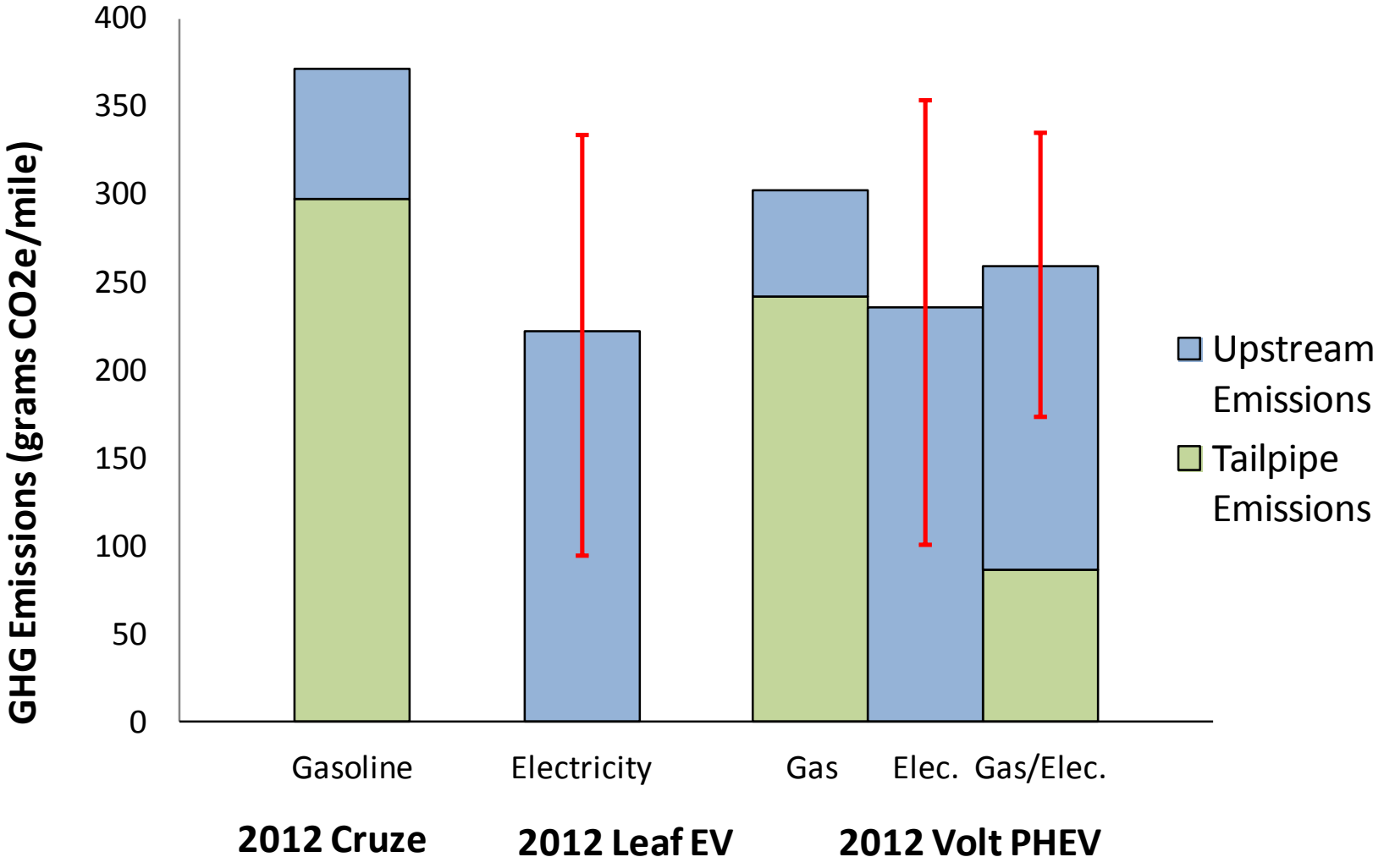
Calculation of Upstream CO_2 for Electrified Vehicles

EVE-9 Meeting UNECE GRPE

18-Feb 14

Lifecycle GHG Emissions Performance

(Real world, based on EPA eGRID2012)



U.S. Perspective on EV Emissions Accounting

- Emissions inventory and regulatory benefits
  - Must reflect state-of-the-art life-cycle GHG accounting
    - For example, always count “upstream” GHG emissions associated with feedstocks, power plants, and grid transmission losses
- Regulatory treatment
  - Regulatory issue
    - Regulate upstream GHG via utilities, automakers, or both?
  - Policy issue
    - Do we want to incentivize potential game-changing technologies?

