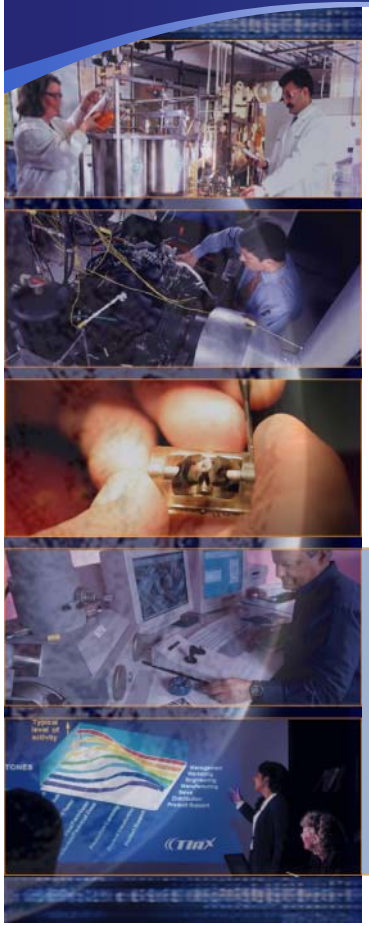
California Low Carbon Fuel Standard (LCFS) Electric Pathway – On-Road and Off-Road



Presentation to:

California Electric Transportation Coalition (CalETC)

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Reference No.:

Electric Credits in the California Low Carbon Fuel Standard

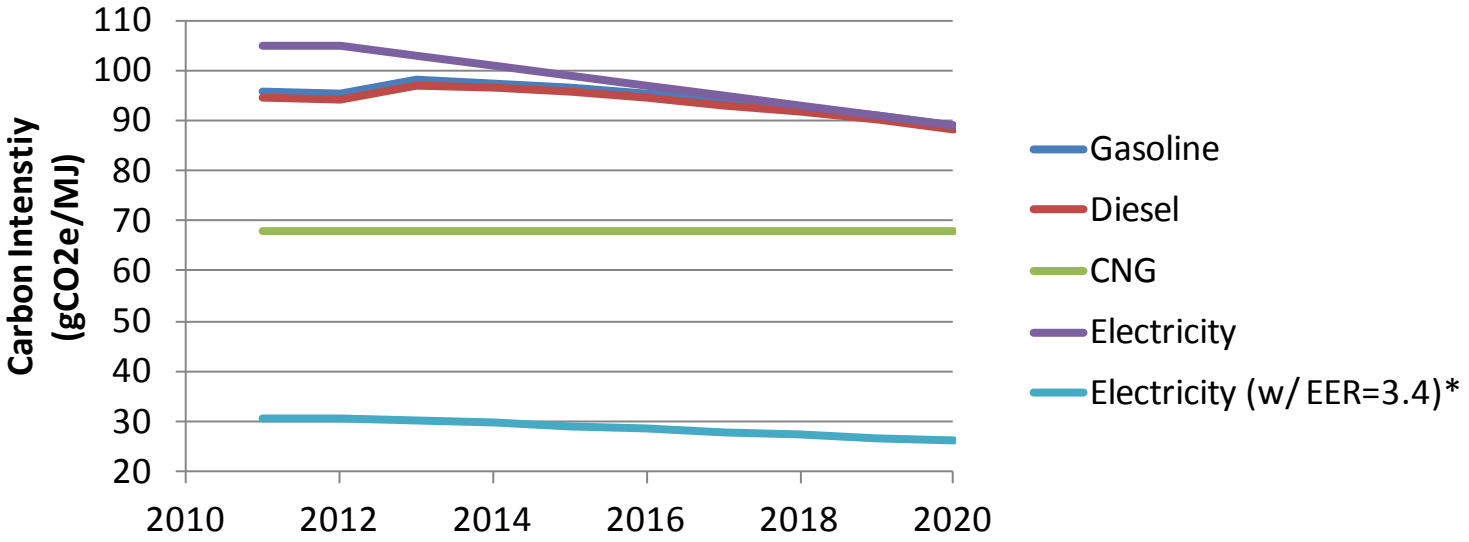
- Electricity consumption in on-road and off-road applications has the potential to produce a significant quantity of LCFS credits
- On-road applications include light-duty plug-in electric vehicles (PEVS) such as battery electric vehicles (BEVs) or plug-in hybrid vehicles (PHEVs)
- Off-road applications include electric passenger rail, electric forklifts and E-transport refrigeration units (e-TRUs)

Not included in this Analysis

- In several ways this analysis is conservative because GHG reductions from several existing and potential segments for electric transportation were excluded
  - Medium and heavy duty PHEVs and BEVs (including over-head wire options)
  - Most of the off-road applications including
    - electric airport ground support equipment,
    - electric golf carts,
    - electric personnel / burden carriers,
    - electric industrial tow tractors,
    - electric sweepers, scrubbers and burnishers
    - electric lawn and garden equipment
    - shore-side electric equipment (cold ironing)
    - electric port cargo handling equipment
    - truck stop electrification
    - electric freight rail and high speed rail
    - expanding market share for electric forklifts and electric TRUs.
- Also this analysis does not count the GHG reductions from PHEVs when they travel in gasoline mode (317,000 tons reduced per year in 2020 for 780,000 PHEVs)

Carbon Intensities

- Gasoline and diesel carbon intensities are the standard values, decreasing from 2011 to 2020, using the September 17, 2012 15 Day Modified Regulatory Order
- CNG carbon intensity stays the same
- RPS regulation has stair-step renewable requirements for electricity between 2013 and 2020; modeled electricity carbon intensity decreasing linearly from 2012 (21.3% renewables; balance natural gas) to 2020 (33% renewables; balance natural gas) for simplicity

