Energy+Environmental Economics

Quantifying Value of V2G

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EPRI IWC

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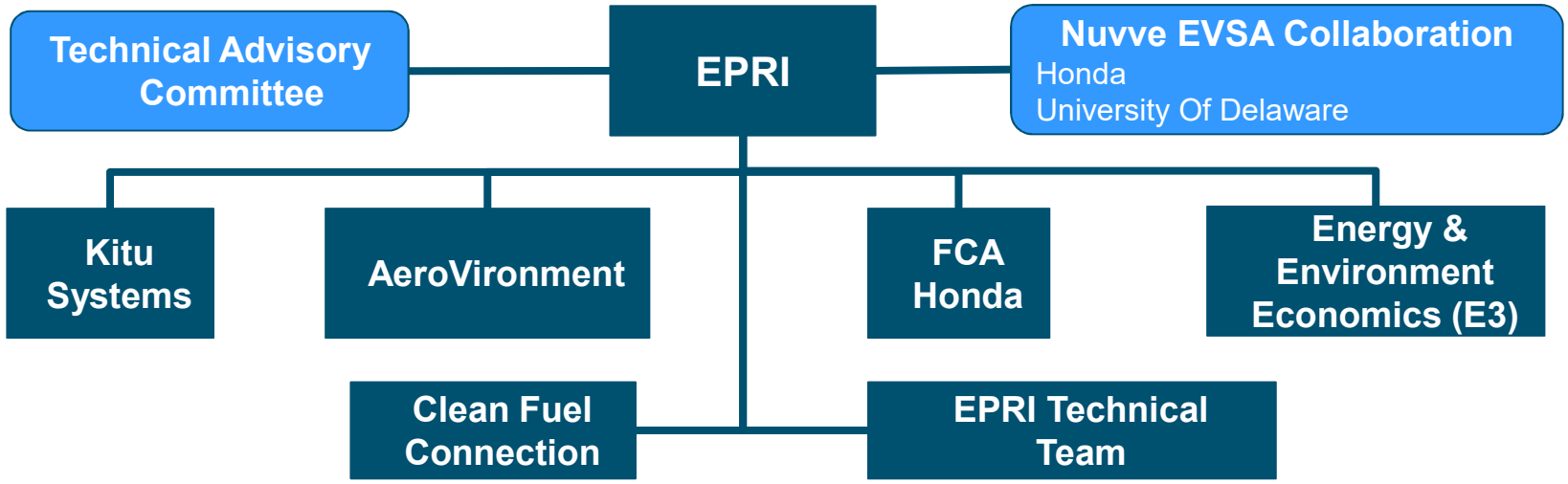
Distribution Aware V2G Demonstration

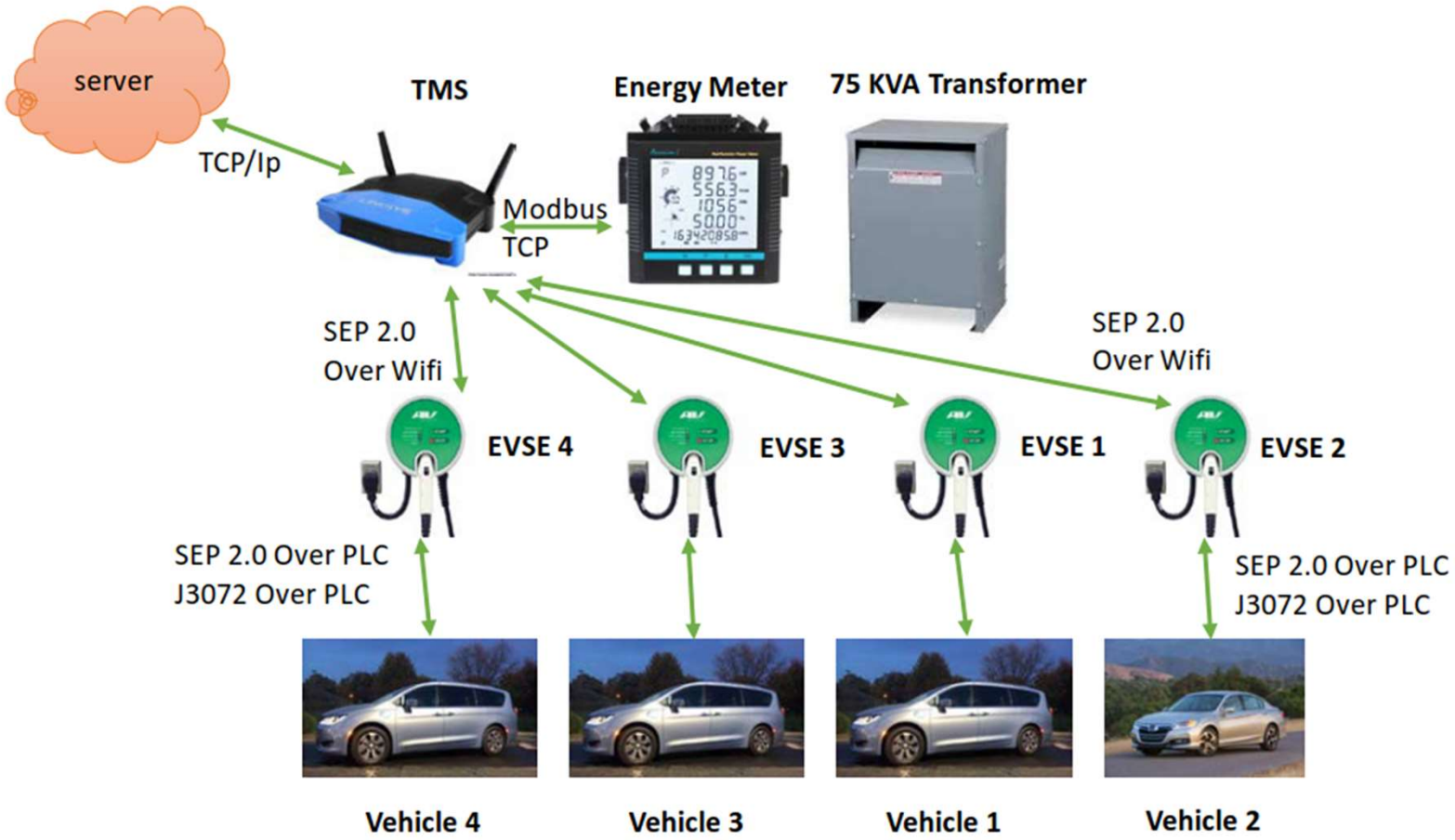
CEC funded project led by EPRI running since 2015



