California Transportation Electrification Assessment

Prepared for:

CPUC Workshop on SB 350

April 29, 2016

Project Objectives

Key aspects of the study:

- **Utility Coordination**: This project includes active coordination and collaboration from utilities – PG&E, SCE, SDG&E, SMUD, City of Palo Alto, LADWP, and CMUA members. Engagement of so many utilities demonstrates the collective commitment of the industry to develop a coordinated plan related to electrification.

- **Changing landscape**: The current trajectory in California, as it pertains to electrification, will achieve one class of benefits. This study seeks to determine: What *could* the trajectory be and what benefits are we leaving on the table? And what is the course of intervention to change the current trajectory?

Work Flow (1 of 2)

Phase 1 of Transportation Electrification Assessment

- **Assess existing studies**: Literature review of transportation electrification opportunities. Dozens of reports reviewed. Focusing on 18 segments.
- **Market sizing**: Segment-by-segment forecasting for 2020 and 2030.
- **Cost and benefits of selected segments**: Reviewing the costs and benefits of selected TE segments. Considering incremental up-front costs, the incremental infrastructure costs, incremental benefits including lower operational costs for TE vehicles and equipment, and cost savings from lower electricity fuel costs.
- **Identify market gaps/barriers and potential solutions to address gaps/barriers:** Focusing on mitigation recommendations that could be implemented for whole or partial gaps and barriers. Identifying the party or parties that would be responsible for implementing the solution or corrective action necessary to address the gap or barrier. Keeping in mind that there may be some market gaps barriers for which there is no immediate mitigating solution.

Work Flow (2 of 2)

Phase 2

- **Grid impacts of light duty plug-in electric vehicles:** Considering a variety of impacts including generation, energy, transmission/distribution, ancillary services, losses, increased RPS procurement.

Phase 3 – Part A

- **Grid impacts of commercial and non-road vehicles and technologies:** Considering a variety of impacts including generation, energy, transmission/distribution, ancillary services, losses, increased RPS procurement.
- **Identify market gaps/barriers and potential solutions to address gaps/barriers:** Focusing on mitigation recommendations that could be implemented for whole or partial gaps and barriers. Identifying the utility based solutions or corrective actions to address the gap or barrier. Keeping in mind that there may be some market gaps barriers for which there is no immediate mitigating solution.

Costs and Benefits of Electrification Technologies

Electrification Technologies

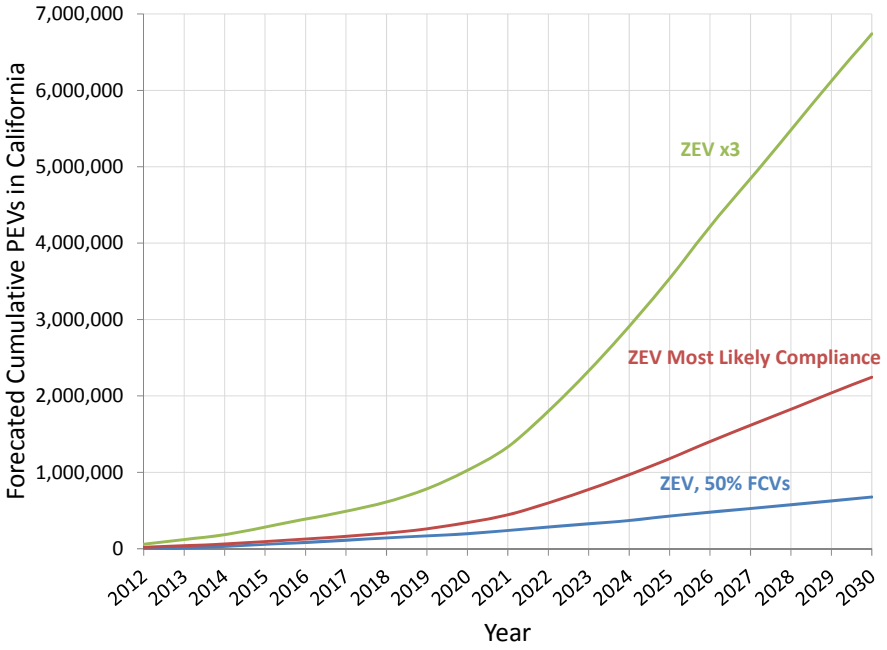
Detailed Forecasting Update and Cost Analysis	Detailed Forecasting Update	Projection to 2030 from Previous Forecast
• *PEVs (PHEVs and BEVs)* • **Forklifts** • **Truck Stop Electrification** • **Transportation Refrigeration Units** *Italic – Phase 2* **Bold – Phase 3**	• Shore Power • Port Cargo Handling Equipment • Airport Ground Support Equipment • High Speed Rail • Light (including trolley buses) and Heavy Passenger Rail (BART, LA Metro, SDMTS) • Commuter Rail (Caltrain) • Dual Mode Catenary Trucks on I-710/SR60 • **Medium- and Heavy-Duty Vehicles**	• Lawn & Garden • Sweepers/Scrubbers • Burnishers • Tow Tractors/Industrial Tugs • Personnel/Burden Carriers • Turf Trucks • Golf carts

Detailed Forecasting

- **Detailed forecasting includes the following:**
  - Literature review to reassess the current market and future market conditions
  - Contacting industry and government experts (including ARB, CEC and EPA) to characterize the future market conditions and regulatory drivers
  - Forecasting future populations and GWh of electricity consumption for three cases:
    - "In Line with Current Adoption" is a low case based on anticipated market growth, expected incentive programs, and compliance with existing regulations; for build/no-build projects like HSR and I-710 catenary could be zero
    - "Aggressive Adoption" is a high case based on aggressive new incentive programs and/or regulations and make sure the high cases are tangibly aggressive and not simply hypothetical maximum
    - "In Between" is a medium case that will fall somewhere in the middle and will vary by technology
  - A working group consisting of utility representatives helped review the electrification forecasts prior to calculation of benefits and costs

