**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY**
WASHINGTON, D.C. 20460

**JUL 2 3 2008**

OFFICE OF
AIR AND RADIATION

The Honorable Henry A. Waxman
United States House of Representatives
Washington, D.C. 20510

Dear Representative Waxman:

Thank you for your letter of May 12, 2008, requesting any analyses which the U.S. Environmental Protection Agency (EPA) has done that evaluate transportation sector greenhouse gas emissions over the long term. I am responding on behalf of Administrator Johnson to provide you with these analyses and supporting documentation.

Specifically, you cited an April 14, 2008, *Detroit News* article which reported that EPA has prepared analyses of motor vehicle technologies, transportation fuels, and transportation strategies that would be needed to achieve significant reductions from 2000 levels of greenhouse gas emissions by 2050. This article arose from comments made by Margo Oge, Director of EPA's Office of Transportation and Air Quality, at the Society of Automotive Engineers International World Congress in Detroit. In her comments, Ms. Oge remarked that the Intergovernmental Panel on Climate Change has suggested that reductions of 50-80 percent from current levels are needed worldwide by 2050. She then gave an illustrative example of what would be needed for light-duty vehicles to achieve a more modest goal of a 20 percent reduction in greenhouse gas emissions from 2000 levels. Our analysis shows that the light-duty vehicle fleet would need to average 75 miles per gallon in 2050 to reach this 20 percent reduction. This example was given not to suggest a regulatory goal; rather, it is just one of many examples that could be given to illustrate the magnitude of meeting various levels of control.

EPA is analyzing this and other scenarios to explore what might be needed to achieve various goals that are being debated in the scientific and policy communities. These analyses are part of a broader set of ongoing work we are doing to assess the transportation sector's contributions toward greenhouse gas emissions and potential reduction opportunities. Specifically, we are assessing the technical feasibility of reducing greenhouse gas emissions from vehicles, engines, and transportation fuels, and are beginning to assess the opportunities for reducing travel demand. These analyses can be used in a number of contexts. The following are enclosed or available at the indicated websites.

1. A description of the assumptions used in the 75 mpg analysis mentioned by Ms. Oge.
2. A chart illustrating the reductions that mobile sources would need to achieve to reach various climate goals by 2050 and those that are projected to be achieved under the Energy Independence and Security Act of 2007.

3. A chart illustrating projected greenhouse gas emissions through 2050 from all mobile sources except light-duty vehicles—such as heavy-duty truck, aircraft, and non-road equipment---relative to climate goals for the sector as a whole. This illustrates that for certain climate goals to be achieved, reductions will be needed from these non-light duty sources as well as from light-duty vehicles.
4. An EPA staff technical report, "Cost and Effectiveness Estimates of Technologies Used to Reduce Light-Duty Vehicle Carbon Dioxide Emissions," which assesses the greenhouse gas reduction potential of today's known feasible technologies, available at http://www.epa.gov/otaq/climate/420r08008.pdf.
5. Another technical feasibility report, "A Study of Potential Effectiveness of Carbon Dioxide Reducing Vehicle Technologies," prepared for EPA by the engineering firm Ricardo under subcontract to Perrin Quarles Associates, Inc., available at http://www.epa.gov/otaq/technology/420r08004.pdf. It provides a detailed assessment of the carbon dioxide emissions reduction potential of a large number of conventional vehicle technology packages, including the synergies between these technologies. Also available is a peer review of the report, http://www.epa.gov/otaq/technology/420s08002.pdf, as well as a presentation given by EPA to the National Research Council's Committee on Fuel Economy of Light-Duty Vehicles, which provides contextual background for this report, at http://www.epa.gov/otaq/technology/nrc-presentation-012408.pdf.
6. An EPA staff report, "A Wedge Analysis of the U.S. Transportation Sector," which applies the concept of greenhouse gas stabilization wedges to the U.S. transportation sector, assessing the potential of improvements in vehicle technology, switching to lower-greenhouse gas fuels, and reduced travel demand, can be found at http://www.epa.gov/otaq/climate/420r07007.pdf.
7. An EPA presentation on the potential greenhouse gas and energy implications of plug-in hybrid vehicles is attached, and an EPA fact sheet on the greenhouse gas reduction potential of plug-in hybrid vehicles is available at http://www.epa.gov/otaq/climate/420f07048.pdf.

Again, thank you for your letter. If you have further questions, please contact me or your staff may call Cheryl Mackay, in EPA's Office of Congressional and Intergovernmental Relations, at 202-564-2023.

Sincerely,

Robert J. Meyers
Principal Deputy Assistant Administrator

Enclosures

# The Potential Energy and GHG Implications of Plug-in Hybrid Vehicles: A Scenario Analysis

2008 SAE Government/Industry Meeting

U.S. EPA
May 14, 2008

# Contents

- What is a Plug-In Hybrid (PHEV)?
- Why the Interest?
- PHEV/Electricity Sector Scenario
- Social & Consumer Cost Perspectives
- Conclusions

# What is a Plug-In Hybrid?

A Plug-In Hybrid Electric Vehicle (PHEV) is a Hybrid Electric Vehicle (HEV) with additional battery energy that can be charged from the electric grid and used to propel the vehicle for some portion of a trip

- Compared to a HEV, the PHEV can drive under an “all electric” mode for a larger fraction of driving time

- If a HEV were getting 50 mpg, a PHEV might achieve 95+ mpg (gasoline) because some of the miles are powered with electricity from the grid, not gasoline.