EV Treatment in U.S. National Program GHG Standards

U.S. National Program GHG/CAFE Standards

(www.epa.gov/otaq/climate/regulations.htm)

	MY 2010 Baseline	MY 2016 Standards	MY 2025 Standards
GHG emissions	351 g/mi (218 g/km)	250 g/mi (155 g/km)	163 g/mi (101 g/km) [54.5 mpg if…]
Fuel economy	25.3 mpg (9.3 L/100 km)	34.1 mpg (6.9 L/100 km)	48.7-49.7 mpg (4.7-4.8 L/100 km)

U.S. National Program
GHG Compliance Incentives for EV/PHEVs

Timeframe	GHG Emissions Compliance Treatment for Grid Electricity	Compliance Multiplier
2012-2016	Below sales limit: 0 grams/mile Above sales limit: Net upstream	None
2017-2021	0 grams/mile	EV: 2.0 … 1.5 PHEV: 1.6 … 1.3
2022-2025	Below sales limit: 0 grams/mile Above sales limit: Net upstream	None

U.S. National Program
Net Upstream GHG Approach for EVs

- Measure vehicle electricity consumption over EPA city and highway test cycles in watt-hours/mile
- Divide value by 0.935 to reflect transmission losses to reflect electricity needed at the electric powerplant
- Multiply value by 0.534 grams/watt-hour to reflect EPA projection of overall electricity upstream GHG emissions (both powerplant and feedstock) associated with extra electricity demand for EVs/PHEVs in 2030
- Subtract the upstream GHG emissions of a gasoline vehicle with the same footprint meeting its CO_2 target

U.S. National Program
Genesis of 0.534 g/w-hr Emissions Factor

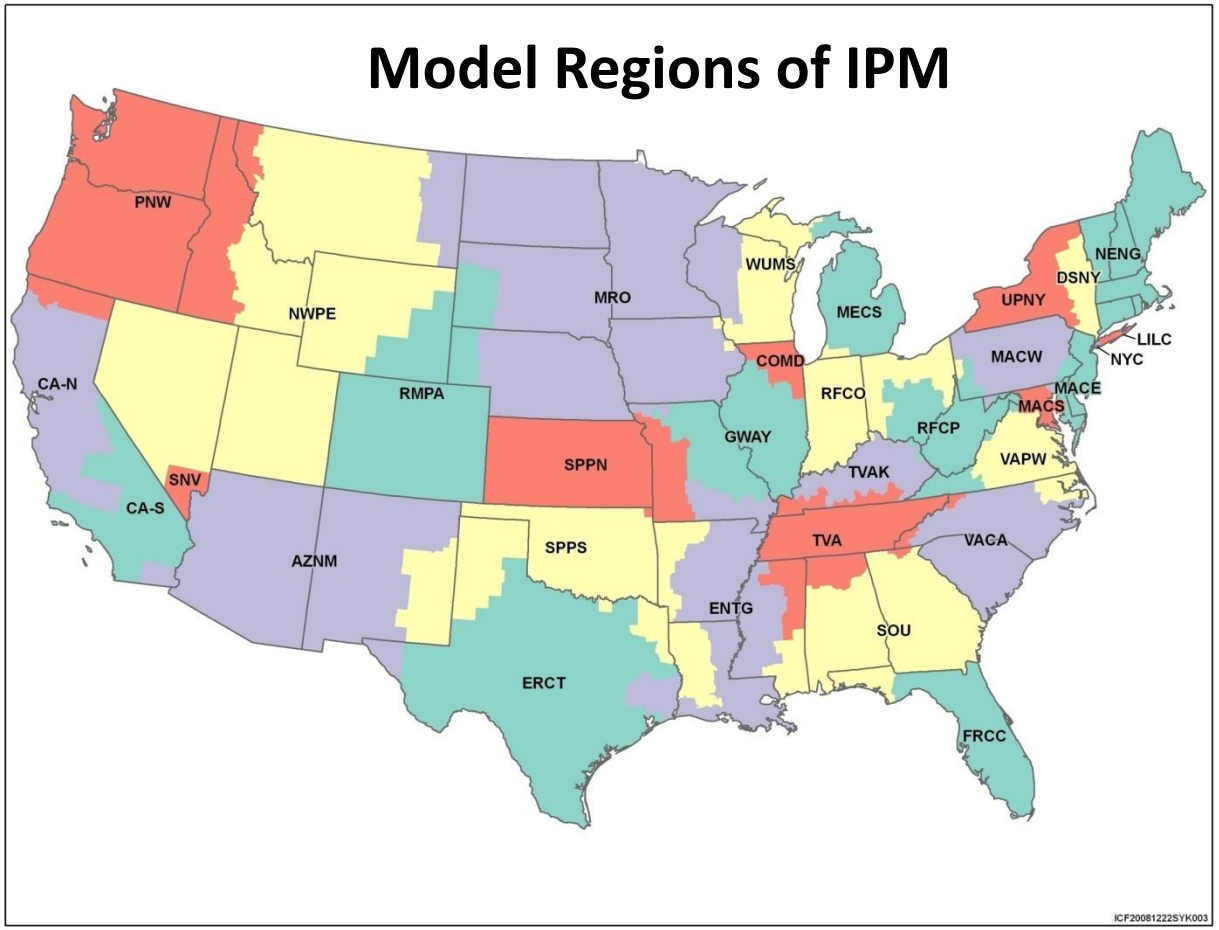
- Used EPA's Integrated Planning Model (IPM) to project how US grid would accommodate "extra" EV/PHEV electricity demand in 2030 timeframe
- Some EV/PHEV-specific assumptions
  - Distributed projected EV/PHEV sales similar to hybrids
    - E.g., more EVs per capita in California than in Wyoming
  - Assumed 25% on-peak charging and 75% off-peak charging
- IPM projected powerplant "mix" to meet "extra" demand
  - 80% natural gas, 14% coal, 6% wind and other feedstocks
- Emissions factors for this powerplant mix
  - 0.445 g/w-hr at powerplant
  - 0.534 g/w-hr for powerplant plus feedstock-related GHG

