

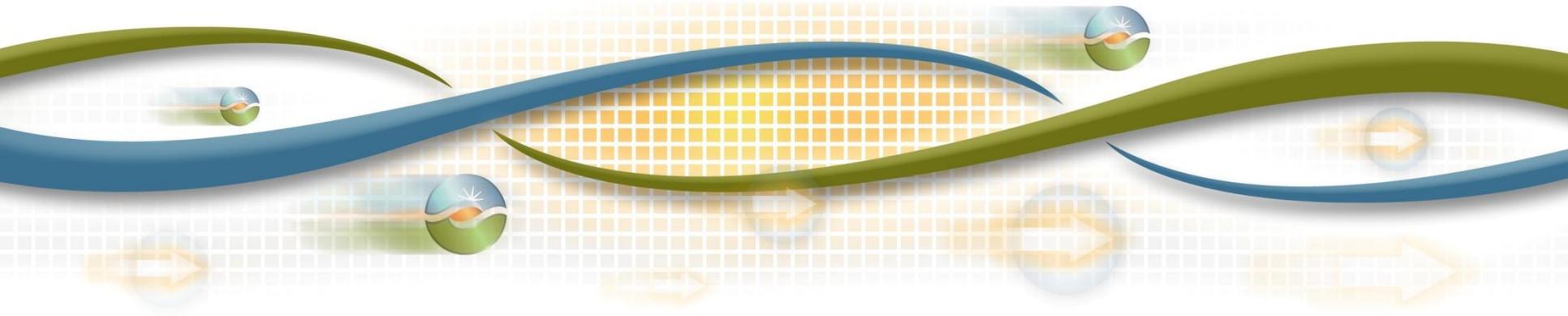


California ISO
Shaping a Renewed Future

Multi-Agency Update on VGI Research

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California Energy Commission
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Agenda

- California VGI Roadmap and CPUC Energy Division VGI White Paper
- The prospect of compensating EV's for wholesale grid services
- Balance of System(BOS) costs
- ISO Efforts
- Research areas that can improve advancement of EVs
- Key Messages

ISO Balancing Authority Area

A balancing authority is responsible for balancing supply and demand in the area under its control.

The ISO manages the flow of electricity across the high voltage, long-distance power lines within its balancing authority area, and matches supply with demand, maintaining frequency within limits and in real time.

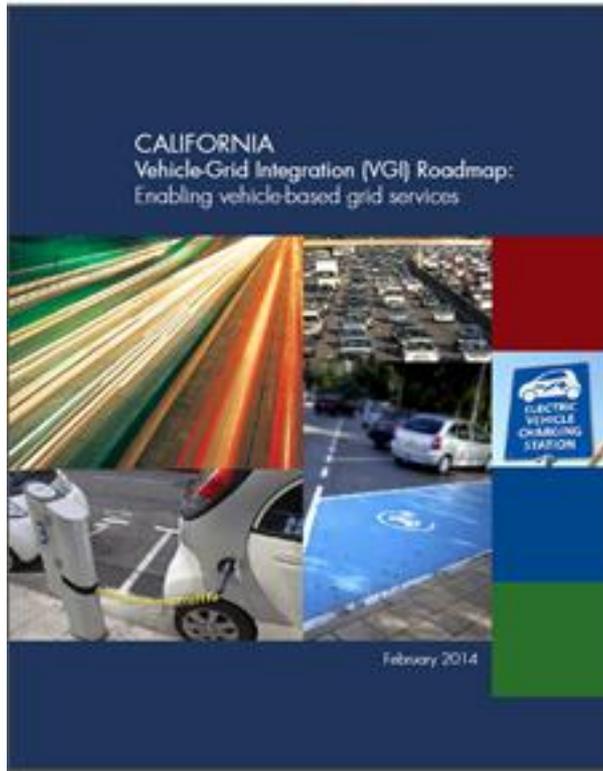
Additionally, the ISO is responsible for procuring sufficient ancillary services to meet reliability requirements for unforeseen events.

