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CEC CTP Benefits Analysis: 2021 Results for the IEPR Workshop

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July 30, 2021

Executive Summary – IEPR Workshop

<u>Overview</u>

Methods Updates

Expected Benefits Results

Market Transformation Results

CEC CTP Benefits Overview

NREL was contracted in 2012 to assess annual benefits of the CTP (formerly ARFVTP) for the California Energy Commission

Expected Benefits (annual and cumulative)

- Petroleum reductions
- GHG emissions
- Other pollutants (e.g., NOx, PM2.5)

Benefits directly associated with vehicles and fuels deployed through projects receiving CTP funds

Market Transformation Benefits

- Increased infrastructure availability
- Enhanced industry capability and know how
- Building upon success

Benefits from the influence of CTP projects on future market conditions to accelerate the adoption of new technologies

Benefits are estimated for projects funded by the State of California and administered by the California Energy Commission under the Clean Transportation Program.

Note: Many non-CEC CTP funding mechanisms may support these clean transportation projects (e.g., CARB's LCFS, Federal tax incentives). This analysis does not attempt to allocate benefits from a project according to these funding mechanisms, rather it attempts to accurately estimate potential benefits from any project the CEC CTP funding supports.

CEC Clean Transportation Program Project Classification for Benefits Analysis

Fueling Infrastructure

- EVSE
- Non-EVSE

Vehicles

- Light-Duty BEVs/PHEVs
- Manufacturing
- MD-HD Truck Demonstration
- NG Commercial Trucks
- CVRP and HVIP Support

Fuel Production

- Biomethane
- Diesel Substitutes
- Gasoline Substitutes

CEC CTP Project Data

- Funding
- Fuel / infrastructure throughput
- Fuel life-cycle carbon intensity
- Project lifetime
- Vehicle type

NREL Modeling and Analysis

- Vehicle stock modeling
- Vehicle adoption modeling
- Emissions accounting

Benefits by Metric

- Petroleum reduction
- Emission (GHG, PM2.5, NOx) reductions
- Equity / Social benefits

Benefits (e.g., petroleum fuel reductions and greenhouse gas emission reductions) are calculated differently for each category of project

Metrics used to assess the CTP benefits

Benefit Metric	2012-2019 Benefits Analysis: Expected Benefits	2012-2019 Benefits Analysis: Market Transformation	2021 Benefits Analysis (this analysis): Expected Benefits	2021 Benefits Analysis (this analysis): Market Transformation
Petroleum Reductions	✓	✓	✓	✓
GHG Reductions	✓	✓	✓	✓
NOx	✓ (V, FI)		✓ (V, FI)	✓
PM2.5	✓ (V, FI)		✓ (V, FI)	✓
Monetized NOx/PM2.5 benefits	✓ (V, FI)		✓ (V, FI)	✓
Regionalized NOx/PM2.5 benefits	✓ (FI)		✓ (FI)	✓ (V)
Equity	✓ (FI)		✓ (V, FI)	✓ (V)
Job Creation			✓	

Metrics quantified for new categories and new metrics added to better quantify high-interest areas from CEC and stakeholders

FI: Fueling Infrastructure
V: Vehicles
FP: Fuel Production
Green: New/added in 2021

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Extract Transform & Load (ETL)

- Demonstrated Throughputs
  - "Throughput" or "Usage" has been updated with guidance to rely on measured production rather than an assumed funded production.
  - This includes the annualization of observed production.
- CALeVIP inclusion (1824 synthetic EVCS sites / 5423 Charge Ports)
  - Non-planned CALeVIP rebate funding has been included with the assumptions:
  - Rebate money that was allocated but currently not spent was used to determine how many EVCS would be established with the remaining funds.
  - The new stations were randomly distributed to locations proportional to the geographical distribution of currently established stations.
  - Roll out was done in a linear time span from now to the expected end of the project.
  - Distribution of L2/DCFC mirrors the historical breakdown between the two levels.

EVSE Station Utilization

	(kWh) in per plug per day	E-miles in per plug per day (*0.25 kWh/mile)	New Data: E-miles in a year per plug	Connected Time (hours) per plug per day	Connected Time (hours) in a week per plug	2019 Data: E-miles in a year per plug
Public L2	7.8	31	**11,421**	2.33	16.33	15,948 (com) 11,093 (res)
Public DC	73.4	294	**107,224**	2.58	18.04	67,690

$$Emiles_{year\_1} = 11{,}471 \times L2_{pub} + 107{,}224 \times DC_{pub}$$

$Emiles_{year\_1} =$ Electric annual vehicle-miles supported by public charging stations (#)

$L2_{pub} =$ total number of public L2 plugs or ports (#)

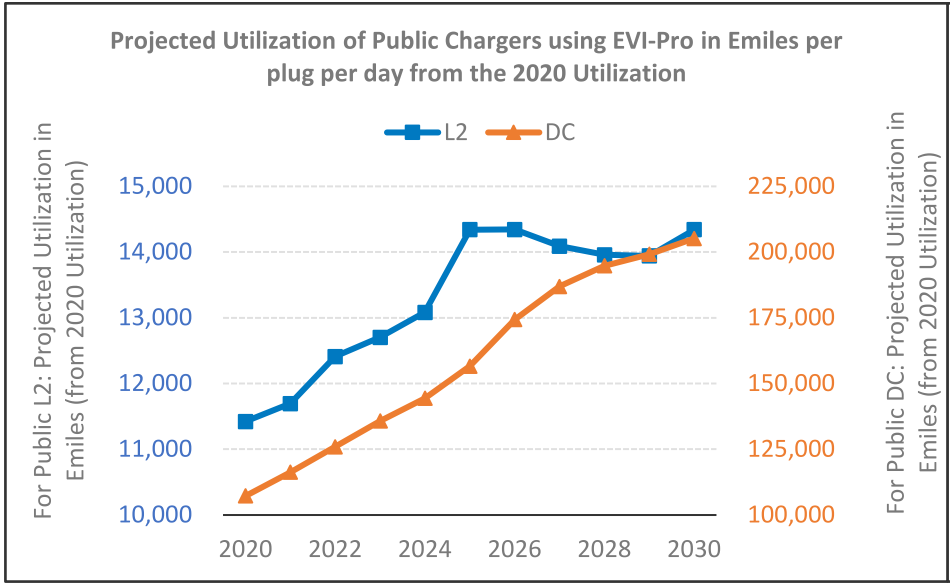
$DC_{pub} =$ total number of public DC plugs or ports (#)

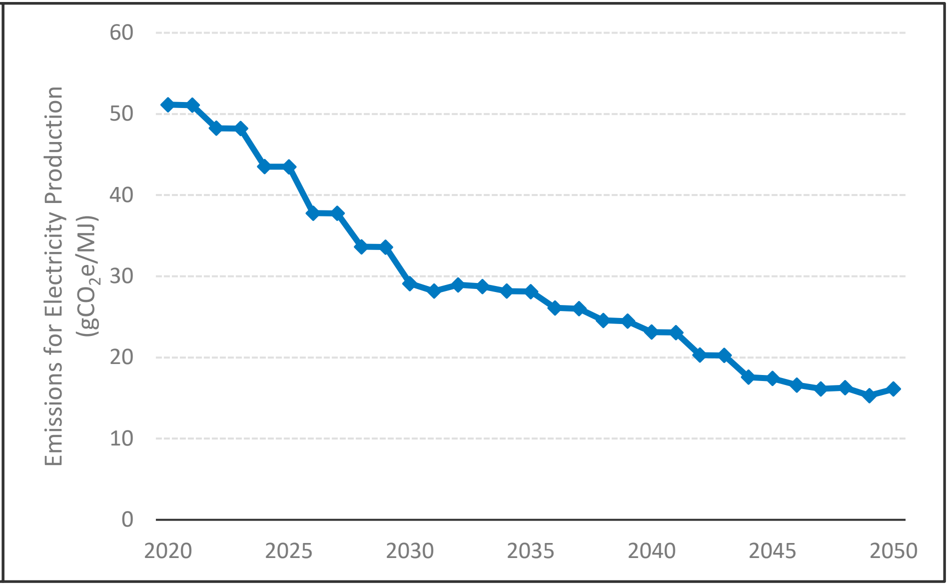
Methods

- Pre-2021 analysis used EVI-Pro estimations of charger utilization
- This 2021 iteration uses demonstrated usage data from EVSE stations in California (charging sessions data from 2016 to 2019)
- For L2: about 1 million charging sessions
- For DC: about 4 million charging sessions
- Values reviewed with NREL experts overseeing AFDC
- Possible update with location specific utilization

Source: AFDC Stations Data (ChargePoint, EVgo, Greenlots, eCharge Network, EV Charging Solutions)