- An owner could “fill-up” with gasoline during the day and charge the vehicle at night


Image: J. Romm, A. Frank, *Scientific American*, April 2006

# Why the Interest?

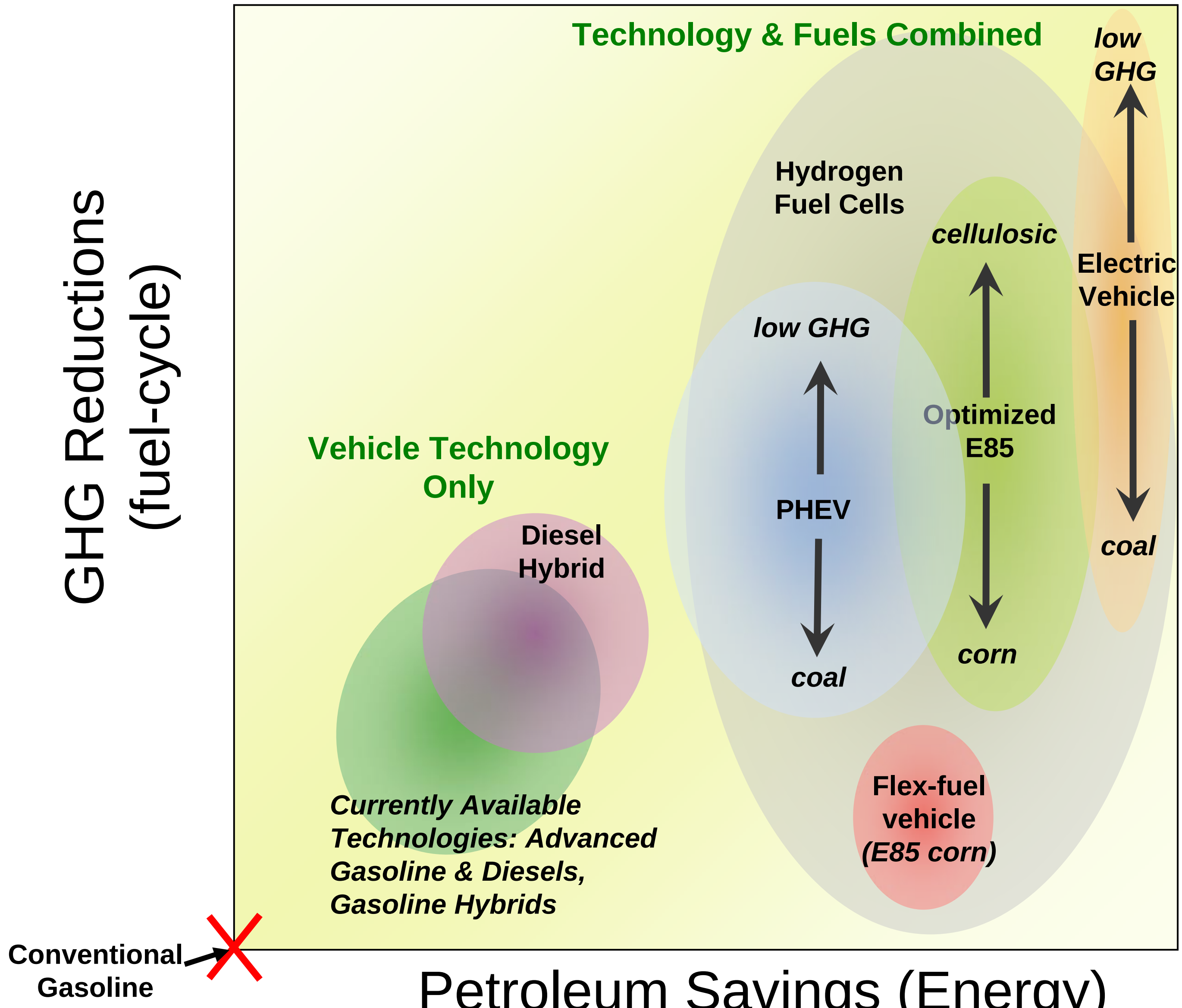
- Possibility of significant GHG reductions over 20 – 30 years with complementary electricity sector GHG reduction technologies
- Large potential petroleum reductions/reduced oil import reductions
- Potentially a “game changing” or “disruptive innovation” that allows transportation energy to be shifted from conventional fuels to electricity.
- Electric mode fuel costs are equivalent to about $0.50 - 0.75/gallon gasoline*
- No need for large new energy supply infrastructure investments since PHEVs use the existing infrastructure for gasoline and electricity

* Breakeven price estimate based on 6 - 10 cents/kWh range, 110 mpg-equiv. (electric) compared to 25 mpg conventional vehicle

# PHEV Challenges

- High up-front costs for PHEVs
  - Currently, after-market conversion kits cost $10,000 - $12,000 or more (retail)
  - Lithium ion battery would likely cost at least $3000- $5000 in near to mid-term
  - Additional costs of electric powertrain
- Battery durability and performance
- Consumers acceptance
  - Fuel/energy efficient products tend to have larger up-front costs
  - Access to garages, some may need to add a charging circuit
  - Availability of off-peak pricing
  - Resale value

# Vehicle Technology & Fuels in Perspective




Caveat: The size of the bubbles and their positions are illustrative and assumptions-driven

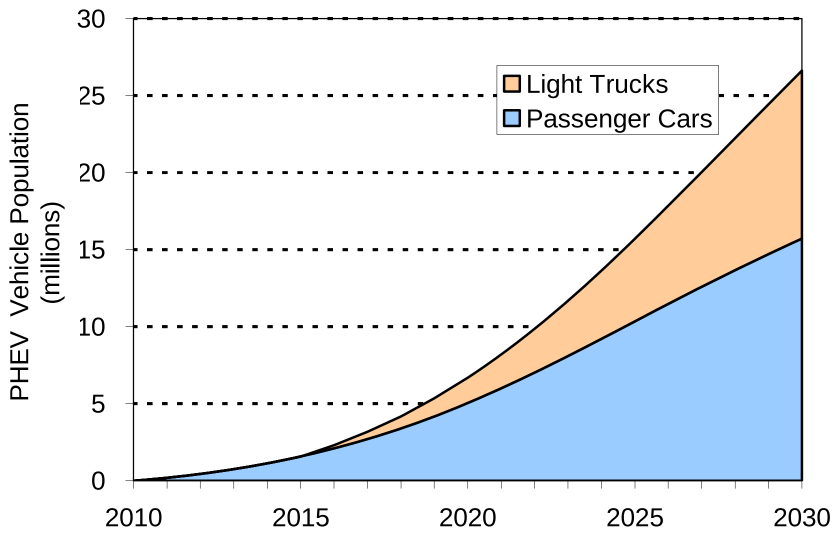
# PHEV & Electricity Sector Scenario

- Desire for approaches that can simultaneously reduce petroleum consumption and reduce GHGs emissions from the U.S. transportation sector

Key Questions:
- What are the interactions between PHEVs and the electricity sector?
- What are the overall petroleum and GHG emission reductions?
- What are the costs of the approach?

