Energy+Environmental Economics

Enabling Vehicle Grid Integration (VGI)

New Jersey Retreat on Advancing Vehicle-to-Grid Technologies

01/23/2020

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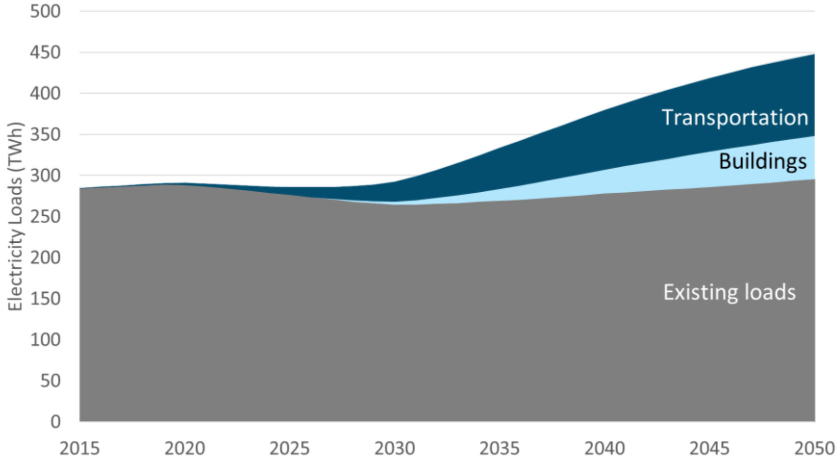
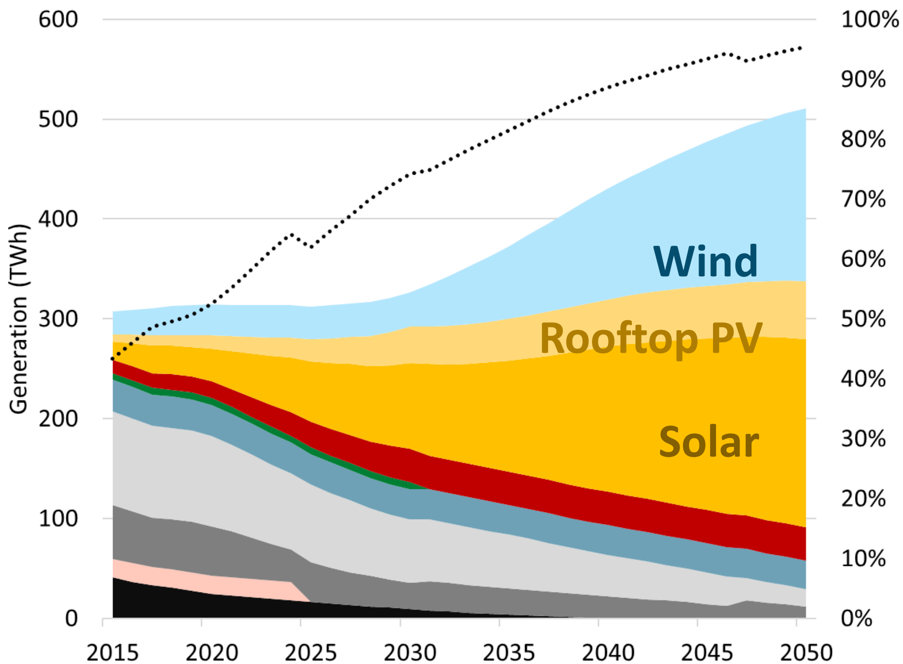
Enabling flexible EV loads is a key transition for low carbon pathways