PEV Forecasts – Three Scenarios representing range of adoption

- **ZEV Program with 50% Compliance from FCVs:** Compliance with the Zero Emission Vehicle Program and modifying the most likely compliance scenario to achieve 50% compliance from FCVs.
- **ZEV Program "Most Likely Compliance Scenario" from CARB:** In the development of the Zero Emission Vehicle Program, CARB staff developed a most likely compliance scenario. There were some modifications to this scenario to reflect recent PEV sales data.
- **ZEV Program Scenario x 3:** This scenario is a factor of three larger than the ZEV program's most likely compliance scenario.



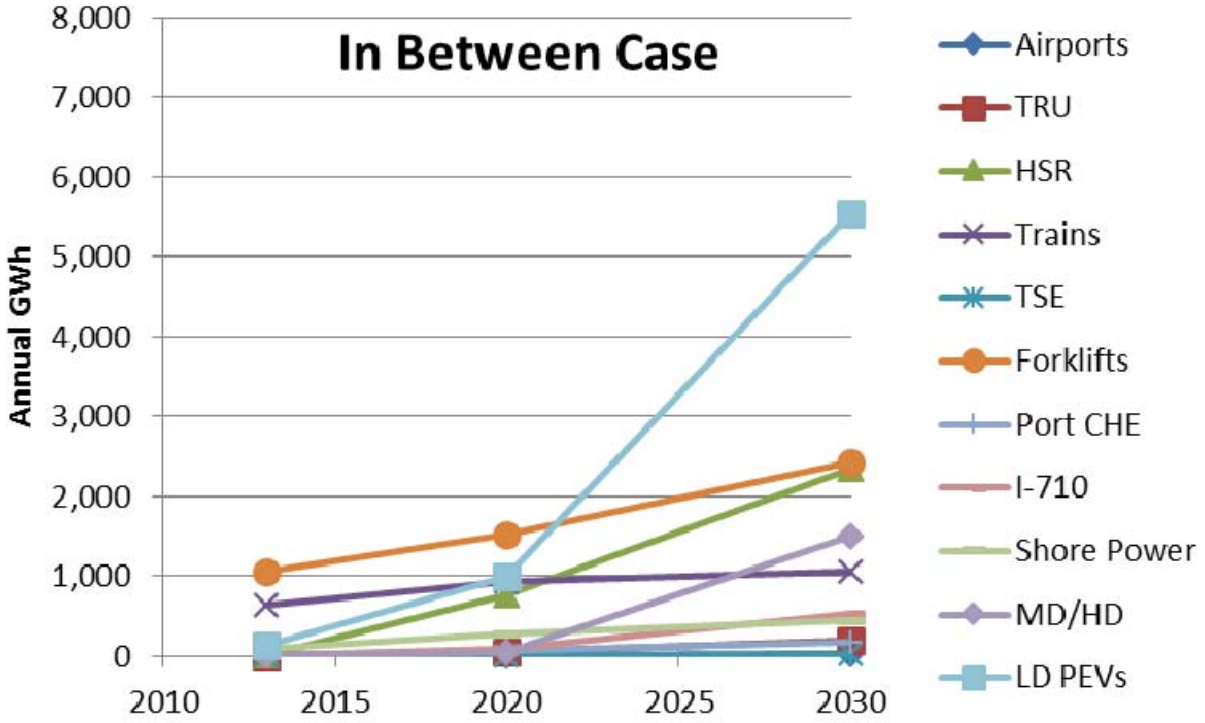
Costs and Benefits of Electrification Technologies

- **Based on the projected GWh and populations for each technology and their comparison conventional fuel technologies, the following societal benefits were calculated for all technologies:**
  - GHG emission reductions
  - Criteria pollutant emission reductions
  - Petroleum displacement
- **The lifecycle cost or savings of electric technologies were analyzed by including the following aspects of lifecycle cost:**
  - Equipment costs
  - Infrastructure costs
  - Operations and maintenance
  - Fuel costs
  - Equipment lifetime