# Modeling of “What If” Scenario

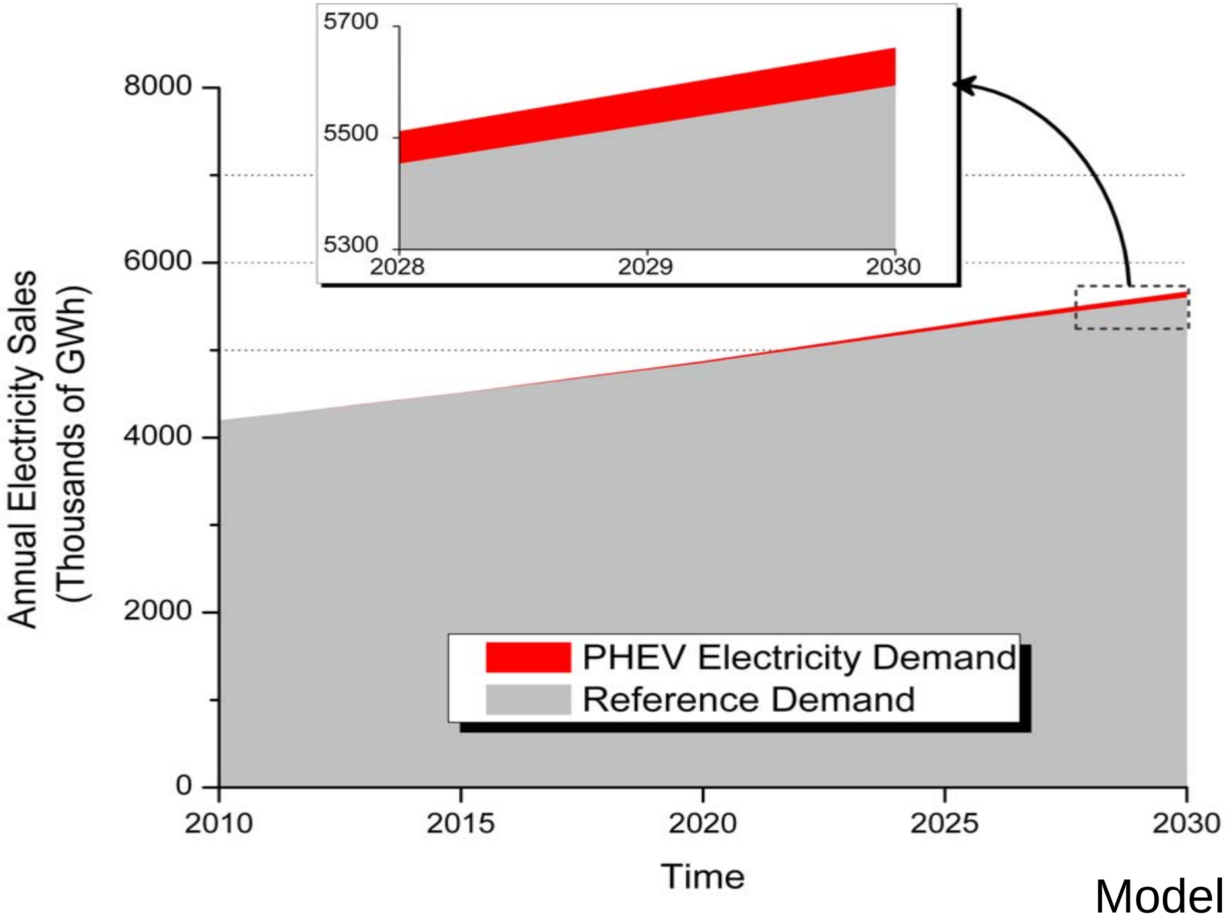
- “What-If Scenario” – PHEVs sales begin in 2011 and grow to 15% of all passenger vehicle sales by 2030.
- In terms of vehicles on the road, this sales trajectory means almost 10% of passenger vehicles would by PHEVs by 2030 (~ 27 million)




- Integrated Planning Model (IPM)* is a dynamic linear programming model of the U.S. electricity sector.
- In-house vehicle stock, fuels and greenhouse gas emissions accounting model based on parameters from MOVES and other EPA estimates

* "Modeling Framework," Introduction to EPA Modeling Applications Using IPM, EPA's Clean Air Markets Division, 2004