Project Objectives

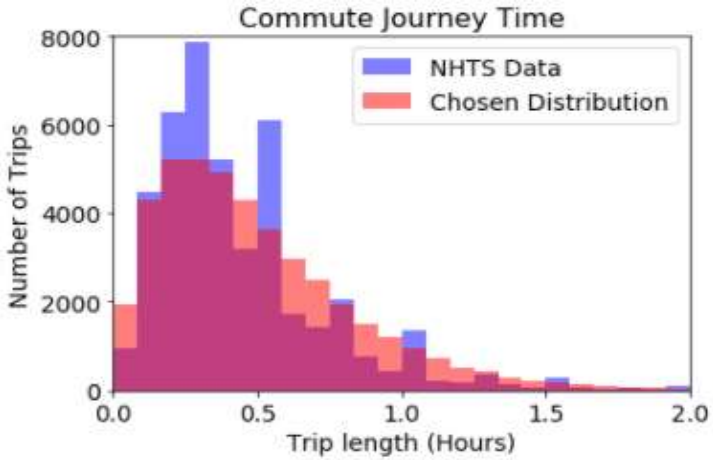
- Develop and implement end to end V2G communications system
- Implement dynamic V2G management use cases
- Data collection and performance analysis
- **Assess costs/benefits – customer and utility perspectives**

System Architecture



Modeling EV Driving and Charging Behavior

- **A randomized driving pattern from National Household Travel Survey data**
- **Modeled 5 Chevrolet Bolts commuting to UC San Diego**
  - 60 kWh battery / 238 mile range
- **V2G capable L2 Charging (6.6kW) available at work and home**
- **No hardware costs included in this analysis**



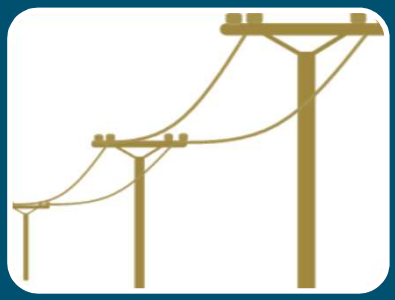
Randomly Generated driving pattern Statistics	EV 1
Hours at Home	6,105
Hours at Work	1,981
Driving Energy (kWh)	3,324
Mean commute (hrs)	0.39
Mean time at work (hrs)	8.93

https://www.autoblog.com/buy/2018-Chevrolet-Bolt+EV/

V2G Dispatch Modes

Ratepayer bill (customer dispatch)

- Bill Savings
- Back-up power
- Ancillary Service Revenue



Grid costs (utility dispatch)