U.S. National Program
Example MY 2025 Calculation
(for vehicle similar to 2014 Nissan Leaf)

- EPA city/highway electricity consumption of 210 w-hr/mi
- Divide by 0.935, to reflect transmission losses, to get 225 w-hr/mi
- Multiply by the 2030 “extra” EV/PHEV electricity GHG emissions factor of 0.534 g/w-hr, to get 120 g/mi
- Subtract the upstream GHG emissions of a comparable-footprint gasoline vehicle of 41 g/mi, to get 79 g/mi

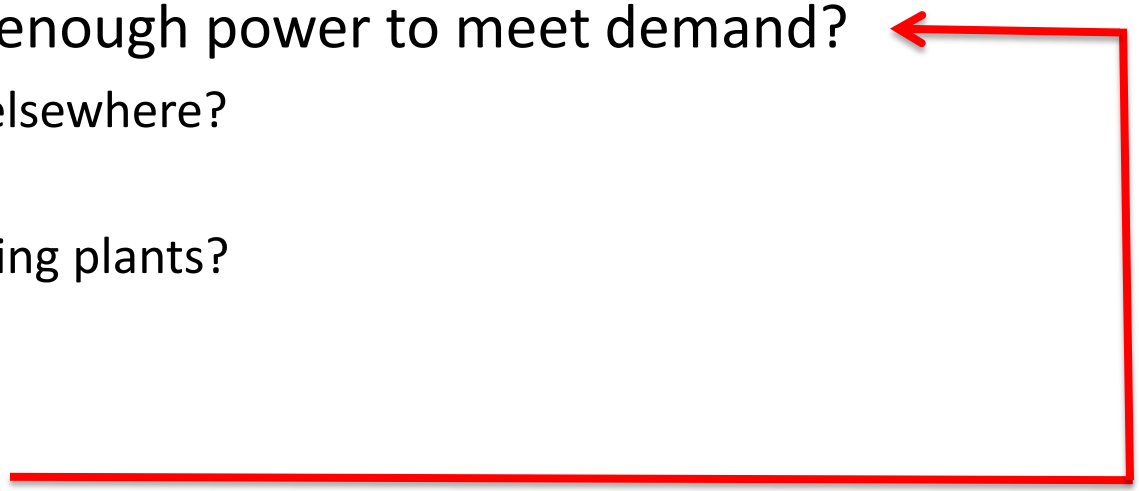
Modeling Power Plant Emissions

- EPA uses IPM to estimate power plant emissions
- Long-term electricity model for U.S. grid
- Provides least-cost solutions subject to
  - Environmental
  - Transmission
  - Reliability
  - Demand