Overview of Results

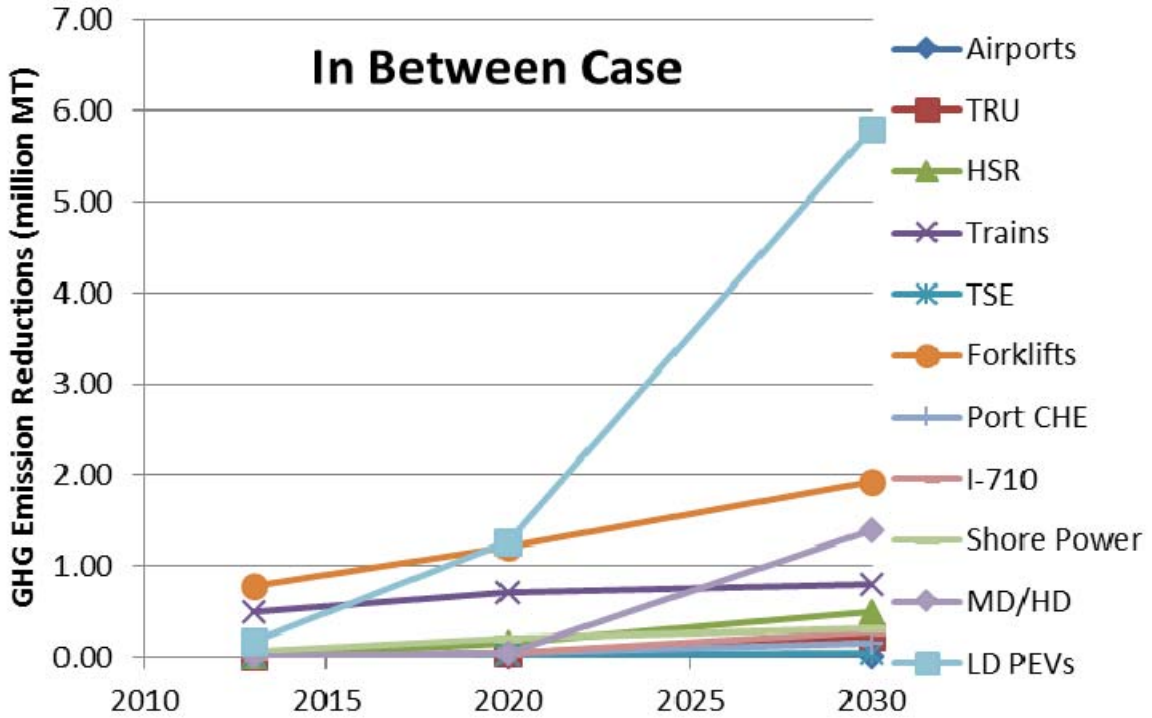
Electricity Consumption, GHG Emission Reductions

Electricity Consumption



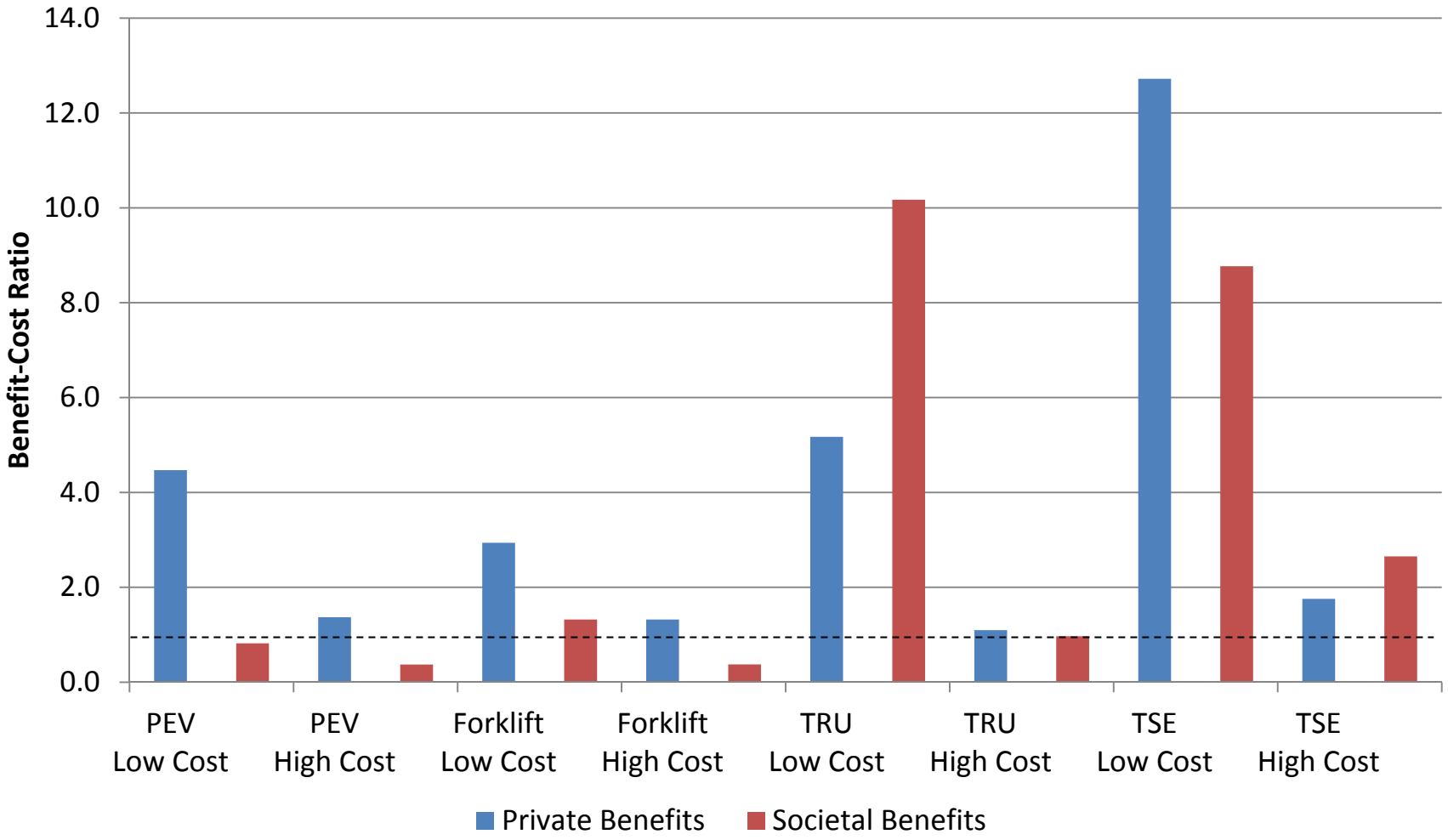
Total Annual GWh	2013	2020	2030
In Line with Current Adoption	1,966	3,702	6,372
In Between	1,966	4,774	14,261
Aggressive Adoption	1,966	7,296	34,238