- System Avoided Costs
- Distribution Deferral Value
- Ancillary Service Revenue

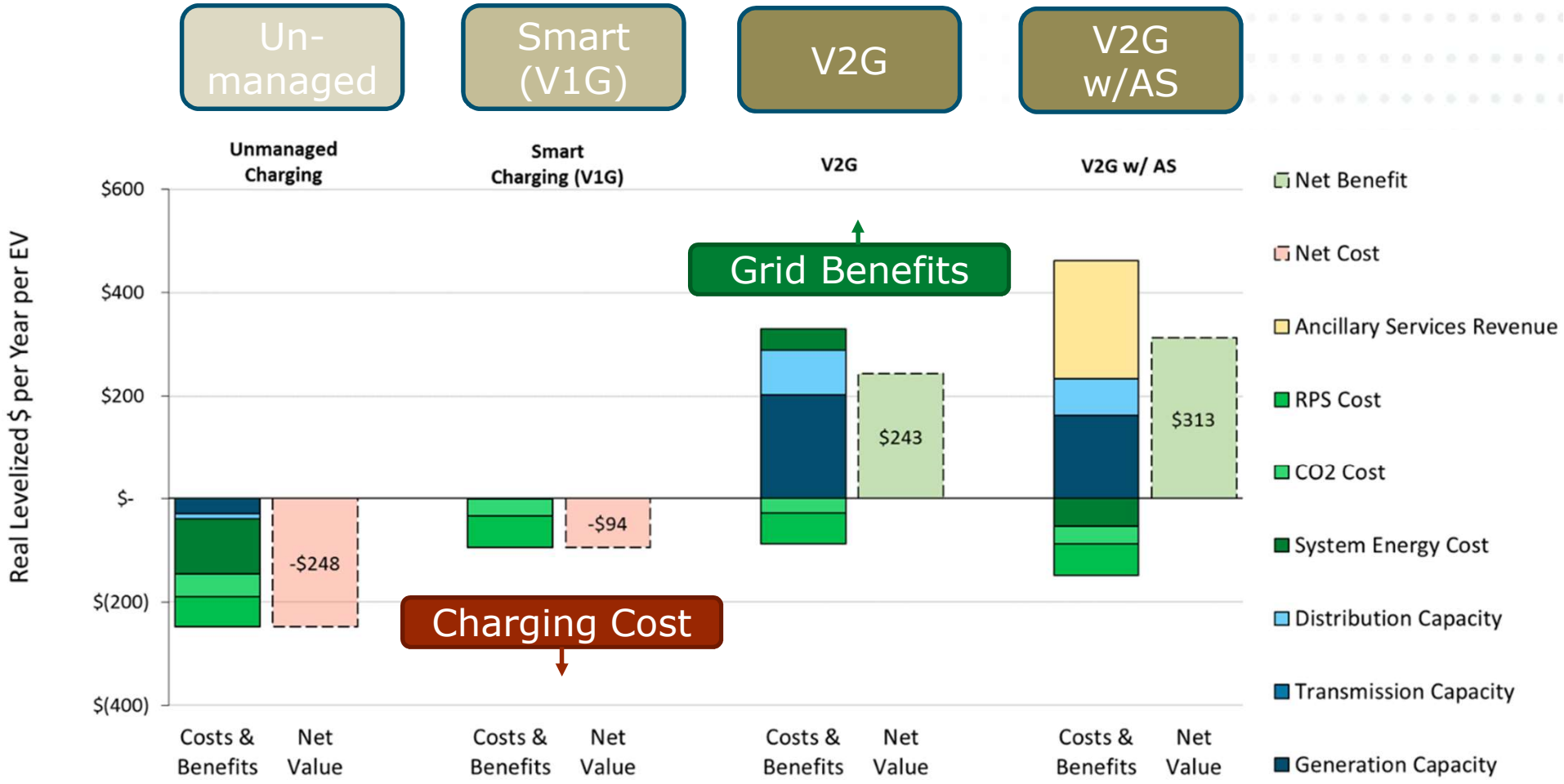
+ **Co-optimized dispatch to maximize benefits**
+ **Perfect foresight, price-taker**
+ **Constrain cycling and SOC for battery health**

Methodology – Use Cases

	Smart Charging (V1G)	V2G
Base Case	V1G Base Case	V2G Base Case
	+ Dist. Deferral	+ Dist. Deferral
		+ AS
High Case	V1G High Case	V2G High Case
	+ Dist. Deferral	+ Dist. Deferral
		+ AS
		+ Unconstrained Operation