Projections for EVSE Station Utilization and CA Grid Intensity





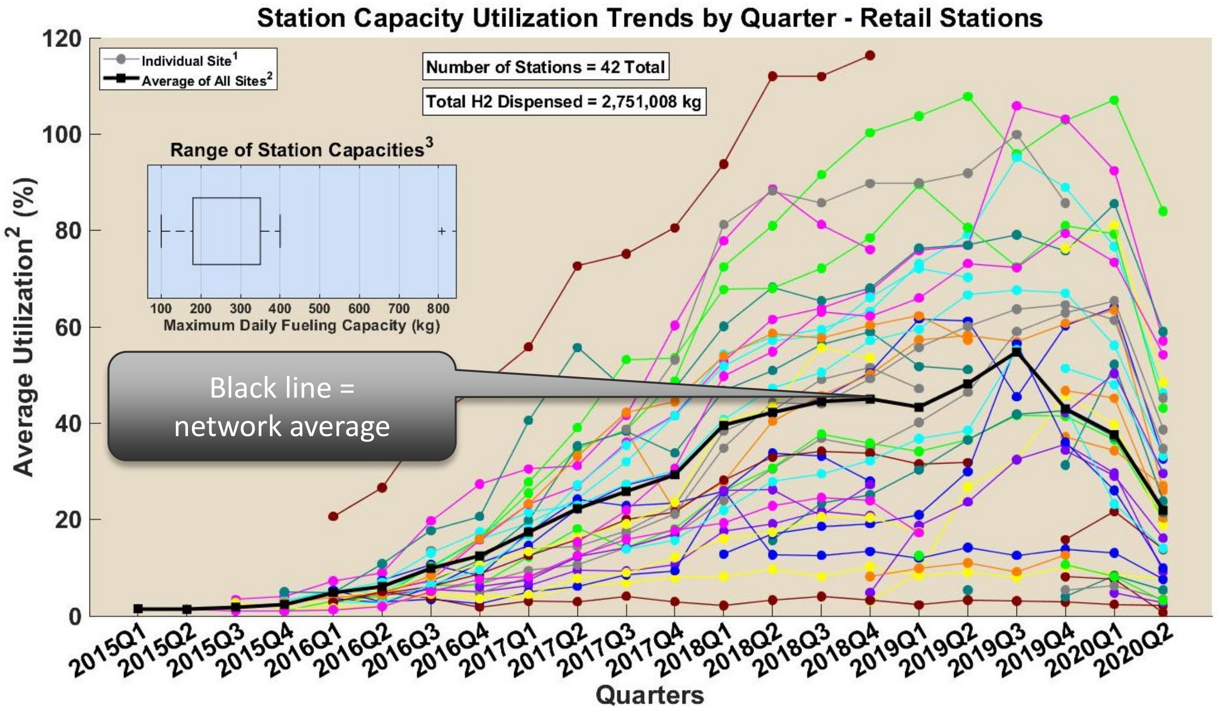
Projections

- Using EVI-Pro2 projections of charger utilization (per plug per day) in future, assuming DC power rating of 50kW
- Estimated the change in the utilization compared to the 2020 utilization

NREL's Cambium contains

- The hourly and annual data on electricity production
- Carbon intensity of a grid
- For CA: A mid-case scenario is selected
- Source: https://cambium.nrel.gov/

Expected Benefits - Hydrogen Refueling Station Utilization and Carbon Intensity Updated



Plotted data from: Genevieve Saur; Spencer Gilleon; Sam Sprik. 2020. *Next Generation Hydrogen Station Composite Data Products: Retail Stations, Data through Quarter 2 of 2020*. https://www.nrel.gov/docs/fy21osti/79141.pdf

Method Updates

- For the 2014-2019 benefits analyses:
  - A 80% utilization of nameplate capacity plateau was assumed after a 5-year ramp up
  - Constant hydrogen GHG intensities were assumed through 2030
- For this 2021 analysis:
  - A 45% utilization plateau used based on NREL hydrogen stations data in CA
  - Project proposals that modeled GHG intensity reductions were incorporated into the analysis

Expected Impact

- Lowing the utilization decreases the estimated petroleum and emission benefits
- Reducing the carbon intensity increases the GHG emissions benefits over time

Social Benefits / Equity – Spatial disaggregation methods to regionalize benefits and perform equity calculations

Spatial Disaggregation:

Approach #1: Fueling Infrastructure Projects

For LD EVSE + hydrogen stations, which include geospatial attributes, we assume most benefits occur in vicinity of the stations

Approach #2: Vehicle Projects

Using Class 8 truck travel data, we disaggregate benefits of vehicle-related projects, assuming a higher penetration of truck instances per census tract area correlates to greater benefits

→

Aggregate to Census Tract

Aggregate benefits to each census tract / legislative district

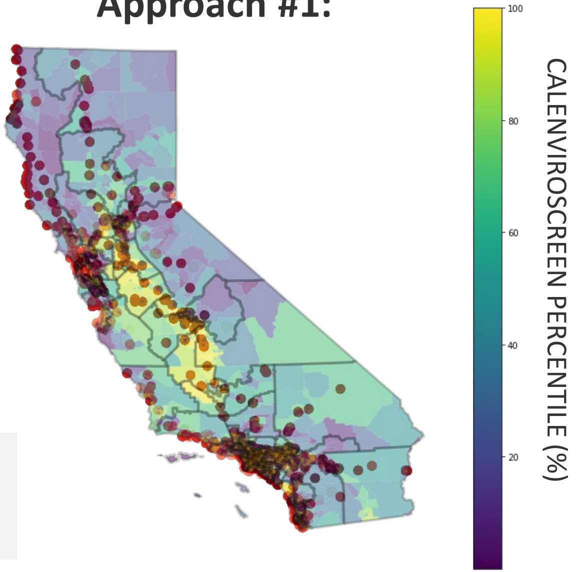
→

Assess Benefits in Disadvantaged Communities

Overlay data of petroleum, GHG PM2.5, and NOx reduction by census tract with CalEnviroScreen 4.0 to see what percentage of benefits occurred in disadvantaged communities

Note: spatial analysis is limited to the Fueling Infrastructure and Vehicles projects (~85% of funding)

Approach #1:



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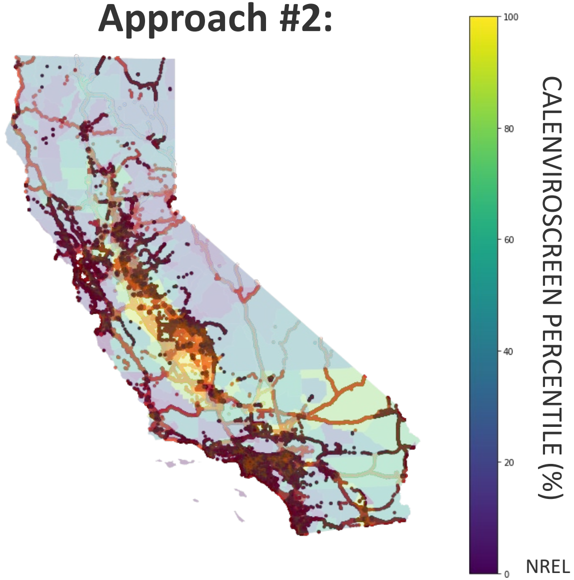


Job Creation: IMPLAN used to quantify employment changes due to CTP investments

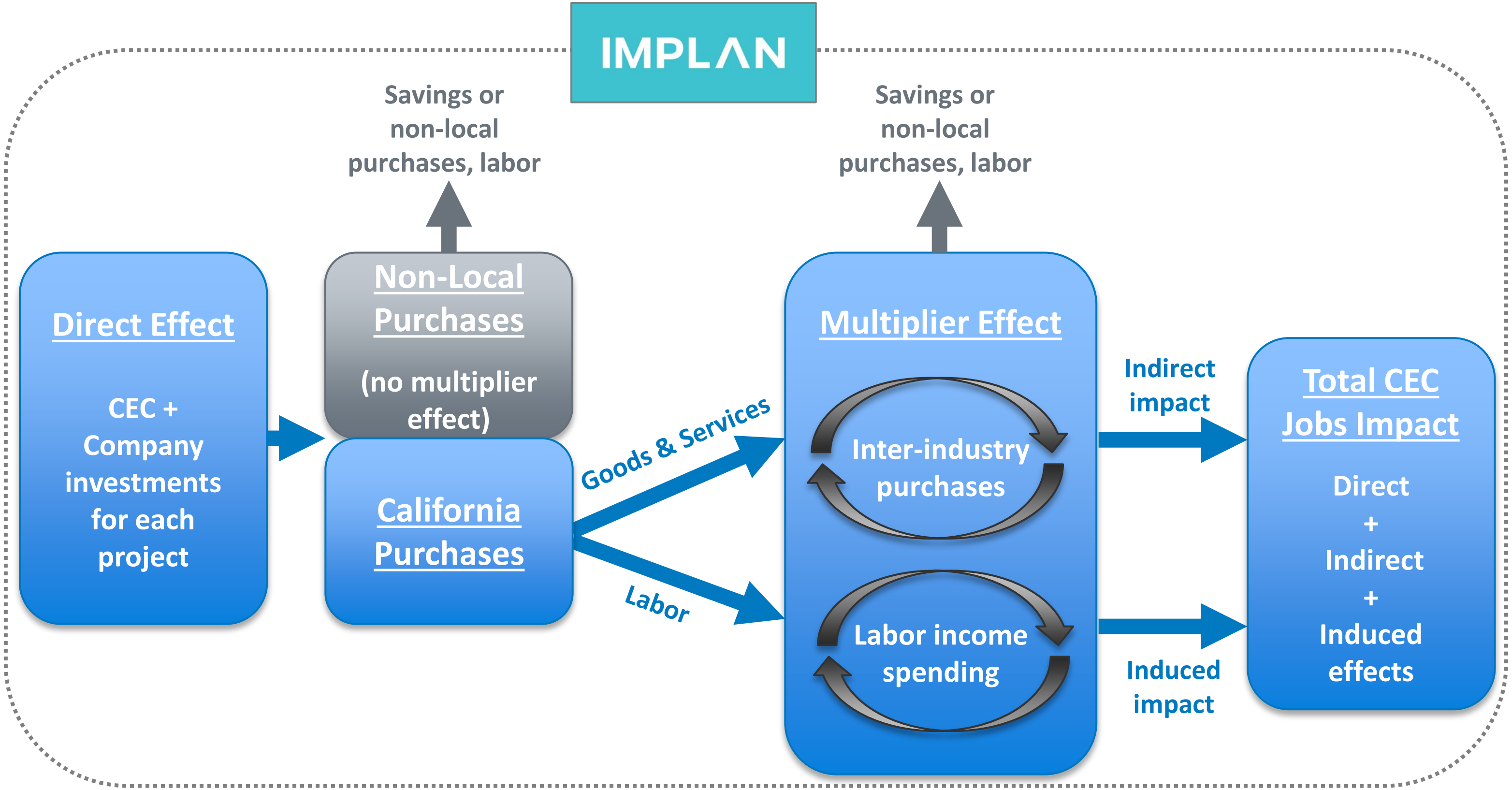
IMPLAN (Economic Impact Analysis for Planning) used to quantify the direct, indirect, and induced job creation (employment) using California-specific multipliers