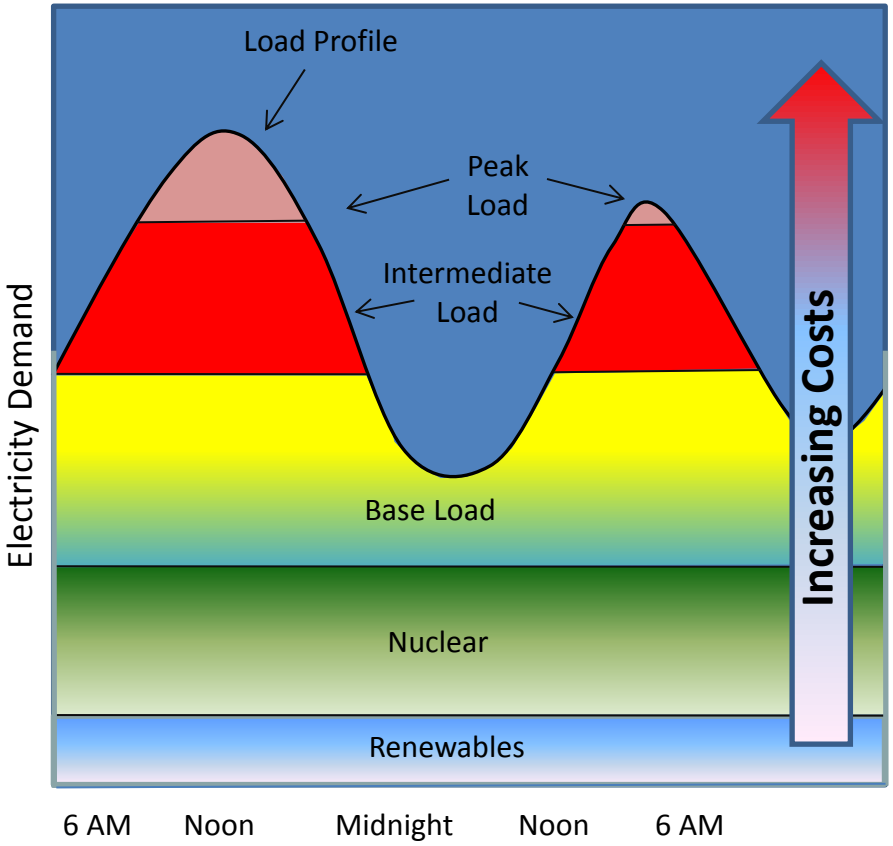
What is IPM?

- Detailed economic dispatch model
  - Simulates least-cost operation of electric power system
- IPM asks: Is there enough power to meet demand?
  - Can I buy it from elsewhere?
    - At what cost?
  - Can I retrofit existing plants?
    - At what cost?
  - Can I build it?
    - At what cost?
- IPM repeats these questions for thousands of power plants in the U.S. for every hour of the year to 2050