Greenhouse Gas Emission Reductions



Total Annual GHG Reductions (MMT)	2013	2020	2030
In Line with Current Adoption	1.53	2.73	4.92
In Between	1.53	3.75	11.4
Aggressive Adoption	1.53	6.71	28.7

Benefit-Cost Ratio of Select TE Technologies



Energy+Environmental Economics

Transportation Electrification Cost-benefit Analysis

CPUC SB 350 Workshop
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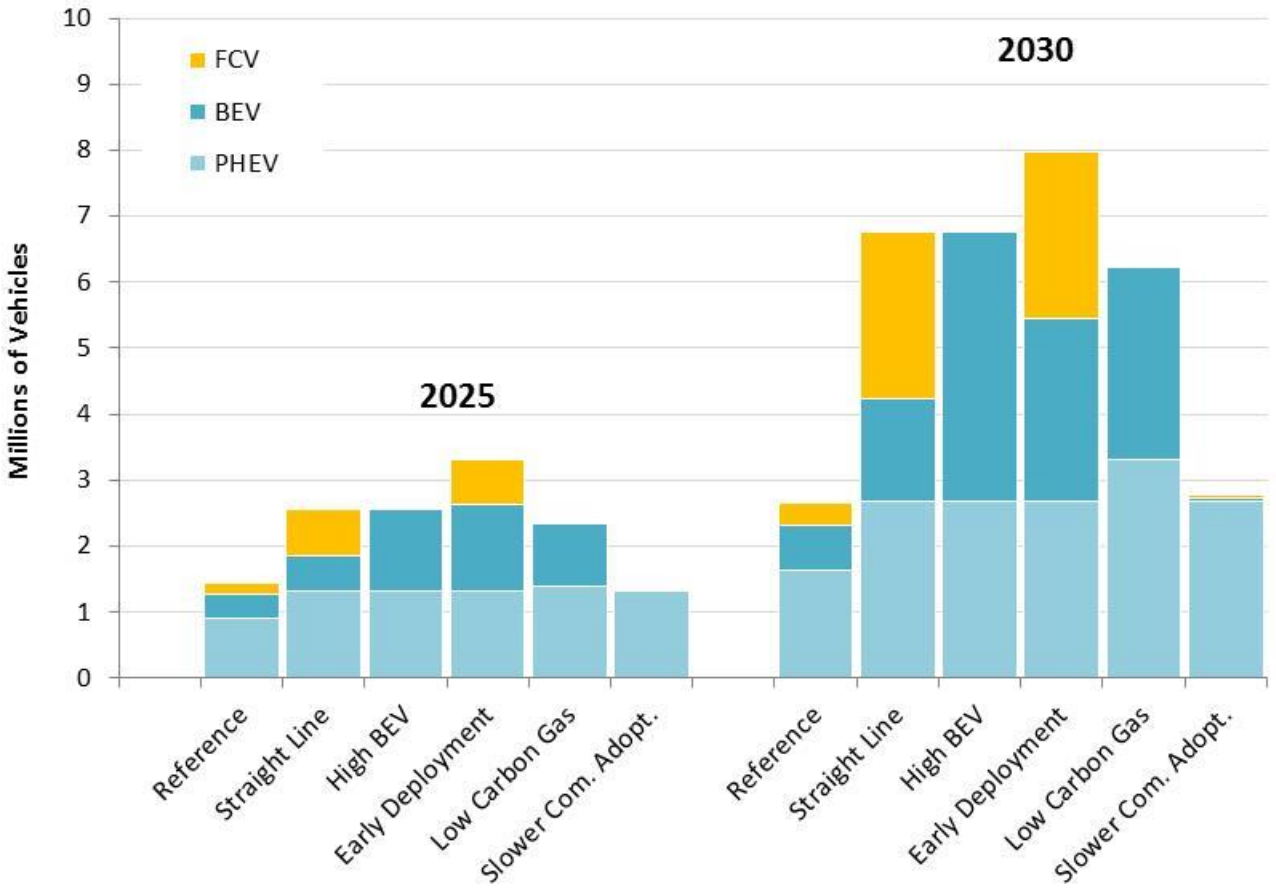
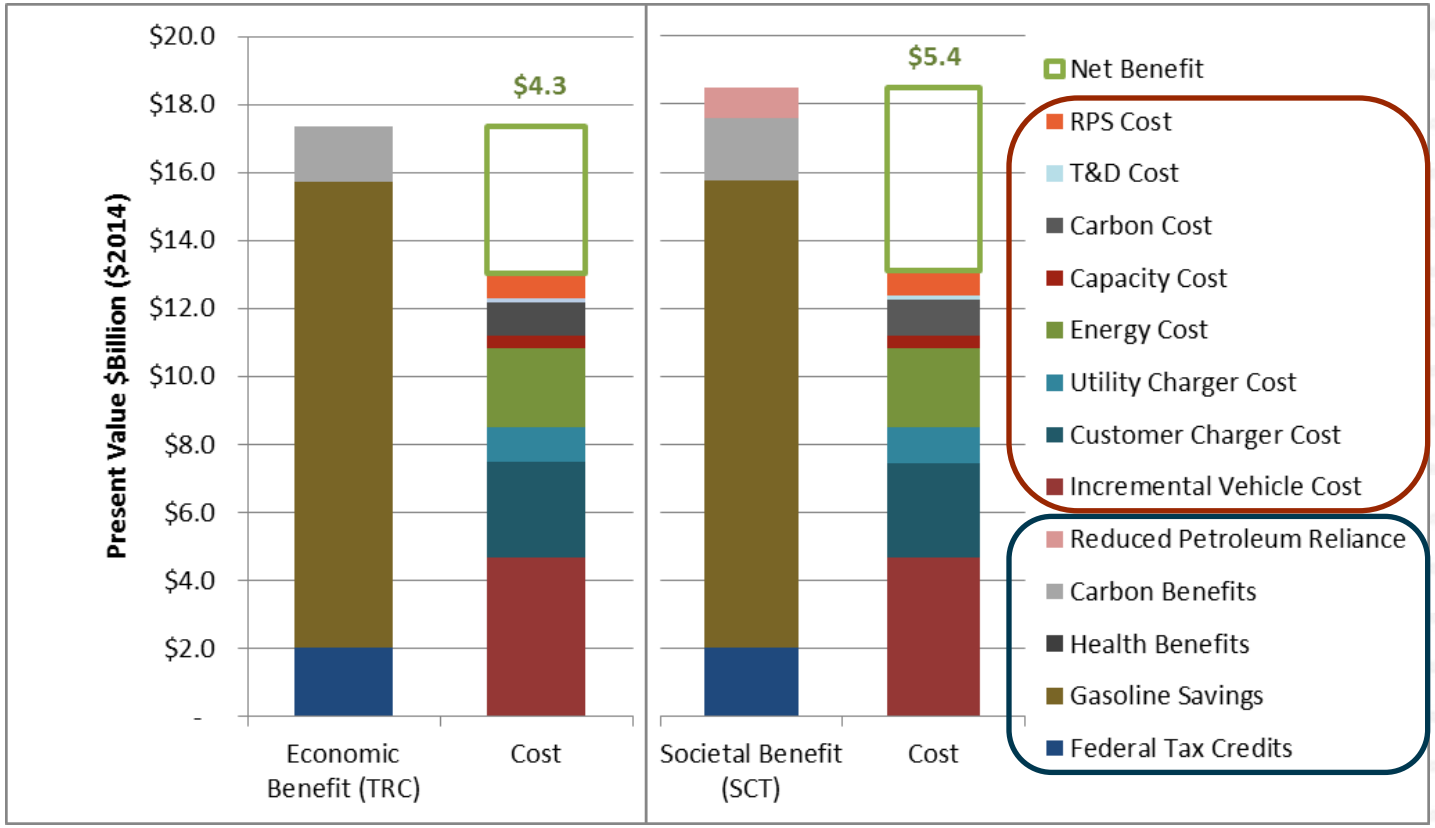
Director, Distributed Energy Resources