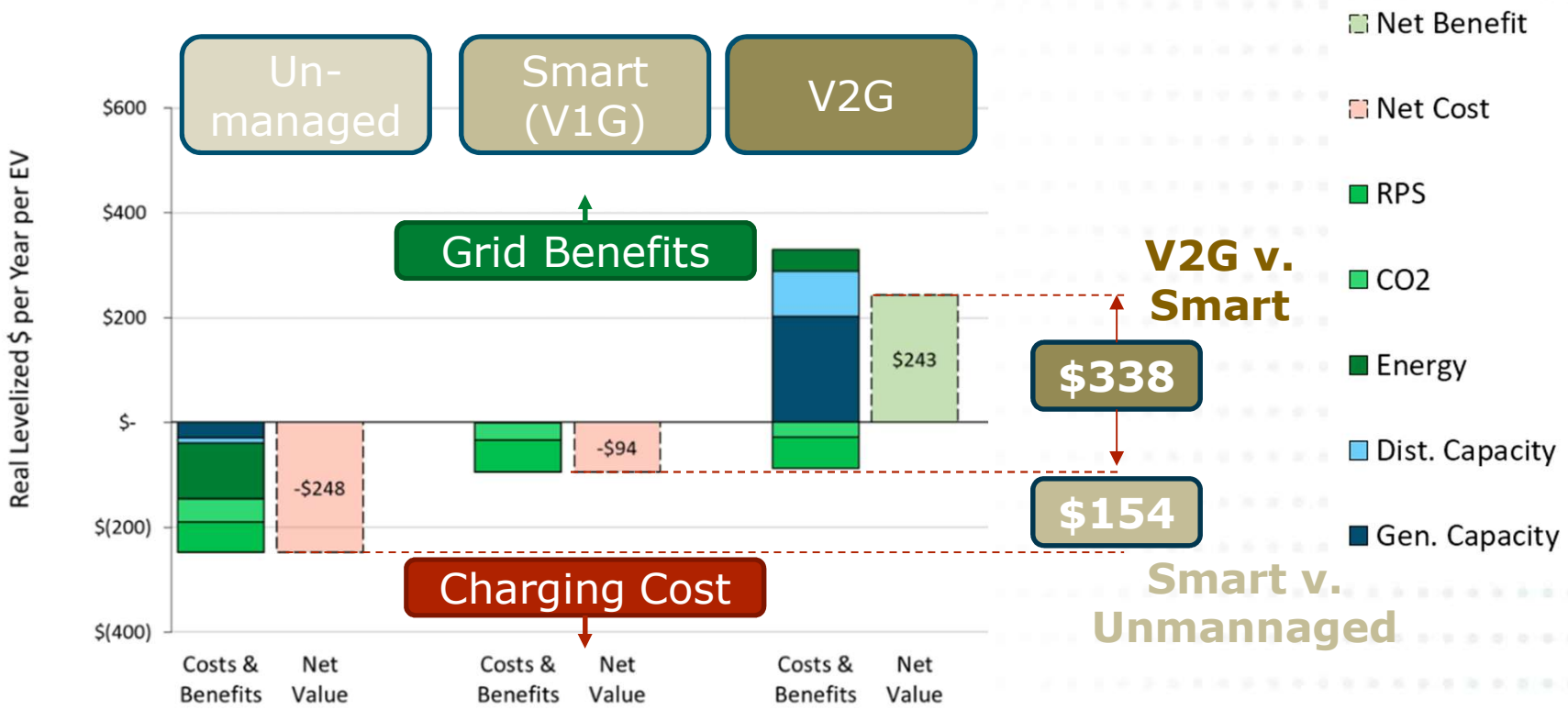
- **Base Case – 2018 CPUC Avoided Costs with current (low) resource adequacy prices**
- **High Case – high renewables (80% GHG reduction by 2030) with high local resource adequacy and distribution deferral value**

Base Case V2G Benefit Results



Incremental Benefits of V2G

Incremental grid benefits of V2G (without AS)



EPRI led CEC EPIC "Distribution Aware V2G Demonstration Project"