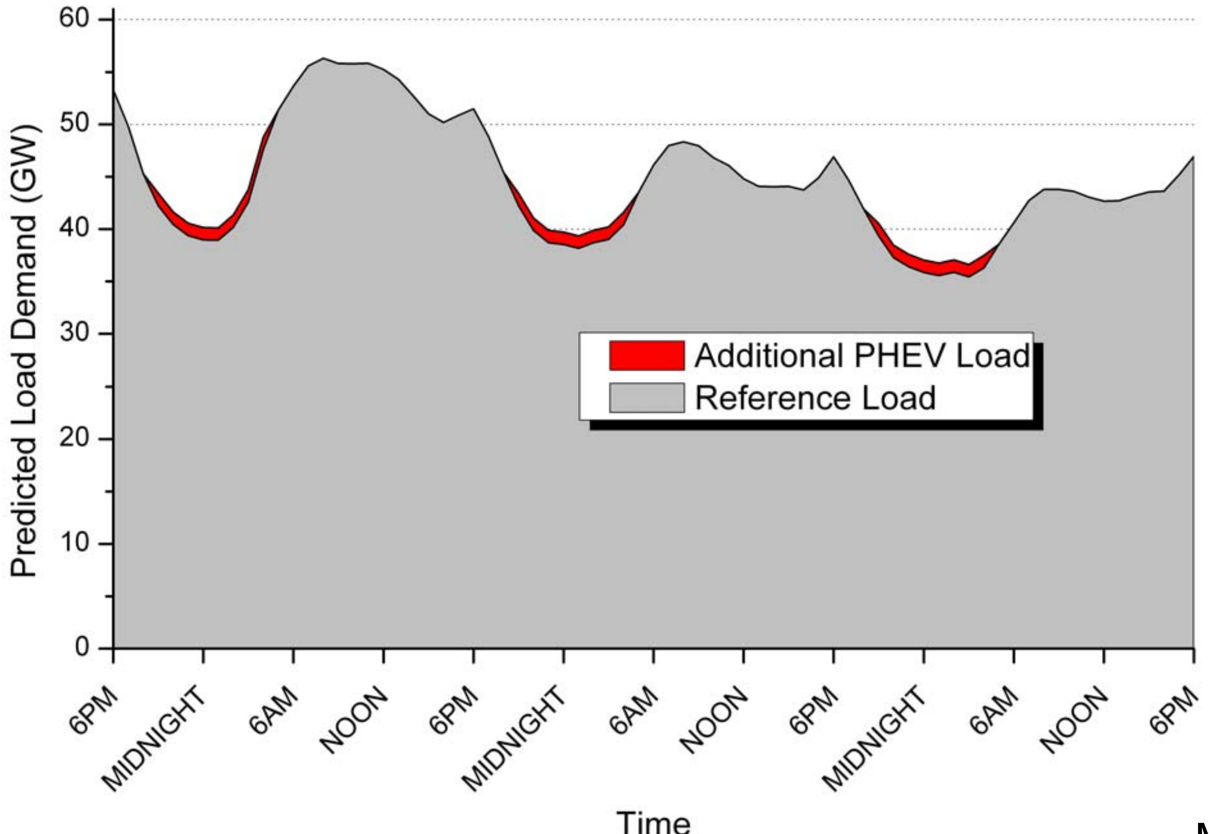
# U.S. Electricity Sales for PHEVs




Model: IPM

- Electricity sales from PHEVs represent a small fraction of total U.S. electricity demand (In 2030, 1.2% of demand is from PHEVs)

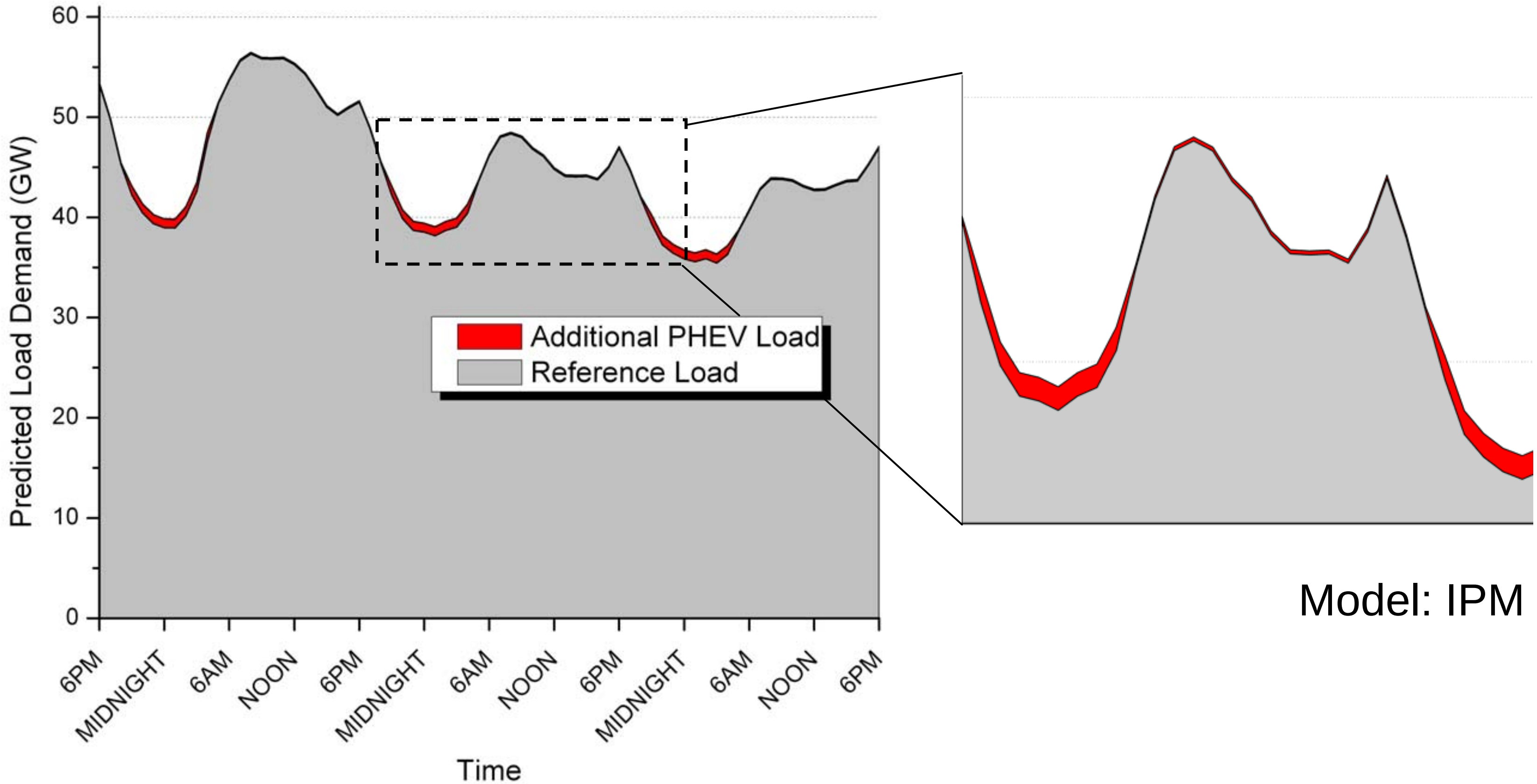
# PHEV Electricity Demand Likely in Off-Peak




Model: IPM

- Additional load from PHEVs is small
- PHEVs could be charged mostly via base-load filling during evenings and nights, when electricity costs are low