Inputs:

- CEC investment
- Match investment

Investment Sectors:

- Sector investments based on proposed budgets of the largest project in each class/subclass combination

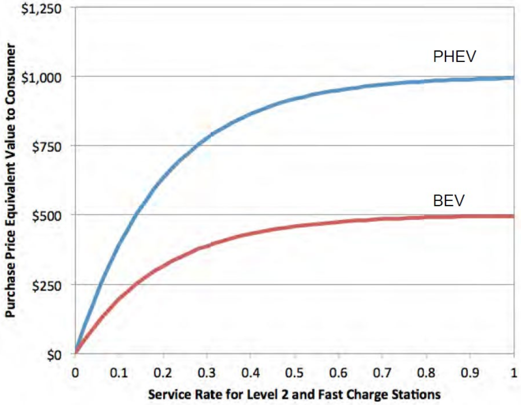


Market Transformation – EVSE Willingness To Pay (WTP)

Updates

- Use of the Greene et al. (2020) "Quantifying the Tangible Value of Public Electric Vehicle Charging Infrastructure" analysis to update EV adoption based on EVSE deployment data

- Past Method: Determines an increase in the perceived value of PEVs as a function of the increased service of recharging
  - Formulae – Value of public EVSE stations (Vc)

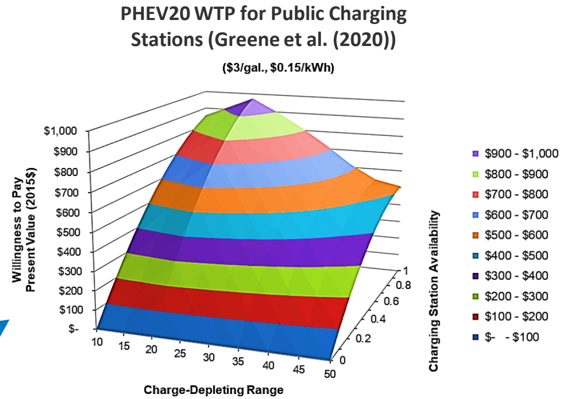


$$V_c = \beta V\left(1 - e^{bf}\right)$$

Where,

β = the coefficient of vehicle price
V = the present value of unlimited public recharging
f = the availability of public EVSE stations relative to gasoline stations
b = slope coefficient

Update with



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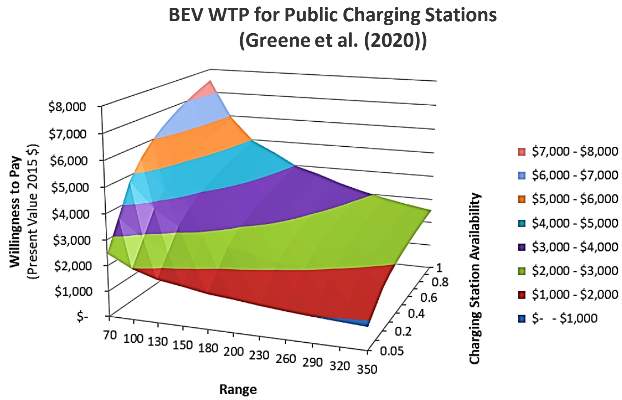
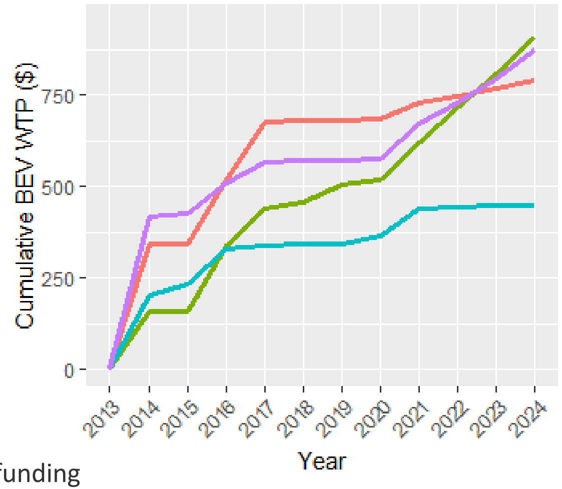


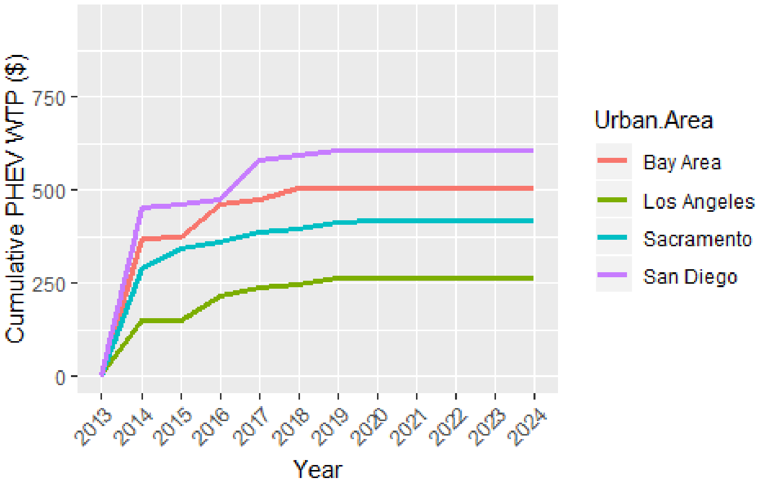
Market Transformation – EVSE Willingness To Pay (WTP)

The move from "perceived value" to the WTP method comes with many enhancements.

- WTP included new factors:
  - PEV Fleet average range
  - Value of time (DCFC vs L2 charging)
  - Value of local charging combined with regional capabilities.
  - Moving from a gas station mode of comparison to a fully electrified mode.

- Assumptions:
  - When public charging, DCFC is expected to be the infrastructure of choice 80% of the time for BEVs.



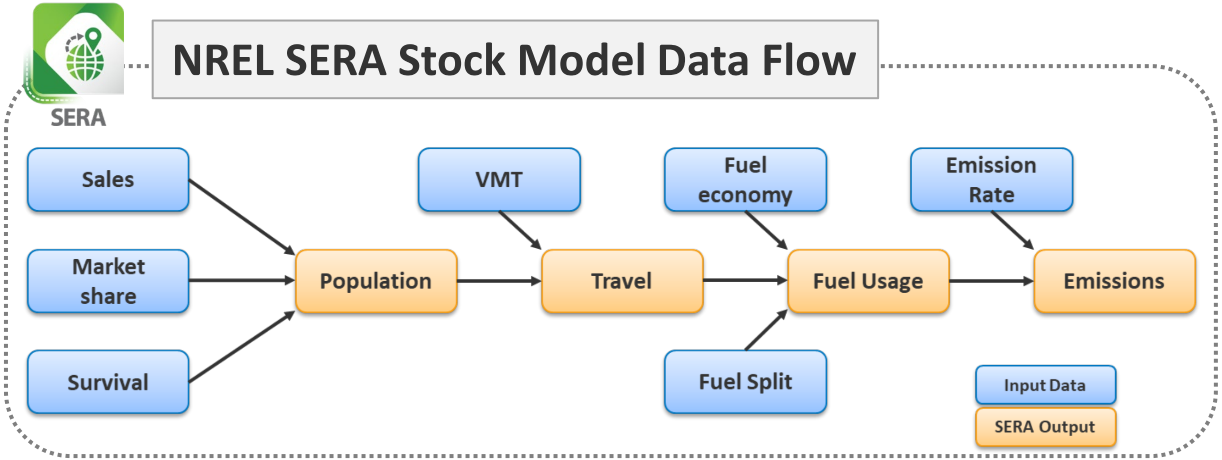


Note: Only includes CTP funding

Market Transformation – General updates to vehicle adoption modeling

Method Updates
- NREL's SERA (Scenario Evaluation and Regionalization Analysis) stock model used and calibrated to CA Vision 2.1
- Market Transformation benefits are implemented on a rolling schedule to account for continued CTP investment over time