V2G Dispatch – Distribution Deferral

Un-managed

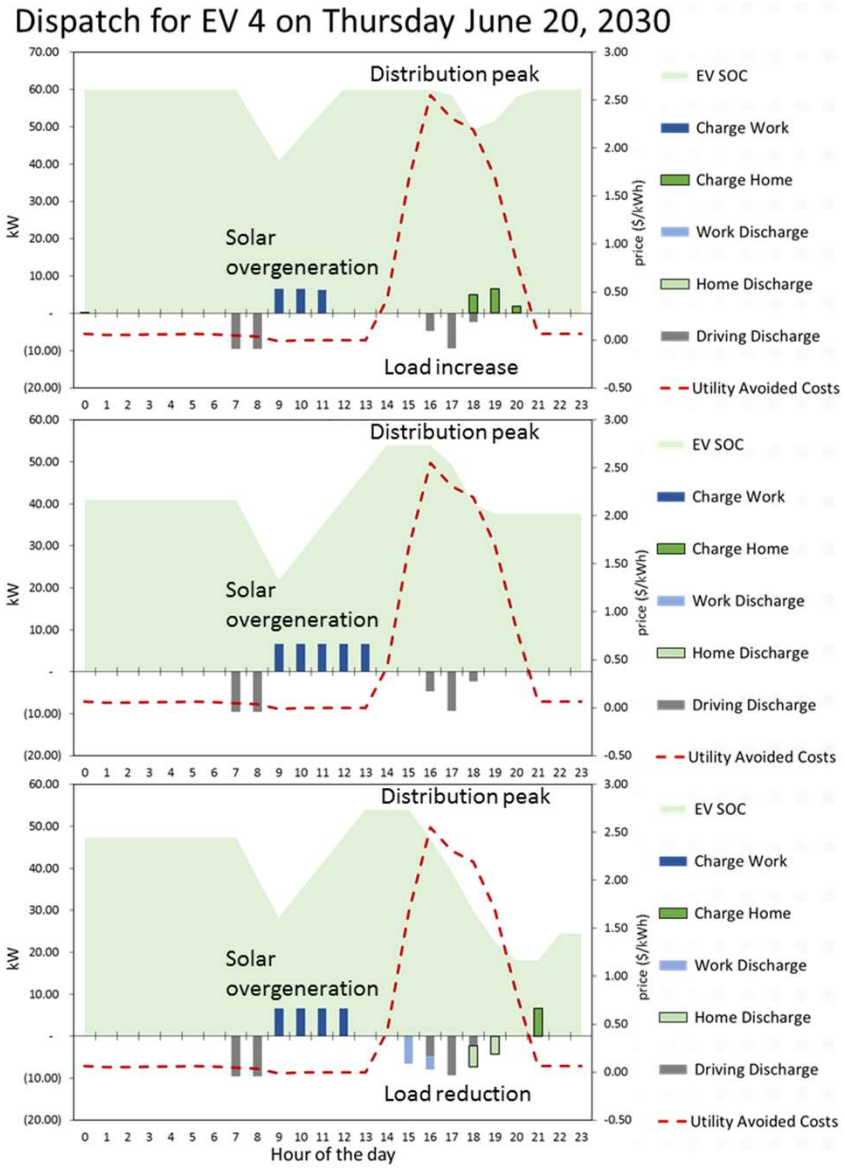
Unmanaged Charging
Utility Cost:
$10.38

Smart (V1G)

V1g
Utility Benefit:
$0.21

V2G

V2g