Yellow on the map represents the California ISO balancing authority area. Non-yellow areas are not part of the ISO's balancing authority area.

The ISO does not operate the transmission nor interconnection facilities outside of its area.

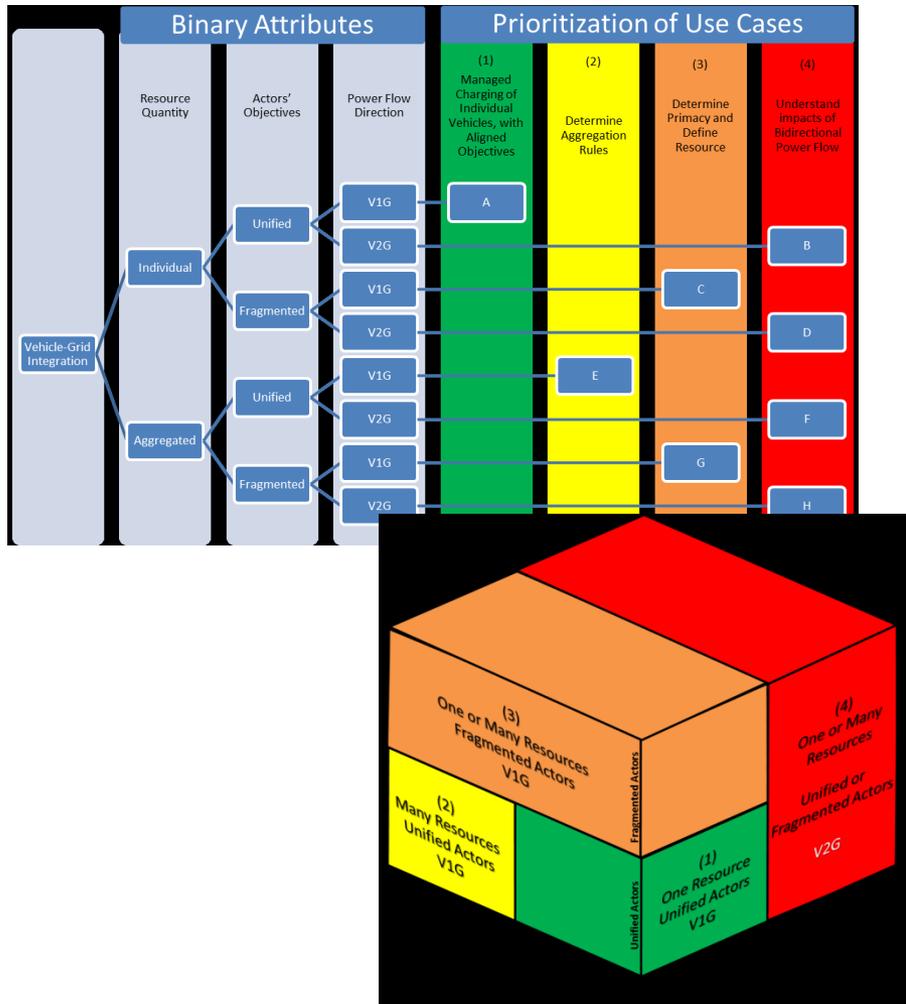


Core Intent of the VGI Roadmap



“keep consumers in the driver’s seat during the transformation to a cleaner grid by enabling managed EV charging consistent with grid conditions. Eventually, two-way interfaces between EV’s and the bulk power network could benefit both EV owners and the grid-at-large.”

CPUC Energy Division Vehicle-Grid Integration



- Start with and learn from use cases that are less complex.
- Evolve and scale the use cases based on value to the grid and to the resource.
- As VGI use cases become more complex, additional regulatory barriers associated with VGI will emerge and will need a resolution framework to address.
- The Alt-Fuels proceeding should focus on providing a regulatory framework that fosters VGI services creation and consumer choice based on values of the EV and EVSE owners.