Data Updates
- CA Vision 2.1 data used for base market share data
- Purchase price projections updated for HEV, PHEV, and BEV based on CEC Energy Assessments Division data



SERA Model Summary:

✓ SERA model built to match CA Vision Scenario Planning Model (base case scenario; <1% difference in vehicle population)

✓ Computation time in seconds compared to CA Vision 2.1 model tens of minutes

✓ Allows for efficient analysis based on Market Transformation adoption modeling results

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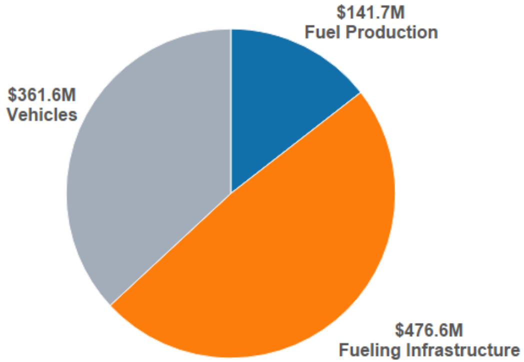
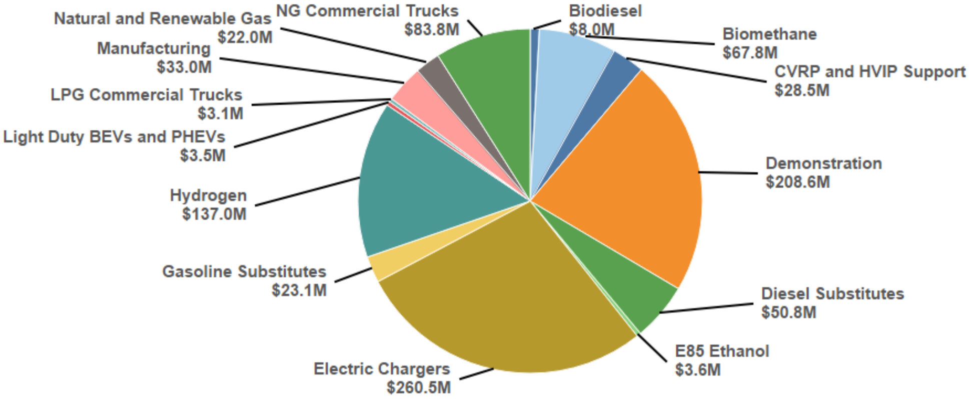
CTP Project Funding Summary

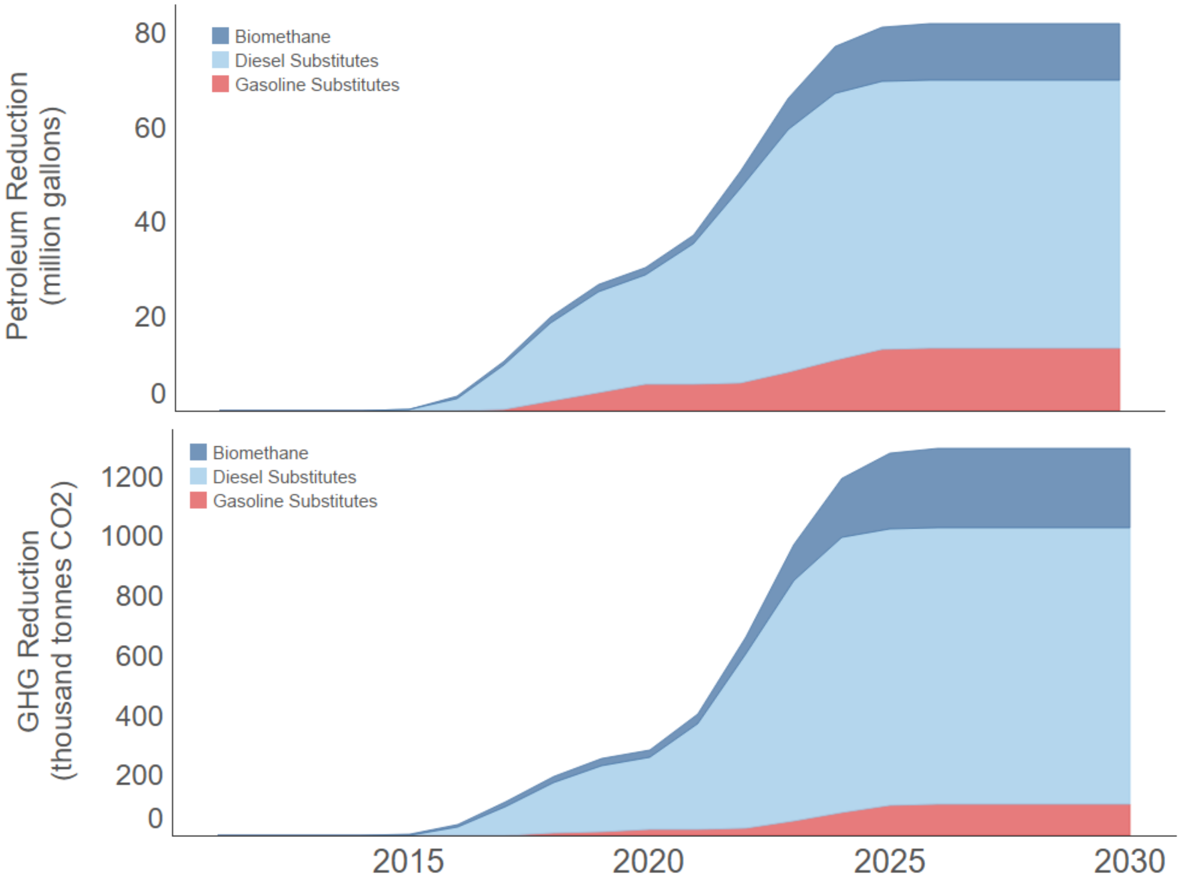




$934M accounted for (vs $671M in the 2019 CTP Benefits Report)

Fueling Infrastructure	Biodiesel	$8.0M
	E85 Ethanol	$3.6M
	Electric Chargers	$260.5M
	Hydrogen	$137.0M
	Natural and Renewable Gas	$22.0M
	Total	$431.1M
Vehicles	CVRP and HVIP Support	$28.5M
	Demonstration	$208.6M
	Light Duty BEVs and PHEVs	$3.5M
	LPG Commercial Trucks	$3.1M
	Manufacturing	$33.0M
	NG Commercial Trucks	$83.8M
	Total	$360.6M
Fuel Production	Biomethane	$67.8M
	Diesel Substitutes	$50.8M
	Gasoline Substitutes	$23.1M
	Total	$141.7M
Grand Total		$933.5M

Expected Benefits – Fuel Production



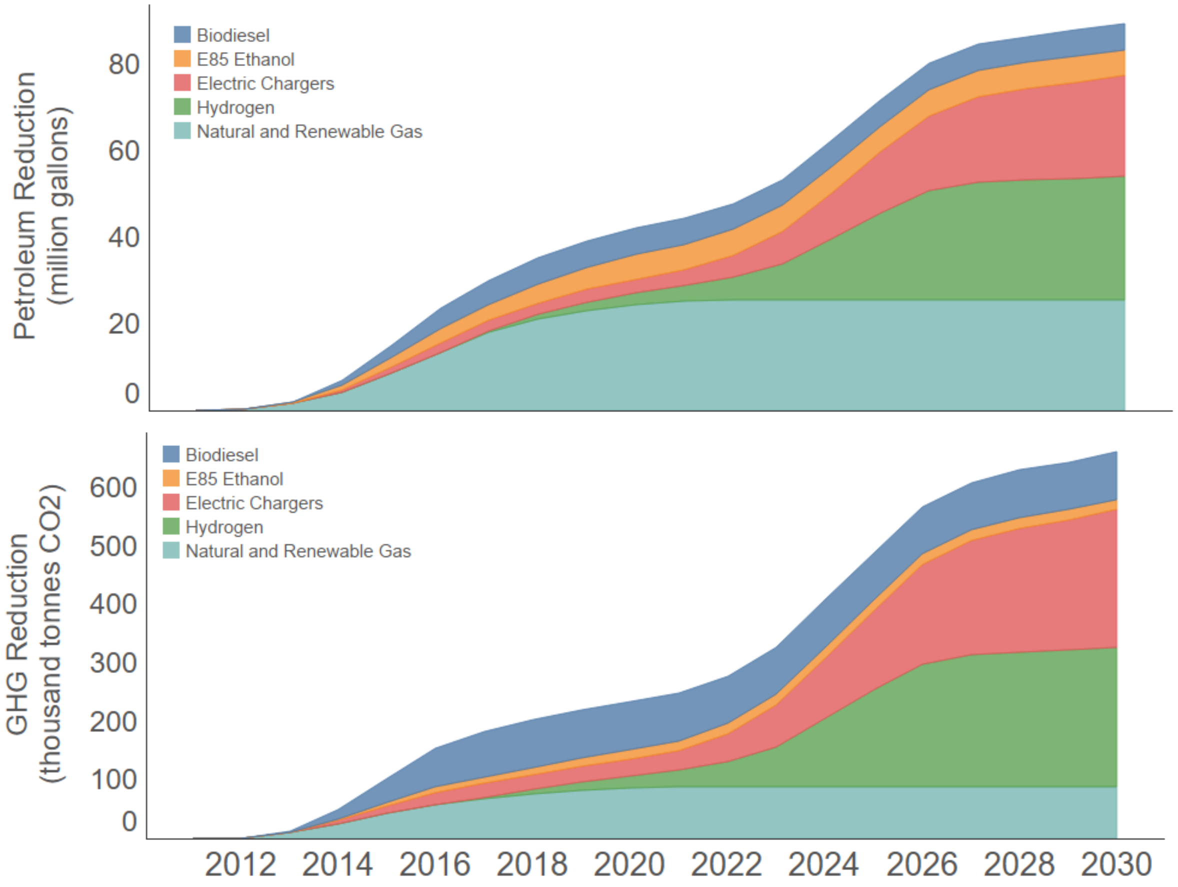
Method:

- Petroleum reduction and GHG emission benefits accrue because the alternative fuels directly displace conventional fuels

Results:

- All fuel production types provide substantial petroleum reduction benefits
- Reductions ramp up over time as fuel production projects achieve target throughput

Expected Benefits – Fueling Infrastructure



Method:

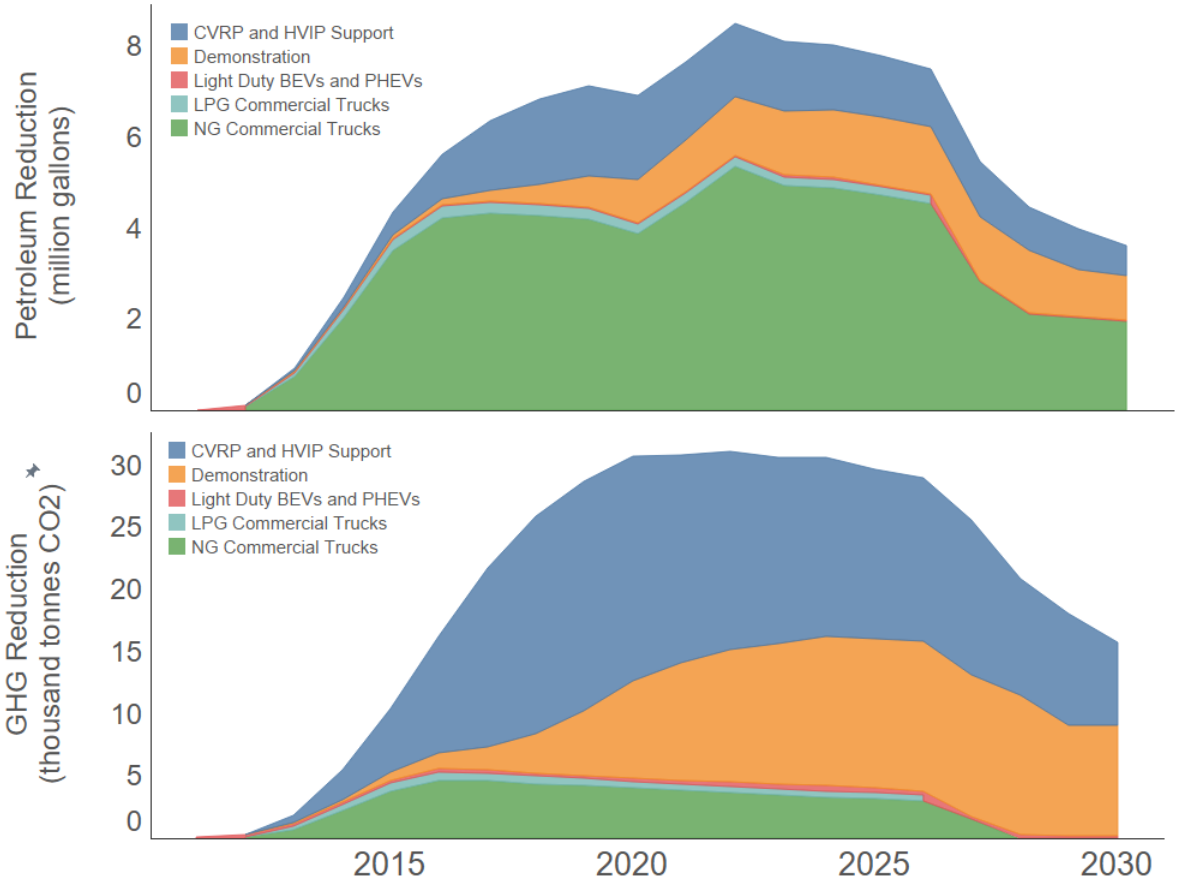
- Fuel throughput at refueling station is converted to an estimate of how many conventional vehicle miles were displaced

- Petroleum reduction and emission (GHG, NOx, PM2.5) benefits accrue because the low-emission vehicle is driven instead of the conventional vehicle

Results:

- Electric charger benefits significantly higher than previous analyses due to updated *e-miles* and grid carbon intensity accounting
- Hydrogen projects have significant benefits due to recent funding opportunity (GFO-19-602) supporting large stations

Expected Benefits – Vehicles



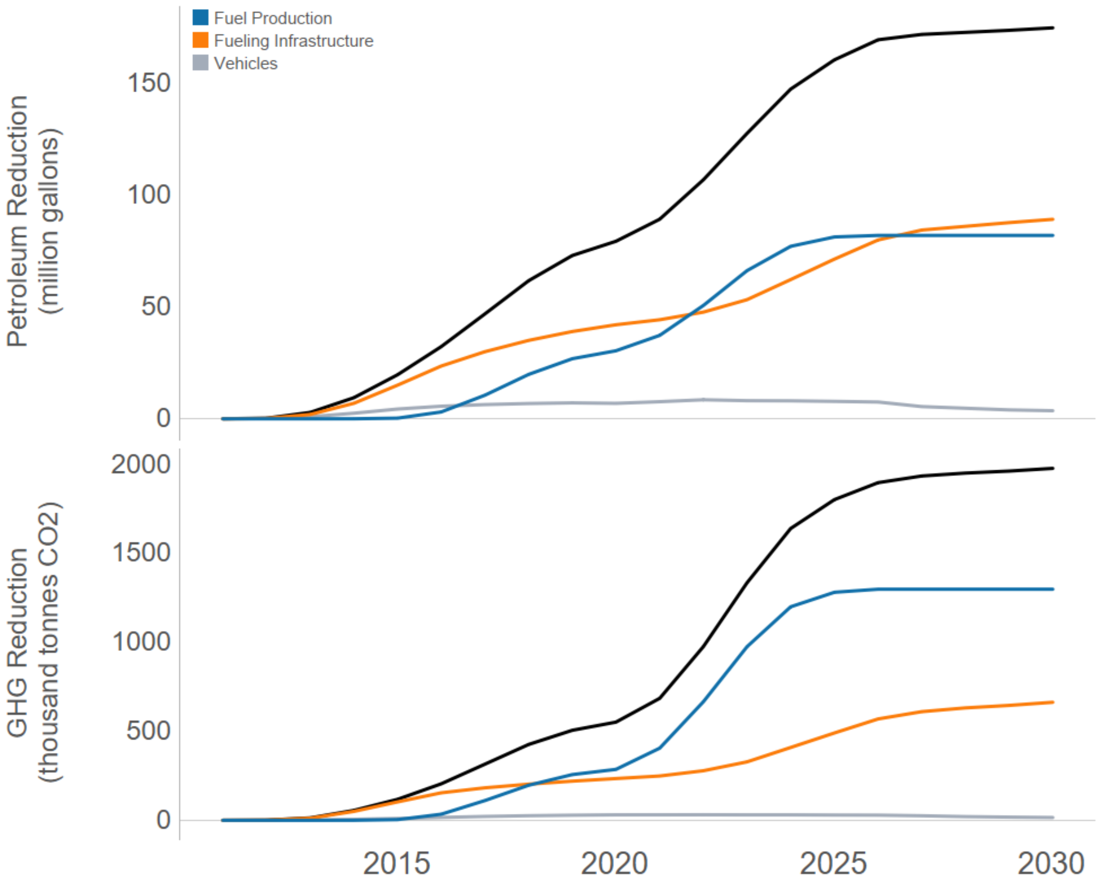
Method:

- Petroleum reduction and emission (GHG, NOx, PM2.5) benefits accrue because the low-emission vehicle is driven instead of the conventional vehicle
- Manufacturing project benefits moved to Market Transformation benefits

Results:

- Natural gas trucks provide significant petroleum reduction due to displacement of commercial vehicles with high diesel fuel consumption
- GHG reduction is dominated by vehicle price rebates due to higher powertrain efficiency and lower carbon intensity electricity

Expected Benefits – Vehicles



Results:

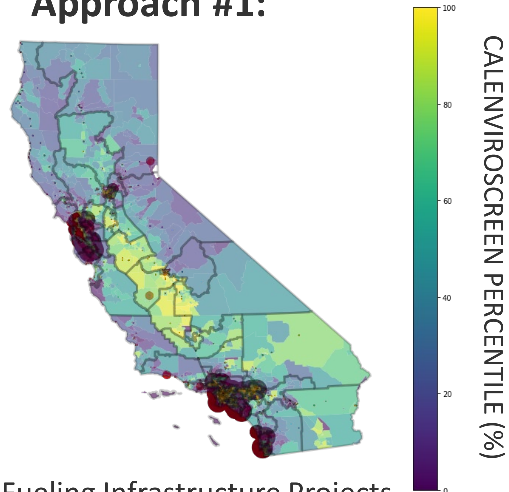
- Fuel production and fueling infrastructure projects result in the largest petroleum reduction and GHG reduction benefits
- Vehicle projects historically were dominated by Manufacturing projects but were accounted for as Market Transformation benefits in this work
- Over 200M gallons of petroleum reduction and 2.5M tonnes of GHG emissions are reduced in 2030