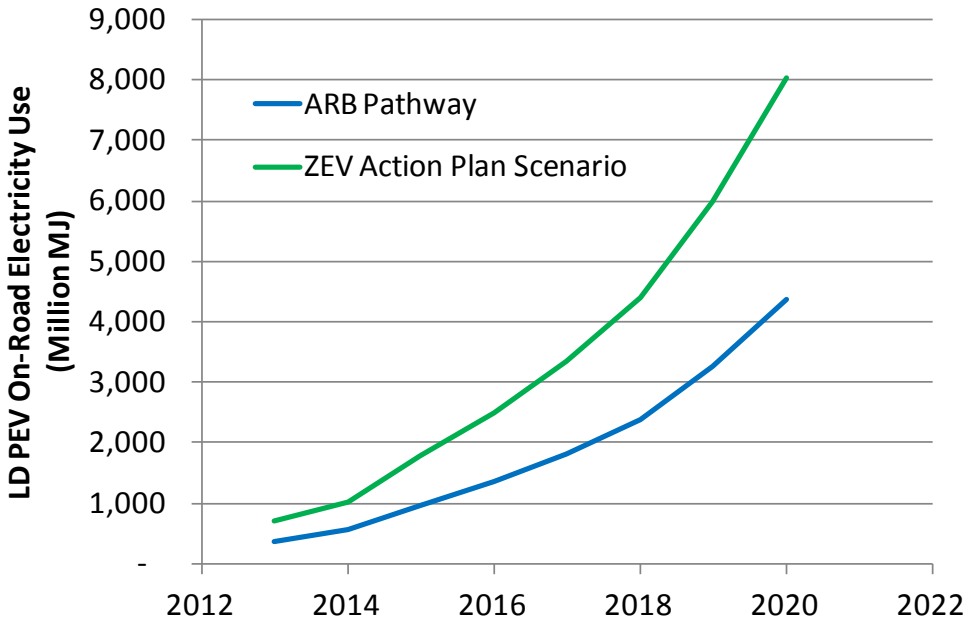


*Taking into account the EER allows for a comparison based on per unit of energy of the replaced fuel (e.g. gasoline or diesel)

On-Road Electrification – LD PEVs (40% PHEV Miles in Electric Mode)

- Electricity consumption based on ARB Illustrative Pathways – 544,000 plug-in vehicles in 2020, 22% of which are BEVs; PHEVs – 40% miles in Electric Mode
- ZEV Action Plan Scenario is 1 million plug-in vehicles in 2020, 22% BEVs and 40% PHEV miles Electric Mode similar to ARB Illustrative Pathways
- ARB Pathway: EER - 3.4; VMT All Vehicles (2020) – 12,000

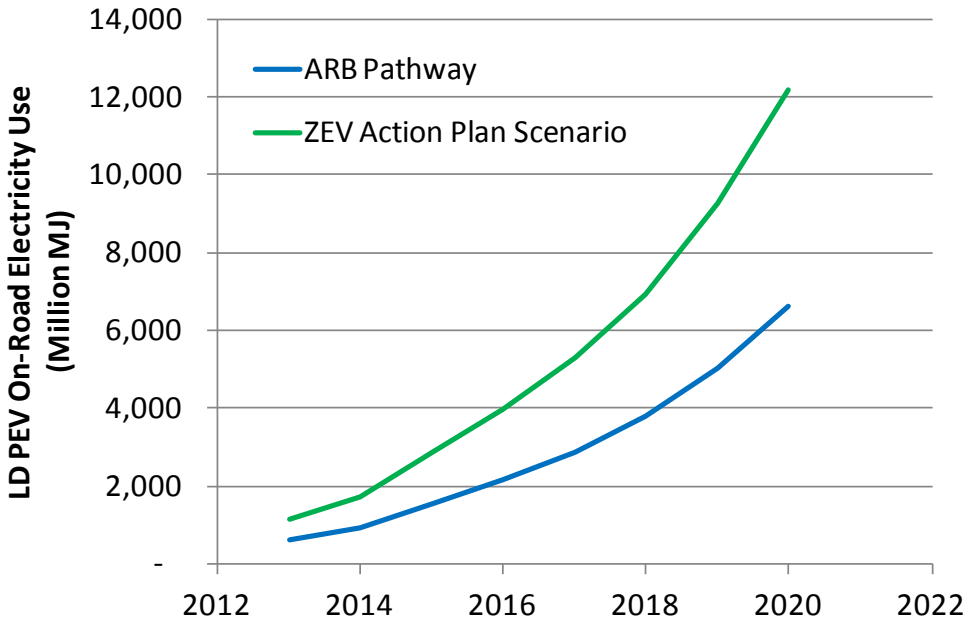
$$(CI_{Standard}^{Gasoline} - CI^{Elec} / EER^{Elec}) * (E^{Elec} * EER^{Elec}) * C = Credits$$



On-Road Electrification – LD PEVs (75% PHEV Miles in Electric Mode)

- Electricity consumption based on ARB Illustrative Pathways – 544,000 plug-in vehicles in 2020, 22% of which are BEVs; PHEVs – 75% miles in Electric Mode
- ZEV Action Plan Scenario is 1 million plug-in vehicles in 2020, 22% BEVs and 75% PHEV miles Electric Mode similar to ARB Illustrative Pathways
- ARB Pathway: EER - 3.4; VMT All Vehicles (2020) – 12,000

$$(CI_{Standard}^{Gasoline} - CI^{Elec} / EER^{Elec}) * (E^{Elec} * EER^{Elec}) * C = Credits$$

