Air Quality Impacts of Electrification

Eladio M. Knipping, Ph.D.
Principal Technical Leader
Air Quality and Multimedia Sciences
Electric Power Research Institute

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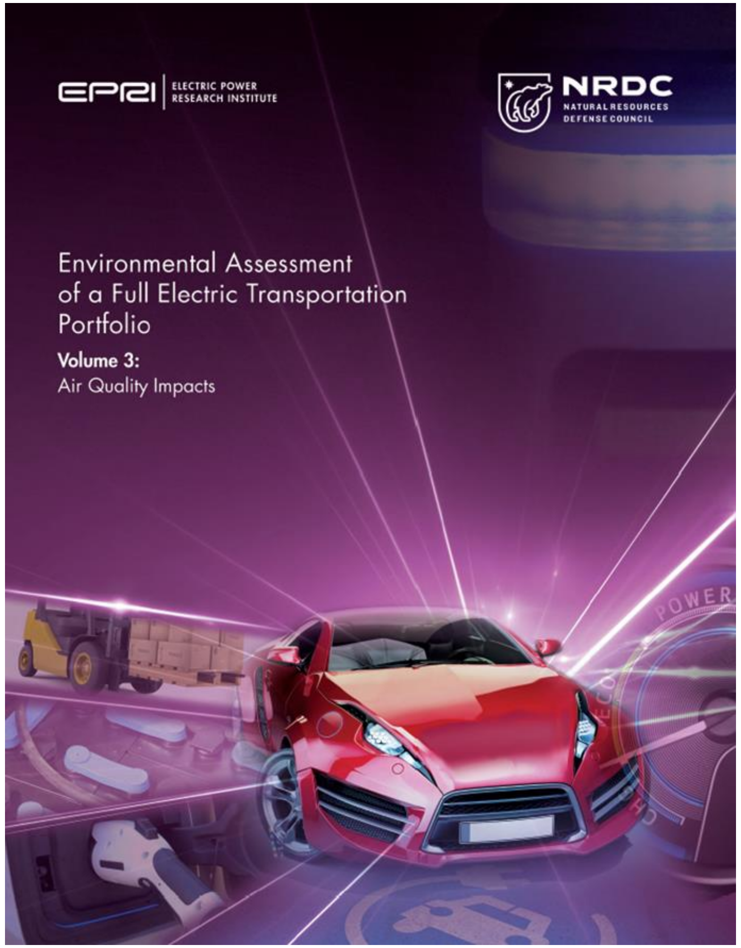
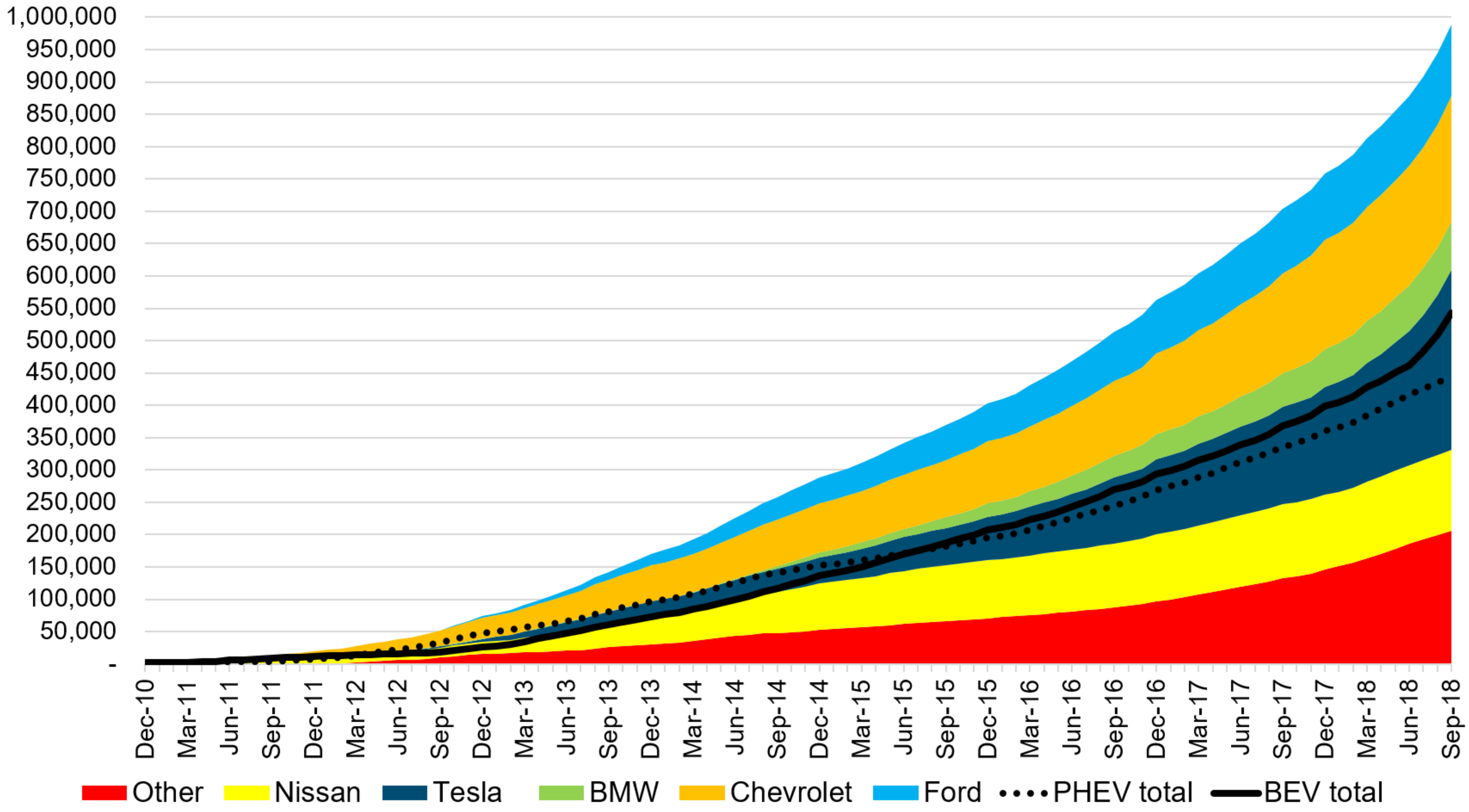
Overview

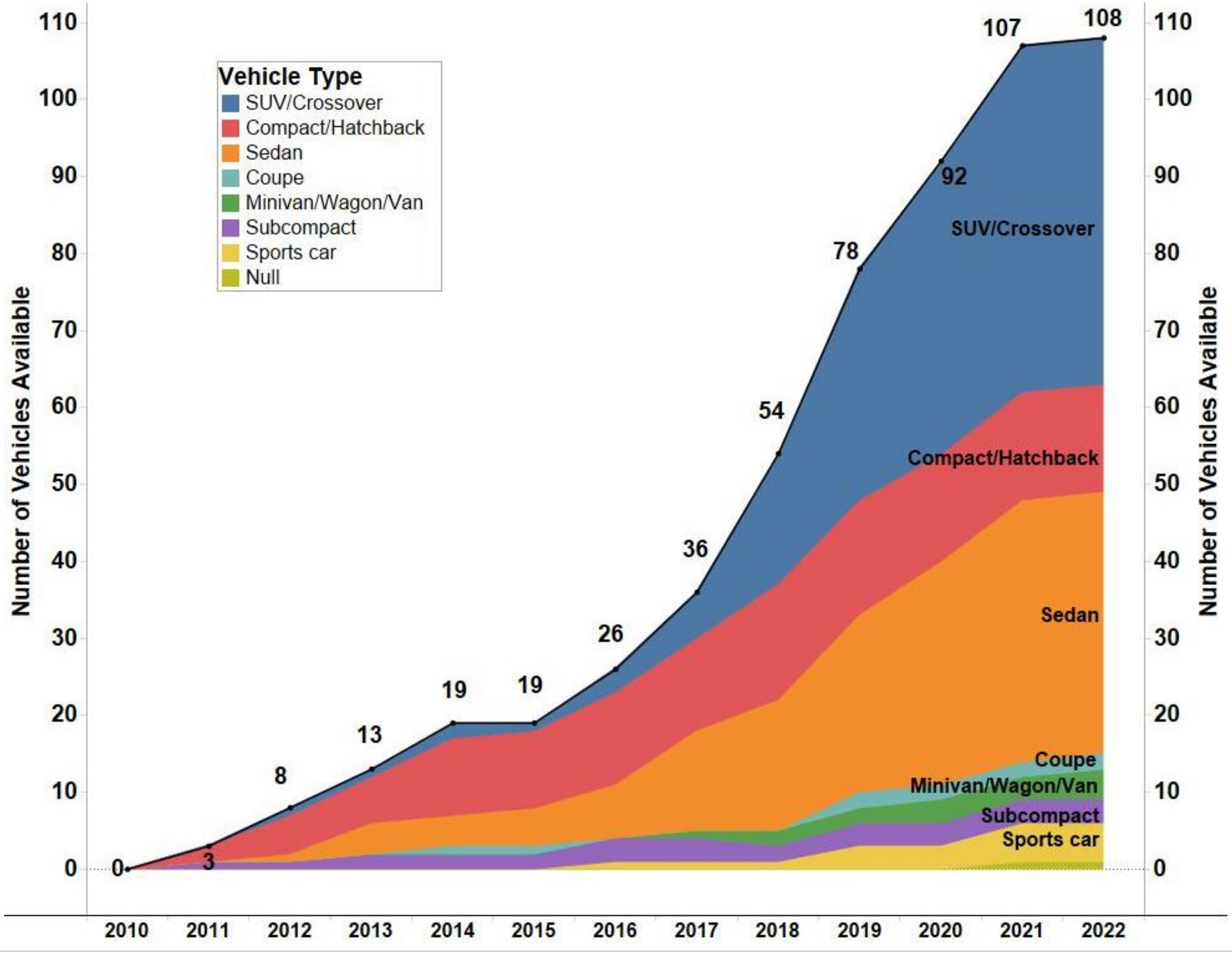
- This presentation focuses of two electrification studies:
  - EPRI-NRDC 2015 study on the air quality and greenhouse impacts of electric transportation
    - Air quality analysis focused on a scenario of potential transportation electrification projection to 2030
  - Aggressive electrification:
    - Air quality impacts estimated from a scenario of aggressive electrification of all amenable end-use sectors projected to 2050 (preliminary results)
    - Supported by California Energy Commission (CEC)