CA Pathways Modeling - LDV



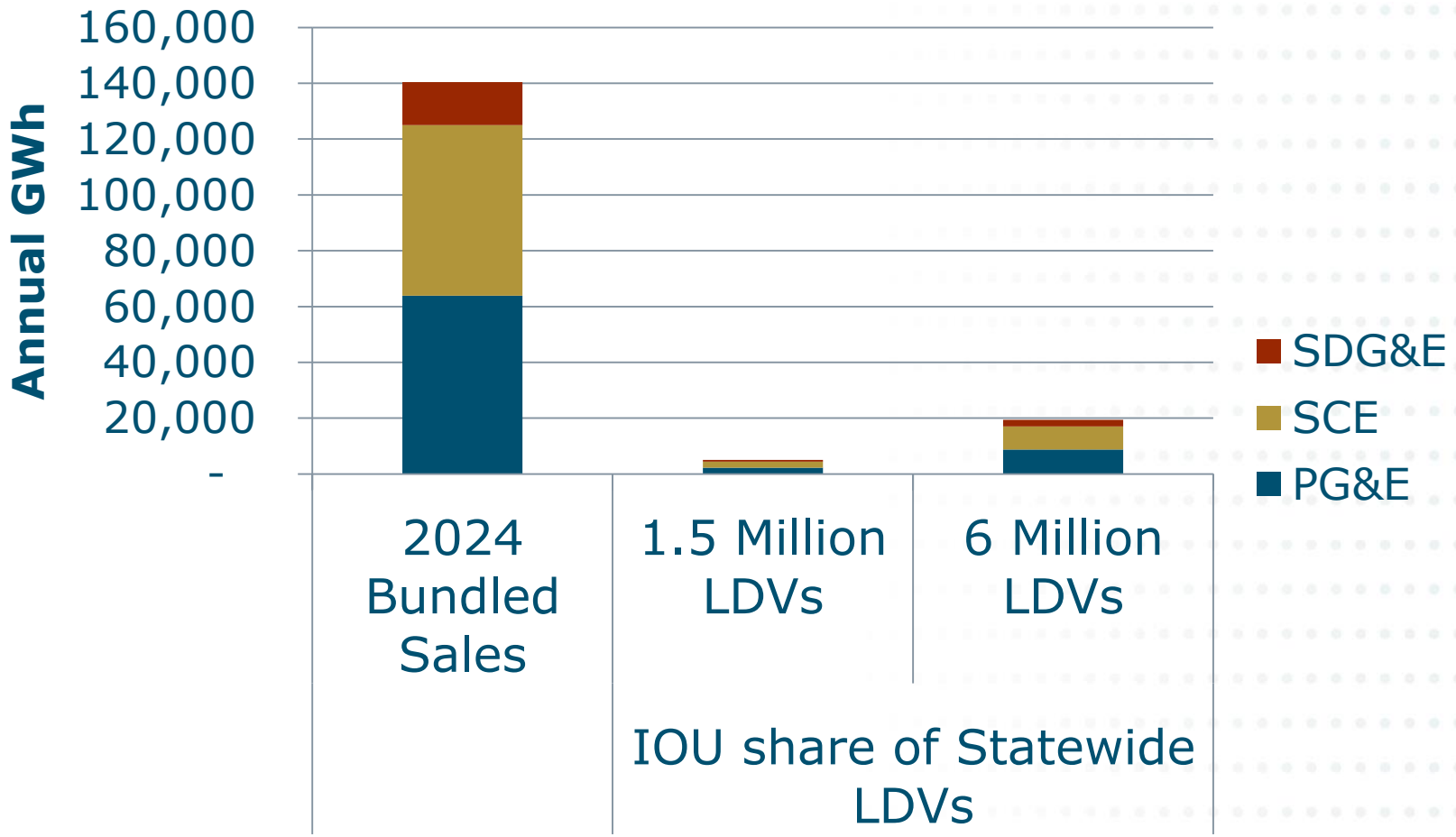
+ ~ 2 million PEVs by 2025 and 4-7 million by 2030
+ New vehicle sales: ~40% by 2025 and 60% by 2030