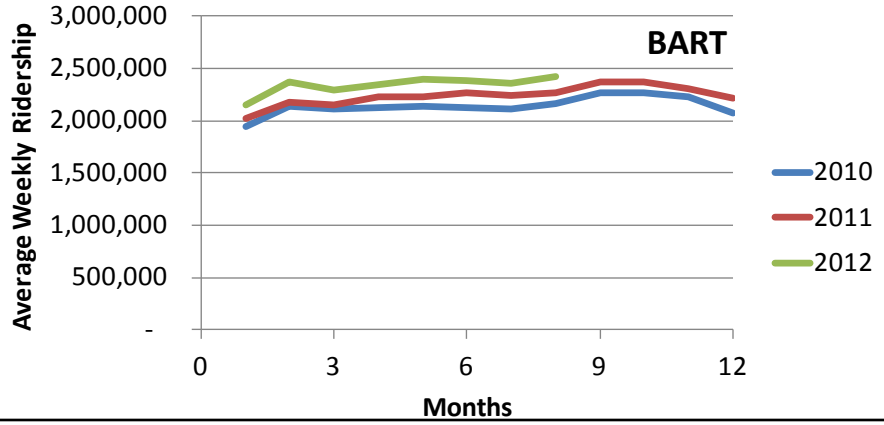


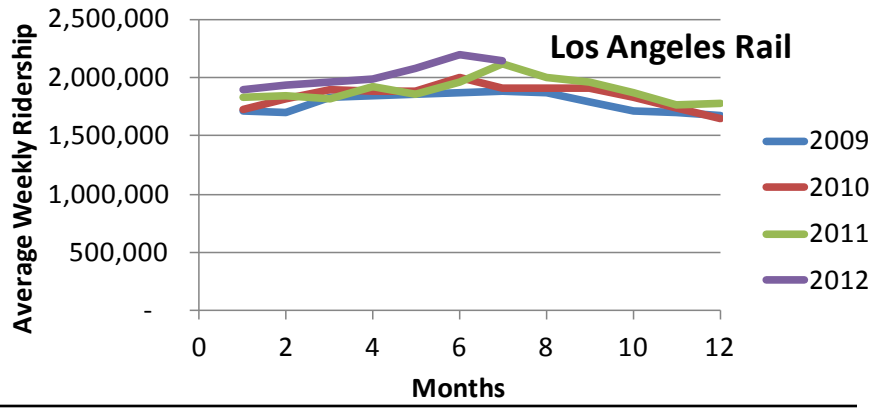
Electric Passenger Rail

- Data from the National Transit Database was used to calculate kWh/mi and MJ/mi for electric rail in California and their corresponding transit bus fleet, rail passenger miles and rail track length in 2010

	Electric Rail		Transit Bus		Rail Passenger Miles	Track Length (mi)
	kWh/mi	MJ(e-)/mi	Fuel	MJ/mi		
Los Angeles HR	0.37	1.34	CNG	3.82	231,935,841	34.1
Los Angeles LR	0.29	1.04	CNG	3.82	333,334,394	116.3
Sacramento	0.42	1.52	CNG	5.54	82,500,482	73.4
San Diego	0.21	0.74	CNG	5.68	186,509,312	102.6
BART	0.20	0.73	Diesel	3.25	1,390,909,655	267.6
San Francisco	0.38	1.36	Diesel	3.25	239,829,549	103.5
Santa Clara	0.45	1.61	Diesel	4.00	50,000,272	79.6

- LA Metro and BART data show ridership has been increasing since 2010 and confirm the use of 2010 data for passenger miles as a conservative assumption



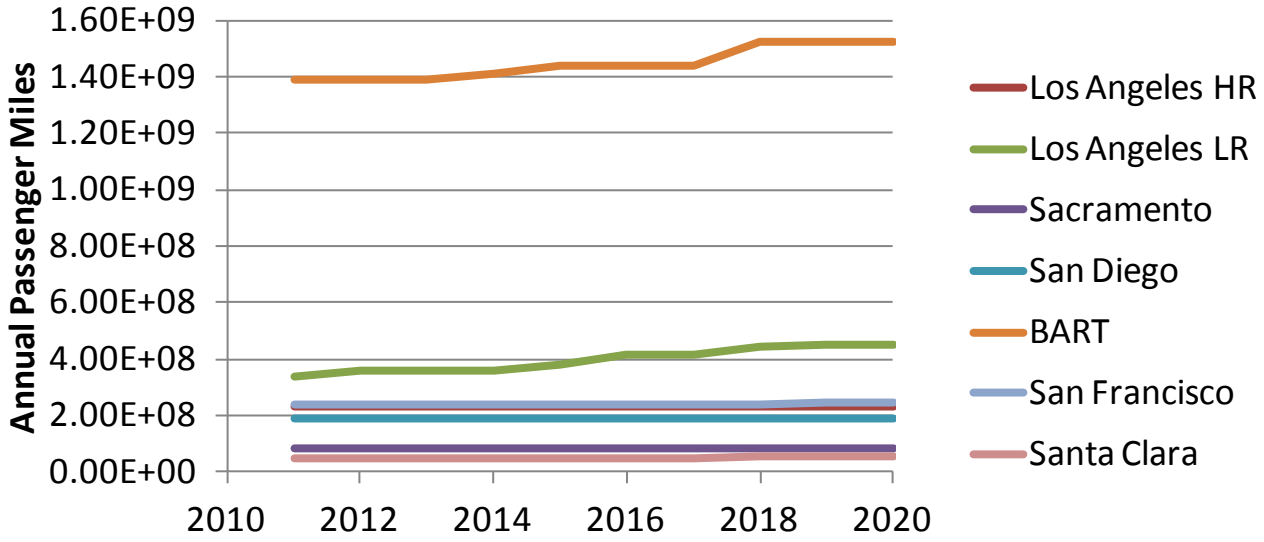


Electric Passenger Rail (cont.)

- Planned and implemented rail expansions taken into account by assuming ratio of passengers to track miles is constant for each transit

2012-2020	Electric Rail Expansion (mi (yr))
Los Angeles HR	none
Los Angeles LR	8.6 (2012); 6.6 (2015); 11 (2016); 8.5 (2018)
Sacramento	1.1 (2012)
San Diego	none
BART	3.2 (2014); 5.4 (2015); 16 (2018)
San Francisco	1.7 (2019)
Santa Clara	10 (2018)

- Increased Passenger-miles based on implemented and planned track increases



Electric Passenger Rail (cont.)

- Used Two (2) Methodologies For Comparison
  - Displacing Light-duty Auto Miles
  - Displacing Transit Bus Miles
- Displacing Light-Duty Auto Miles
  - Used EMFAC fleet average fuel economy (~23.3 mpg) and 1.1 Passenger's per vehicle to calculate MJ/mi (~4.64MJ/mi)

$$\left[(CI_{\text{Standard}}^{\text{Gasoline}} * (MJ / pass-mile)^{Gasoline}) - (CI^{Elec} * (MJ / pass-mile)_{Rail}^{Elec}\right]$$

$$* pass-miles_{rail}^{annual} * C = Credits$$

Electric Passenger Rail (cont.)