Expected Benefits - Petroleum and GHG Reductions Summary

		Petroleum Reduction (million gallons)				GHG Reduction (thousand tonnes CO2e)			
		2017	**2020**	**2025**	**2030**	**2017**	**2020**	**2025**	**2030**
Fuel Production	Biomethane	0.8	1.6	11.6	12.0	12.8	25.5	250.8	264.4
	Diesel Substitutes	9.5	23.3	56.9	56.9	97.2	241.8	927.8	927.9
	Gasoline Substitutes	0.3	5.5	12.9	13.2	1.0	18.2	99.4	102.8
Fueling Infrastructure	Biodiesel	5.7	6.0	6.0	6.0	77.8	81.0	81.0	81.0
	E85 Ethanol	3.6	5.9	6.0	6.0	10.8	17.8	18.1	18.1
	Electric Chargers	2.6	2.9	14.0	23.2	23.1	27.5	135.4	236.3
	Hydrogen	0.3	2.8	20.1	28.6	2.4	21.5	166.1	237.2
	Natural and Renewable Gas	17.9	24.5	25.5	25.5	68.2	86.2	88.9	88.9
Vehicles	CVRP and HVIP Support	1.5	1.8	1.4	0.7	14.4	18.1	13.6	6.7
	Demonstration	0.2	0.9	1.5	1.0	1.9	7.9	12.0	8.8
	Light Duty BEVs and PHEVs	0.0	0.0	0.0	0.0	0.2	0.2	0.5	0.2
	LPG Commercial Trucks	0.3	0.2	0.2		0.6	0.6	0.5	
	NG Commercial Trucks	4.3	3.9	4.7	2.0	4.6	4.0	3.2	-0.1
Grand Total		47.0	79.5	160.7	175.0	315.0	550.3	1797.2	1972.4

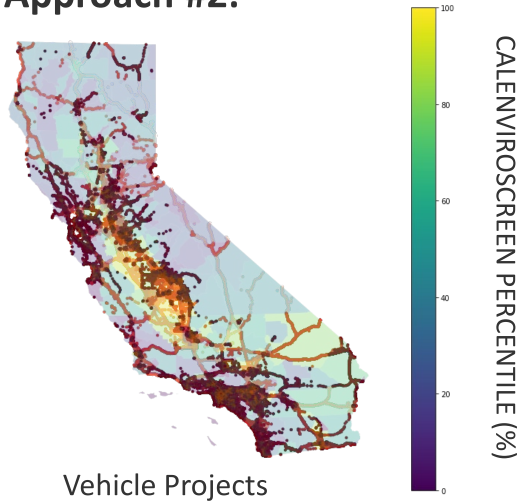
Equity Benefits – Estimating Percentage of Benefits in Disadvantaged Communities

Approach #1:



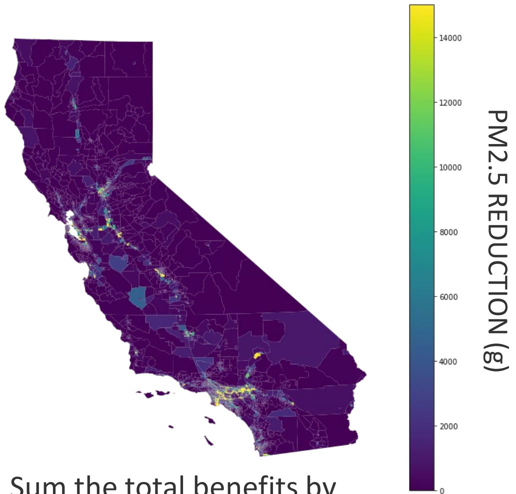
Fueling Infrastructure Projects

Approach #2:



Vehicle Projects

Aggregate to Census Tract



Sum the total benefits by census tract

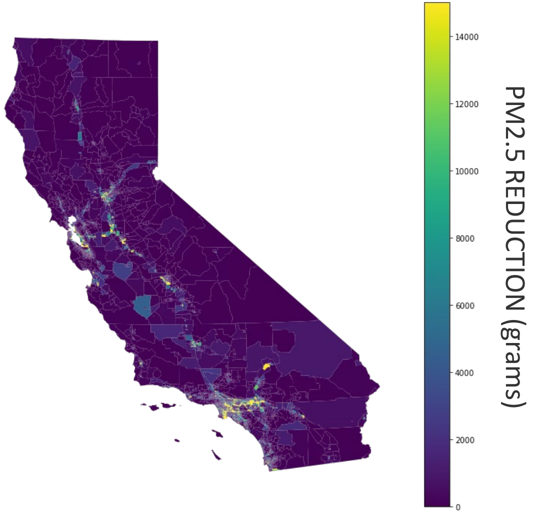
	Disadvantaged Community	Other
Petroleum Reduction (millions of gallons)	42.64	64.42
GHG Reduction (thousand tonnes CO2eq)	472.78	654.50
NOx Reduction (tonnes)	358.55	339.79
PM 2.5 Reduction (tonnes)	14.16	13.53

Spatially disaggregating benefits by census tract, we estimate that **~40% of reductions happen in disadvantaged communities**

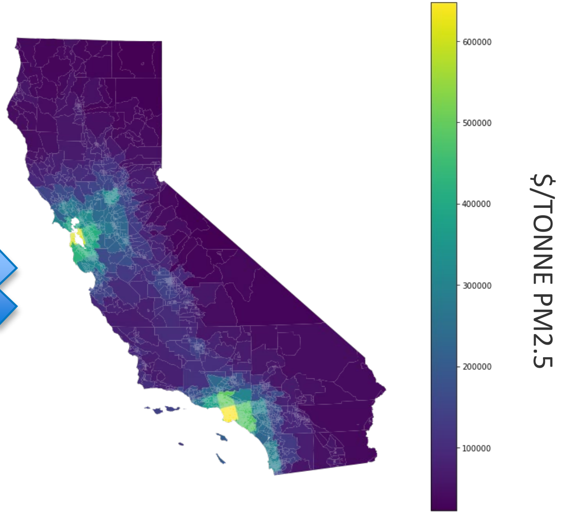
Social Benefits – Monetizing the social cost of emissions reduction using EASUIR model

- We use the Estimating Air pollution Social Impact Using Regression (EASIUR) model, which **estimates the social cost (or public health cost) of emissions** in the US, to calculate the public health benefits of emissions reductions due to CEC projects
- We took the expected benefits for **NOx and PM2.5 reductions by census tract (shown in previous slide)** and multiplied by their corresponding **EASUIR coefficients for $/tonne of NOx or PM2.5** to compute total social cost/public health cost savings for each census tract for each year

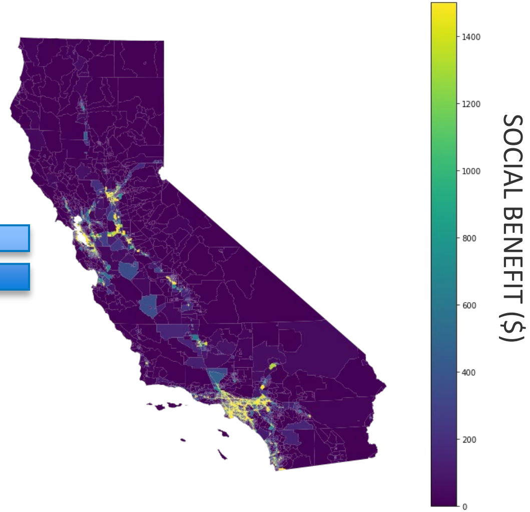
PM2.5 benefit by census tract



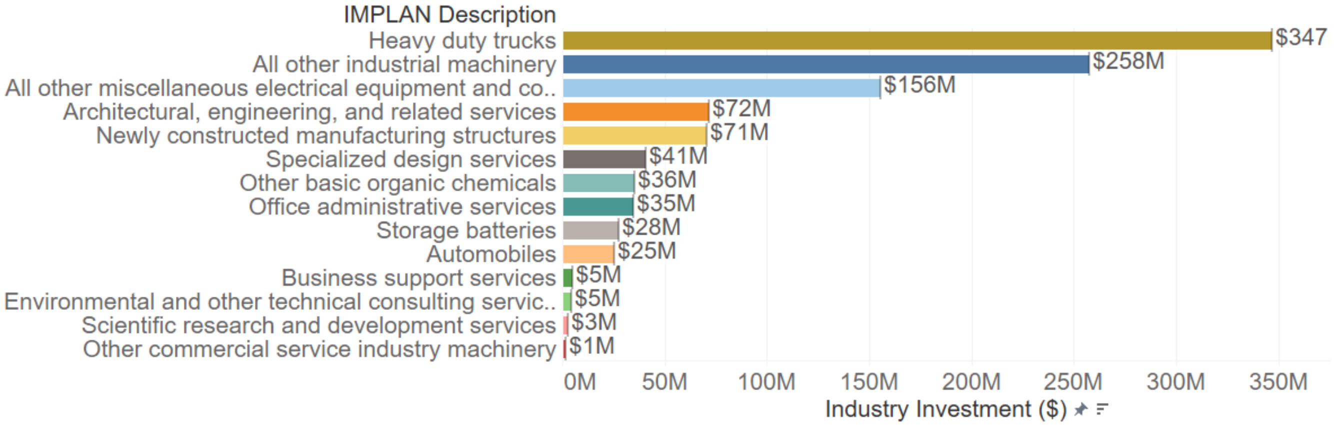
PM2.5 $/tonne by census tract using EASUIR model (input census tract centroid)