Basis of Least-Cost Selection

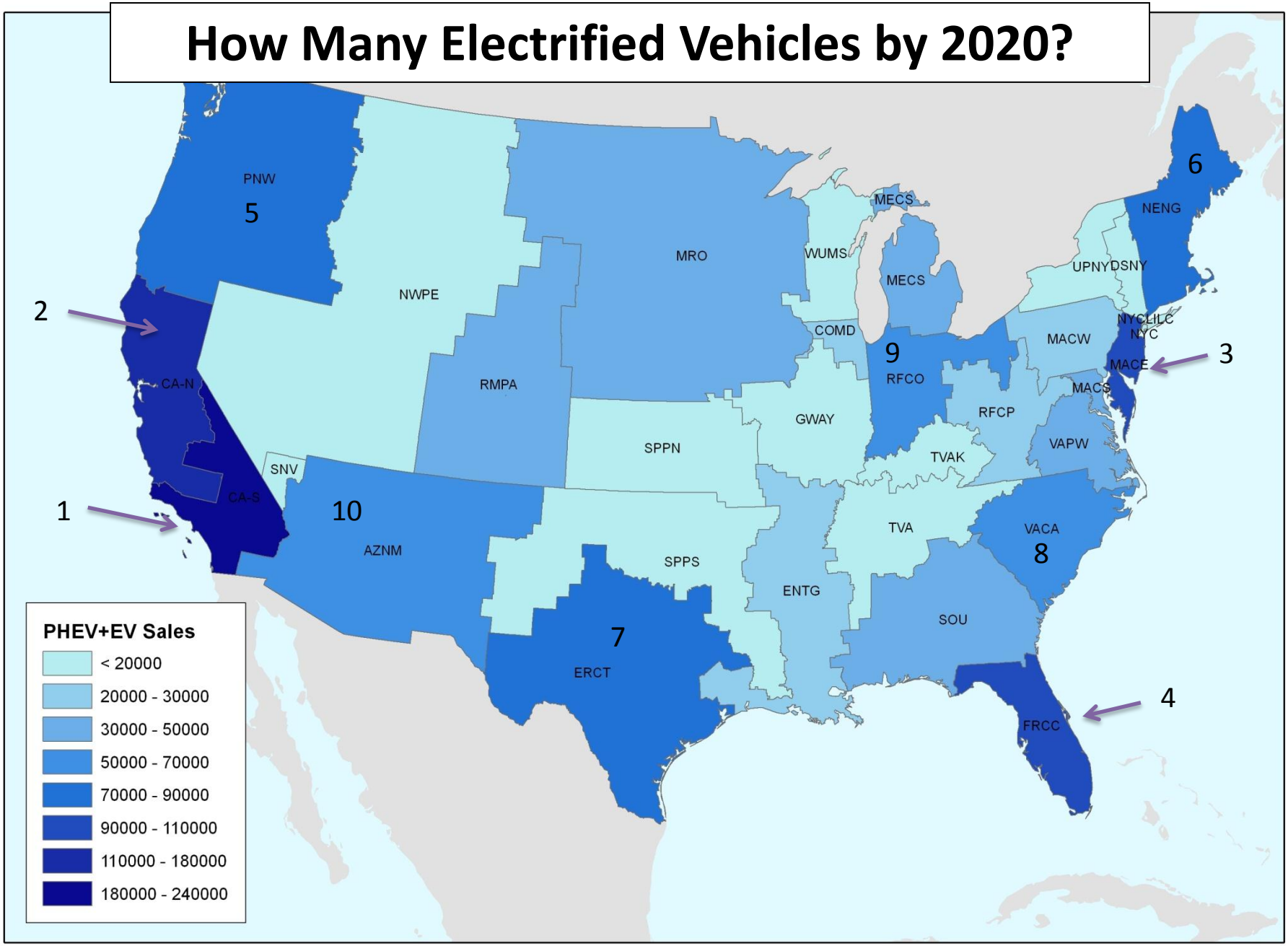
- Dispatch Stack - Hierarchy which calls generators by increasing operating costs
  - Renewables
  - Nuclear Base Load
  - Base Load
  - Intermediate Load
  - Peaking Plants
- **Generation mix sensitive to time of day**
  - **Emissions impacts vary greatly between on-peak & off-peak**



To Evaluate Impacts of Electrified Vehicles

1. Start with USDOE fleet size projections
2. Estimate nationwide EV fleet/energy requirements w/OMEGA
    a. 2012-2025: Interpolate from no fleet to 2025 levels
    b. 2025-2050: Technology penetration stabilizes; fleet grows though attrition
3. Distribute EV fleet into 32 IPM regions
    a. Front-load ZEV & §177states
    b. Top 40 US Bureau of Census Metropolitan Statistical Area (MSA)
    c. Historical precedent, manufacturer production plans, etc

How Many Electrified Vehicles by 2020?