California PATHWAYS





Transportation is first, new flexible load in pathways portfolio…

…establishing business models for flexible building loads to follow…

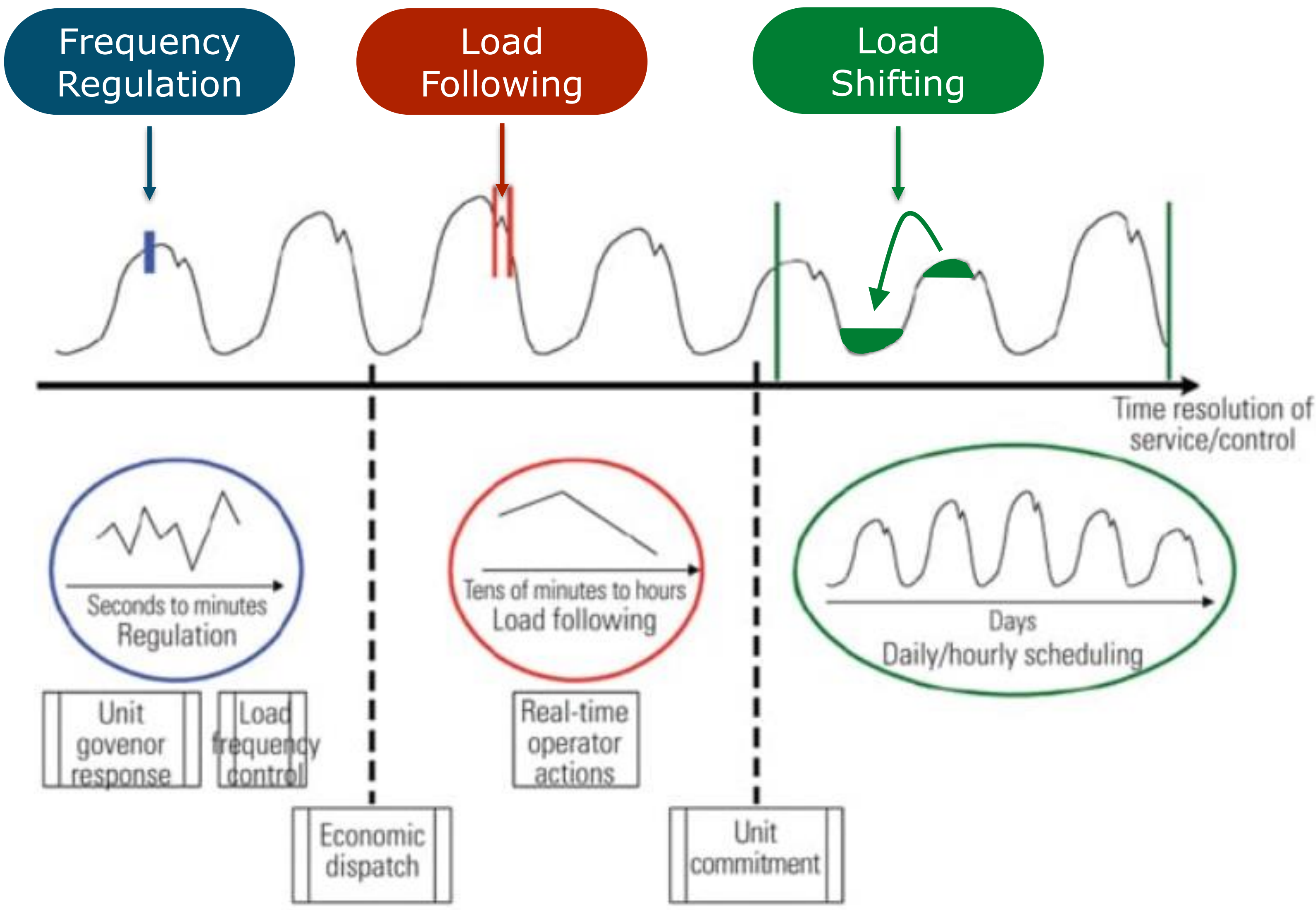
…enabling increase in low carbon electricity