Costs and benefits - LDV

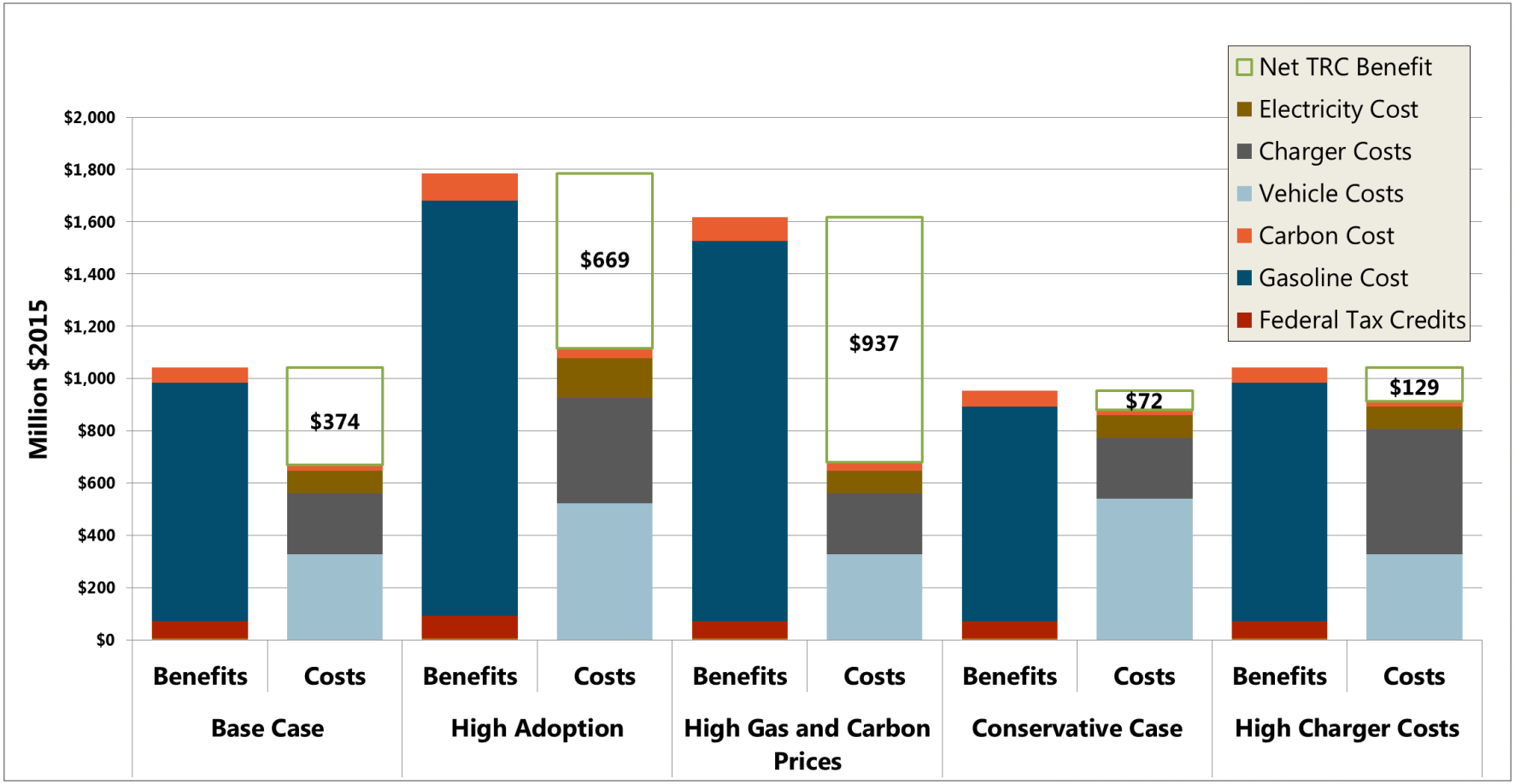


- 'ZEV Most Likely' LDV adoption 2015-2030
- Present Value TRC and SCT benefits of $4.3 and $5.4 Billion respectively