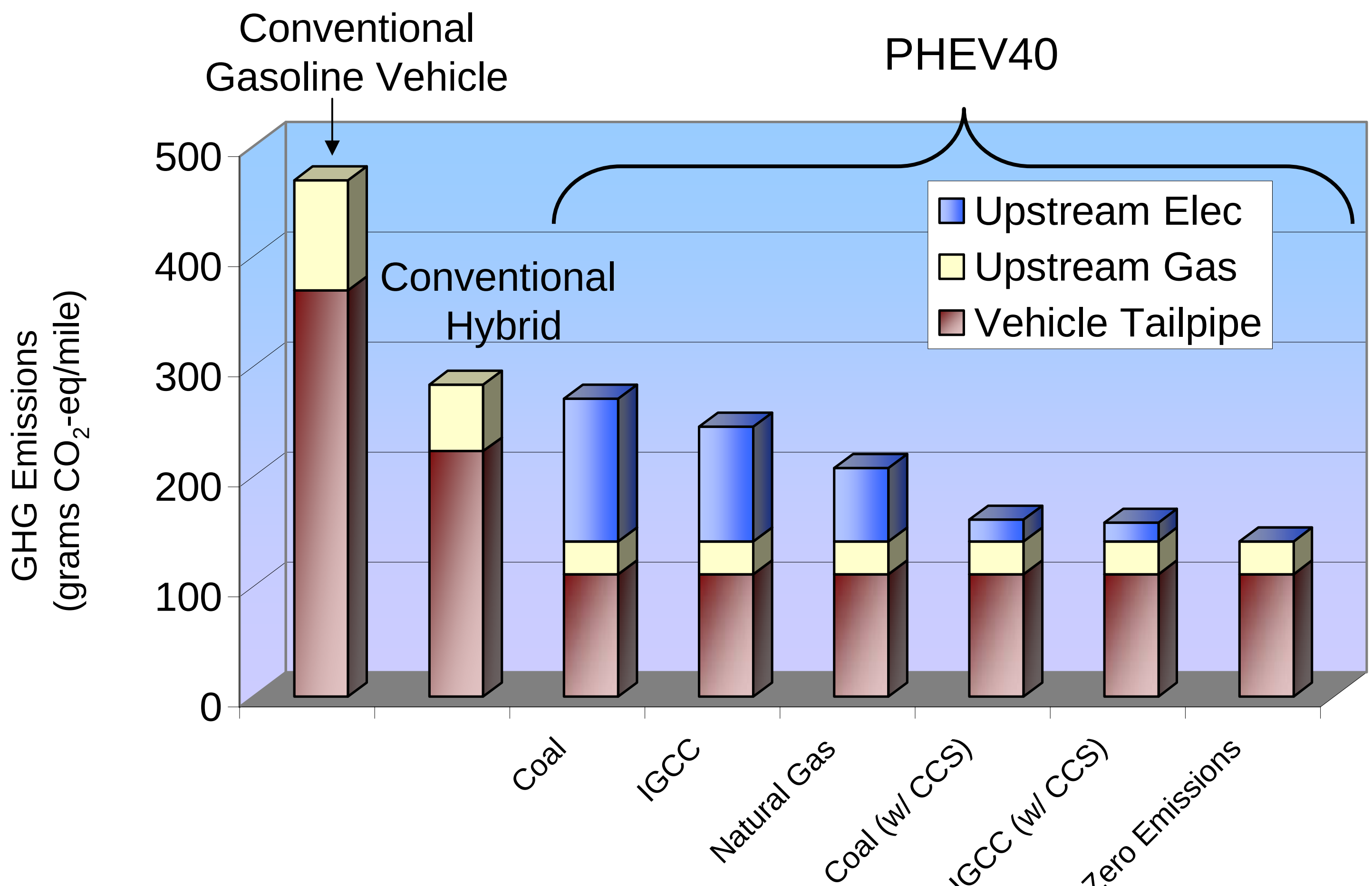
# PHEV Electricity Demand with Partial Day-Time Charging




Model: IPM

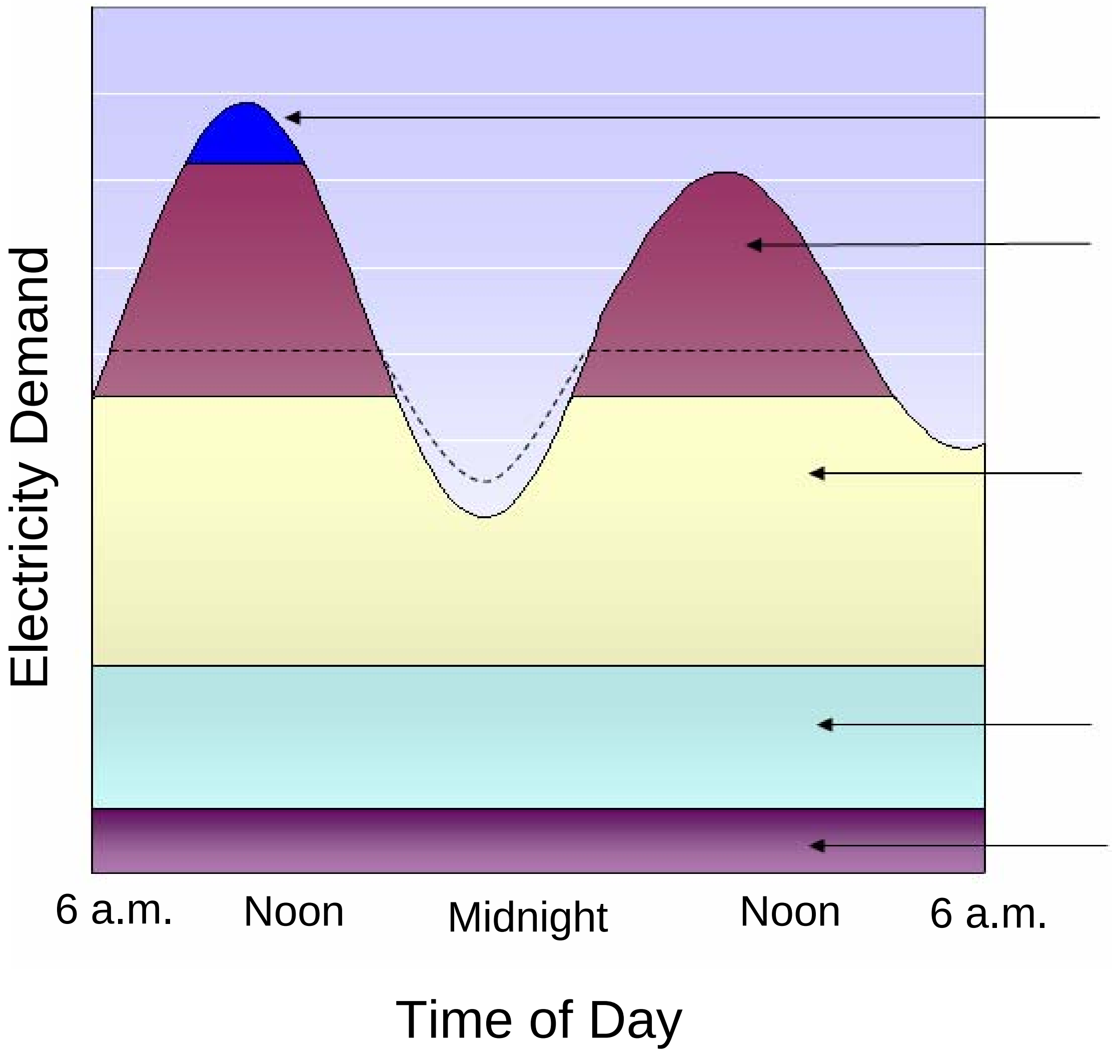
- Also considered scenario where 25% of the charging occurs during the day time, and 75% during the evening and nights