The driver comes first

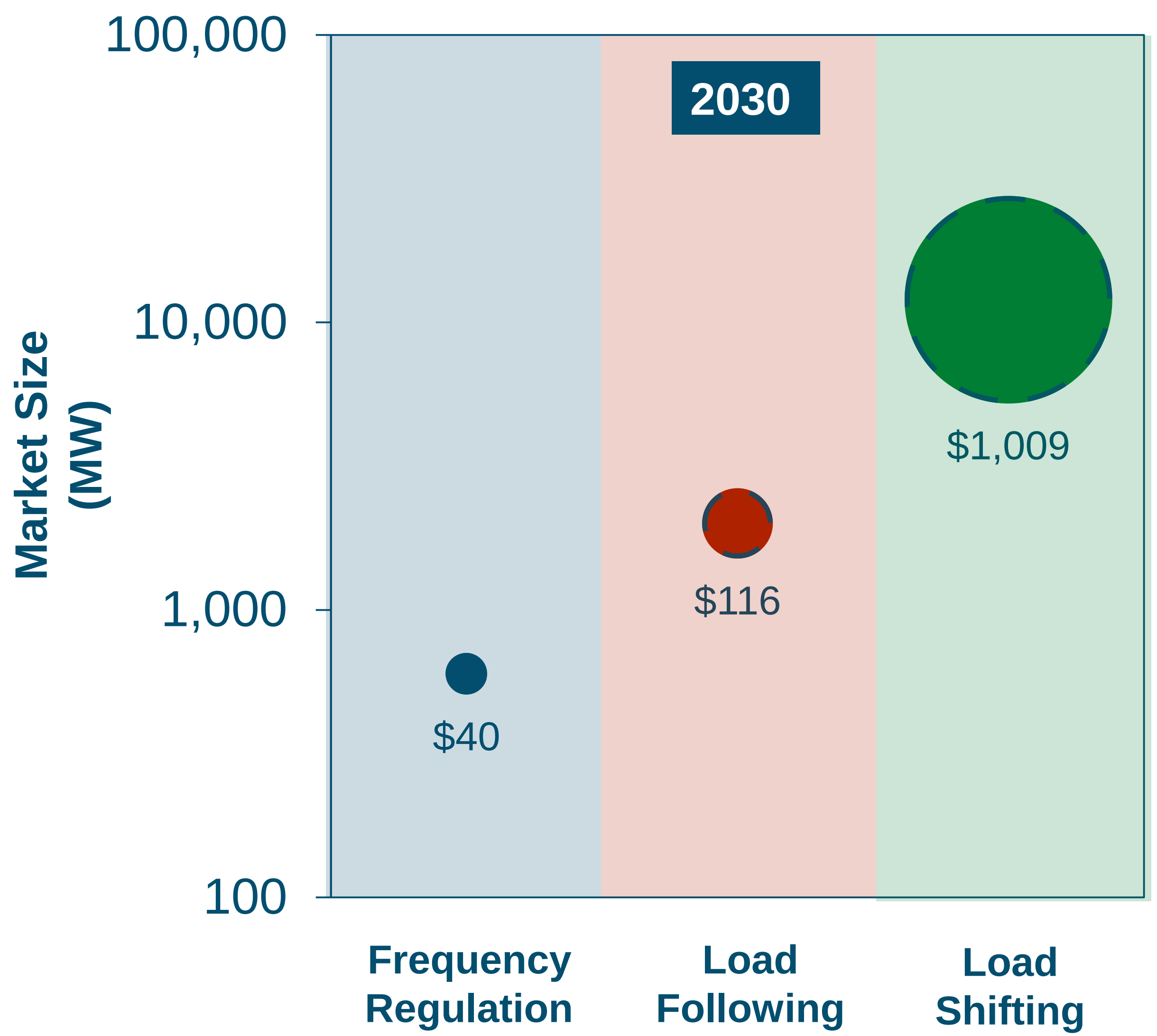
+ Meeting driver mobility needs is paramount
+ Driver enrollment in VGI has been a challenge
+ Grid operators view driver response as uncertain