Utility Benefit:
$35.73



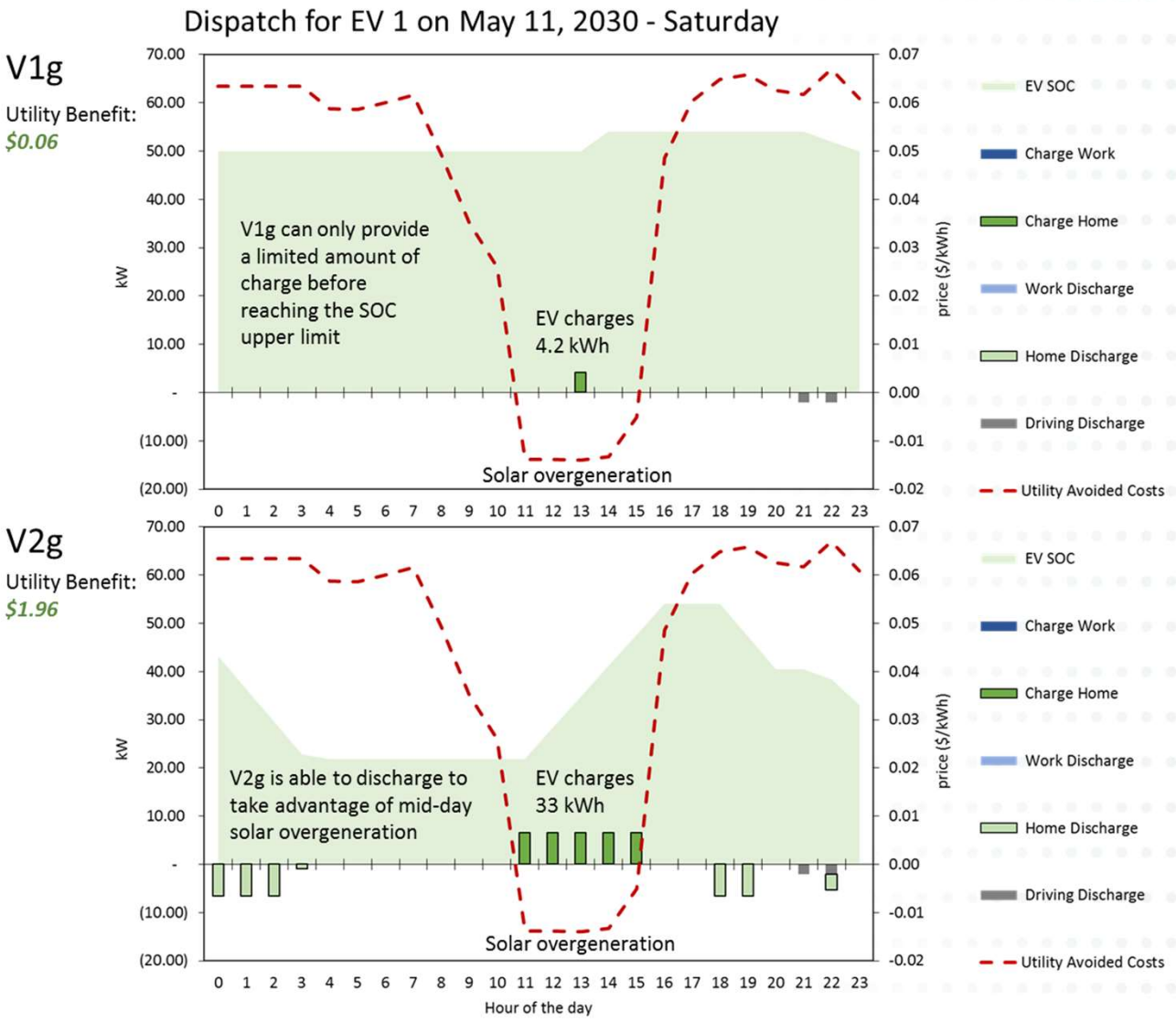
V1G: the PEVs must be charging to provide benefits and they cannot provide services once the battery is full.