EV loads are manageable

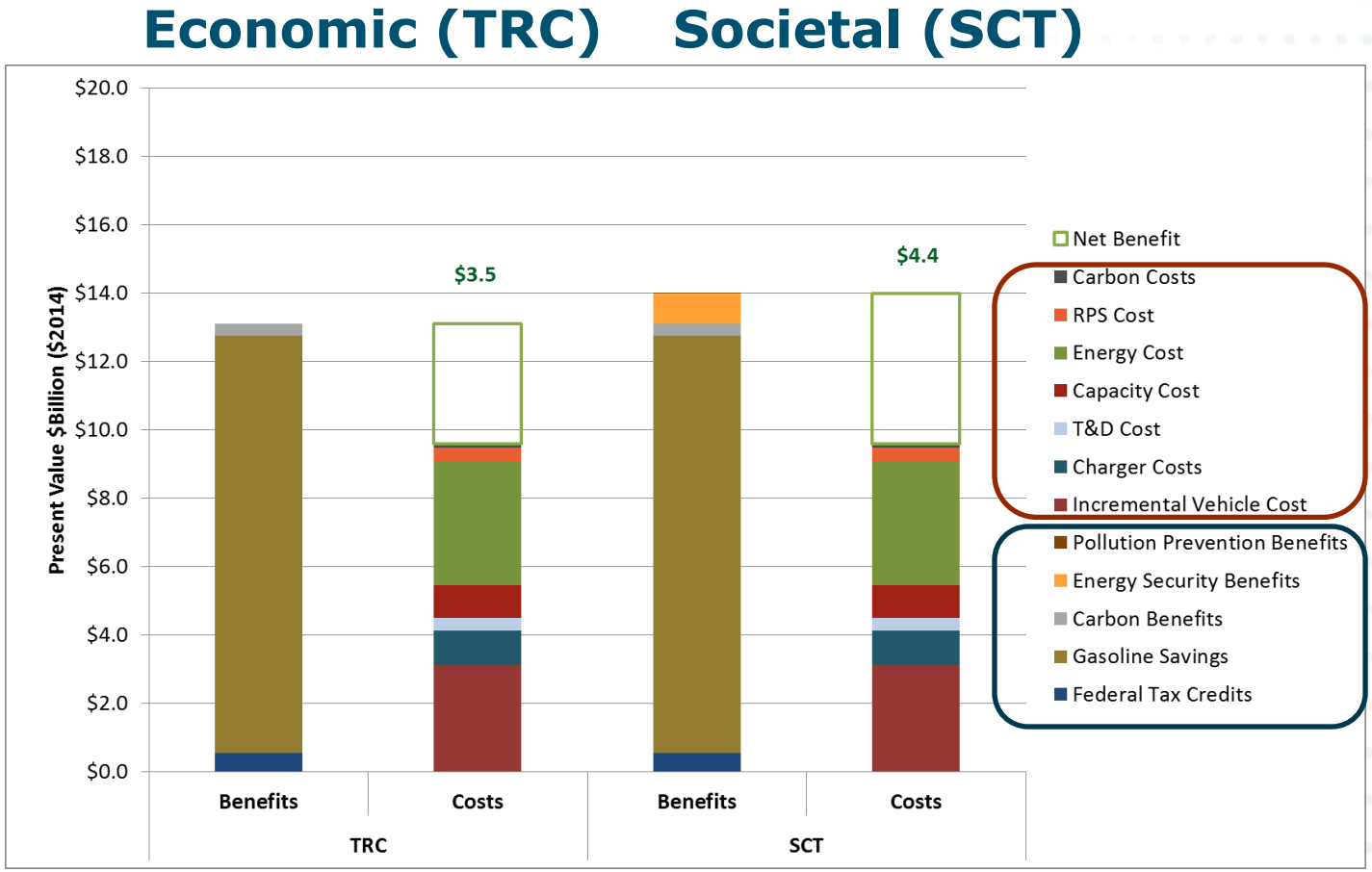


Net economic benefits are robust across multiple scenarios



+ **Pacific Northwest: net economic (TRC) benefits for Seattle City Light (2015-2030)**

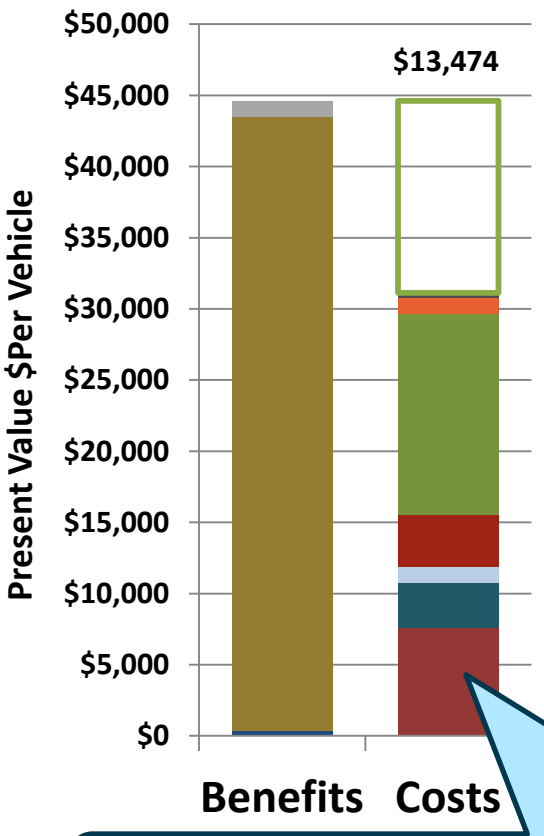
Costs and benefits – MDV & HDV



- **Present Value TRC and SCT benefits of $3.5 and $4.4 Billion respectively (2015-2030)**