Don’t’ think of EV’s as a toaster with wheels

Which VGI services have the highest value?



Load shifting will have the largest value in high renewables systems

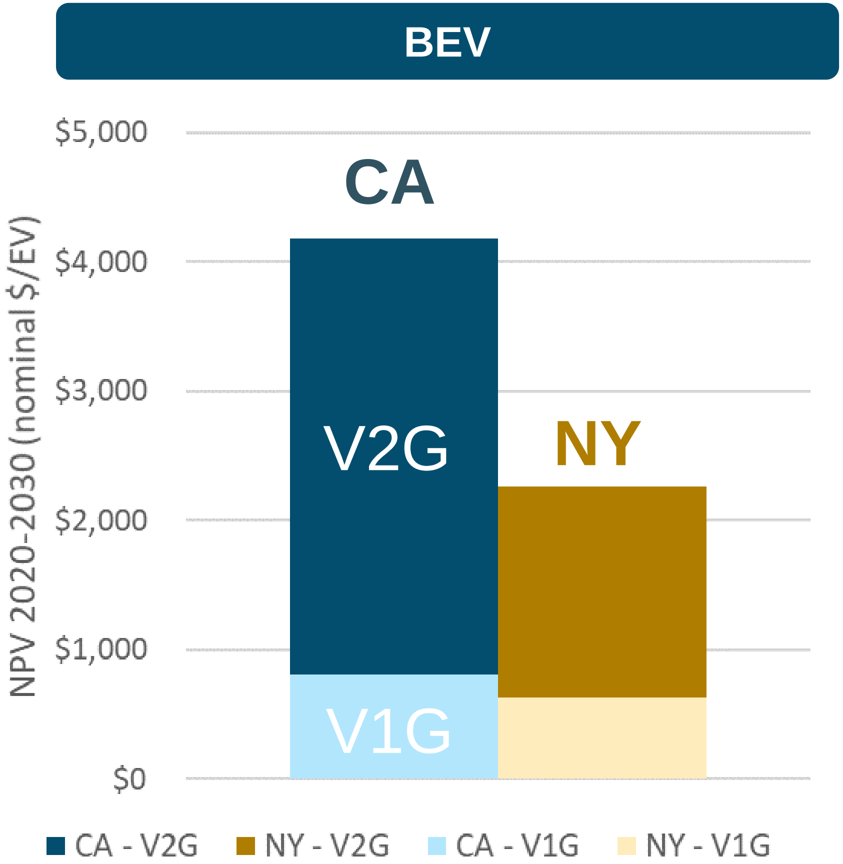


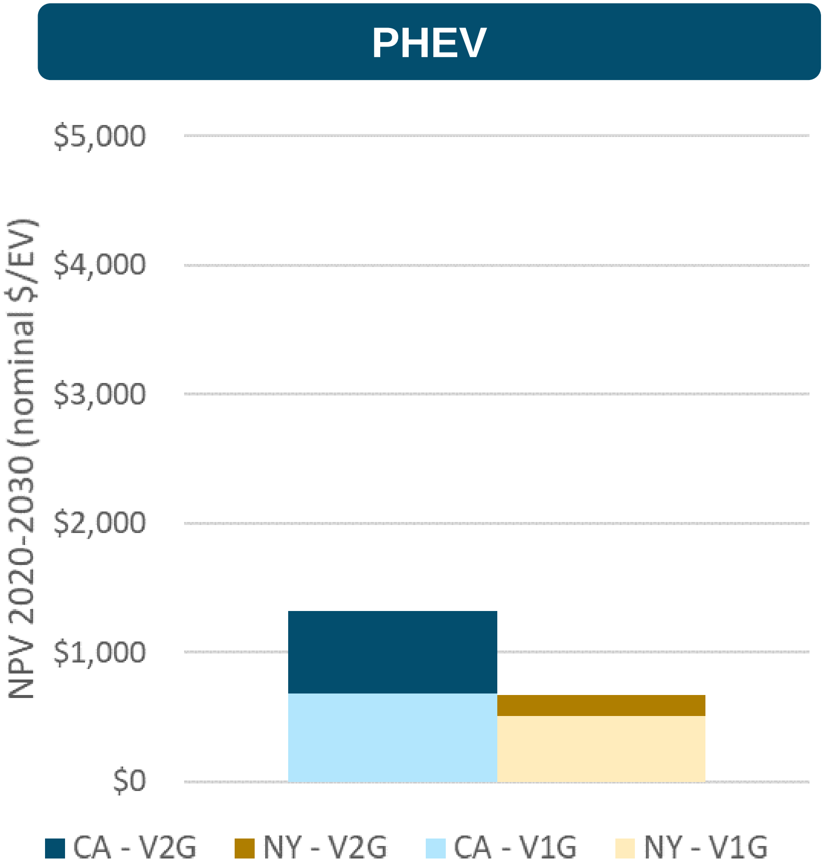
Market Values are in 2016 $Million

2018 CPUC IRP (CA 2018-2030 levelized value, 2016 $/kW-yr.)

With increasing renewables, value of VGI will grow over time

+ California is leading, but Northeast is a fast follower





Note that the unmanaged charging baseline is used for calculating the value of providing V1G and V2G

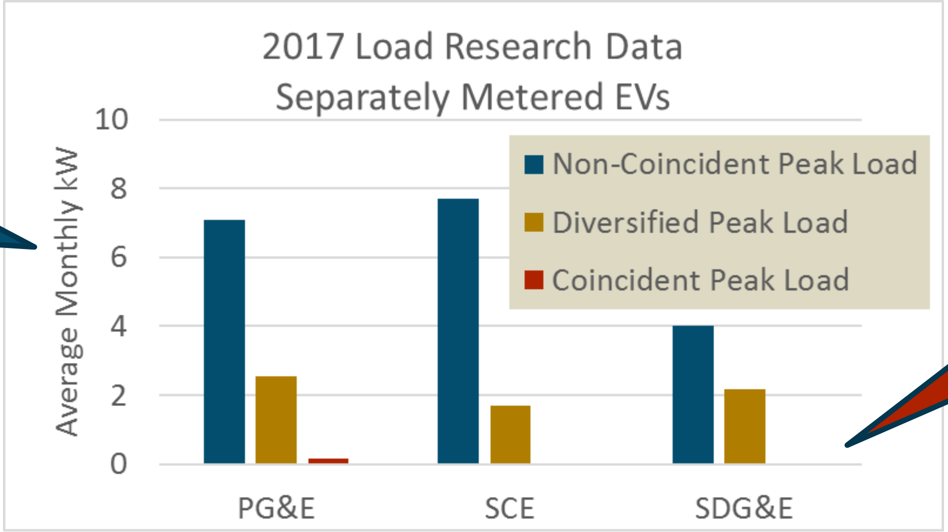
Added value of V2G is significant

- Capacity for grid services is double
- Low daily VMT limits value of managed charging alone
- V2G can provide grid services after battery is full
- V2G can be precisely timed to grid need