Light-duty sales at about 1 million vehicles

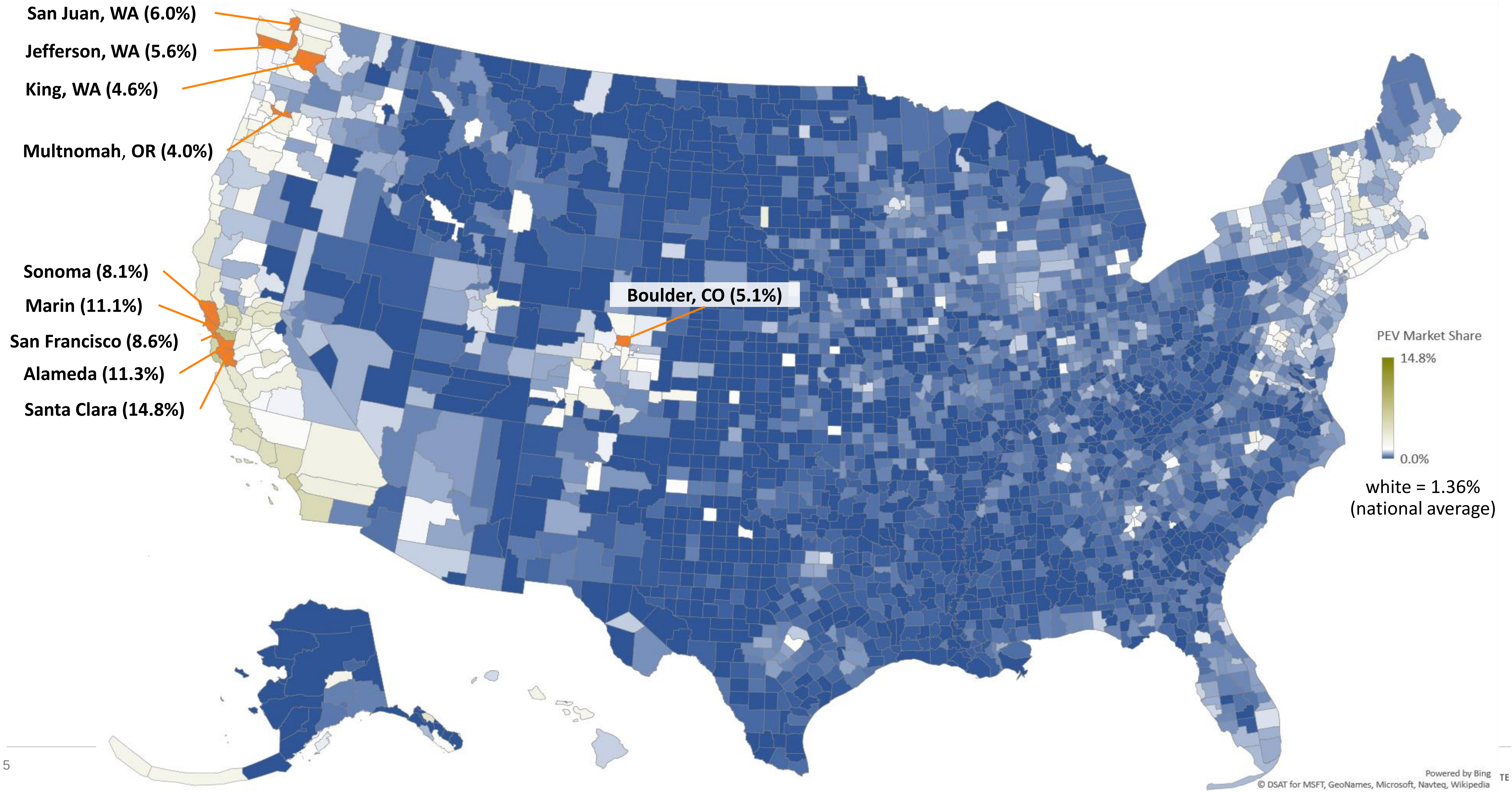


Customer choice increasing with ~~108~~ 116 EVs by 2023

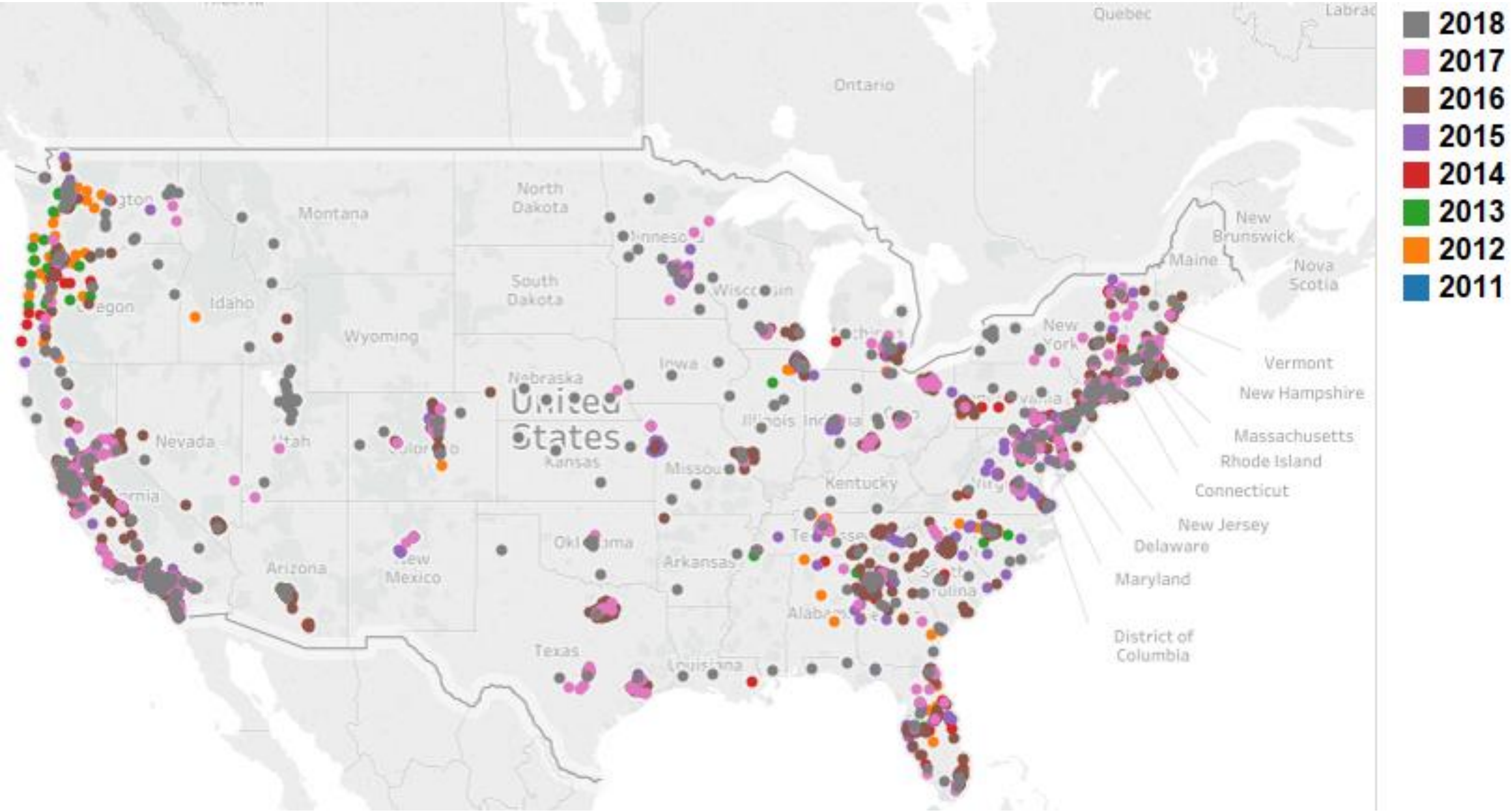


Updated 10/03/2018

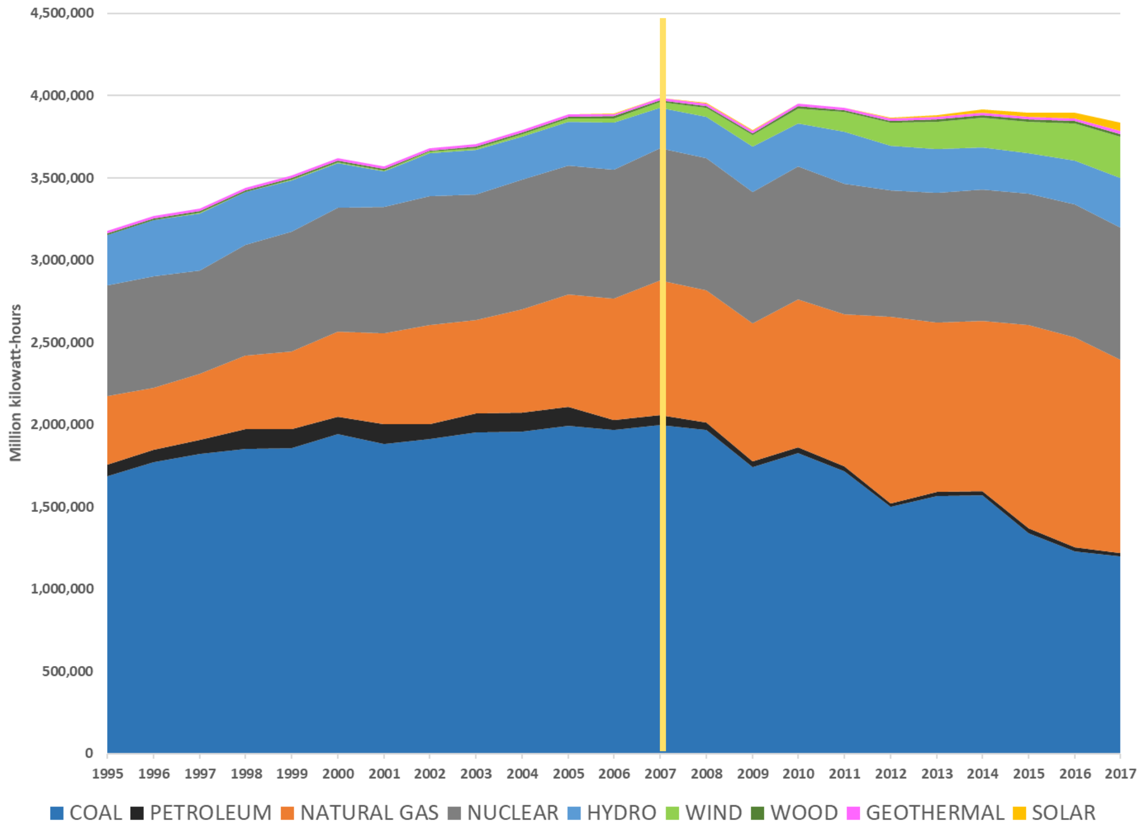
97 counties in 16 states have > 2.0% EV sales (through June 2018)