V2G: the ability 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



Key Insights / Conclusions

+ V2G shows significant net benefit relative to V1G

- Short commutes and high SOC can limit value of managed one way charging
- Capacity value can be high in constrained areas
- Ancillary services are not necessarily dominant value

+ Next Steps

- More diverse vehicles and driving behavior
- Model reliable response of aggregated fleet
- Electric Vehicle Storage Accelerator (EVSA) Project at UC San Diego with Nuvve
- CPUC/CEC VGI Roadmap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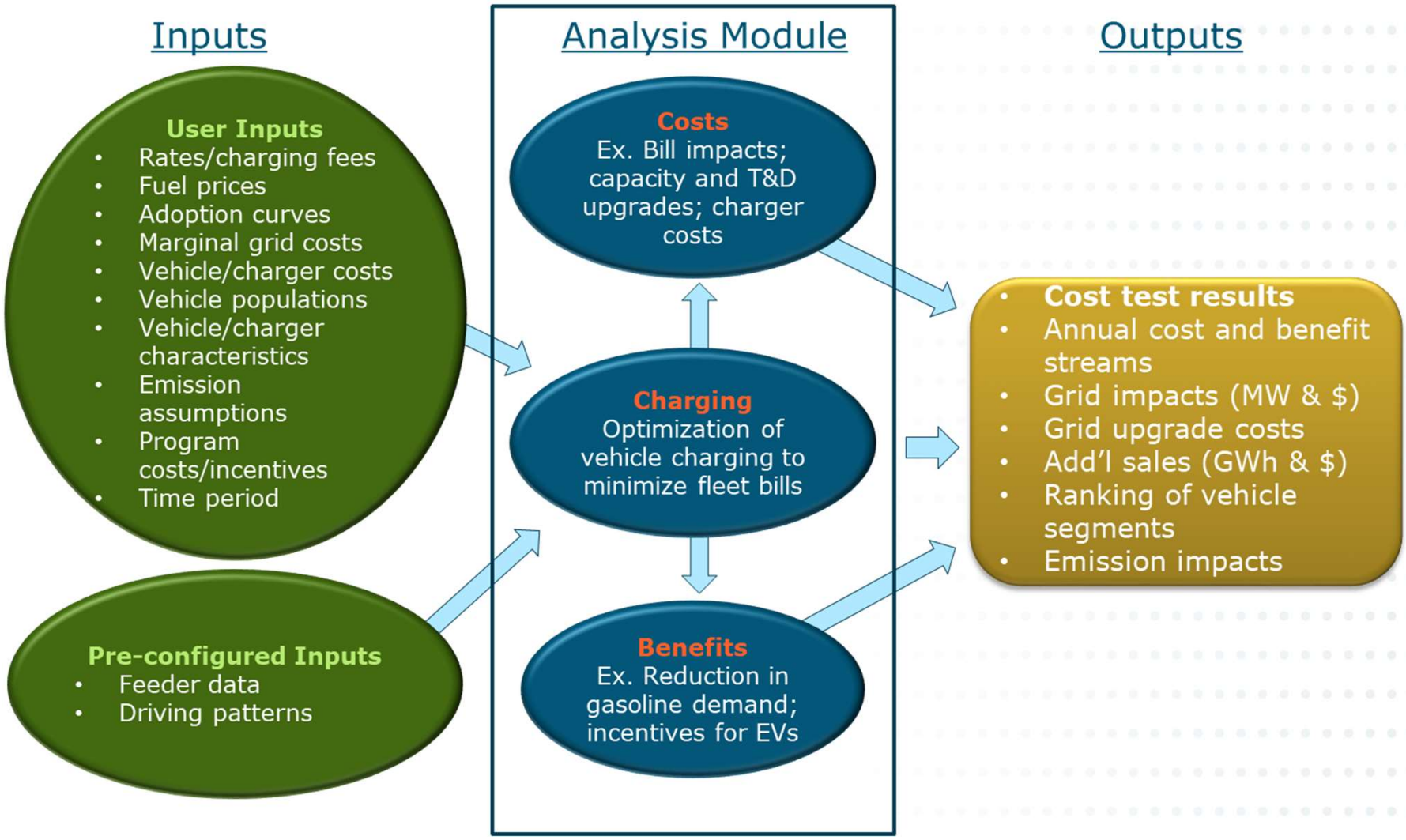
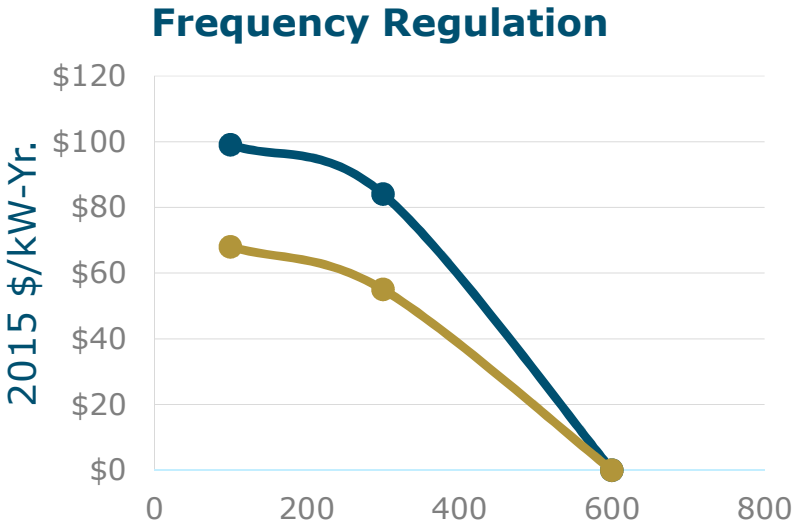
KILOWATTHOURS
SINGLE-STATOR WATTHOUR METER
TYPE AB1 S.
200 CL 240 V 3 W 60 Hz TA 30
MADE
IN