# Choice of Electricity Generation Influences PHEV GHG Emissions




CCS = Carbon Capture & Sequestration
Electricity emission factors based on average new plant in forecast period (IPM)
Mid-size passenger cars shown, with conventional gasoline vehicle obtaining 25 mpg

# Typical Dispatch Schematic




**Peaking Generation**, typically simple cycle oil and gas fired turbines. Capacity factors for peaking generation are less than 3 - 5%.

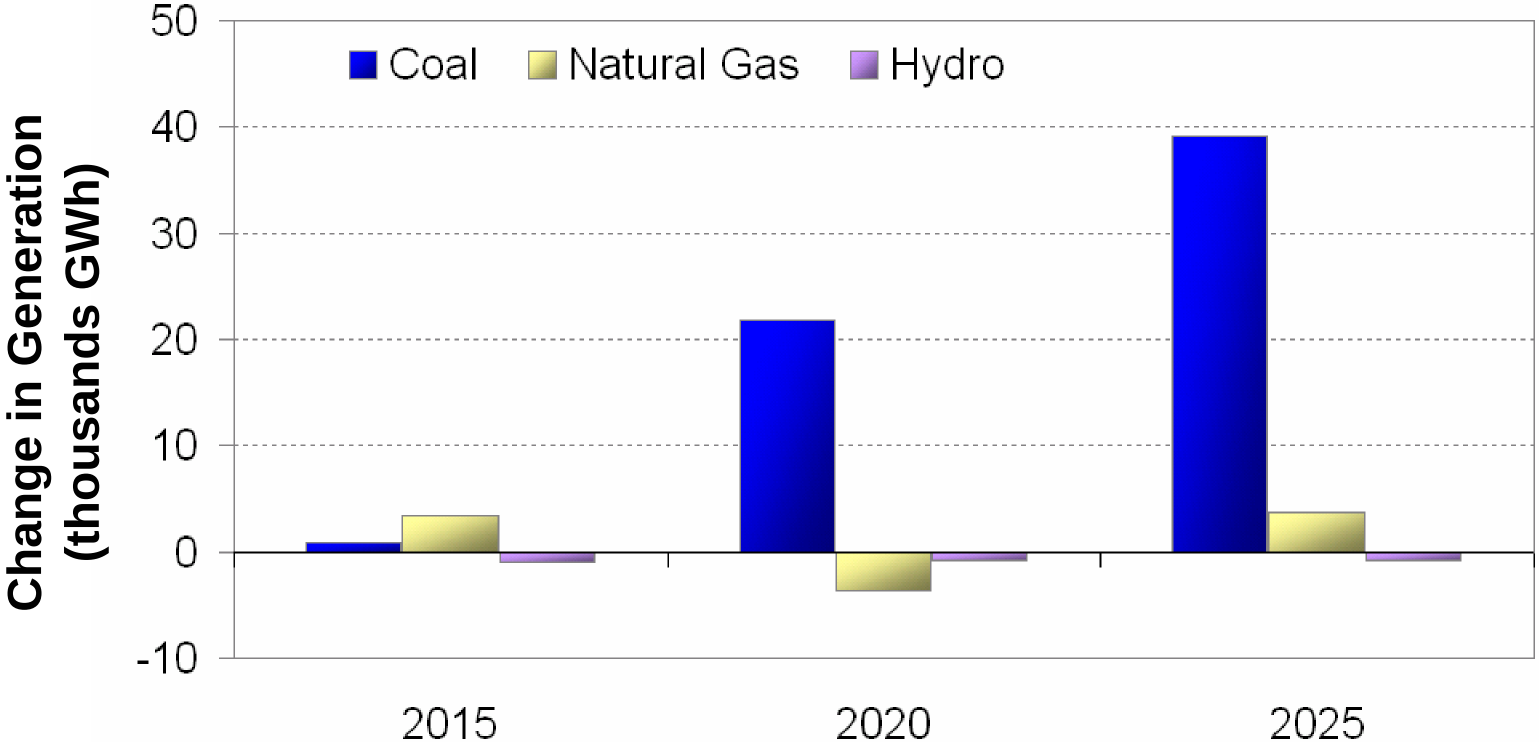
**Intermediate Load Generation**, typically gas-fired combined cycle systems. Units in this range offer fast ramp rates and short start-up times.

**Base Load Generation**, typically coal fired. Base load generation has some ability to follow loads, though ramp rate and minimum nighttime load constraints exist.