ISO Products and Services

Energy

Physical Supply
and Demand

Virtual Supply
and Demand

Ancillary services

Regulation up

Regulation down

Spinning reserves

Non-spinning
reserves

Other services

Residual Unit
Commitment
(RUC)

Congestion
Revenue Rights
(CRR)

The CAISO faces four related operational challenges

1. Downward ramping capability

Thermal resources operating to serve loads at night must be ramped down and potentially shut down to make room for a significant influx of solar energy at sun rise.

2. Minimum generation flexibility

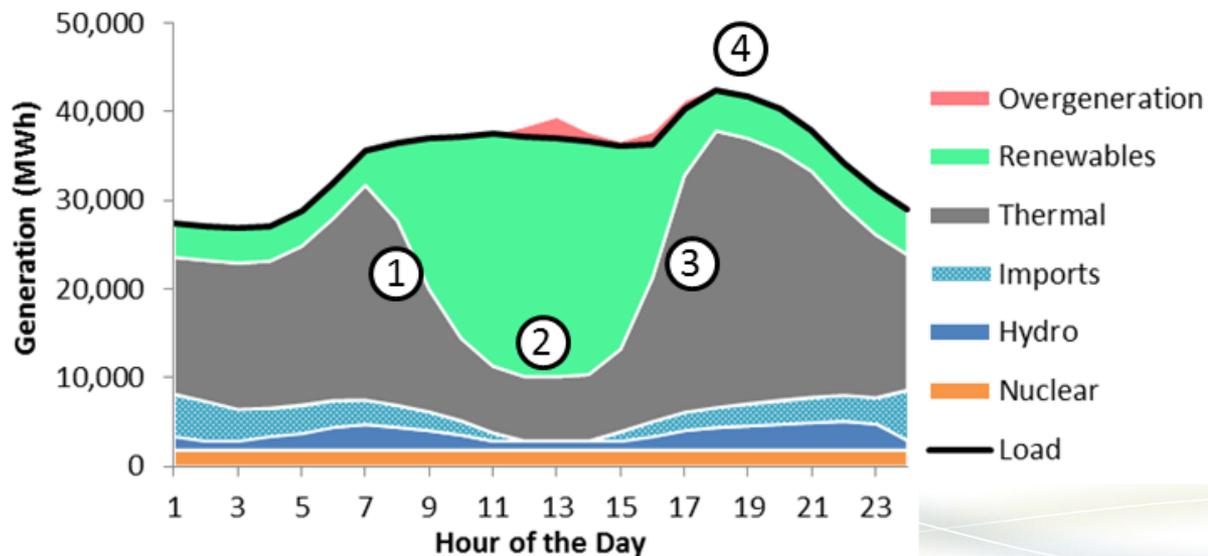
Over-generation may occur during hours with high renewable production even if thermal resources and imports are reduced to their minimum levels. A system with more flexibility to reduce thermal generation Pmin will incur less over-generation.