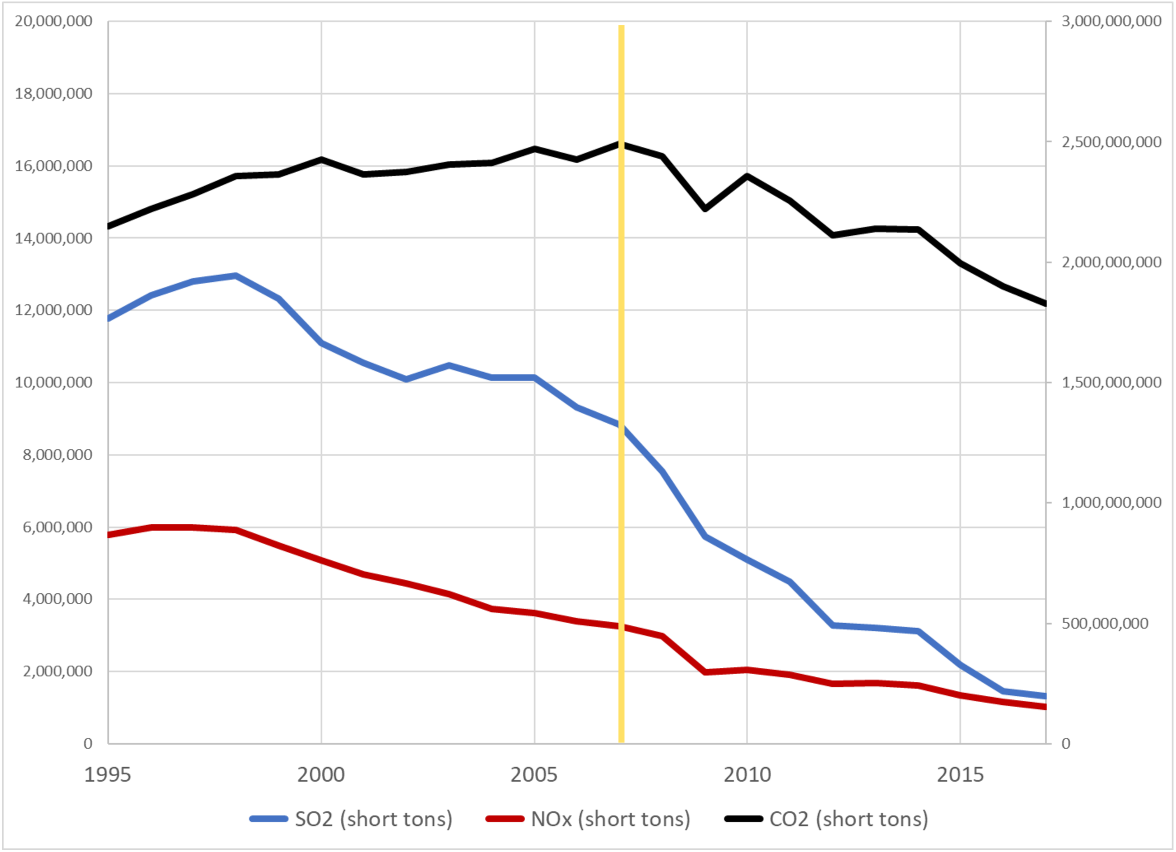


Public DC fast charging infrastructure is increasing

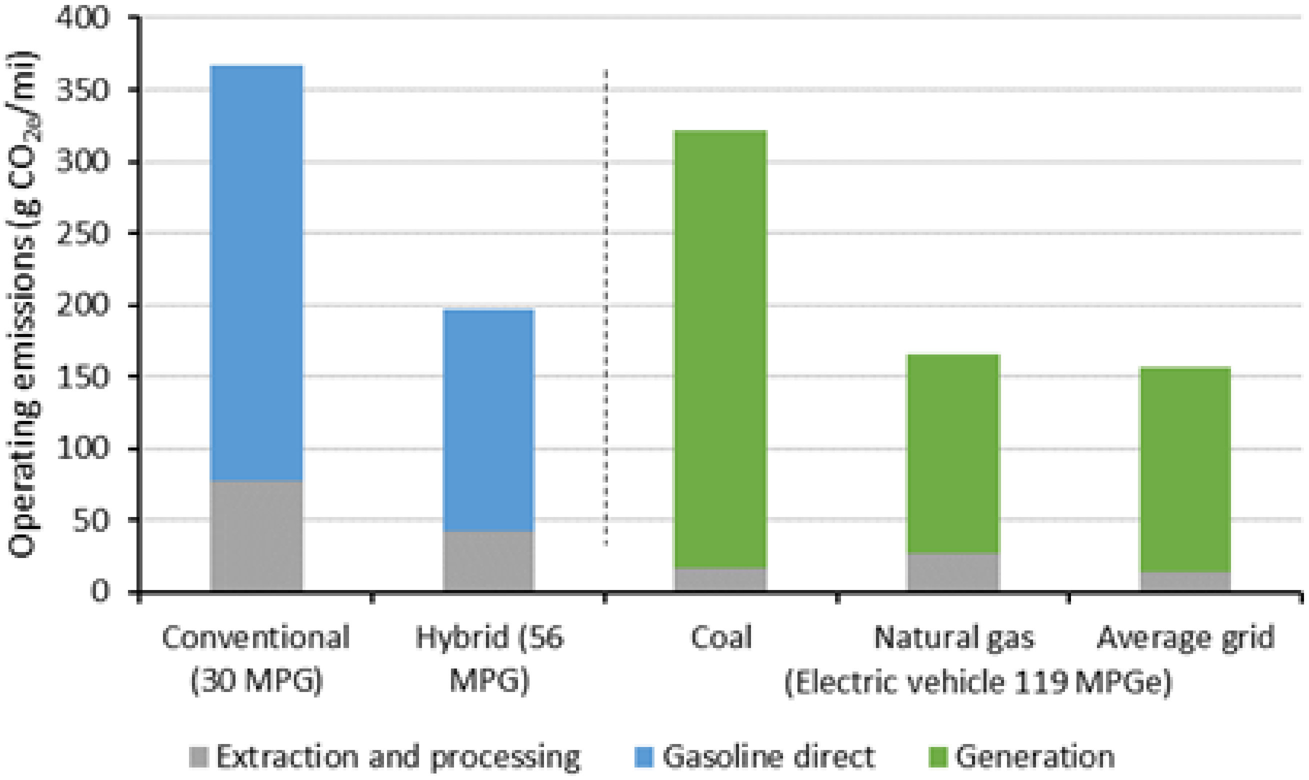


Generation and Emissions Trends in the Electric Power Industry: 1995-2017



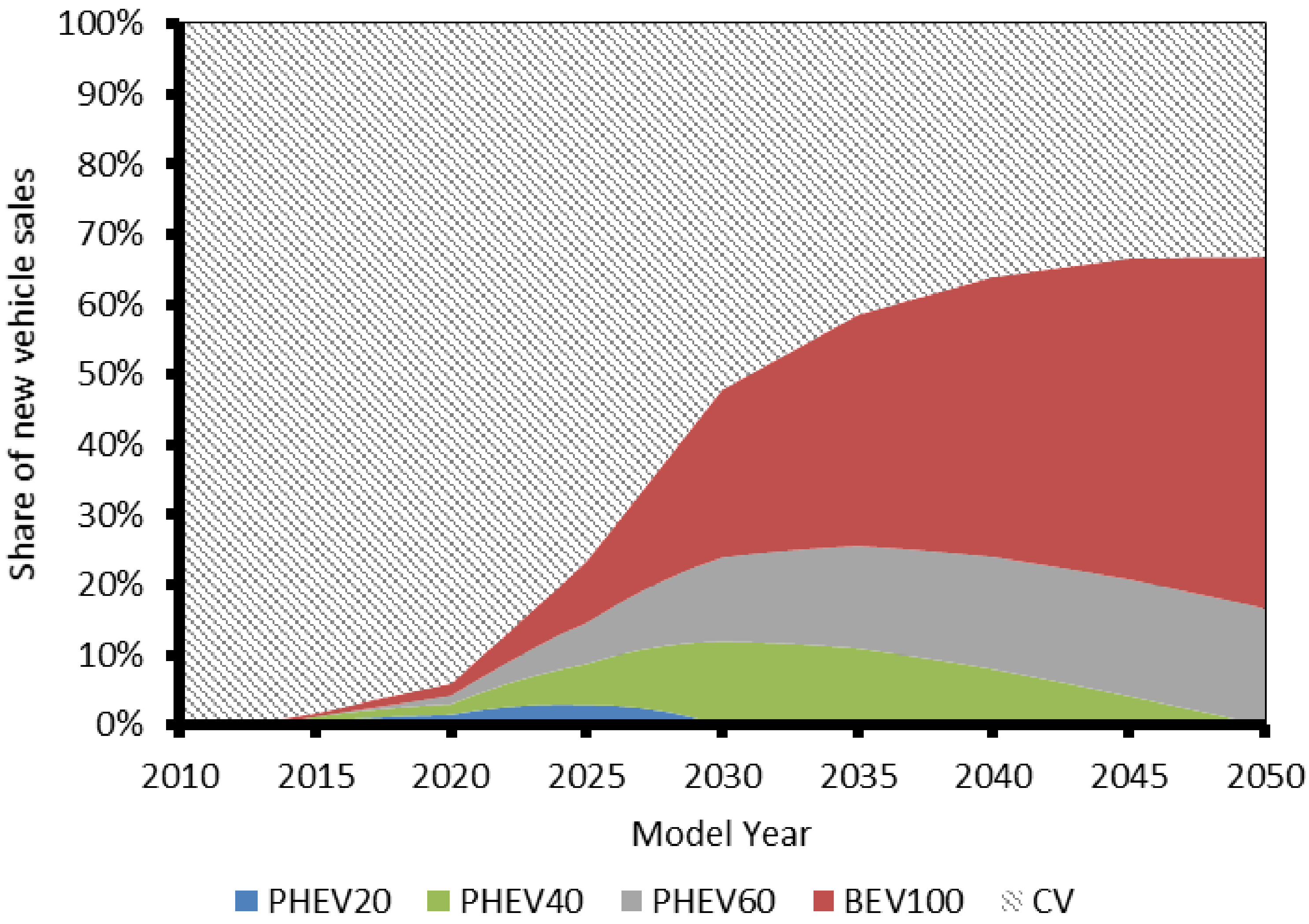


Per-vehicle greenhouse gas emissions results (present day)

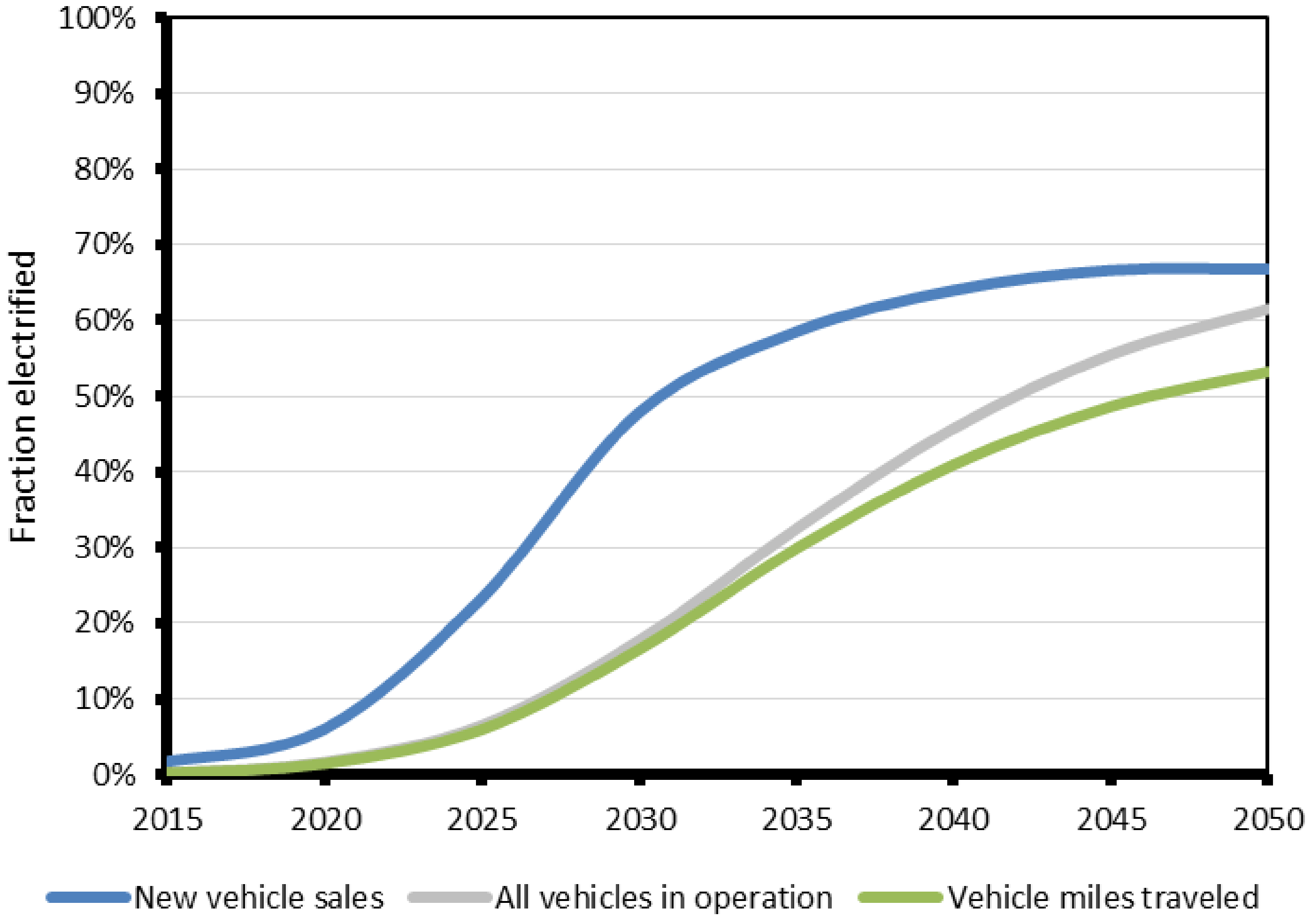


EPRI-NRDC 2015 Study:
Near-term (2030) Impacts of Transportation Electrification

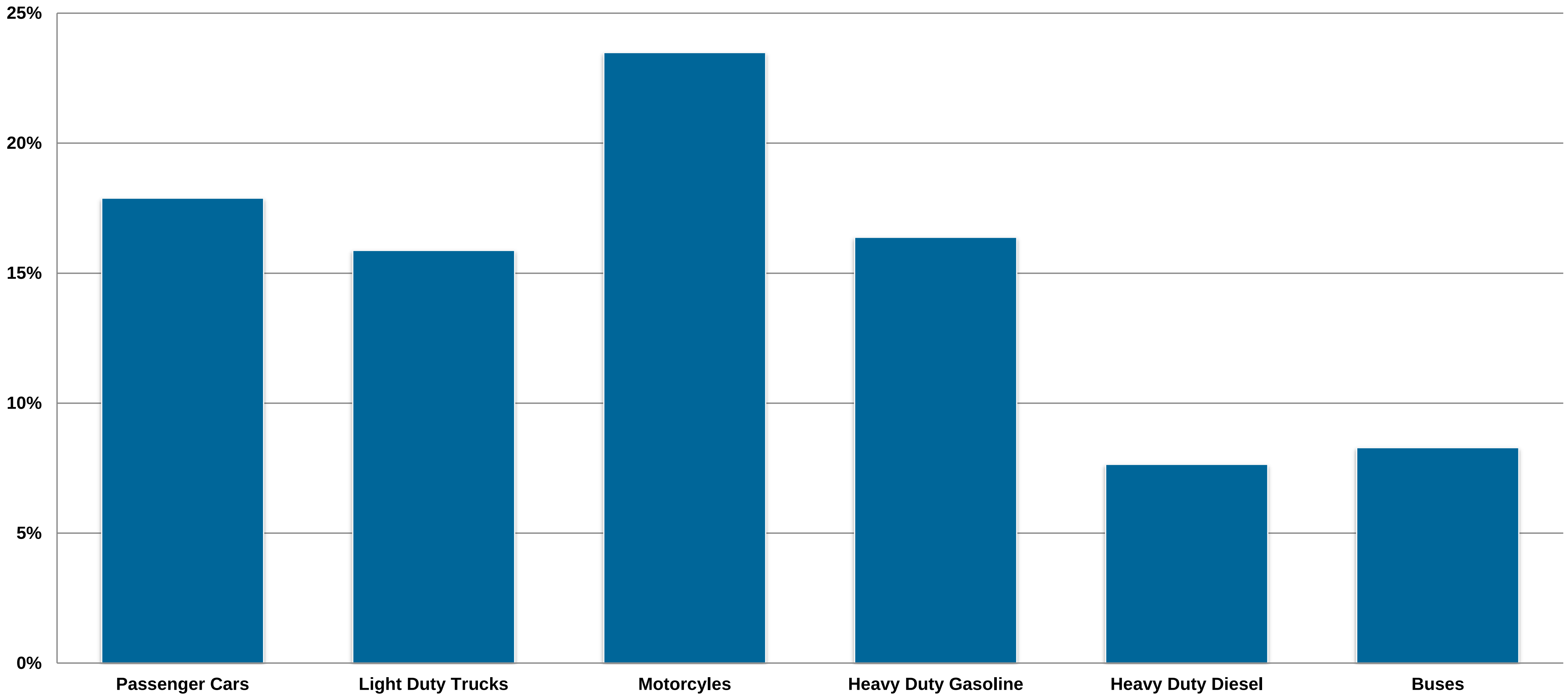
Transportation Sector Modeling (Passenger Vehicles)



Transportation Sector Modeling (Passenger Vehicles)