- Displacing Transit Bus Miles
  - Use MJ/mi from NTD and corresponding fuel Carbon Intensity (CNG or Diesel) for each transit agency
  - Diesel

$$\left[\left(CI_{\text{Standard}}^{\text{Diesel}} * (MJ/pass-mile)_{TransitBus}^{Diesel}\right) - \left(CI^{Elec} * (MJ/pass-mile)_{Rail}^{Elec}\right]\right.$$

$$* pass-miles_{rail}^{annual} * C = Credits$$

  - CNG

$$\left[\left(CI^{\text{CNG}} * (MJ/pass-mile)_{TransitBus}^{CNG}\right) - \left(CI^{Elec} * (MJ/pass-mile)_{Rail}^{Elec}\right]\right.$$

$$* pass-miles_{rail}^{annual} * C = Credits$$

Electric Forklifts

- Electric forklift population based on US factory shipments of electric rider (Class 1&2) and motorized hand (Class 3) forklifts from 2000-2010[A] (Industrial Truck Association); used year 2000 shipments as a surrogate for 2011 assuming forklifts have an 11 year lifetime and 2011 shipments replace 2000 shipments
- Pro-rated California share of 12% (2010 Census Population Data)
- Split Electric Rider into Class 1 & 2 using the World Industrial Truck Statistics for America[A] in 2009 and 2010 (60% Class 1, 40% Class 2)
- Conservatively estimate current population equals 2013 – 2020 population

	Class 1+2	Class 3
2000-2010 US Shipments	488,853	458,502
CA Share	58,662	55,020
CA Class 1 (60%)	35,197	
CA Class 2 (40%)	23,465	

[A] – Industrial Truck Association http://www.indtrk.org/market-intelligence

Electric Forklifts (cont.)

- EER of 3.0; Assume a diesel standard
- Class 1 and Class 2 estimated battery size of 43.6 kWh[A]
- Class 3 estimated battery size of 12.5 kWh[B]
- 3,150 hrs/yr of operation per forklift[C] (50% single shift; 25% each double and triple shift)
- Assume 80% depth of charge and full battery usage per shift resulting in an average load of 4.36kW for Class 1 and 2 and 1.25 kW for Class 3

$$(CI^{Diesel}_{\text{Standard}} - CI^{Elec} / EER^{Elec}) * (E^{Elec} * EER^{Elec}) * C = Credits$$

[A,B] – Based on spec sheets for Nissan and Crown Class 1 and 2 Forklifts, http://www.crown.com, http://nissanforklift.com/

[C] – Based on TIAX Phase 2 Report for CalETC communications with SCE and industry members

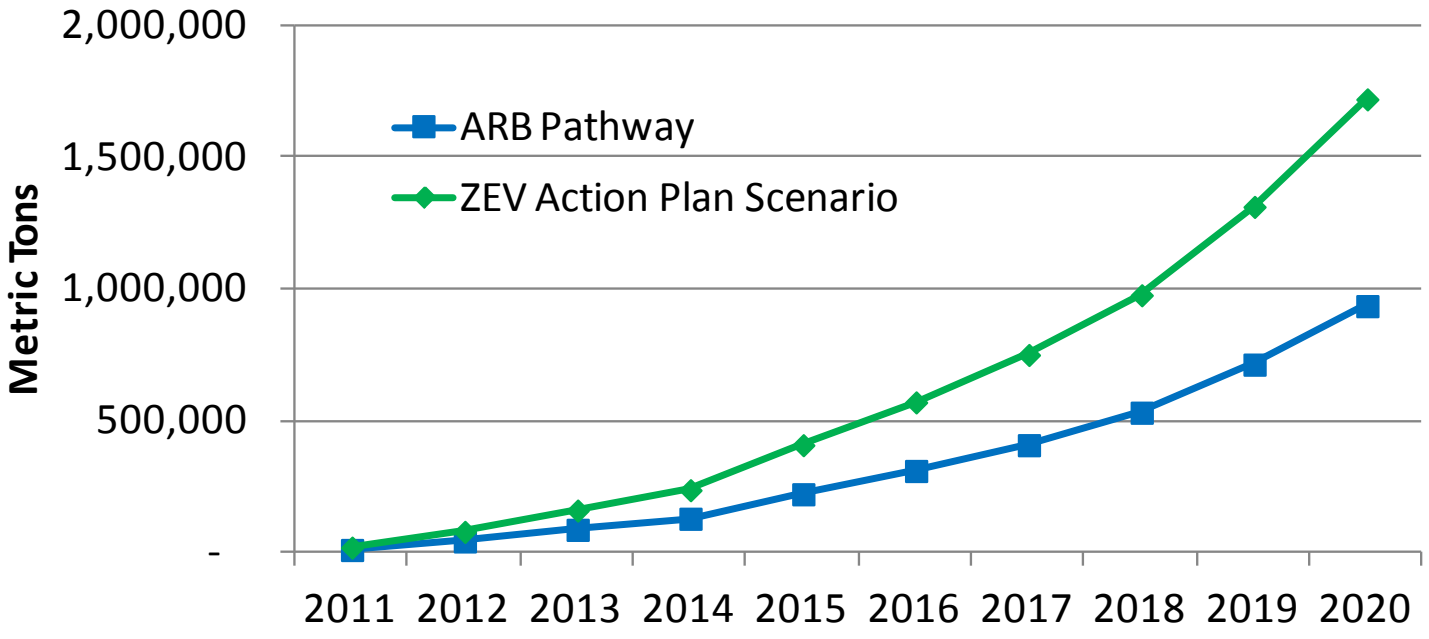
E-Transport Refrigeration Units

- Data Supplied by ARB:
  - 2,100 registered hybrid eTRUs in California
  - Conservatively estimate current population equals 2013 – 2020 population
  - Operate 3hrs/day, 6 days/wk, 52 wks/yr
  - Motor rating of 8 kW and a load factor of 0.75
  - Estimated 11.7 million kWh of electricity consumed each year by e-TRUs
  - Offset diesel consumption
  - EER = 3.0

$$(CI^{Diesel}_{\text{Standard}} - CI^{Elec} / EER^{Elec}) * (E^{Elec} * EER^{Elec}) * C = Credits$$