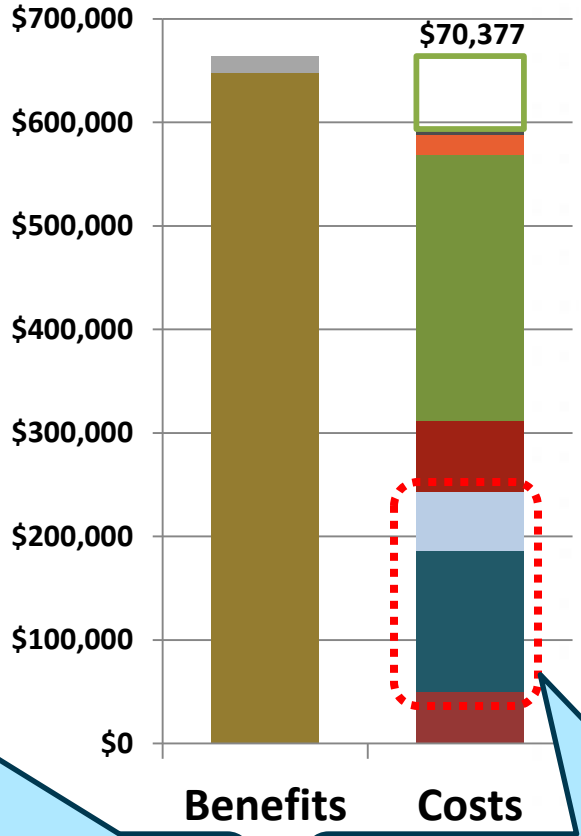
MDV/HDV sectors are very diverse

Medium Duty Trucks



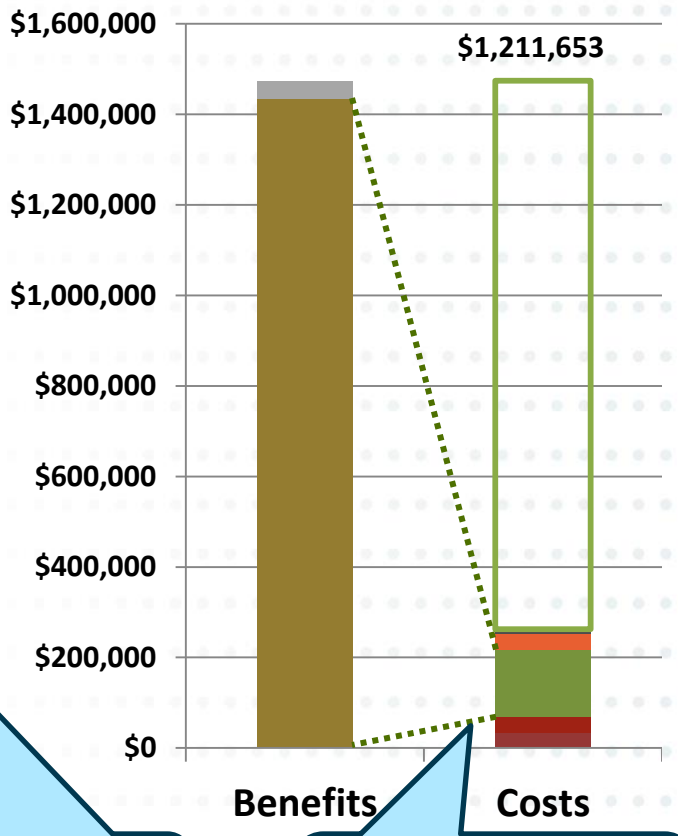
Vehicle cost and availability varies widely

Busses



High Charging Demand (kW)

Truck Stop Electrification



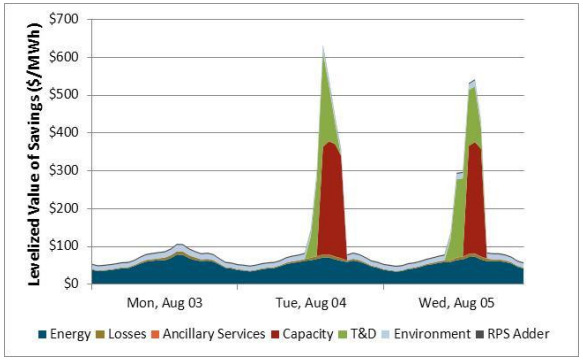
Avoid inefficient idling

Key Drivers and Uncertainties

	Key drivers of net-benefits	Key levers to drive benefits
	Vehicle adoption and utilization	Cost & performance Convenient charging
	Charger utilization	Performance & location Business model
	Charging infrastructure costs	'Make-ready' costs Charging level Public chargers per car
	Distribution infrastructure costs	Managed charging Charger utilization Charging level

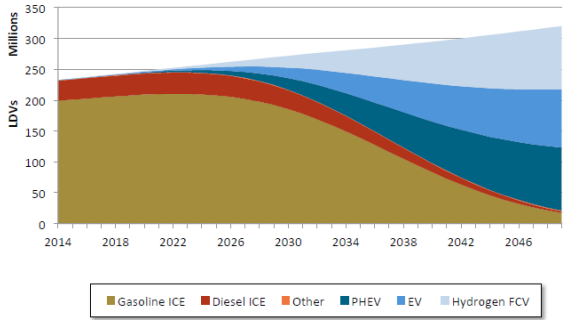
'Cost-effectiveness' is changing across multiple proceedings

+ Cost-effectiveness Framework



- reduce cost and emissions required to meet forecasted loads with distributed energy resources
- Compare cost of delivered electricity to conventional resource plan (*$/kWh, $/kW-Yr.*)
- Evaluate marginal changes in energy sector

+ GHG Reduction Goals



- Minimize costs to achieve forecasted GHG reductions across energy, transportation and industrial sectors
- Compare cost of carbon reduction in transformational resource plans (*Hint: not just comparing $/ton*)
- Evaluate systemic changes across multiple sectors

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Thank You!

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