EPRI-NRDC Study: Percent Electric Vehicle Miles Traveled by 2030

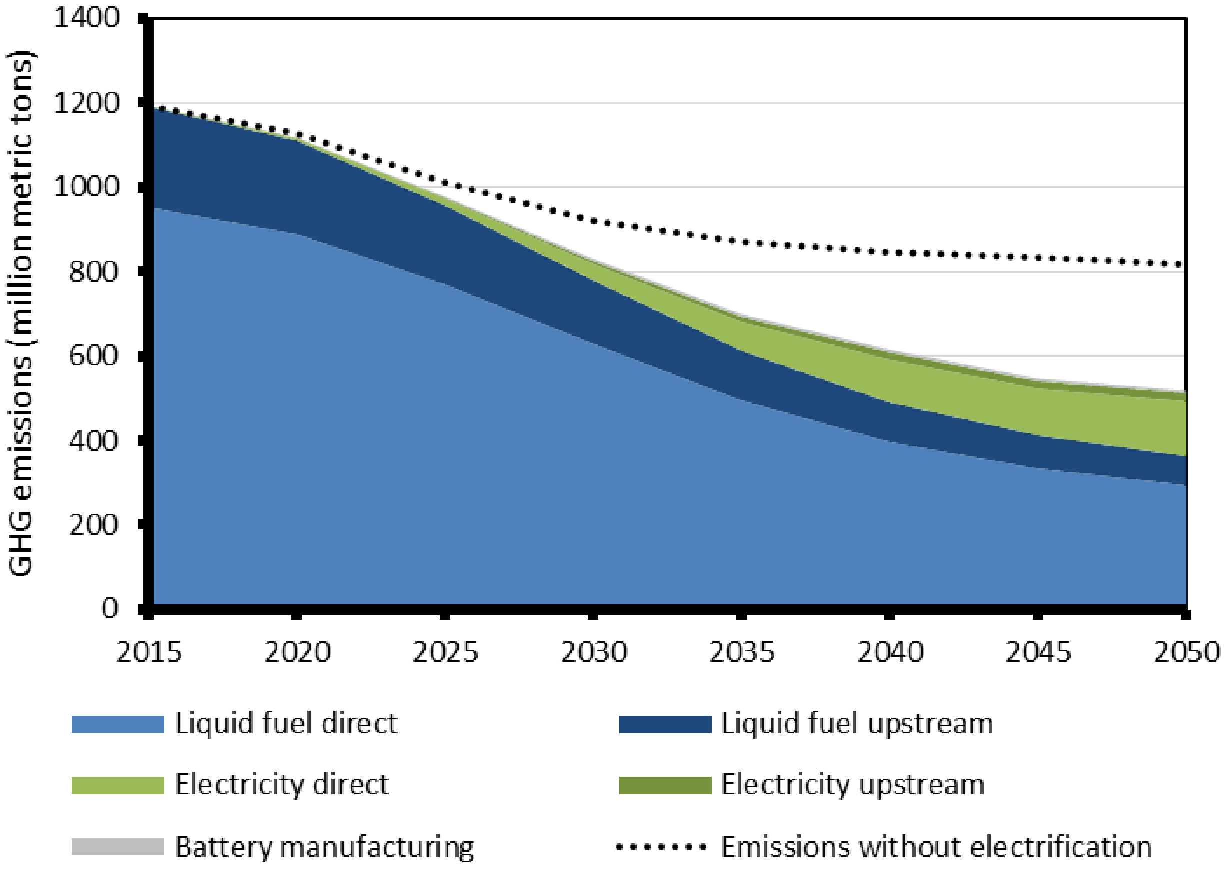


EPRI-NRDC Study: Examples of Electrified Non-Road Equipment

Lawn and Garden	
Chain Saws (units ≤6 horsepower)	Push Lawn Mowers
Chippers/Shredders *(units ≤6 horsepower)*	Riding Lawn Mowers *(units ≤40 horsepower)*
Commercial Turf Equipment (units ≤25 horsepower)	Snow Blowers (units ≤3 horsepower)
Leaf Blowers	Trimmers/Edgers
Industrial	
Agricultural Pumps	Port Cranes
Aircraft Auxiliary Power Units	Shoreside Power
Airport GSE (units ≤175 horsepower)	Sweepers / Scrubbers *(units ≤25 horsepower)*
Dredging Craft	Switching Locomotives
Forklifts (units ≤175 horsepower)	Transportation Refrigeration Units
Recreational	
ATVs	Motorcycles
Golf Carts	Special Vehicle Carts *(units ≤25 horsepower)*

Only electrified the "low-hanging fruit" technologies already "primed" for electrification

EPRI-NRDC Study: Passenger Vehicle Greenhouse Gas Emissions



For passenger vehicles, transportation electrification increases the reduction in transportation GHG emissions between 2015 and 2050 from 32% to 57%

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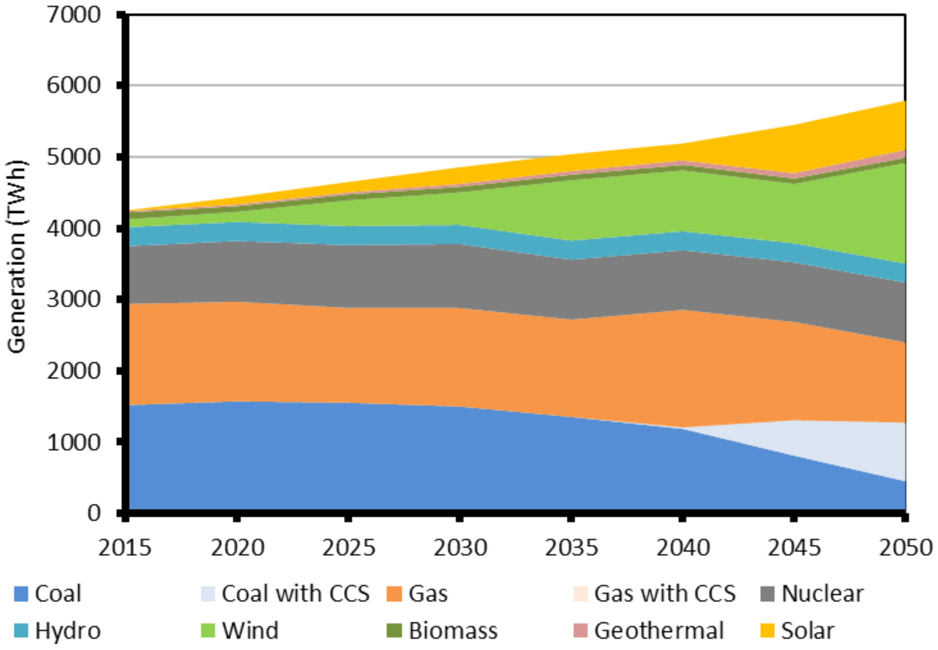
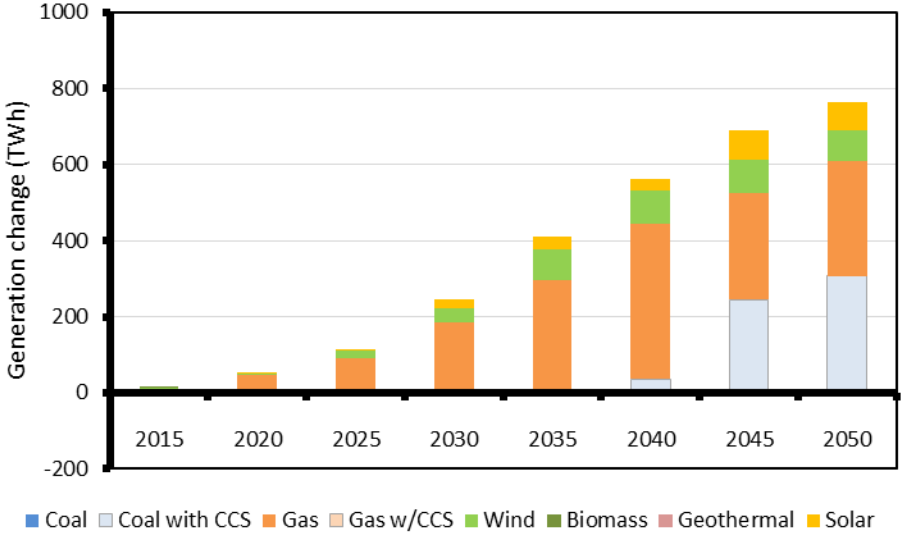
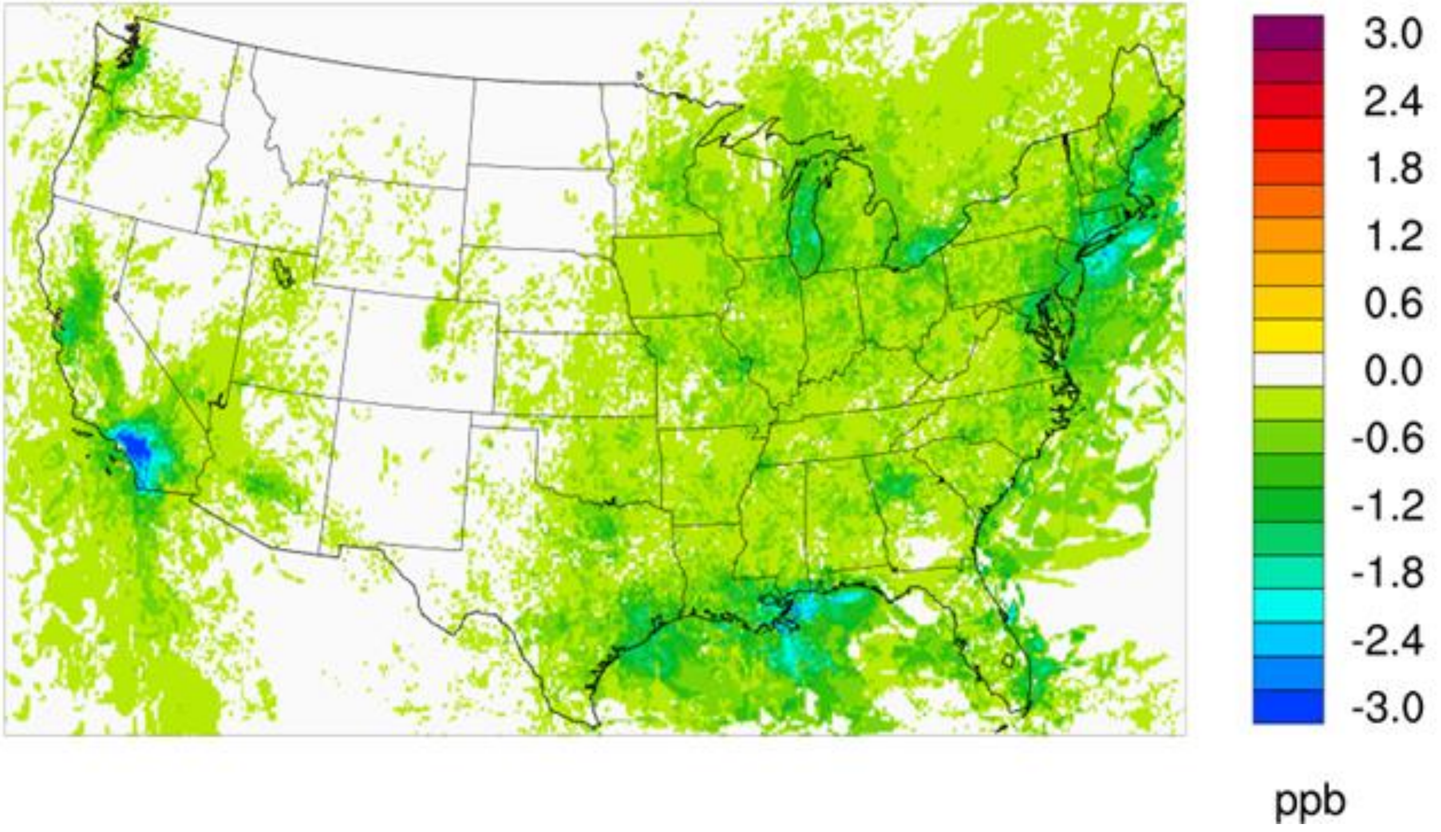
EPRI-NRDC Study: Base GHG Scenario (Electric Sector)





- Without electrification, the Base GHG Scenario projects most new load being met with renewable generation, with some additional combined cycle natural gas (CCNG)
- The marginal transportation load is met by a combination of CCNG and renewables, with increasing amounts of coal with carbon capture and storage (CCS) in the post-2040 timeframe

EPRI-NRDC Study: Ozone Impacts in 2030



- There are modest, but widespread air quality benefits, i.e. reduced ozone concentrations
- ~1 ppb benefits are widespread and benefits are higher in urban areas