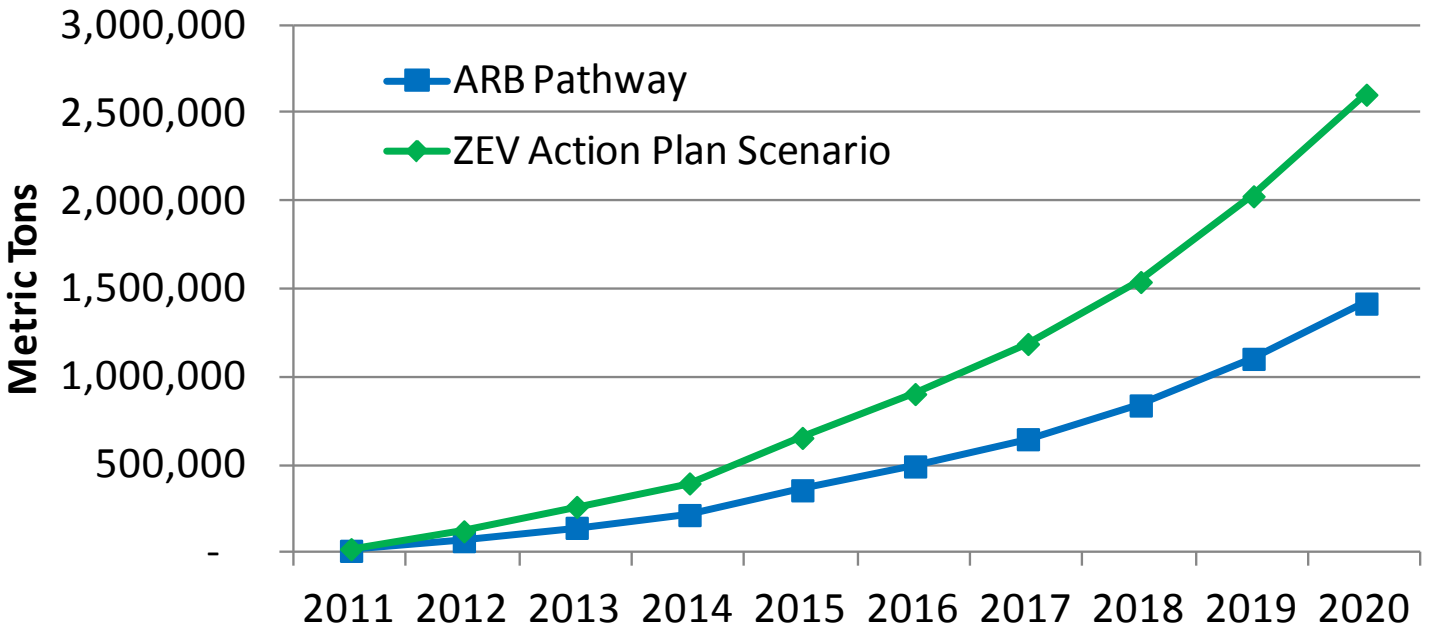
2013-2020 Potential Credits (40% PHEV Miles in Electric Mode)

- LD PEV on-road electrification yields almost 1 million credits in 2020 for the ARB Pathway and over 1.7 million credits in the ZEV Action Plan Scenario with 40% PHEV miles in electric mode



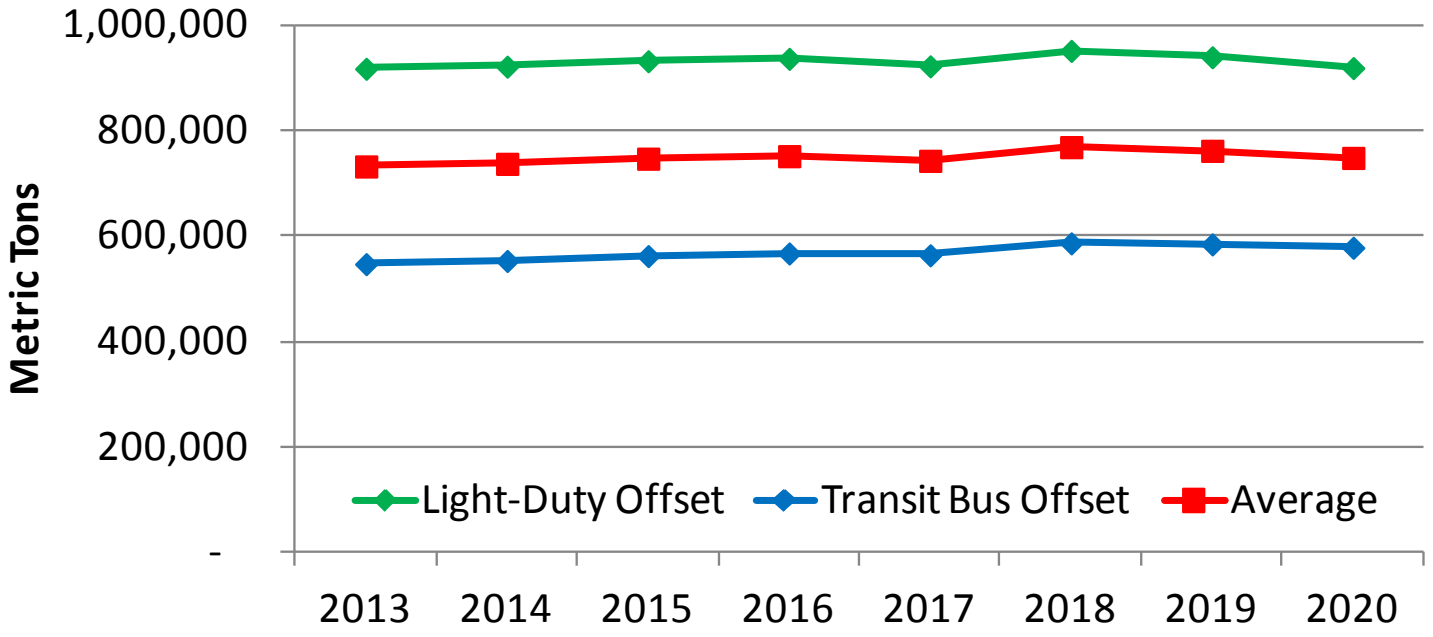
2013-2020 Potential Credits (75% PHEV Miles in Electric Mode)