2 x

Non-Coincident Peak Load

CA Separately metered EVs on TOU Rates

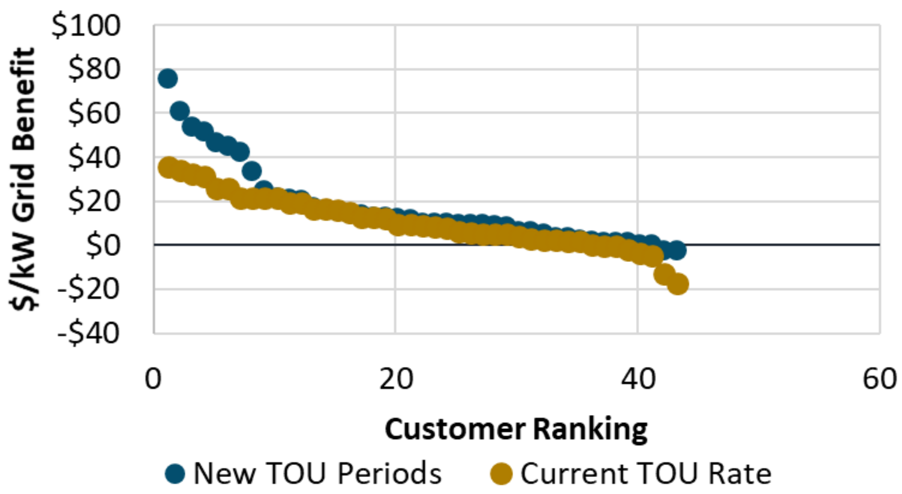


Coincident Peak Load

Grid benefits of dynamic rates

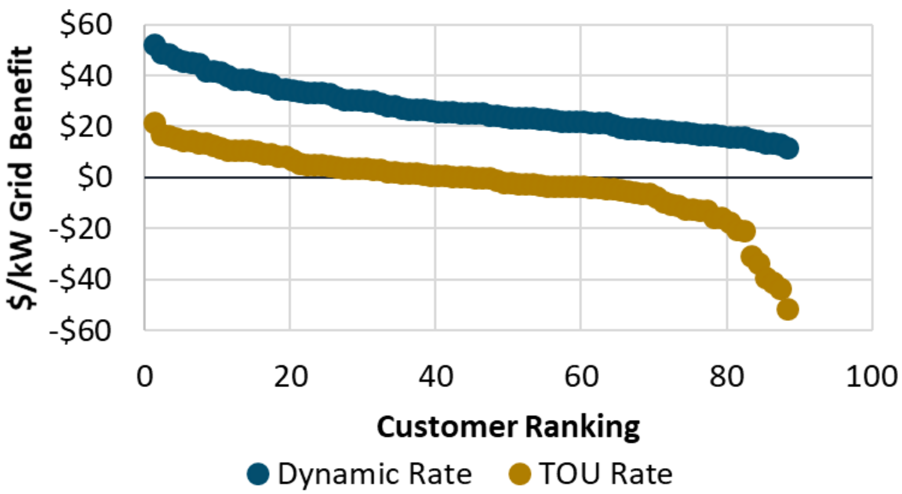
$/kW grid benefits of energy storage

Revised TOU Rates



Modified TOU periods increase grid benefits by average of $16/kW for some customers

Hourly Dynamic Rates



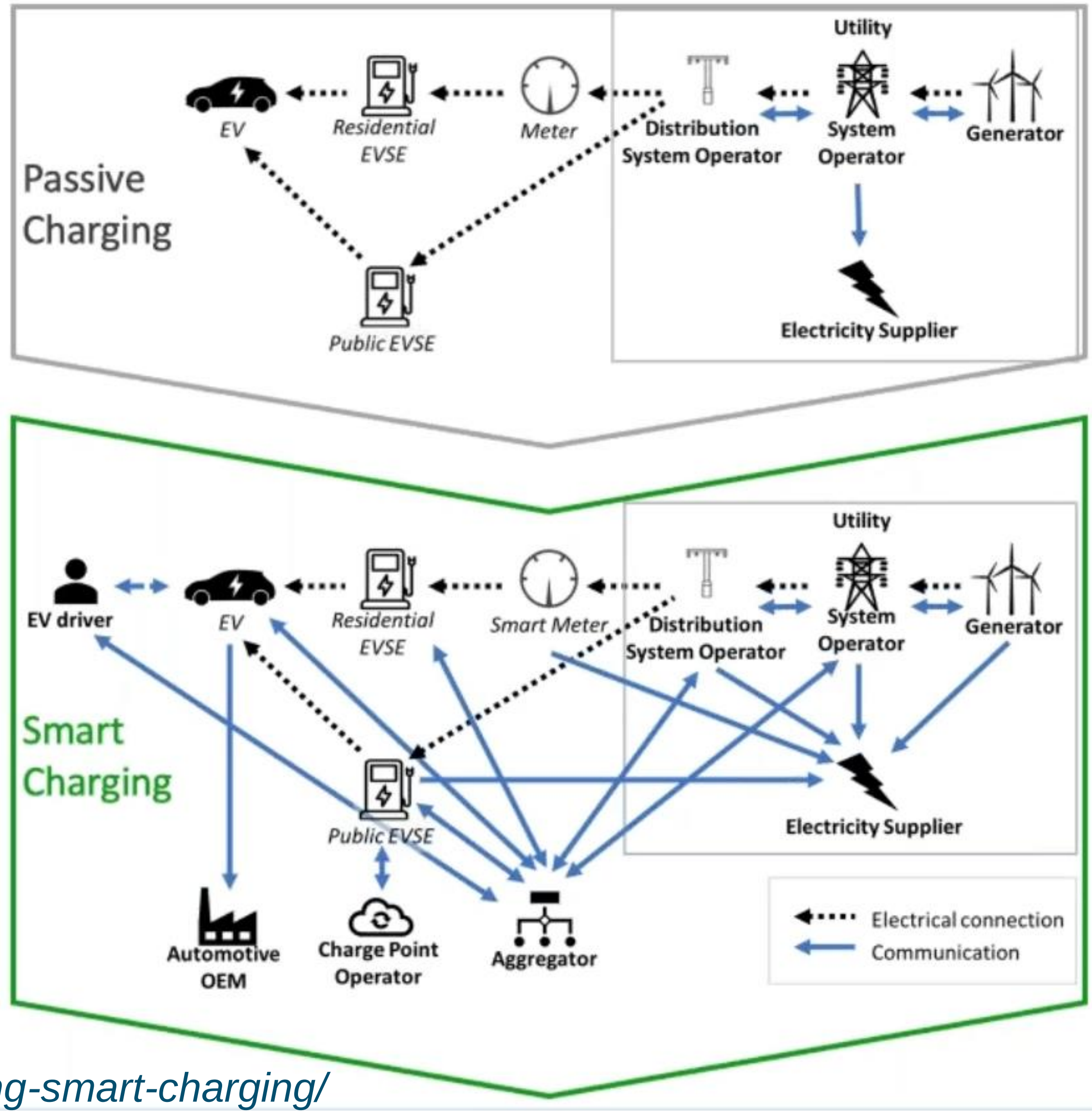
Hourly dynamic rates increase grid benefits by average of $35/kW for all customers