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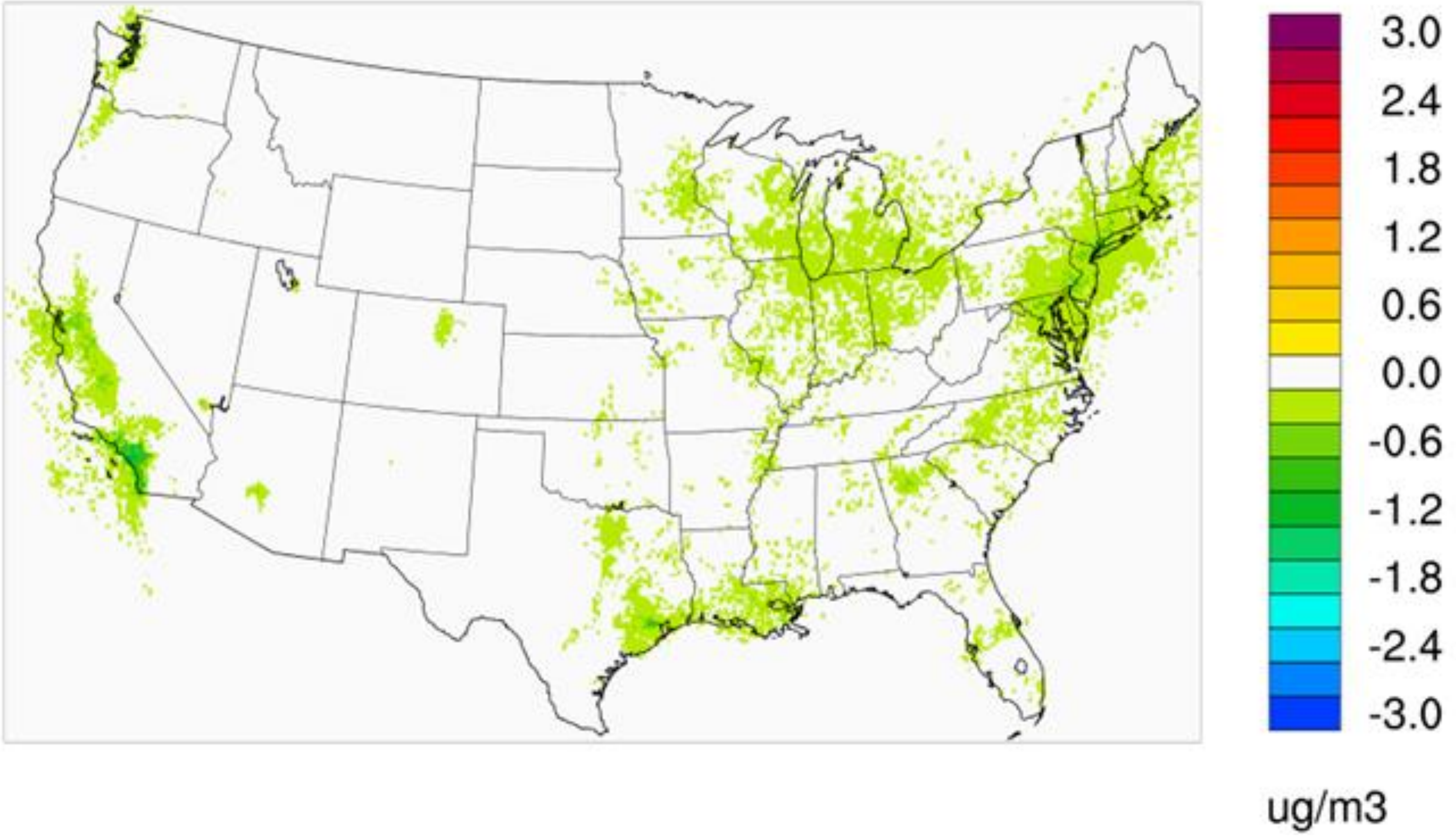
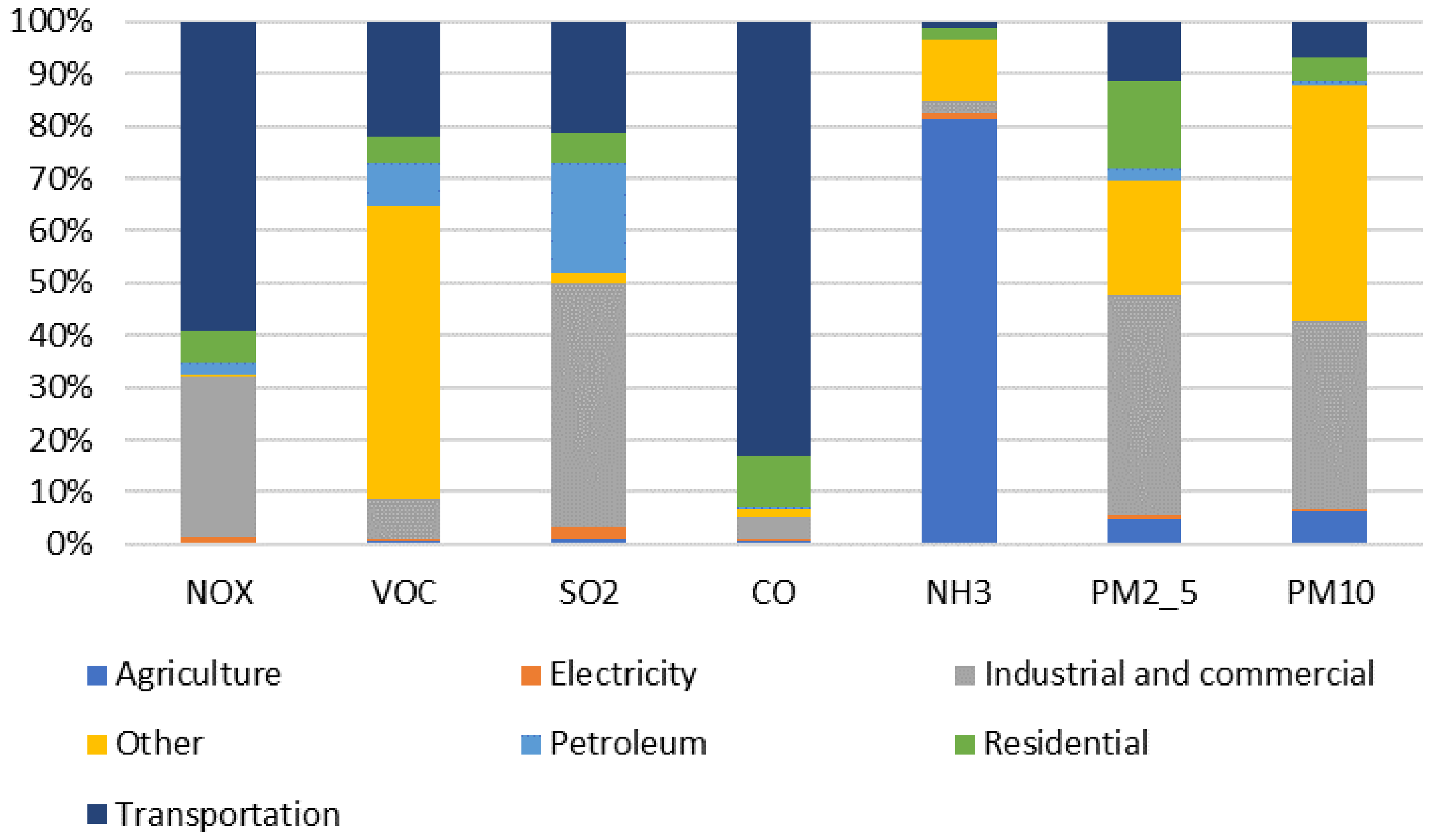
EPRI-NRDC Study: Fine Particulate Matter ($PM_{2.5}$) results



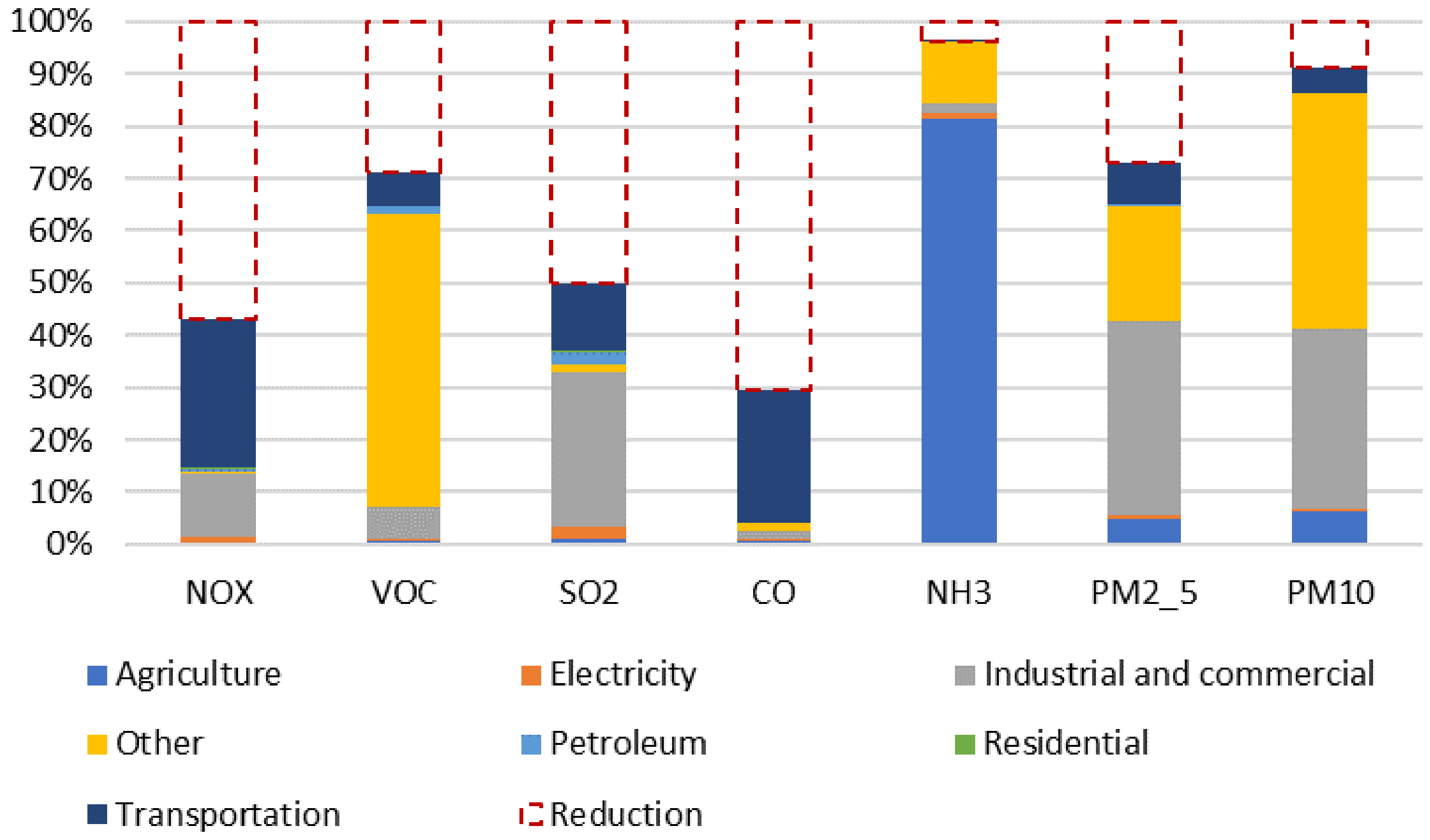
- There are also reductions in fine particulate matter, $PM_{2.5}$, mostly concentrated in urban areas

Aggressive Economy-wide Electrification in 2050
California Case Study
(supported by California Energy Commission)

Emissions Inventory: Reference (Overall)



Emissions Inventory: Electrification Scenario



Electrification Assumptions 2050 (On-Road)

Fuel use category	Electrification share	Source
combination long-haul	**80%**	**LTES heavy duty adoption**
combination short-haul	**80%**	**LTES heavy duty adoption**
intercity bus	88%	LTES bus adoption
light commercial truck	85%	TAC suggestion
motor home	80%	LTES heavy duty adoption
motorcycle	93%	LTES light duty adoption
passenger car	**93%**	**LTES light duty adoption**
passenger truck	**93%**	**LTES light duty adoption**
transit bus	88%	LTES bus adoption
refuse truck	80%	LTES heavy duty adoption
school bus	88%	LTES bus adoption
single unit long-haul	**66%**	**LTES medium duty adoption**
single unit short-haul	**66%**	**LTES medium duty adoption**

LTES - "Long-Term Energy Scenarios In California" performed by Energy and Environmental Economics (E3) for CEC (project EPC-14-069).