- LD PEV on-road electrification yields almost 1.5 million credits in 2020 for the ARB Pathway and over 2.5 million credits in the ZEV Action Plan Scenario with 40% PHEV miles in electric mode



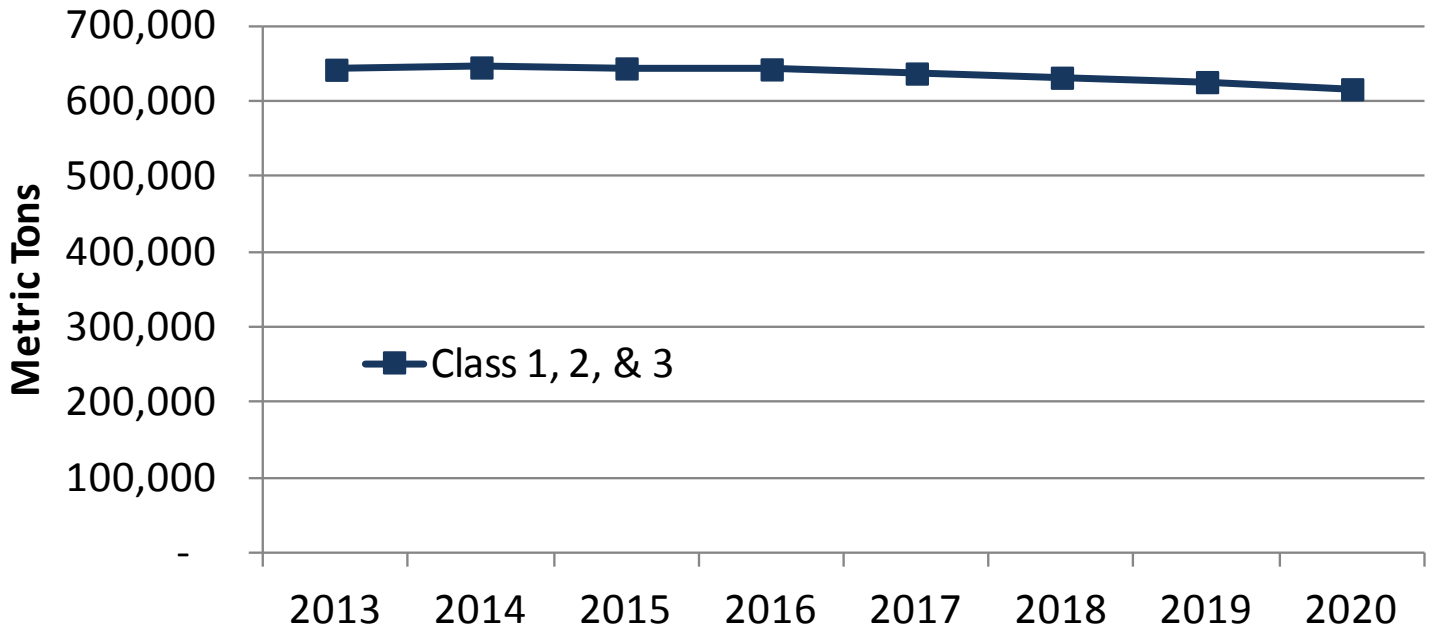
2013-2020 Potential Credits

- Displacing light-duty vehicles yields 910,000-950,000 metric tons of credits per year
- Displacing transit bus usage yields between 540,000-570,000 metrics tons of credits per year
- Average of both methodologies yields between 730,000-770,000 metric tons of credits per year