**Nuclear**

**Hydro**

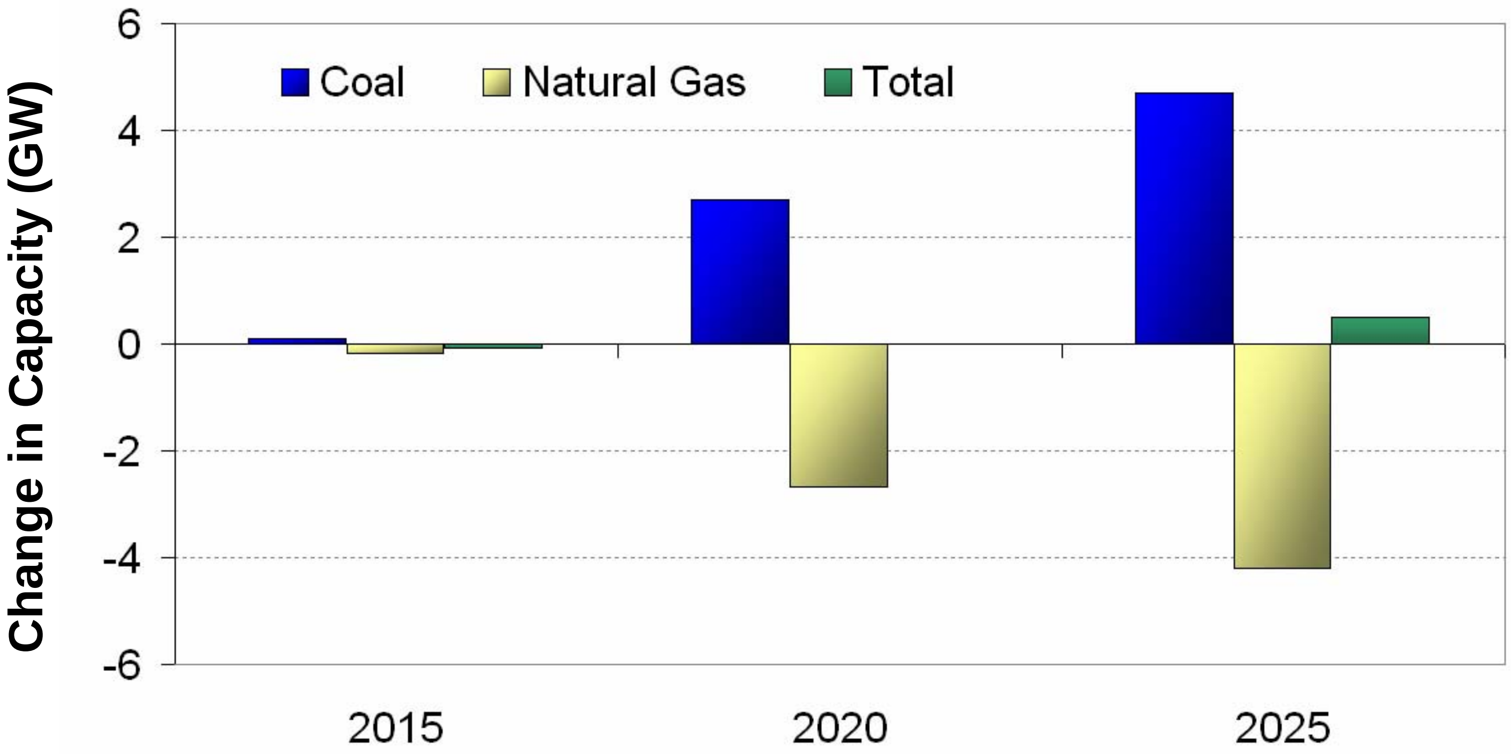
# Additional Electricity Generation for PHEVs (Night-Time Case)




- Additional generation is initially natural gas fired plants
- After 2020, increased generation is almost all from coal