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Electrification Assumptions 2050 (Non-Road)

Fuel use category	Electrification share	Source
agricultural	15%	TAC suggestion
aviation	10%	TAC suggestion
construction and mining	0%	
forklift	100%	Assume aggressive adoption
ground support equipment	**100%**	**Assume aggressive adoption**
lawn and garden	**100%**	**Assume aggressive adoption**
marine	10%	TAC suggestion
marine (port)	**100%**	**Assume aggressive adoption**
other non-road	0%	
rail	0%	
rail (yard)	**100%**	**Assume aggressive adoption**
recreational equipment	0%	
recreational marine	25%	TAC suggestion
refrigeration	100%	Assume aggressive adoption
terminal tractor	100%	Assume aggressive adoption
truck apu	100%	Assume aggressive adoption

Electrification Assumptions 2050 (Various Sectors)

Sector	Fuel use category	Electrification share	Source
Industrial	boiler	98%	LTES commercial water heating adoption
Industrial	chemical manufacturing	0%	No electrification assumed
Industrial	heat	60%	EPRI assumption
Industrial	motion	100%	Very high adoption assumed
Industrial	other	0%	No electrification assumed
Industrial	solvents	0%	No electrification assumed
Industrial	space heat	80%	LTES commercial space heating adoption
Petroleum	boiler	90%	Petroleum use reduction
Petroleum	heat	90%	Petroleum use reduction
Petroleum	other	90%	Petroleum use reduction
Residential	**heating**	**99%**	**LTES residential water heating adoption**
Residential	**space heating**	**83%**	**LTES residential space heating adoption**
Residential	**wood heating**	**100%**	**Complete replacement of wood heating assumed**

Preliminary CEC Study Air Quality Impacts: July 2050

Maximum daily 8-hour average (MDA8) ozone

Average monthly ozone

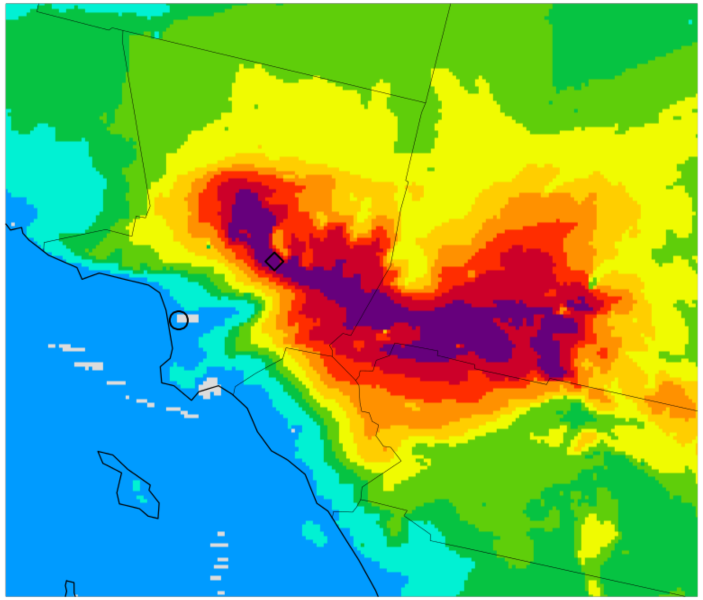
24-hour average fine particulate matter ($PM_{2.5}$)

Average monthly $PM_{2.5}$

July 2050 Maximum MDA8 Ozone in South Coast Air Basin

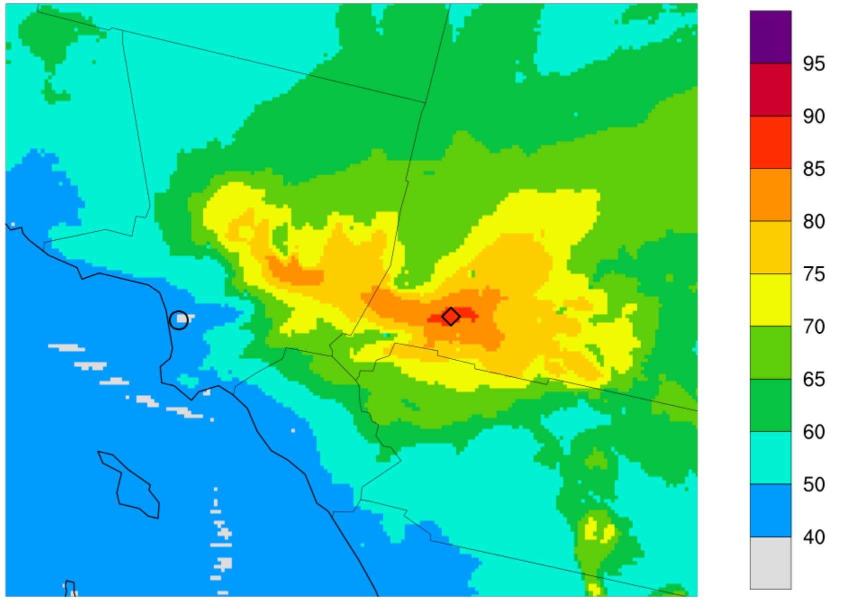
- Broad reductions maximum daily average 8-hour ozone (July 2050) within 10-20 ppb
- Up to 33 ppb reduction; small area of NOx disbenifit generally within 1-3 ppb (up to 14 ppb increase near Long Beach) in region with low baseline ozone

Reference



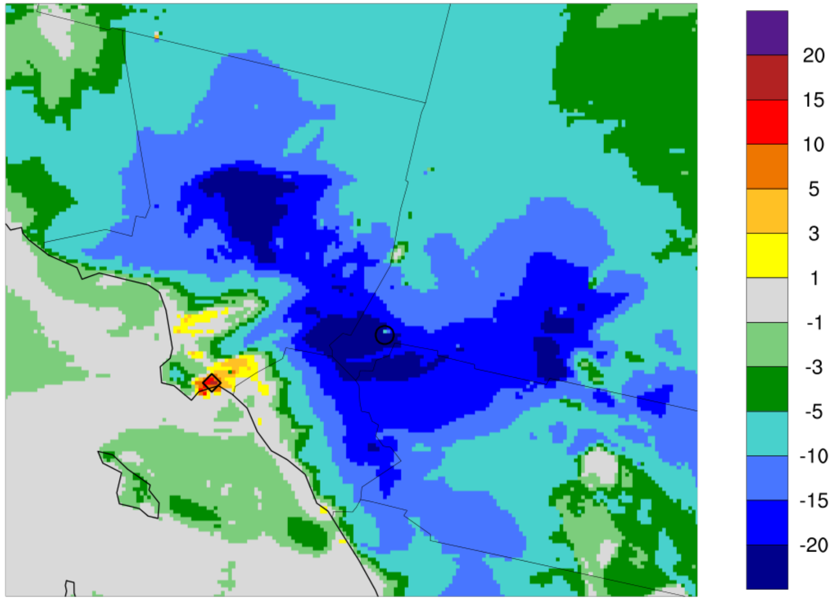
◇ max(74,92) = 103.3 ppb
○ min(48,76) = 4.8 ppb

Electrification



◇ max(122,77) = 86.2 ppb
○ min(48,76) = 5.3 ppb

Elec - Ref



◇ max(57,59) = 16.2 ppb
○ min(104,72) = -33.3 ppb

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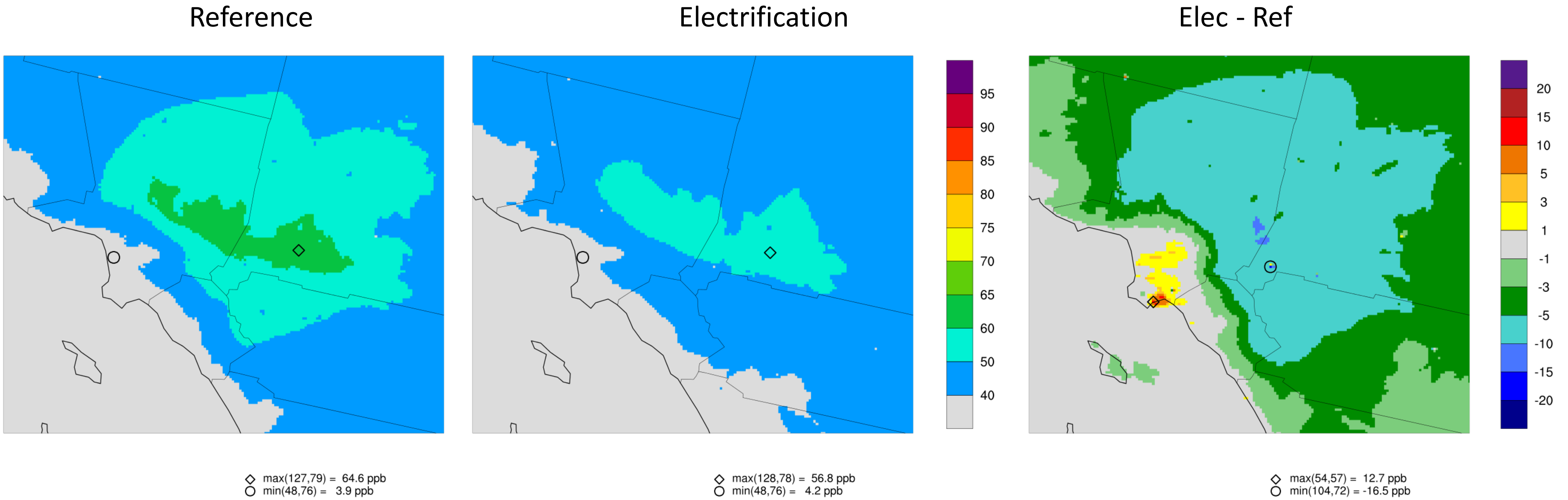
July 2050: Monthly Average MDA8 Ozone in South Coast Air Basin

- Broad reductions in monthly average ozone within 5-10 ppb
- Up to 16 ppb reduction; NOx disbenefit near ports generally within 1-3 with a highly localized maximum 13 ppb



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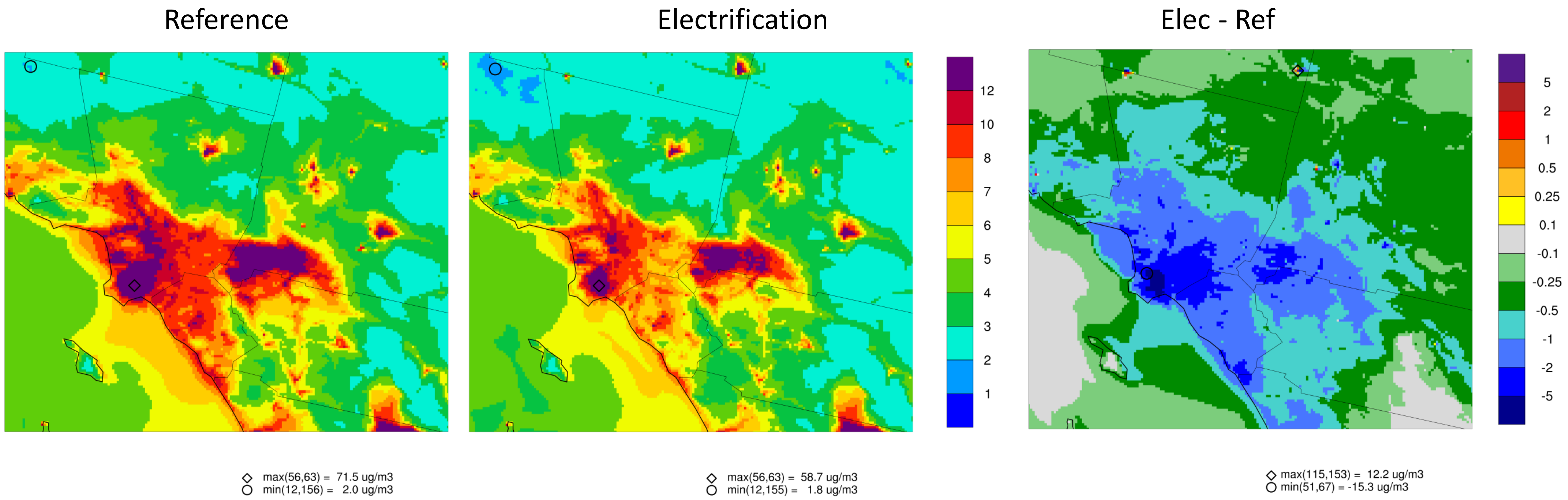
July 2050: Maximum 24-hr $PM_{2.5}$ in South Coast Air Basin

- Broad reductions within 1-5 μg/m^3
- Maximum reduction of 15 μg/m^3 near Long Beach; large reductions in elemental carbon and primary organic aerosol as well as other $PM_{2.5}$ constituents



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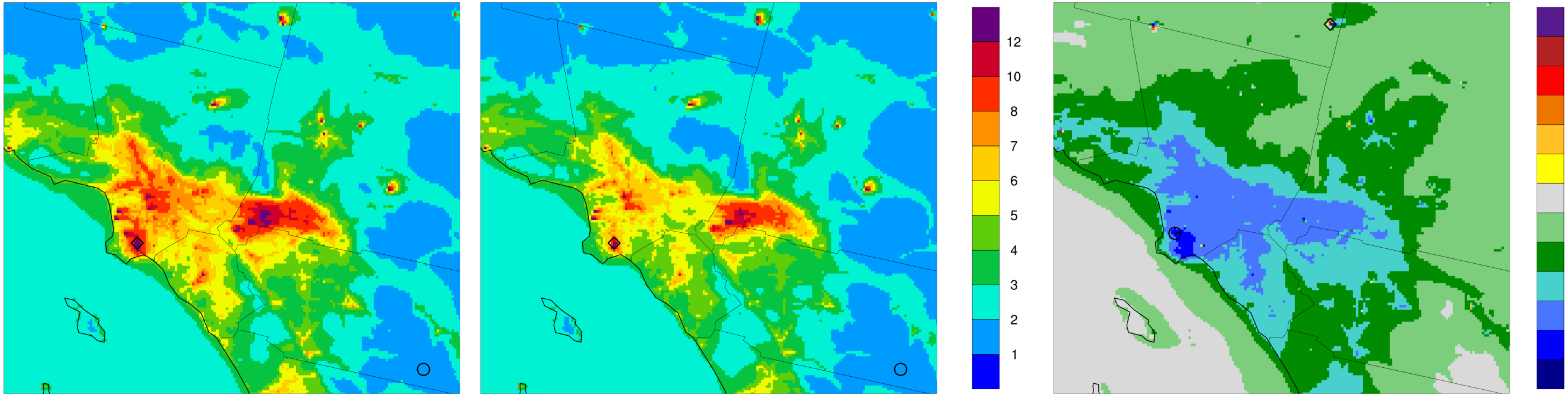
July 2050: Monthly Average $PM_{2.5}$ in South Coast Air Basin