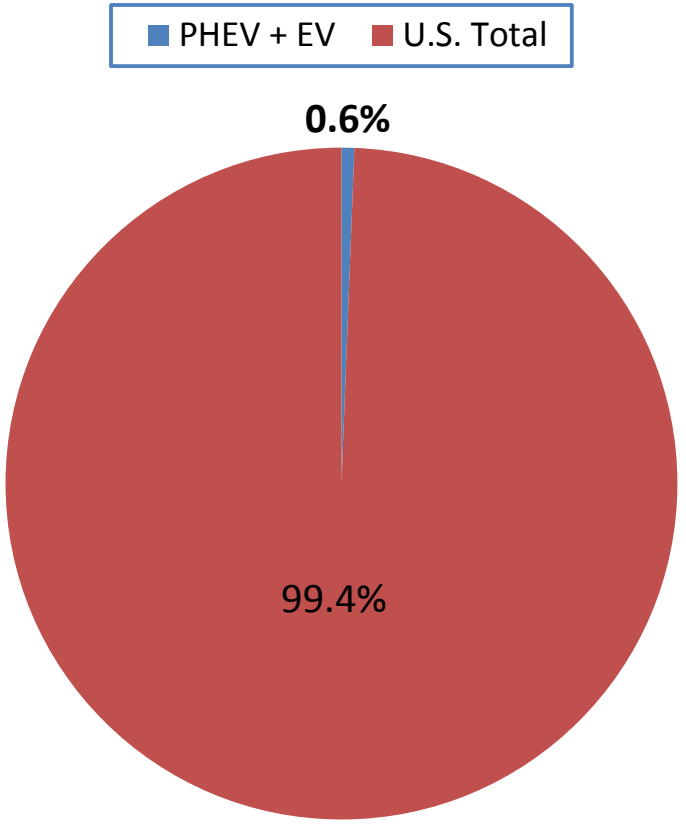


IPM Electrification Scenarios

4. Estimate VMT using MOVES
5. Combine vehicle energy requirements w/VMT
6. Allocate energy charging requirements by time of day
    a. 25% On-peak, 75% Off-peak
7. IPM estimates incremental emissions/price impact

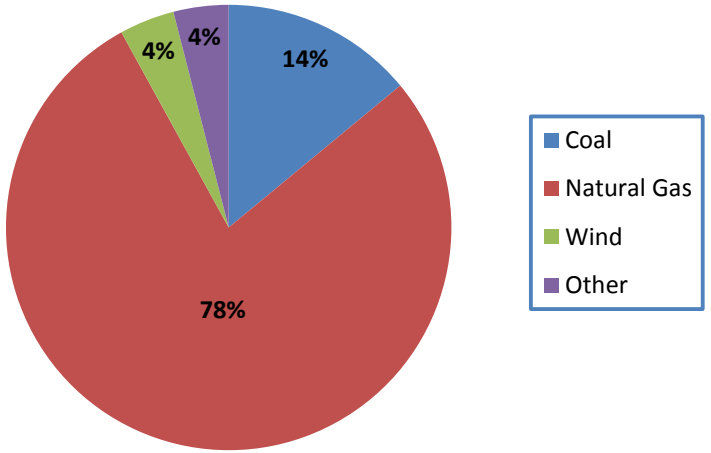
Insignificant Power Consumption

- U.S. Total (2025)
  - 4.6 million GW-hr
- PHEV/EV Total (2025)
  - 28.5 thousand GW-hr