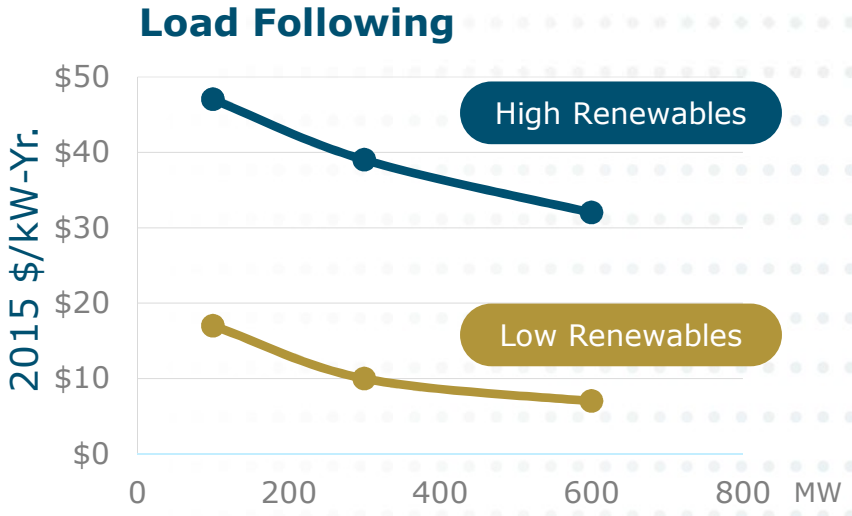
THANK YOU

EV Grid Model



Grid Demand for Frequency Regulation and Load Following



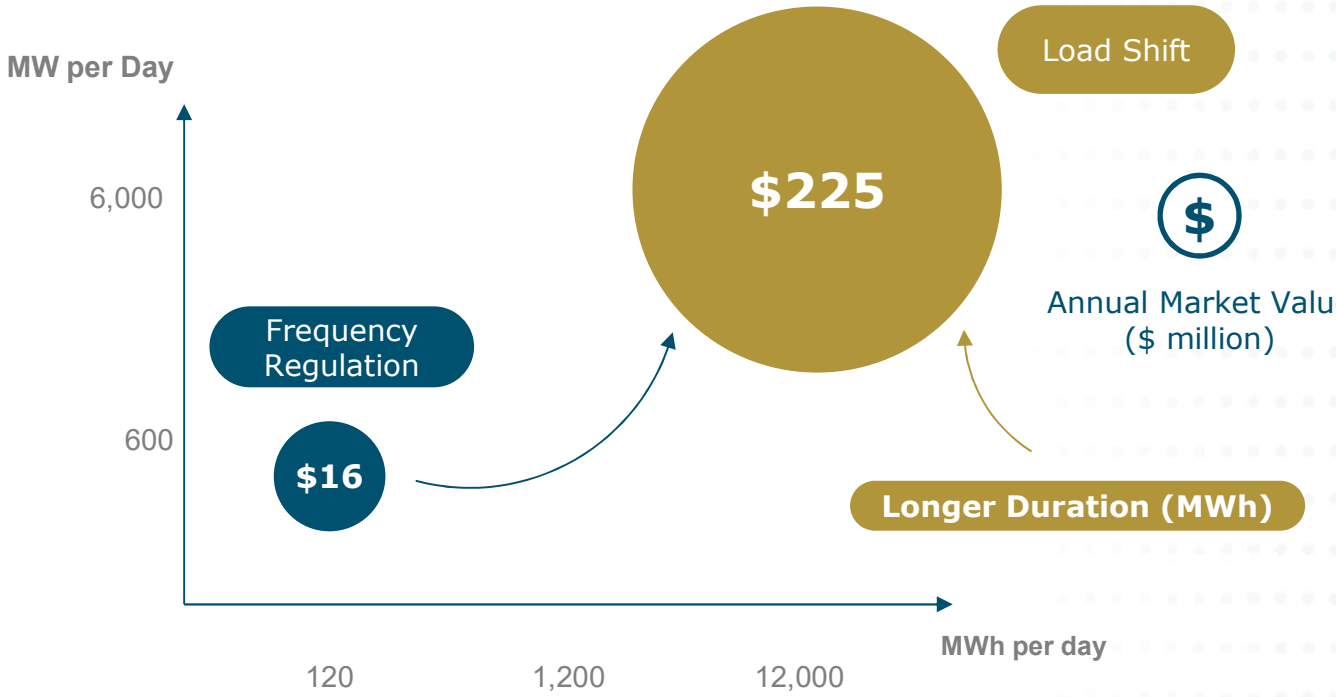


+ **Frequency Regulation market is fully saturated at 600 MW**

+ **Larger market for load following at higher prices**

E3 & LBNL modeling for CPUC Advanced DR Potential Study

Load Shift Will Be Larger Market



+ 2025 Market Value

Grid Net Value Summary

+ **Net Costs and Benefits are real levelized values per EV per year**

		Grid Net Cost / Benefits (real levelized)			V2G Battery Use	
Case Description	**Control Mode**	**Un-managed**	**V1G**	**V2G**	**Battery cycles**	**Discharge Energy (kWh)**
Unconstrained High Value V2G	Utility	**-$345**	**-$92**	**$1,380**	251	15,051
High Value V2G	Utility	**-$345**	**-$92**	**$1,021**	164	10,225
High Value V2G without AS	Utility	**-$345**	**-$92**	**$1,005**	133	7,969
Base V2G Case	Customer	**-$248**	**-$94**	**$313**	105	6,293
Base V2G Case w/o AS	Utility	**-$248**	**-$94**	**$243**	105	6,322
Base V2G Bill Optimized Case	Customer	**-$248**	**-$278**	**$105**	155	9,325

Incremental Grid Benefit of V2G

- **Incremental benefit is presented as a real levelized value per EV per year**

		Incremental Grid Benefit		V2G Battery Use	
Case Description	**Control Mode**	**V1G vs Unmanaged**	**V2G vs V1G**	**Battery cycles**	**Discharge Energy (kWh)**
Unconstrained High Value V2G	Utility	**$253**	**$1,472**	251	15,051
High Value V2G	Utility	**$253**	**$1,113**	164	10,225
High Value V2G w/o AS	Utility	**$253**	**$1,097**	133	7,969
Base V2G Case	Utility	**$154**	**$407**	105	6,293
Base V2G Case w/o AS	Utility	**$154**	**$337**	105	6,322
Base V2G Bill Optimized Case	Customer	**- $30**	**$383**	155	9,325