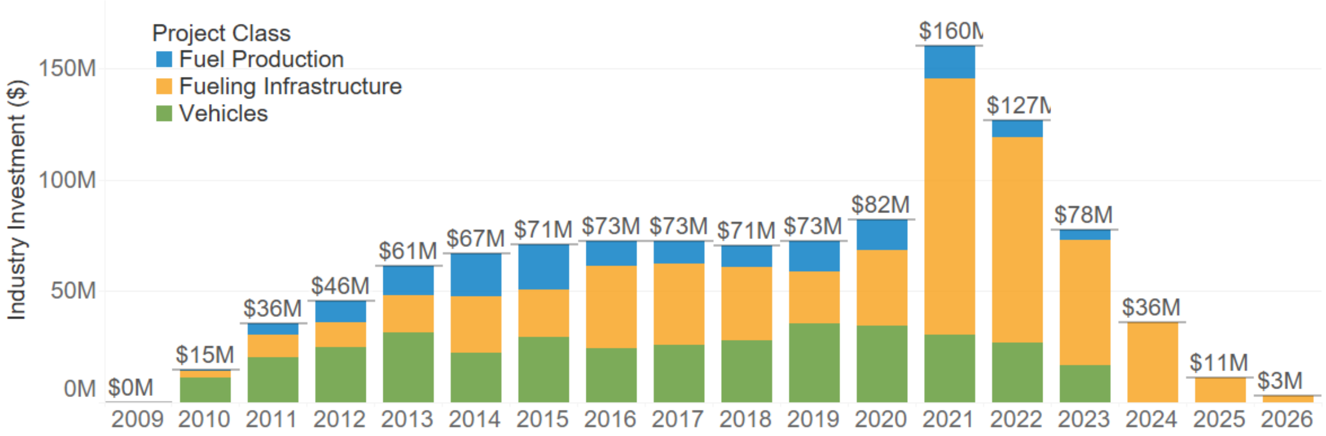


Social cost benefits from PM2.5 by census tract



Jobs Modeling - IMPLAN Input Data Summary

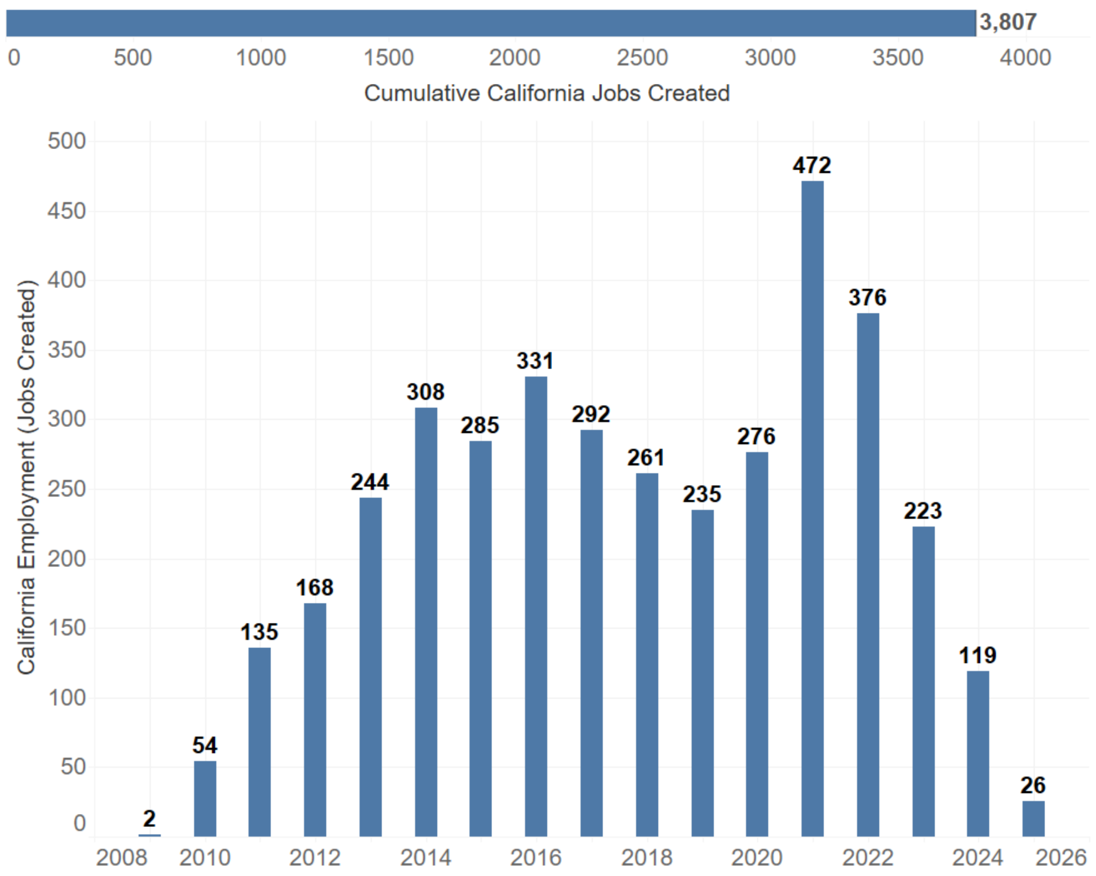




Method:

- Project investment broken down using project proposal budgets and mapped to NAICS codes
- Project investment (CEC + match) allocated over time
- A total of $1.001B of project investment was accounted for
- Typical CEC CTP yearly investment was $60-80M/year

Jobs Modeling - IMPLAN Results for CA Employment Impacts



Results:

- A total of nearly 4,000 full-time jobs have been created in California due to CEC investment
- Over half of the direct impact of some high investment sectors is estimated to occur outside of California (imports)
- High levels of automation in manufacturing results in relatively low job creation statistics (e.g., ~3 jobs created per $1M invested in vehicle manufacturing)
- Typical yearly job creation of ~200-400 jobs due to CEC CTP investment

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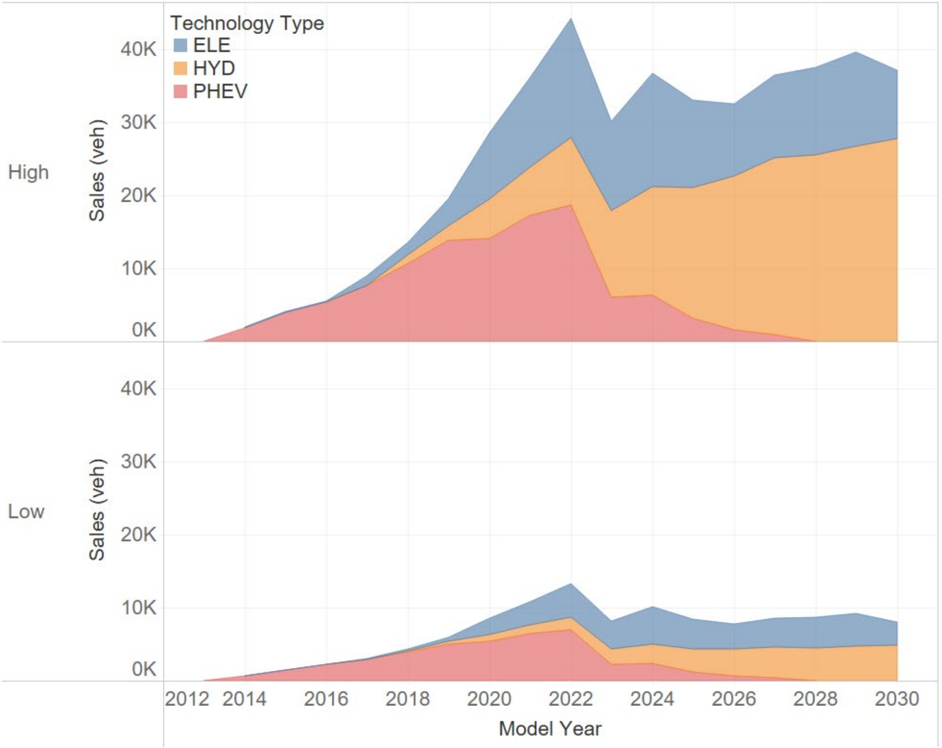
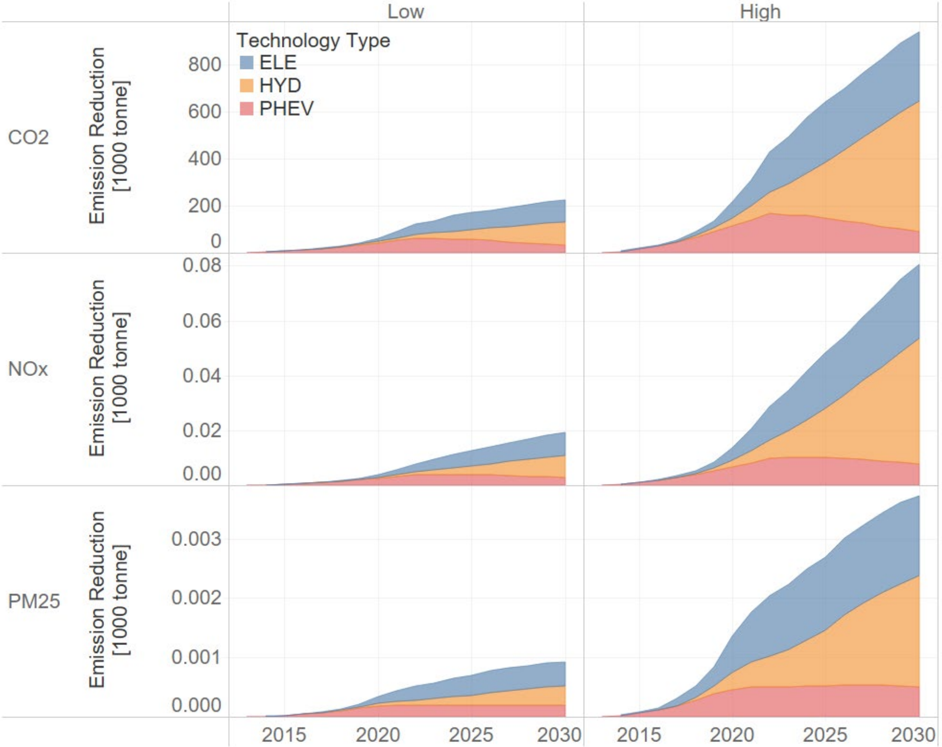
Market Transformation – Perceived Vehicle Price Reductions (EVCS, HRS)