3. Upward ramping capability

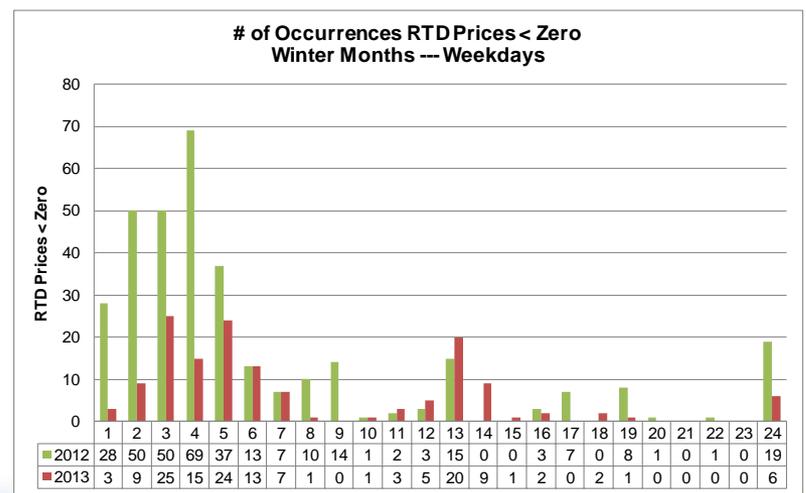
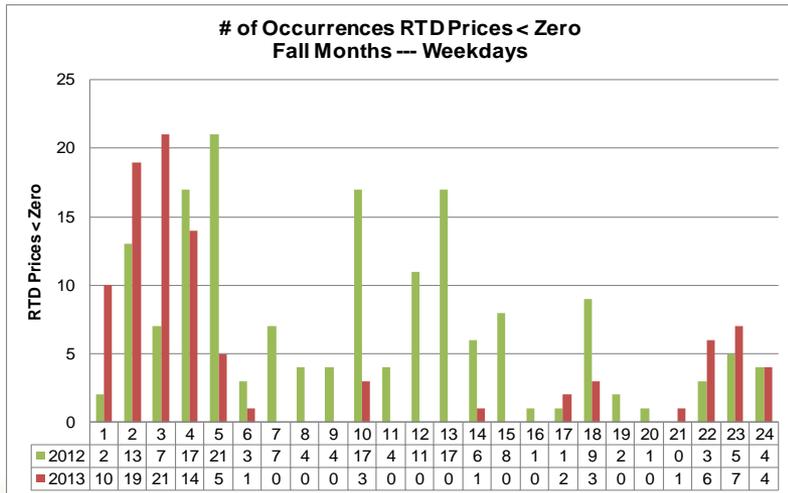
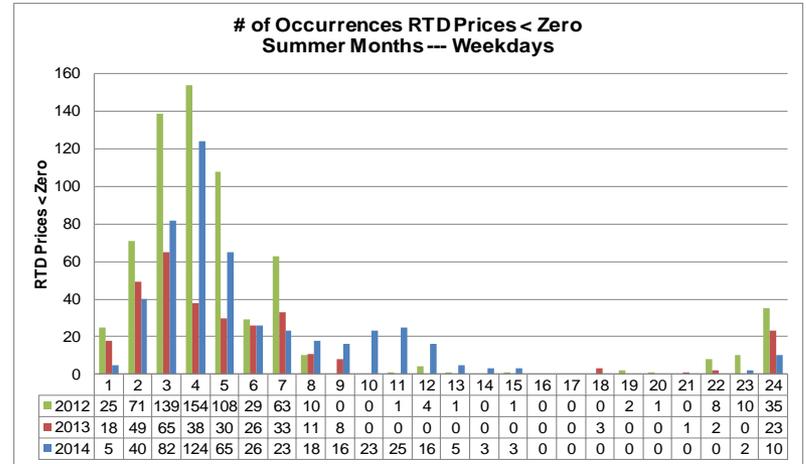
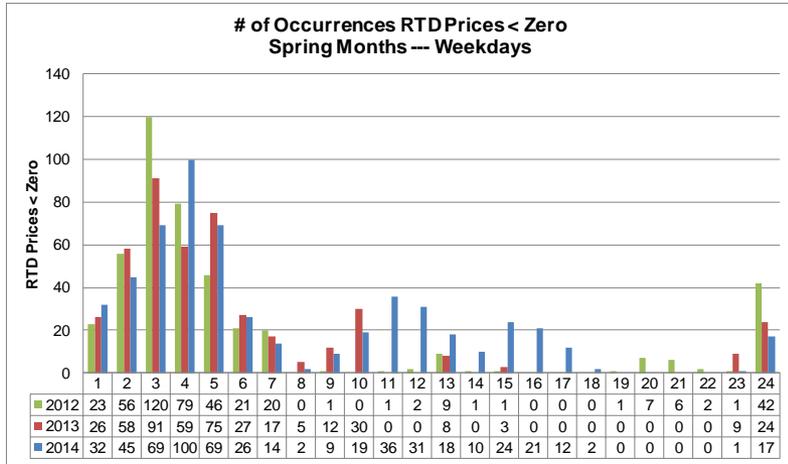
Thermal resources must ramp quickly from minimum levels during daytime hours and new units may be required to start to meet high net peak demand occurring shortly after sundown.