Analysis for 2017 and 2018 California Self-Generation (SGIP) Incentive Program

VGI requires unprecedented coordination between power and transportation sectors

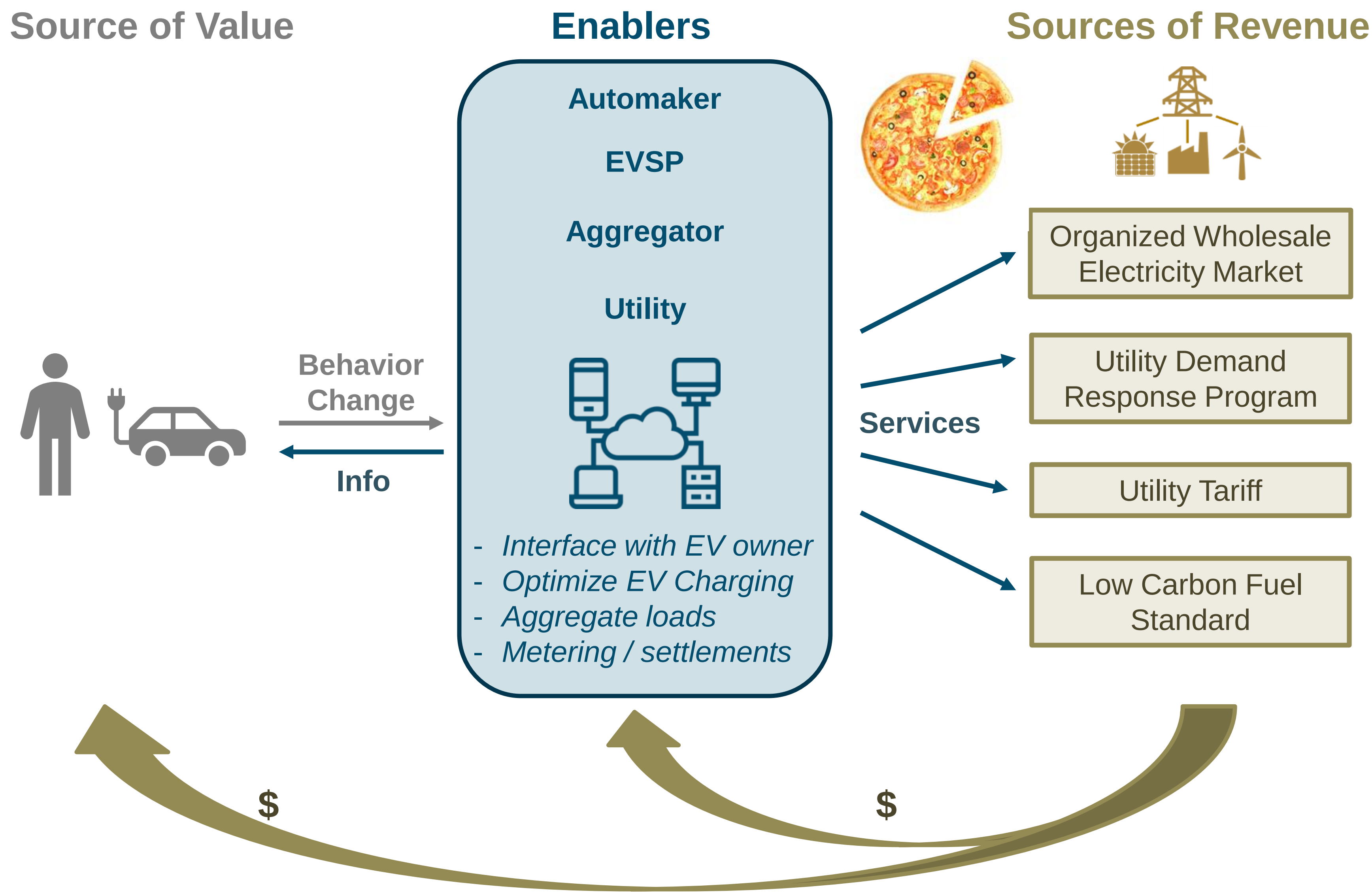
Key Questions for Regulators

- **Enabling viable business models**
- **Role of regulated utility vs. competitive market**
- **Attracting market investment**

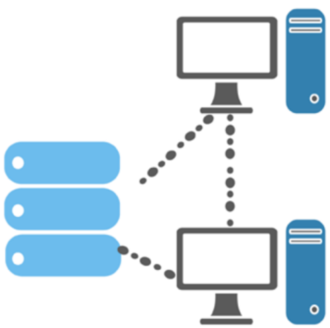


Element Energy: http://www.zevalliance.org/implementing-smart-charging/

Multiple players between consumer and revenue sources seek a slice of the pie



Enabling VGI



- **Enable collaboration while protecting sensitive data**
  - Avoiding data silos between automakers, ride share companies, EVSPs and utilities
- **Open and interoperable standards**
  - Heavy lobbying to pick a standard, but it is too early to do so
- **Increase efficiency and reduce costs**
  - Strategies to avoid or minimize need for real-time telemetry and revenue grade meters
- **Where should 'smartness' lie?**
  - EV, EVSE, Aggregator, Utility DERMS?