Induced Vehicle Sales

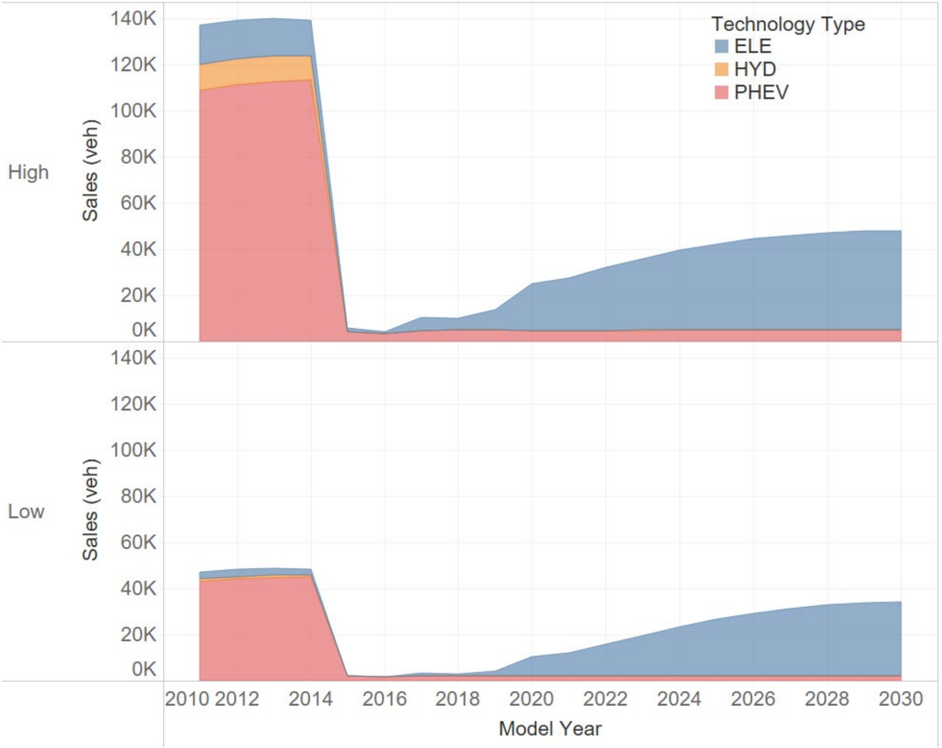


Emissions Reductions



Market Transformation – Vehicle Cost Reductions (CVRP, EV Component Manufacturing, EV Manufacturing)

Induced Vehicle Sales



Emissions Reductions

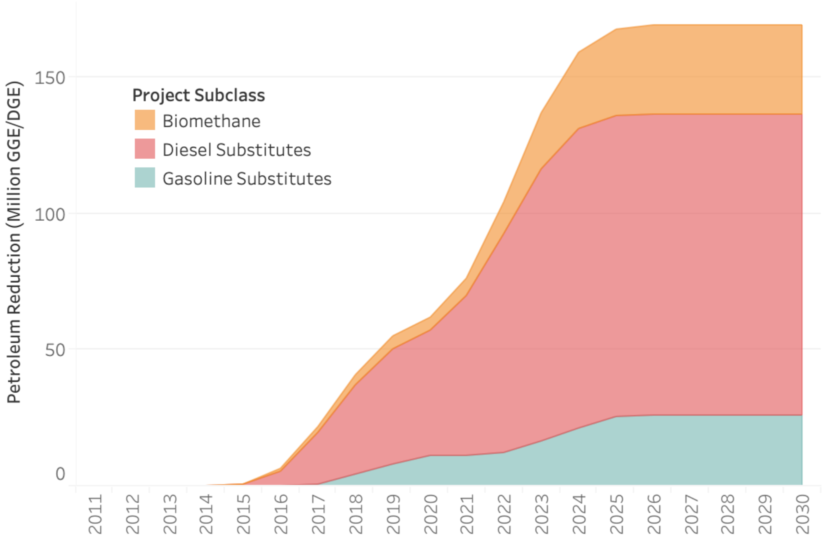
Advanced Truck Market Transformation Benefits

- **MD-HD ZEV Truck Demonstrations / Electric Commercial Trucks**

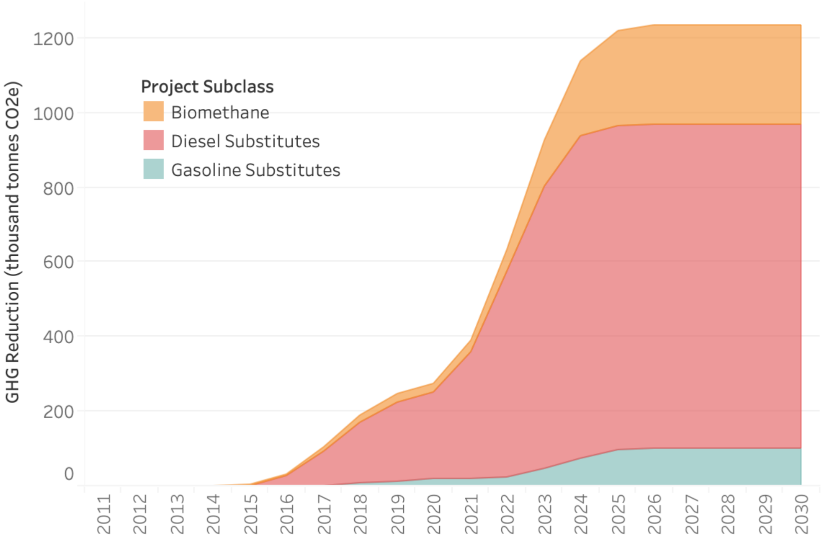
Advanced Truck Category and Case	No. Vehicles (additional)	New Fuel Economy (mi per DGE)	Fuel Use per Vehicle (DGE/yr/veh)	Fuel Use Total (Million DGE/yr)	Petrol Fuel Reduced (Million DGE/yr)	GHG Reduction ($MMTCO_2e$/yr)
Electric MDTs						
High	27,985	9.1	2,173	60.81	15.20	0.2021
Low	5,391	9.1	2,173	11.71	2.93	0.0389
Electric HDTs						
High	41,977	4.2	23,570	106.06	52.07	0.6923
Low	8,086	4.2	23,570	106.06	10.03	0.1334
Gaseous M/HDTs						
High	7,941	4.3	22,555	179.10	197.01	0.9287
Low	1,269	7.3	2,716	3.45	3.45	0.0133
Gasoline Sub MDTs						
High	10,000	7.3	2,716	27.16	27.16	0.0108
Low	1,000	7.3	2,716	2.72	2.72	0.0011

Next generation fuels reductions

Petroleum Reduction



GHG Reduction



Market Transformation Results Summary (2030)

Market Transformation Influence	Case	Petroleum Displacement (M gal)	GHG Reduction (thousand tonnes CO2e)	NOx Reduction (tonnes)	PM 2.5 Reduction (tonnes)
Perceived Vehicle Price Reductions	High	75	974	84	3.9
Perceived Vehicle Price Reductions	Low	19	237	20	1
Vehicle Cost Reduction	High	120	2064	767	34.1
Vehicle Cost Reduction	Low	71	1522	707	30.2
Next-Generation Trucks	High	292	1825	NA	NA
Next-Generation Trucks	Low	19	187	NA	NA
Next-Generation Fuels	High	237	1630	NA	NA
Next-Generation Fuels	Low	59	404	NA	NA
Total	**High**	**724**	**6493**	**851**	**38**
Total	**Low**	**168**	**2350**	**727**	**31**

Thank you

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