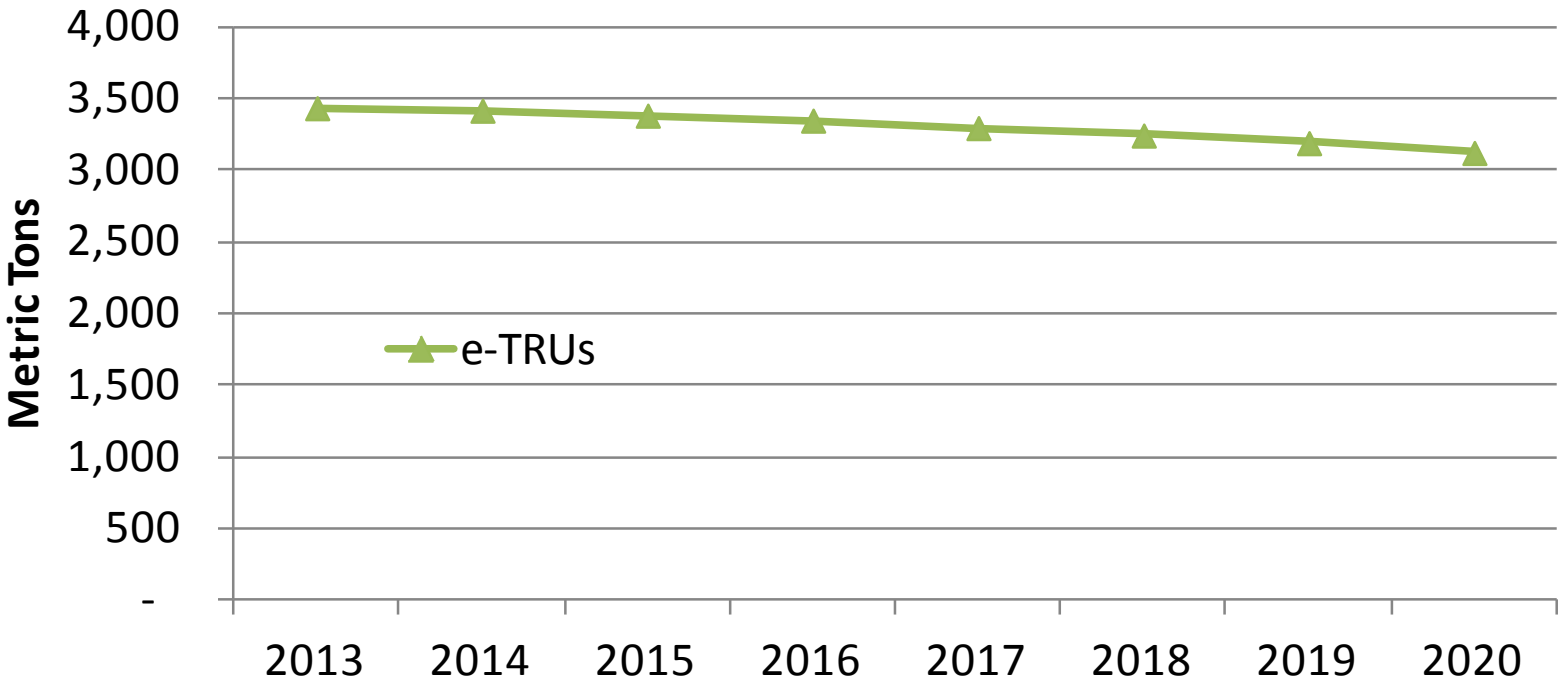
2013-2020 Potential Credits

- E-Forklifts yield over 600,000 metric tons of credits with the estimated current population



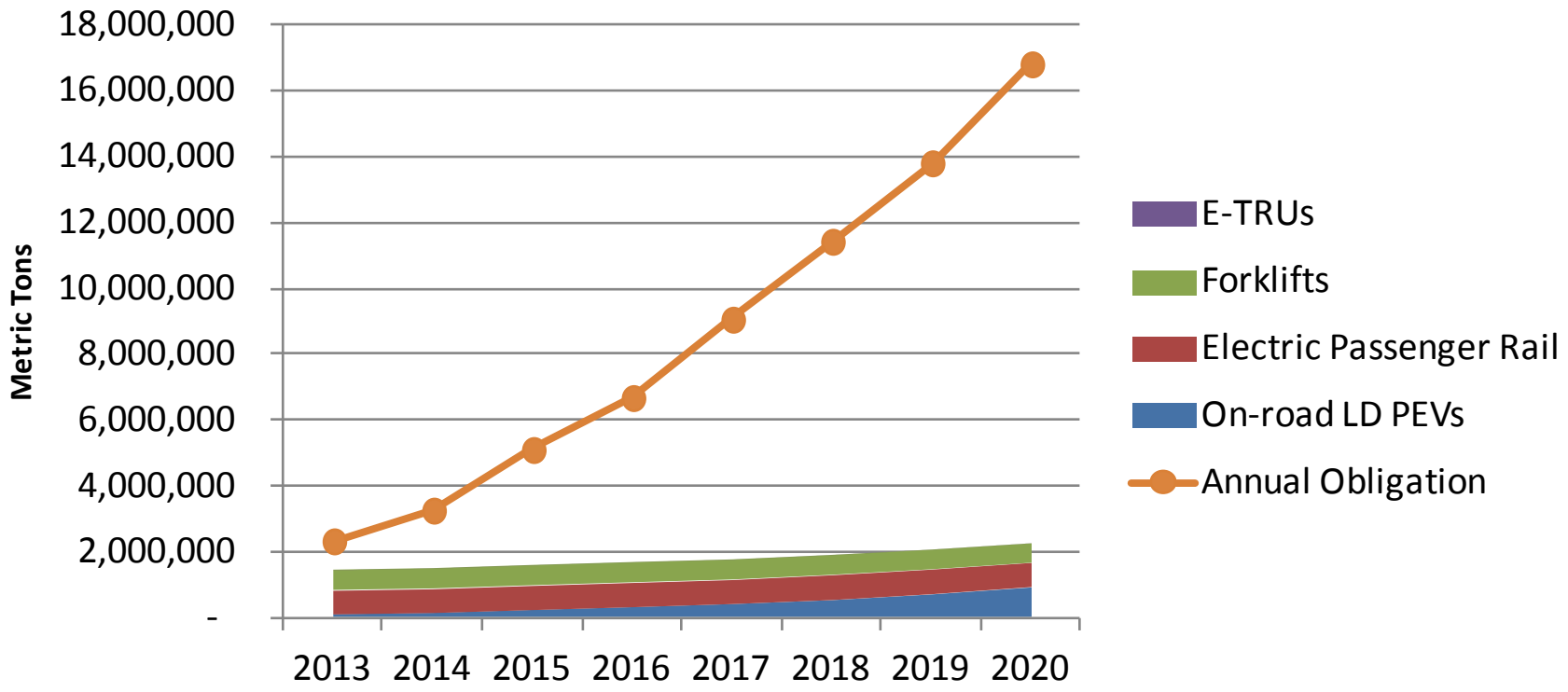
2013-2020 Potential Credits

- E-TRUs yield over 3,000 metric tons of credits per year



2013-2020 Potential Credits (40% PHEV Miles in Electric Mode)

- Annual obligation and on-road credits in the figure below based on ARB illustrative pathways and 40% PHEV miles in electric mode
- Electric passenger rail credits based on average of light-duty and transit bus offsets