Element Energy and Energy and Environmental Economics
http://www.zevalliance.org/implementing-smart-charging/

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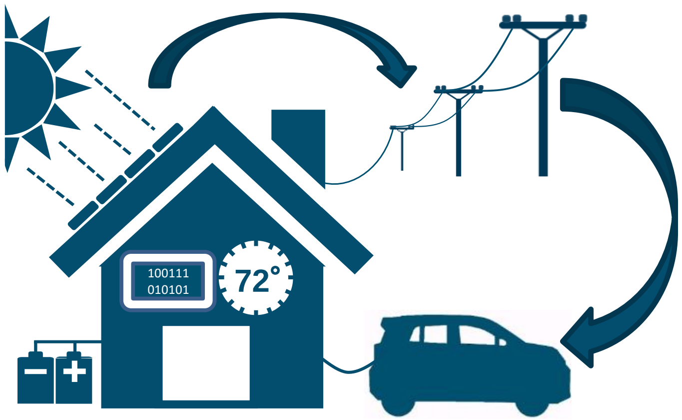
Appendix

Advanced rate design for EVs



Part 1: Embedded Costs Customer Charge	$/customer $/meter
Part 2: Embedded Costs Network/Grid Access Charge	kW Monthly kWh
Part 3: Dynamic Marginal Cost Based Charge/Payment	Coincident kW kWh

Examples

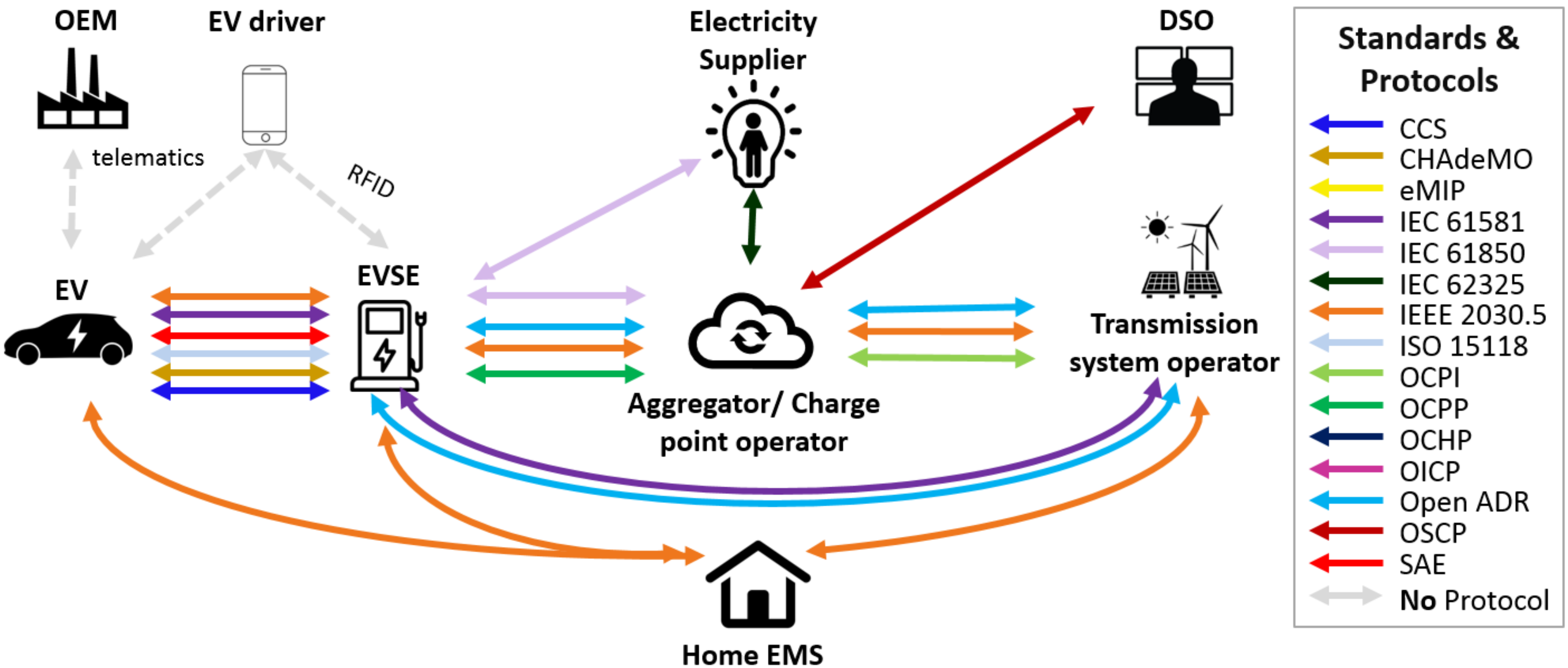
ConEd & ORU
NY REV Smart Home Demonstration Rates

SDG&E
Grid Integration Rate

APS
Saver Choice Rates

Full Value Tariff for NY REV Proceeding

Communication Standards



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Key functions and roles for enablers along the V1G/V2G value chain