4. Peaking capability

The system will need enough resources to meet the highest net-loads with sufficient reliability



Weekdays --- real-time energy prices vary by season and VERs' production levels (negative prices)

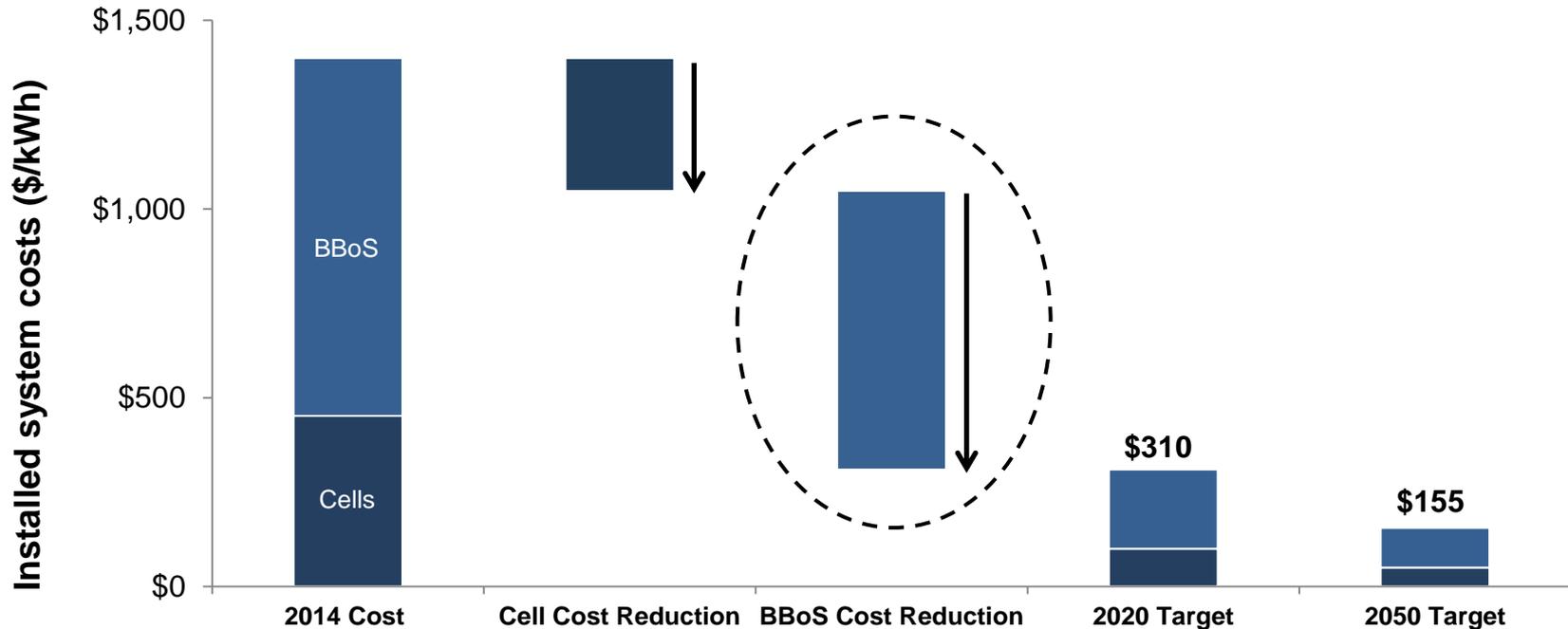


Can EV loads with the right characteristics be used to manage California's RPS?

