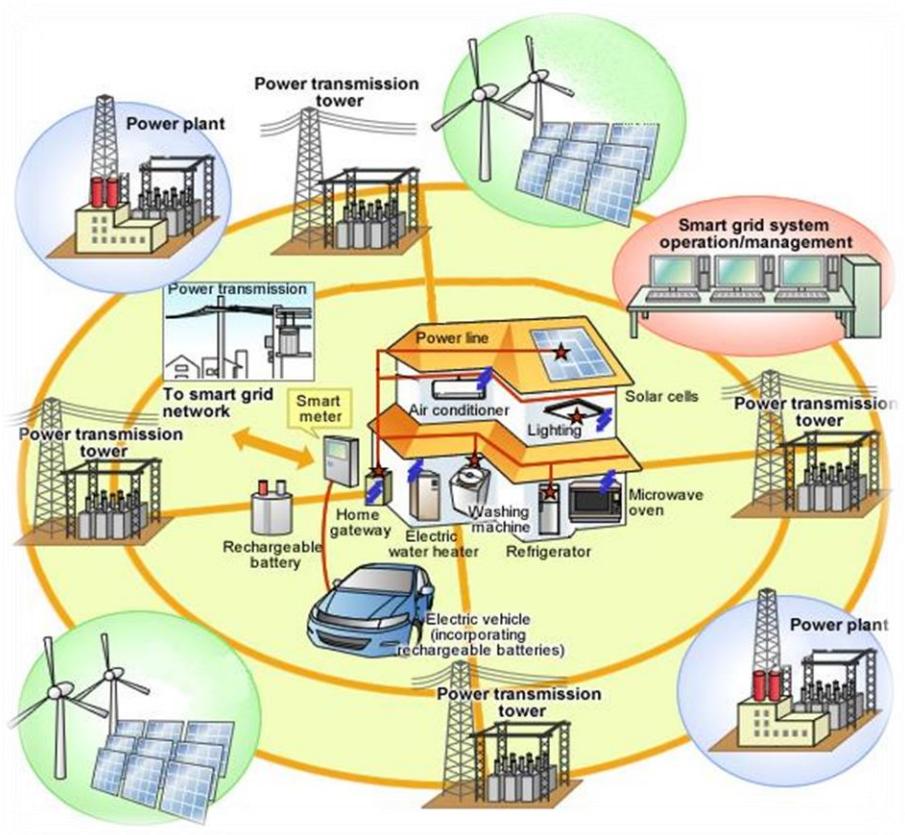
- Reduce GHG to 40% below 1990 levels by 2030
- 1.3 GW of storage by 2020



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Q&A