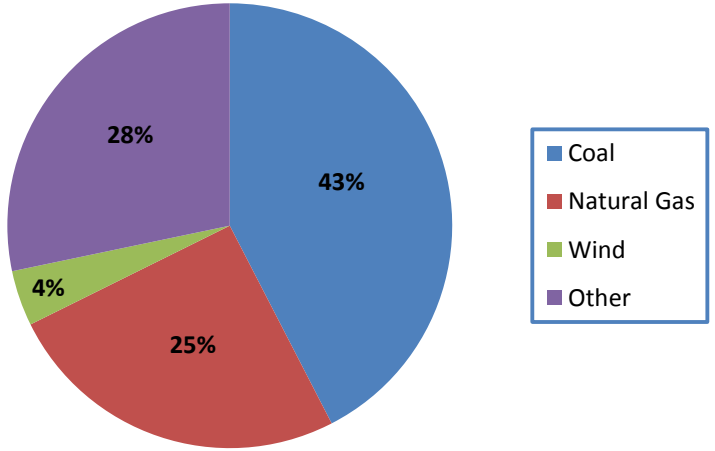


Projected Fuel Mix in 2030

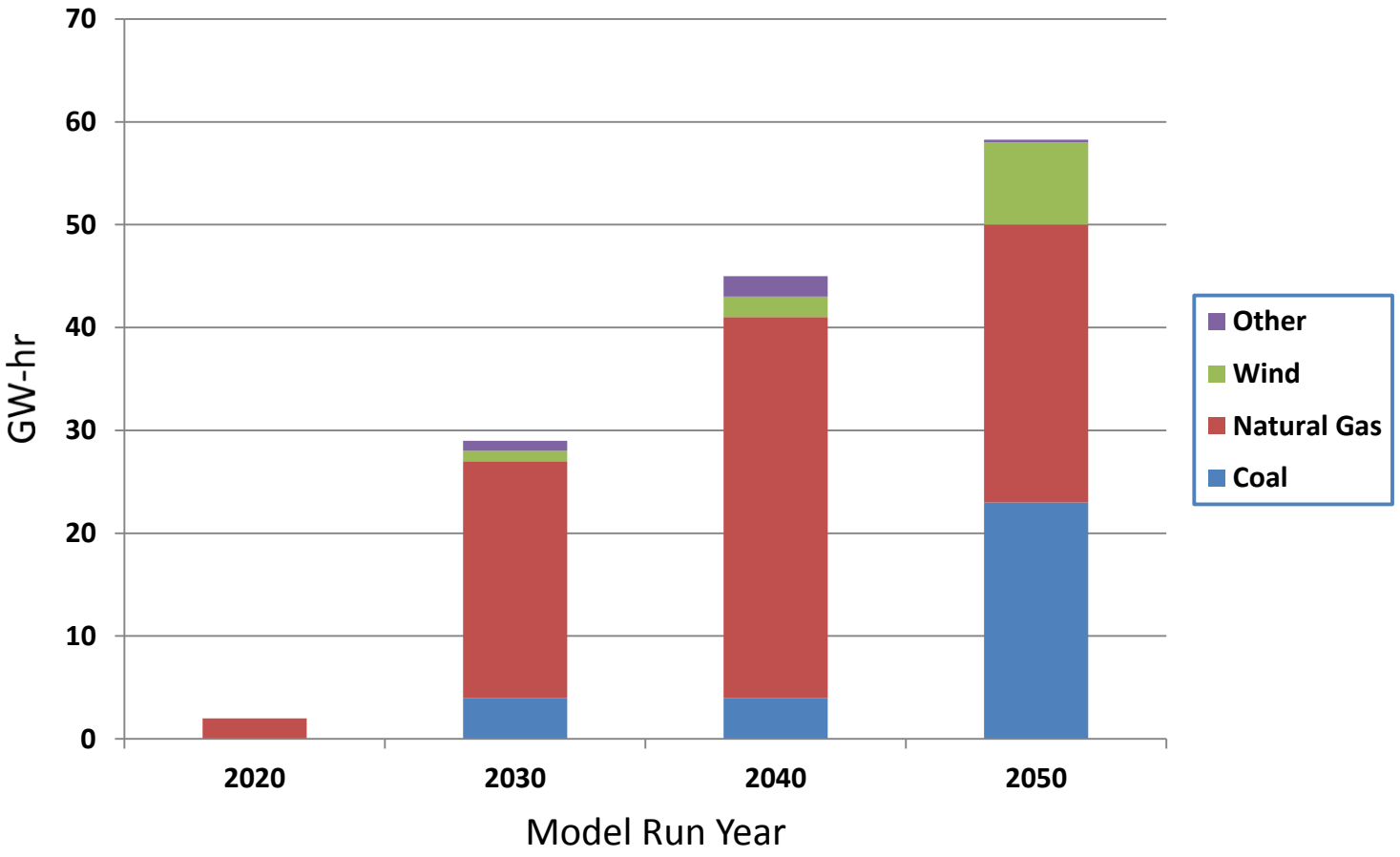
PHEV/EV Charging

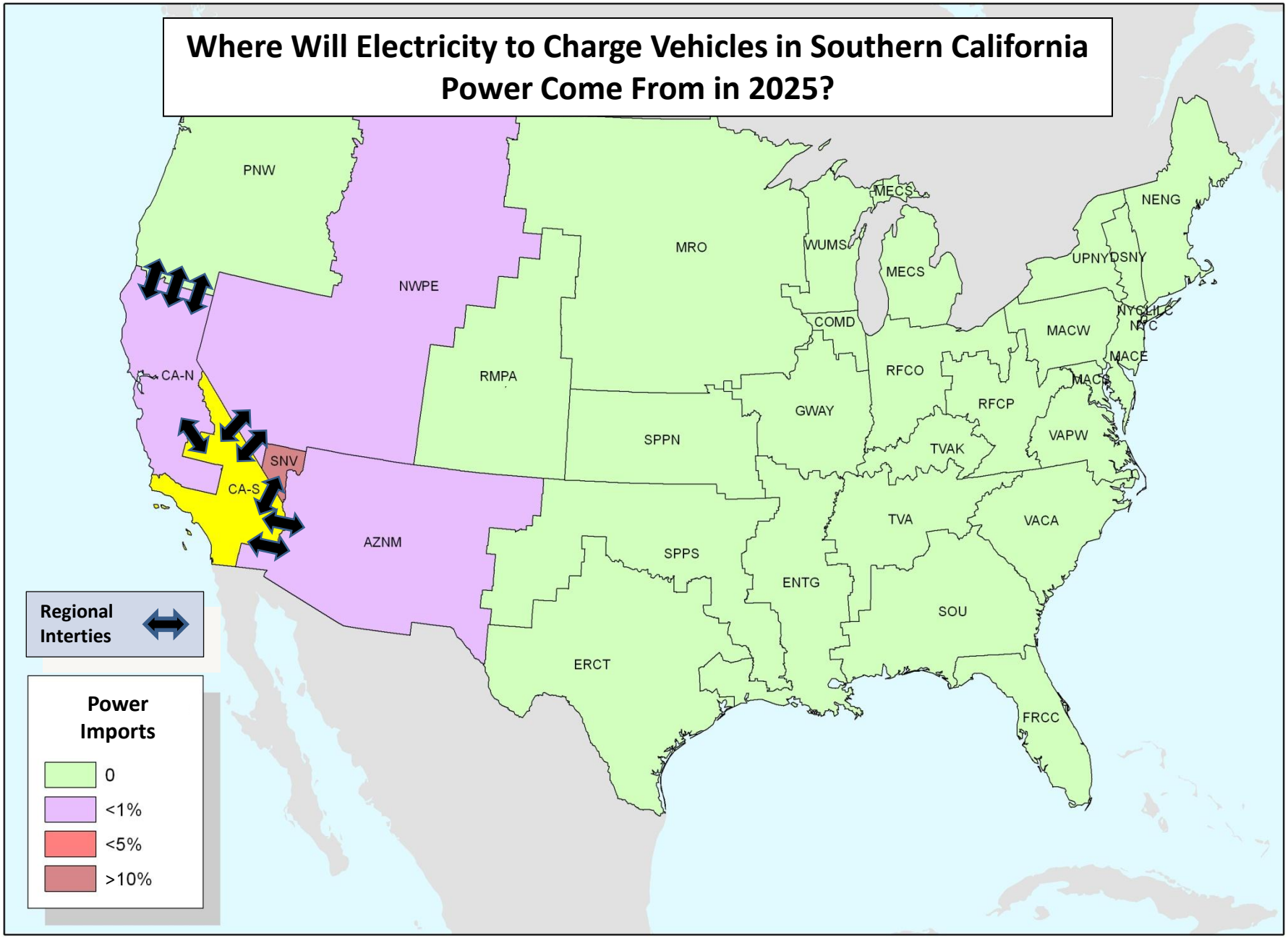


All Electric Power Sector



Projected Fuel Mix by Model Run Year




Where Will Electricity to Charge Vehicles in Southern California Power Come From in 2025?
PNW
NWPE
MRO
WUMS
MECS
MECS
NENG
UPNY
DSNY
NYCW
NYCE
NYC
MACW
MACE
MACS
COMD
RFCO
RFCP
VAPW
TVAK
GWAY
RMPA
SPPN
CA-N
SNV
CA-S
AZNM
SPPS
ENTG
TVA
VACA
SOU
ERCT
FRCC
Regional Interties
Power Imports
0
<1%
<5%
>10%