- Managed EV charging can help smooth and flatten the net load curve by season by:
 - Shifting peak load demand
 - Incentivizing load to consume during low demand periods to minimize over-generation
 - Reducing the need for flexible capacity resources, i.e. reduce the magnitude of upward and downward ramps through managed load response



Commercial Energy Storage System Costs: 2014—2050



Energy storage system costs must come down further and faster than business as usual in order to meaningfully contribute to the electricity system of the future—regardless of the use case

The concept of Balance of System costs can be applied to EV resources participating with the grid

- Interconnection
- Network upgrades
- Settlements and Real Time Visibility and Control
 - Revenue Metering
 - Telemetry
- Costs of Participation
 - 24x7 Operation
 - Communications Network Fees
 - Scheduling Coordinator and Participation Fees (wholesale participation)
 - System Access and Integration Costs
- These costs can vary dramatically depending on what services you are providing.

Path 1: EV Load Management under PDR

Pros

- Easier interconnection and participation agreements
- Less stringent metering and telemetry requirements
- Allows for aggregations of smaller resources to one ISO resource
- Allows for third party representation of resources
- Model is 'mature' and has been used for several years

Cons

- Qualifies for fewer wholesale services (Energy/Non Spin)
- Baseline settlement methodology is less than perfect

The ISO is supporting EV load management under ISO's Proxy Demand Resource (PDR) Model

- PG&E's Intermittent Renewable Management Pilot Phase 2 (IRM2)
 - Phase 2 of this pilot is in progress and includes participation in the ISO day ahead market
 - Planned phases will include real-time market services and potential expansion to 'second-life' use of EV batteries
- SDG&E's Optimized Pricing and Resource Allocations (OPRA) Pilot
 - Participating in the ISO's day-ahead energy market
 - Project will evolve to real-time and ancillary service markets
- Others are in discussion

Path 2: EV Ancillary Services under the NGR Model

Pros

- Qualifies for all wholesale services (Energy, Non Spin, Spin, Regulation)
- Arguably better utilization of the resource by allowing bi-directional power flow

Cons

- More complex interconnection and participation requirements
- More stringent metering and telemetry
- More limited in terms of aggregations (EV Fleet management)
- More complex for third party representation
- Newer model with limited use to date

The ISO is supporting EV wholesale participation for energy and regulation services

- Vehicle to Grid Efforts to demonstrate wholesale participation for Energy and Ancillary Services (Regulation)



Los Angeles Air Force Base

- 500-600 kW capacity
- 25+ V2G capable vehicles/trucks
- 2015 Planned Market Participation



Naval Air Weapons Station – China Lake

- 1.5-2.0 MW capacity
- 45+ V2G capable vehicles/trucks
- 2015-16 Target Market Participation

The ISO is active in several internal efforts that support EV resource development

- Advancing on the Expanding Options for Metering and Telemetry Initiative
- Advancing on the Energy Storage Interconnection Stakeholder Initiative
- Development of the multi agency California Energy Storage Roadmap
- Discussion of model enhancements that combine some features of PDR and NGR that can reduce costs and simplify participation requirements
- Discussion of frequency control (governor-type) requirements and market products

Research areas that have the potential for further reduction in balance of system costs

- Utilizing resource management systems to dispatch small behind the meter resources as a single resource entity
- Standardizing and leveraging embedded meters that meet defined revenue quality meter standards
- Standardizing and leveraging logical/software based meters and reconciliation of meter data within facilities for greater visibility and granularity
- Cloud based metering to support resource concentrations and aggregations
- Frequency responsiveness controls (as opposed to frequency regulation)

Key Messages

- The ISO supports CPUC proceedings and CEC research opportunities that further advance reliable EV load management and increased customer engagement as grid resources
- The ISO supports utility pilots that demonstrate how EV resources can collectively support grid reliability through wholesale participation
- Many technical and regulatory challenges exist to justify EVs participating at a transmission grid level
- Reducing balance of system costs will be key to advancing vehicle to grid opportunities

Thank You

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