- Broad reductions within 1-2 µg/m^3
- Maximum reduction of 9.5 µg/m^3 near Long Beach; large reductions in elemental carbon and primary organic aerosol as well as other $PM_{2.5}$ constituents

Reference | Electrification | Elec - Ref



◇ max(56,63) = 43.1 ug/m3
○ min(174,11) = 1.2 ug/m3

◇ max(56,63) = 39.7 ug/m3
○ min(174,11) = 1.2 ug/m3

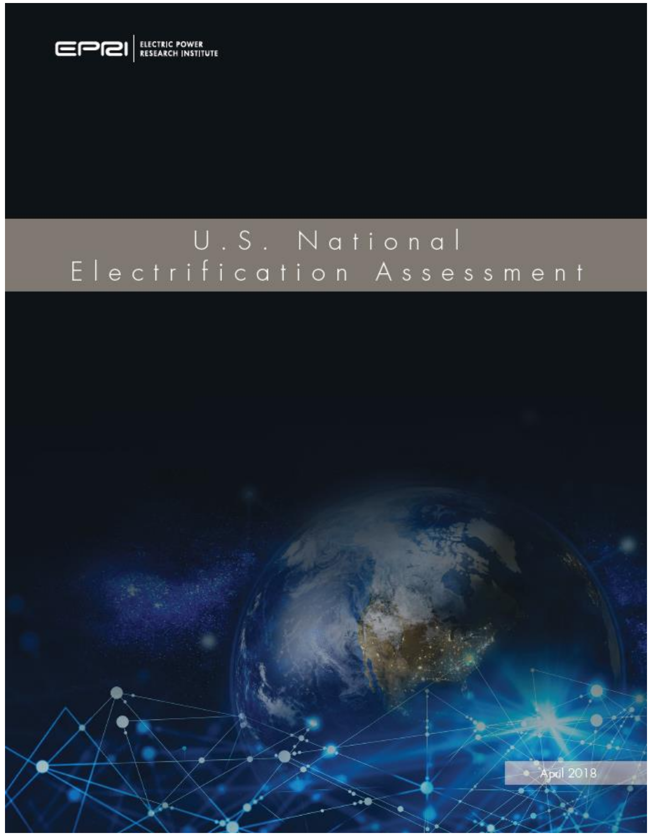
◇ max(115,153) = 6.8 ug/m3
○ min(51,67) = -9.5 ug/m3

National Electrification Assessment

U.S. National Electrification Assessment (USNEA)

U.S. NATIONAL ELECTRIFICATION ASSESSMENT (USNEA)

2018



National assessment *of the potential to increase* electrification by 2050

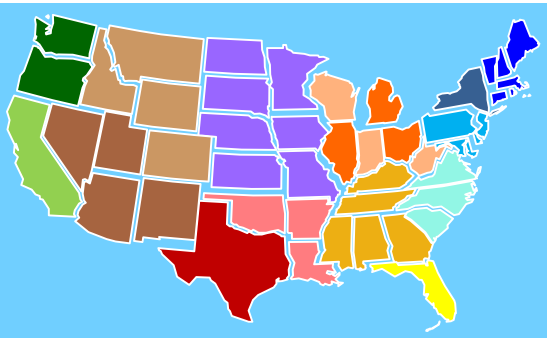
- Energy demand by sector
- Electricity load shapes
- Electric capacity and generation
- Energy prices
- CO_2, air emissions, other
- Drivers/barriers

Preview released at NARUC on Feb. 11

Full Report rolled out at National Press Club in Washington, DC on April 3, 2018

FOLLOW-ON STUDIES 2018+

STATE-LEVEL ASSESSMENT



Energy System Assessment

Environmental Assessment

Transmission Assessment

Electrification Potential Assessment and Implementation Plan

Member Advisory Group – Leadership, Technical, Business

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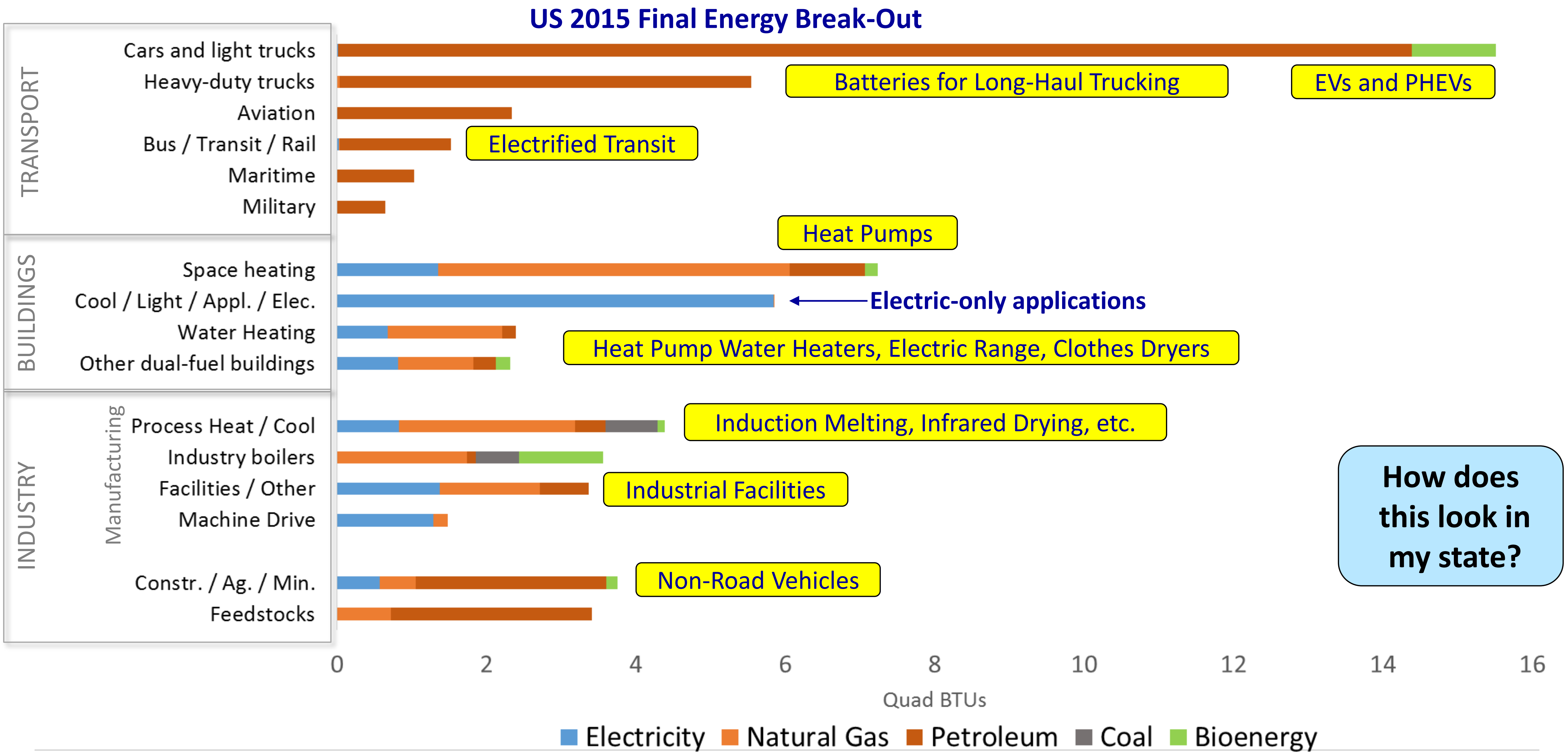
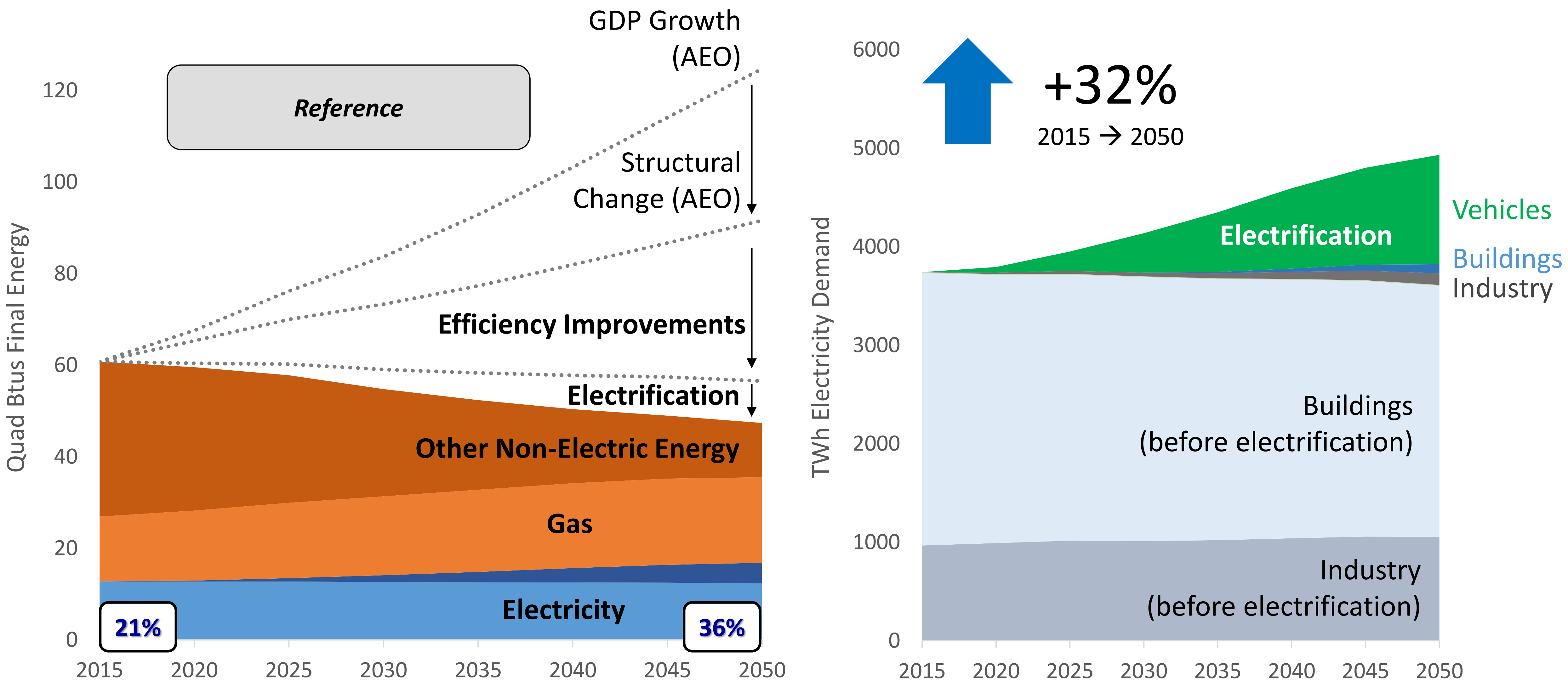
Potential for Efficient Electrification Varies by End-Use Application