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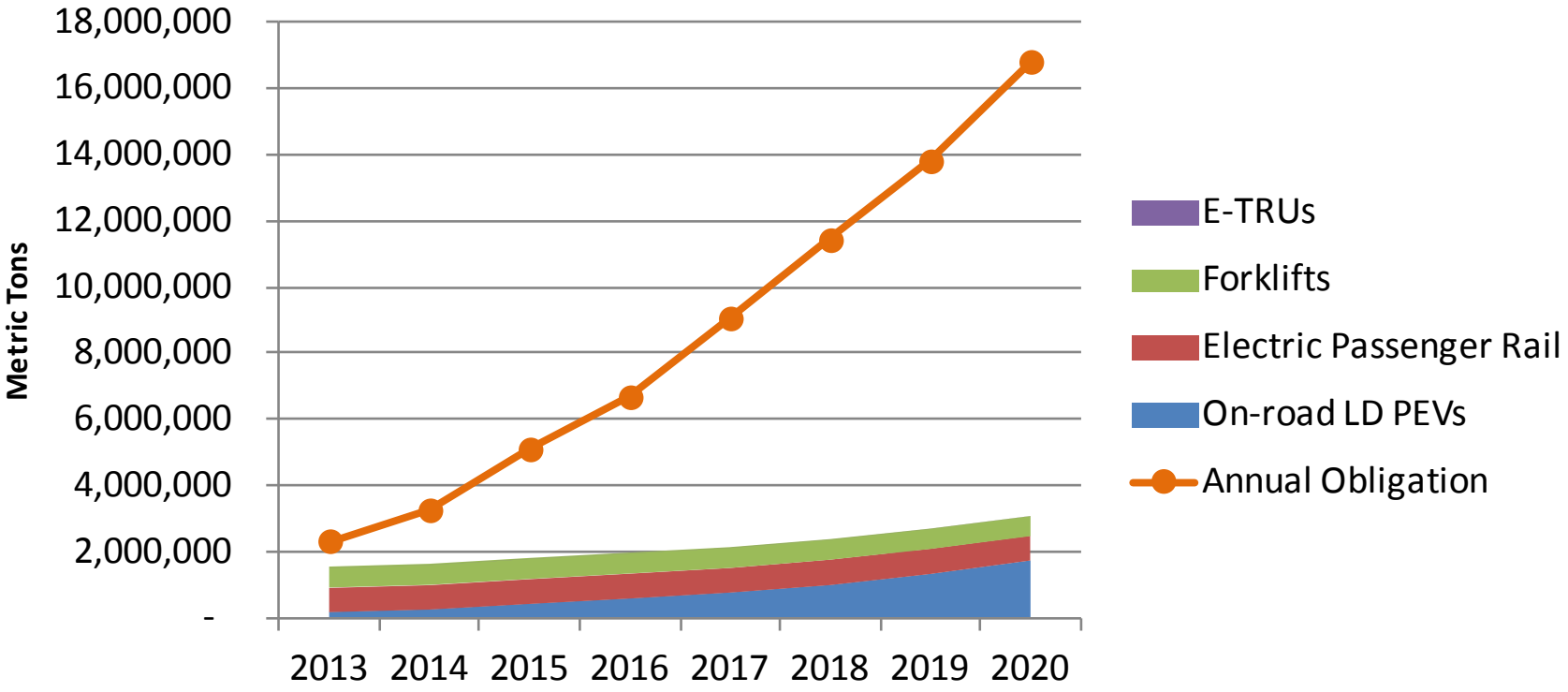

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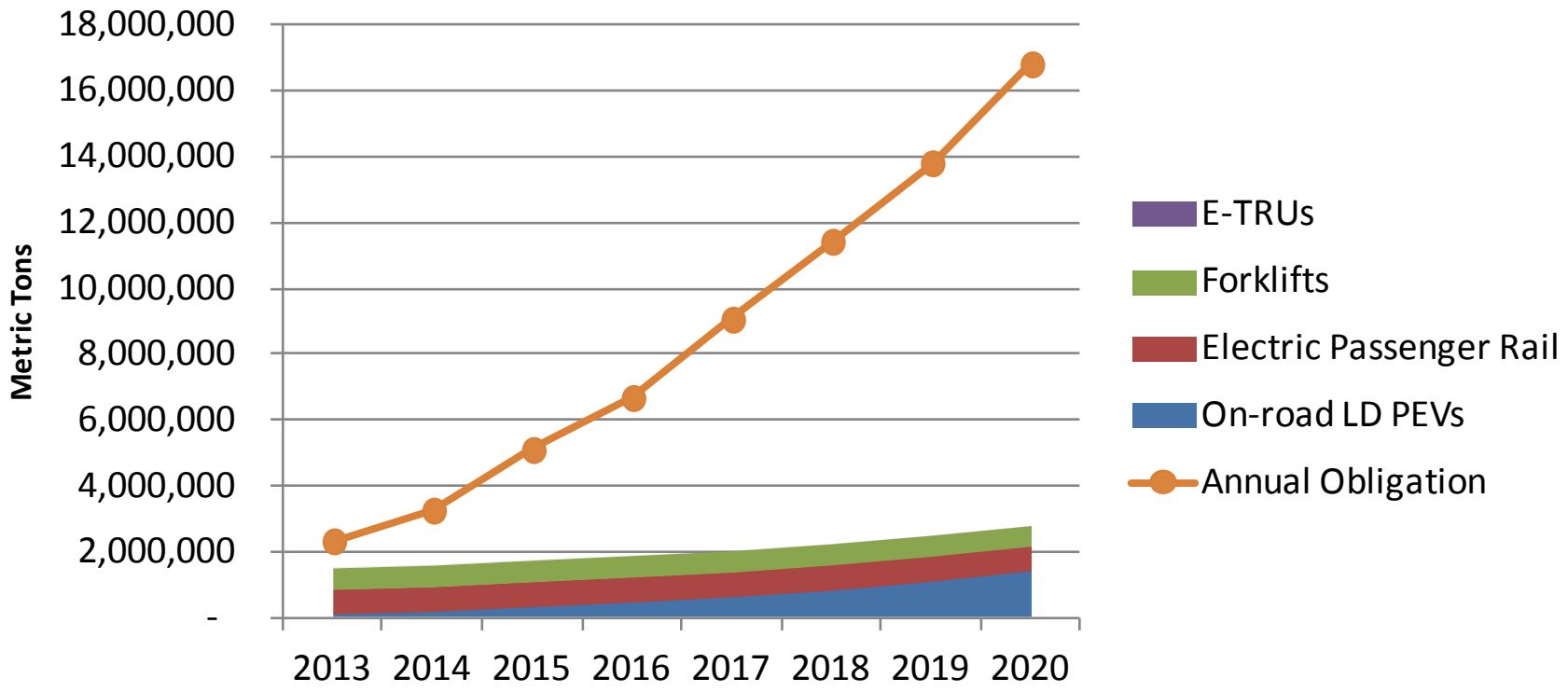

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