Function/Role	OEM	EVSP	Aggregator	Utility
Recruit participants	Potential capability ★	Potential capability	Current capability	Potential capability
Provide customer interface	Potential capability ★	Current capability	Current capability	Stretch capability
Forecast customer driving / SOC needs	Potential capability ★	Potential capability	Potential capability	
Manage charging for customer	Potential capability ★	Current capability	Current capability	Potential capability
One-stop shop for demand side flexibility			Potential capability ★	
Offer into markets / utility programs	Stretch capability	Potential capability	Current capability ★	Current capability
Provide very accurate energy meter services	Stretch capability	Potential capability	Potential capability	Current capability ★
Backhaul, data management, settlements	Stretch capability	Current capability ★	Current capability ★	Potential capability
Install (cost-effective) bidirectional inverter	Potential capability ←★→	Potential capability		
Enable bidirectional power flow to grid				Current capability ★

Primary regulatory barriers

Current capability   Potential capability   Stretch capability   ★ Competitive advantage

Potential monetization options for flexible EV load

A) Share Bill Savings	B) Utility Payments	C) Market Payments
Actively manage EV charging on dynamic rate to reduce charging costs; charge customer higher default rate, a service fee, or share savings with customer	Enter into a contract with the utility (or participate in a utility program) providing payments based on grid benefits of managed charging	Bid an aggregate EV resource into the wholesale electricity market (e.g. CAISO) and earn payments for energy and capacity from managed charging
Pro: direct arrangement with customer and no need for an EVSP or aggregator to get involved	**Pro**: monetizes value of providing local network capacity to utility while avoiding complications of wholesale market participation	**Pro**: direct access to liquid, transparent market prices with flexibility to not participate
Con: going beyond the home is complex because it would require understanding the fee structure across all EVSE equipment	**Con**: utility acts as an intermediary between the EV and the market, potentially reducing the amount of value that can be captured	**Con**: the market has strict rules around minimum size of aggregate resource and accuracy/latency of meter data

Share savings/revenues with drivers

V2G Dispatch – Distribution Deferral

Un-managed

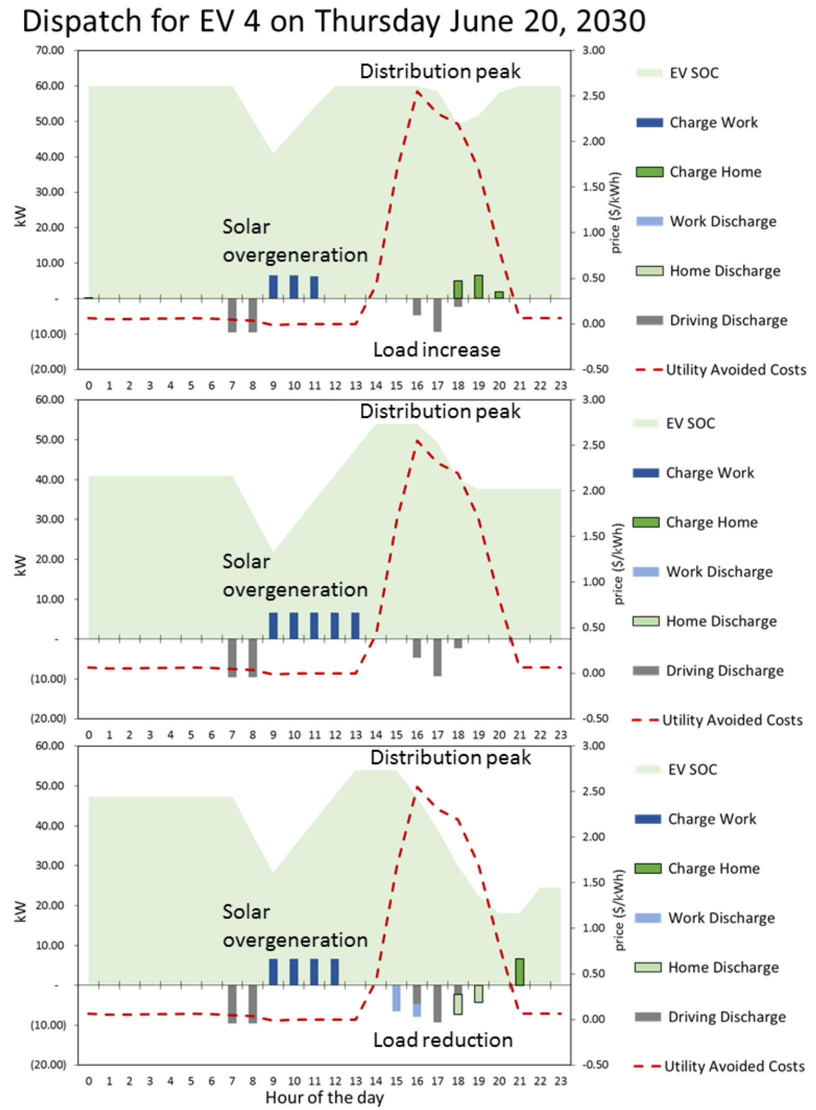
Smart (V1G)

V2G

Unmanaged Charging
Utility Cost:
$10.38

V1g
Utility Benefit:
$0.21

V2g
Utility Benefit:
$35.73



V1G: the PEVs must be charging to provide benefits and they cannot provide services once the battery is full.

V2G: the capacity for grid services is doubled, the dispatch can be precisely timed to coincide with peak loads and the battery can be used for grid services even after the battery is full.

V2G Dispatch - Overgeneration

Smart (V1G)

V2G