Efficient Electrification: Reference



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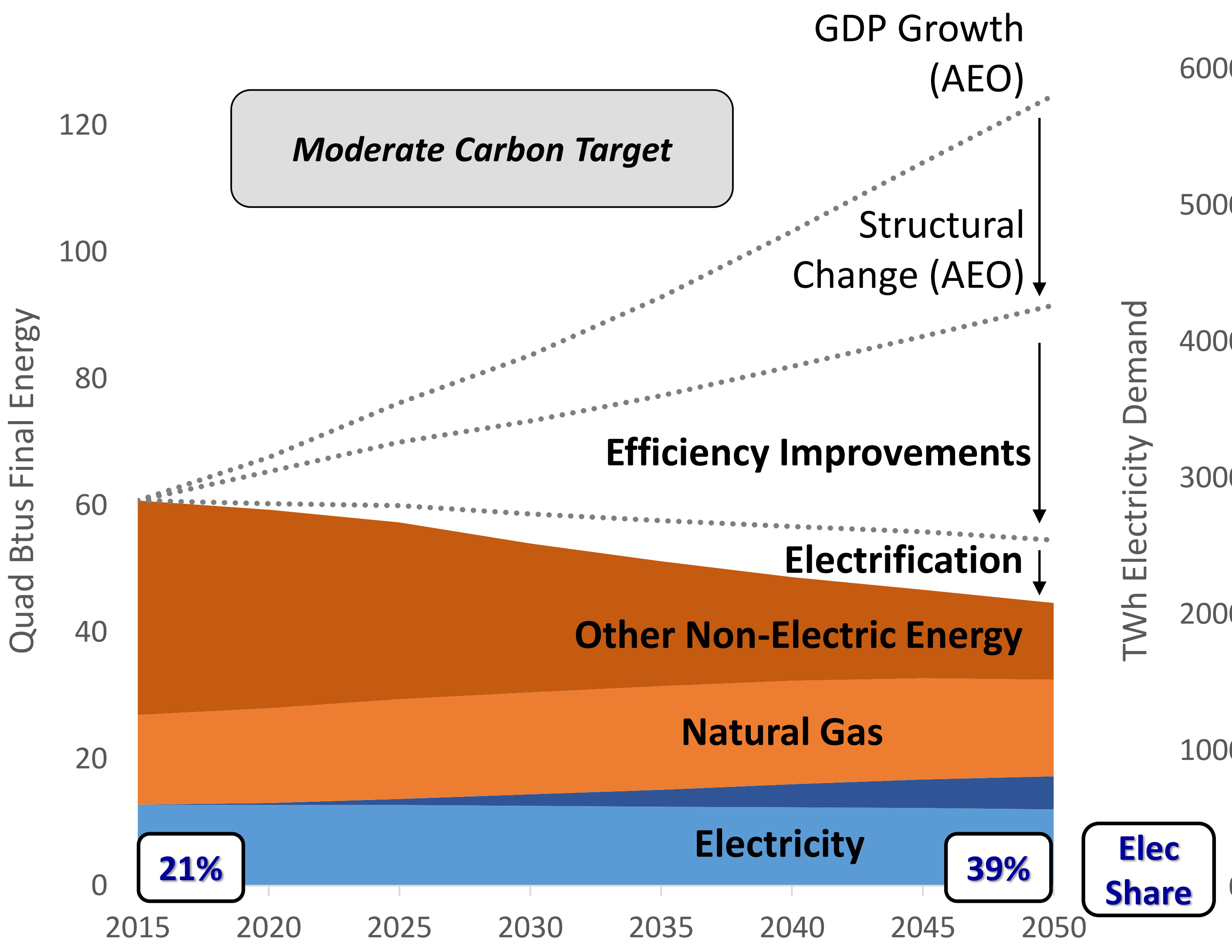
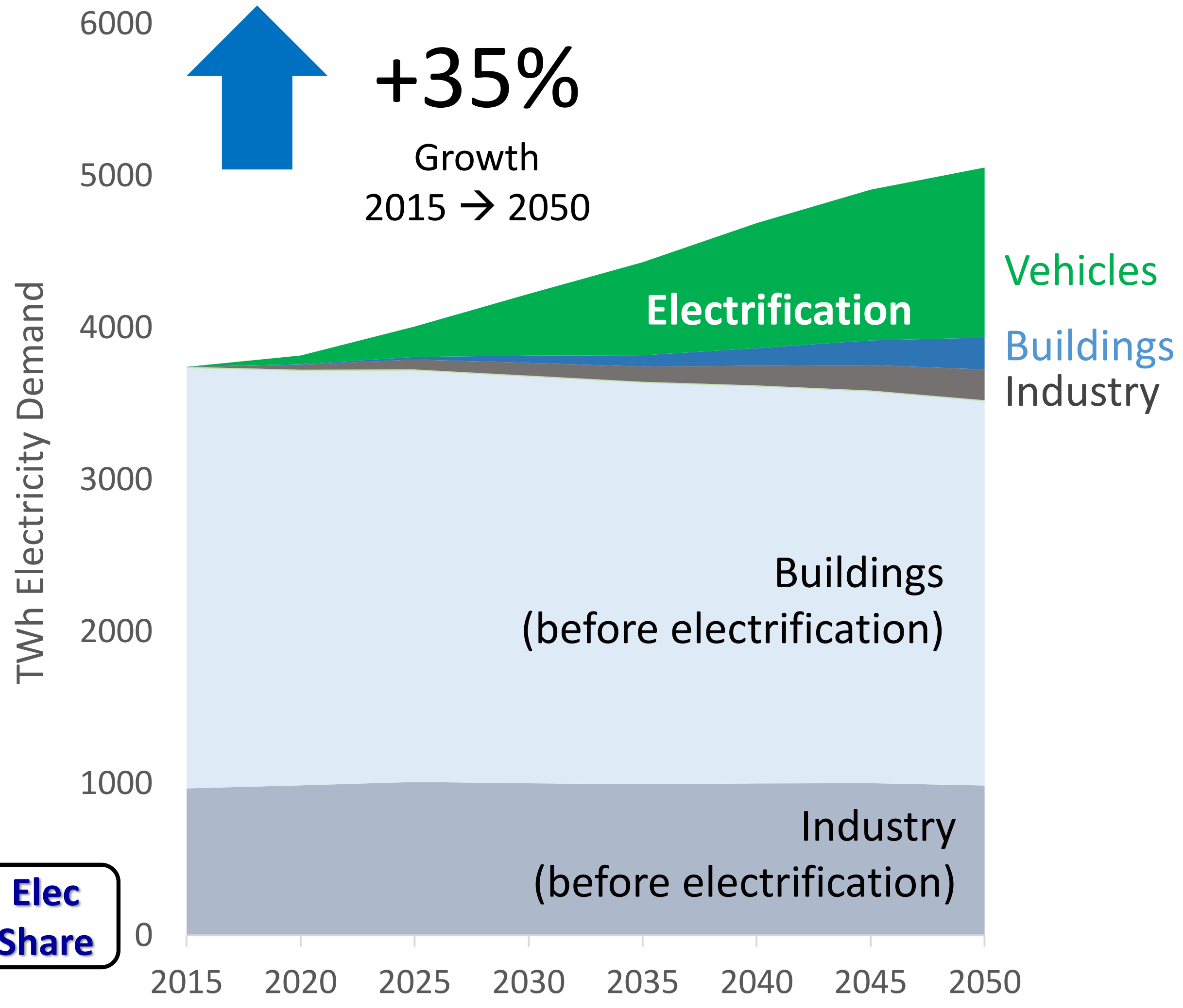
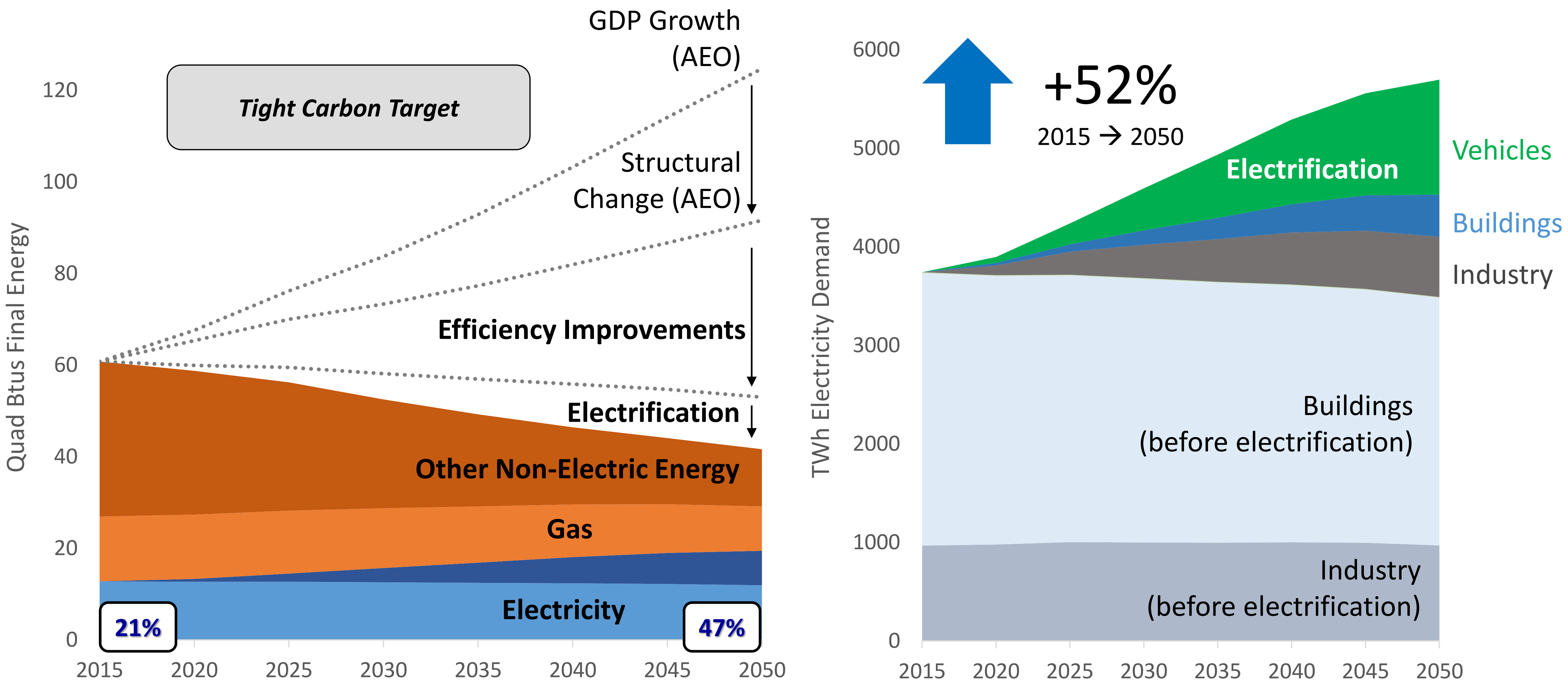
Efficient Electrification: Progressive



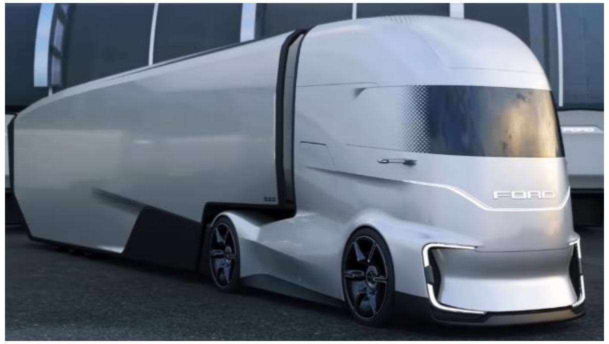


Efficient Electrification: Transformation



C&I/MD/HD EV Market Update (1 of 2)

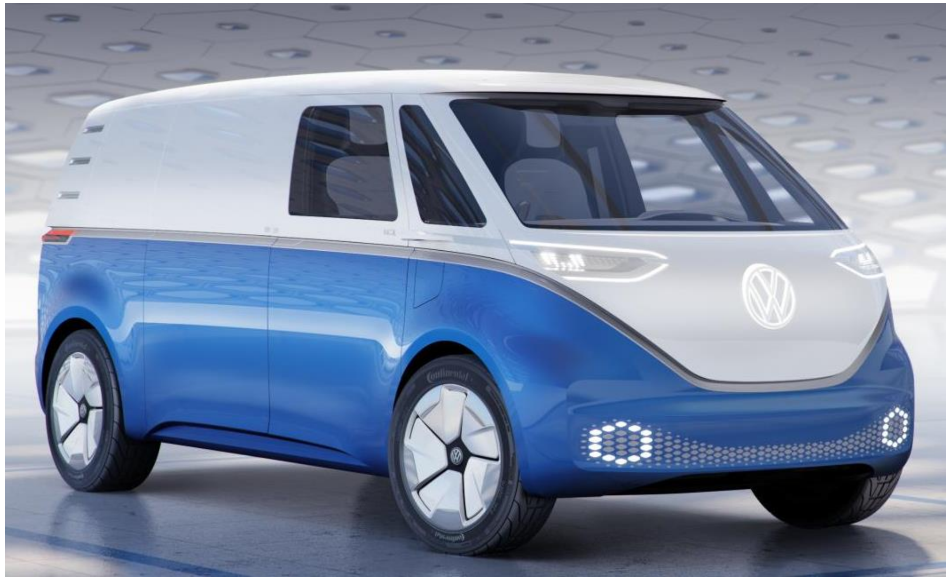
- MAN eGTM truck (125 miles)
- SCANIA PHEV truck (18.4 kWh, 6 miles)
- DAF CF Electric truck (220 kWh, 137 miles)
- Ford autonomous truck
- DAF CF Hybrid truck
- Daimler truck
- Volvo Class 8 port truck



Photos from www.insideEVs.com and www.greencarreports.com

C&I/MD/HD EV Market Update (2 of 2)

- Mercedes eCirtaro bus (243-330 kWh)
- MAN City 12E bus (480-640 kWh, 125 miles)
- SCANIA/VW bus
- MAN/VW eCrafter van (36 kWh)
- VW I.D. Buzz Cargo (111 kWh, 342 miles)



Photos from www.insideEVs.com and www.greencarreports.com

Charging for Medium and Heavy Duty Vehicles

- High uncertainty
- Tesla Semis appear to need ~2MW per truck for fast charging
- Some applications can be even higher
- How much charging should happen at depots over night and how much during the day?

Air Quality Impacts of Electrification Conclusions

Conclusions

- Electric sector emissions have decreased significantly due to shifts in generation and a myriad of air quality regulations

- The EPRI-NRDC study shows that, in the near term, transportation electrification can lead to modest but widespread air quality benefits

- Preliminary results (limited to July 2050) from a study supported by the California Energy Commission demonstrates that aggressive electrification can lead to even greater air quality benefits

Together…Shaping the Future of Electricity