Model: IPM

# Capacity Changes for Electricity Sector (Night-time Case)

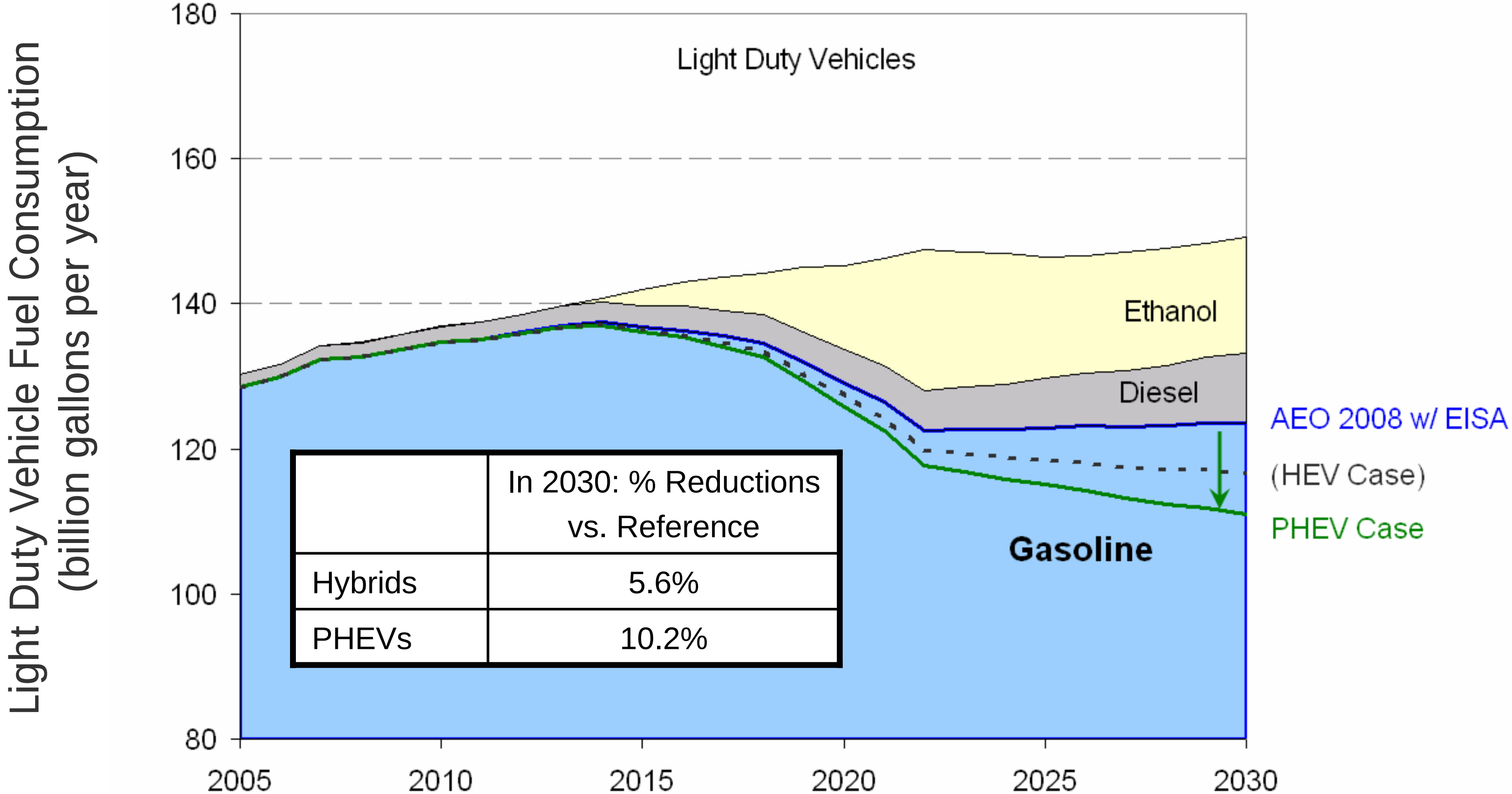



Model: IPM

- Electric utilities build more coal, less natural gas
- Net increase in capacity is only 500 MWs by 2025

* 2025 change in coal capacity includes a 0.1 GW decrease in expected retirements;
2025 change in natural gas capacity includes a 0.6 increase in expected retirements

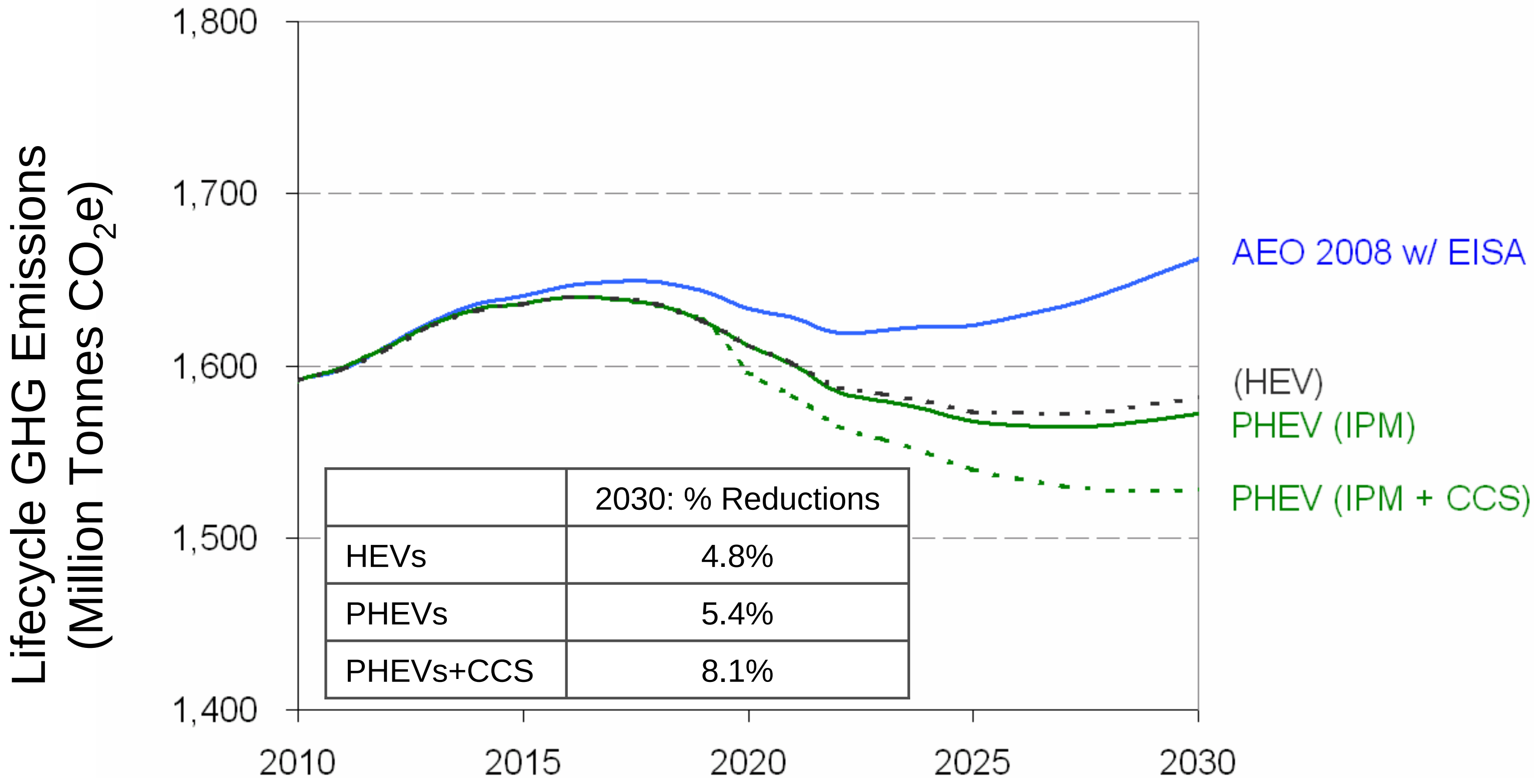
# Impact on Light-Duty Fleet Petroleum Consumption




| | In 2030: % Reductions vs. Reference |
|---|---|
| Hybrids | 5.6% |
| PHEVs | 10.2% |

- In 2030, annual gasoline savings of 820,000 barrels per day (versus 450,000 barrels per day for the "Hybrids" Scenario)
- Purchasers of PHEV40s reduce gasoline fuel purchases by 65 to 70%

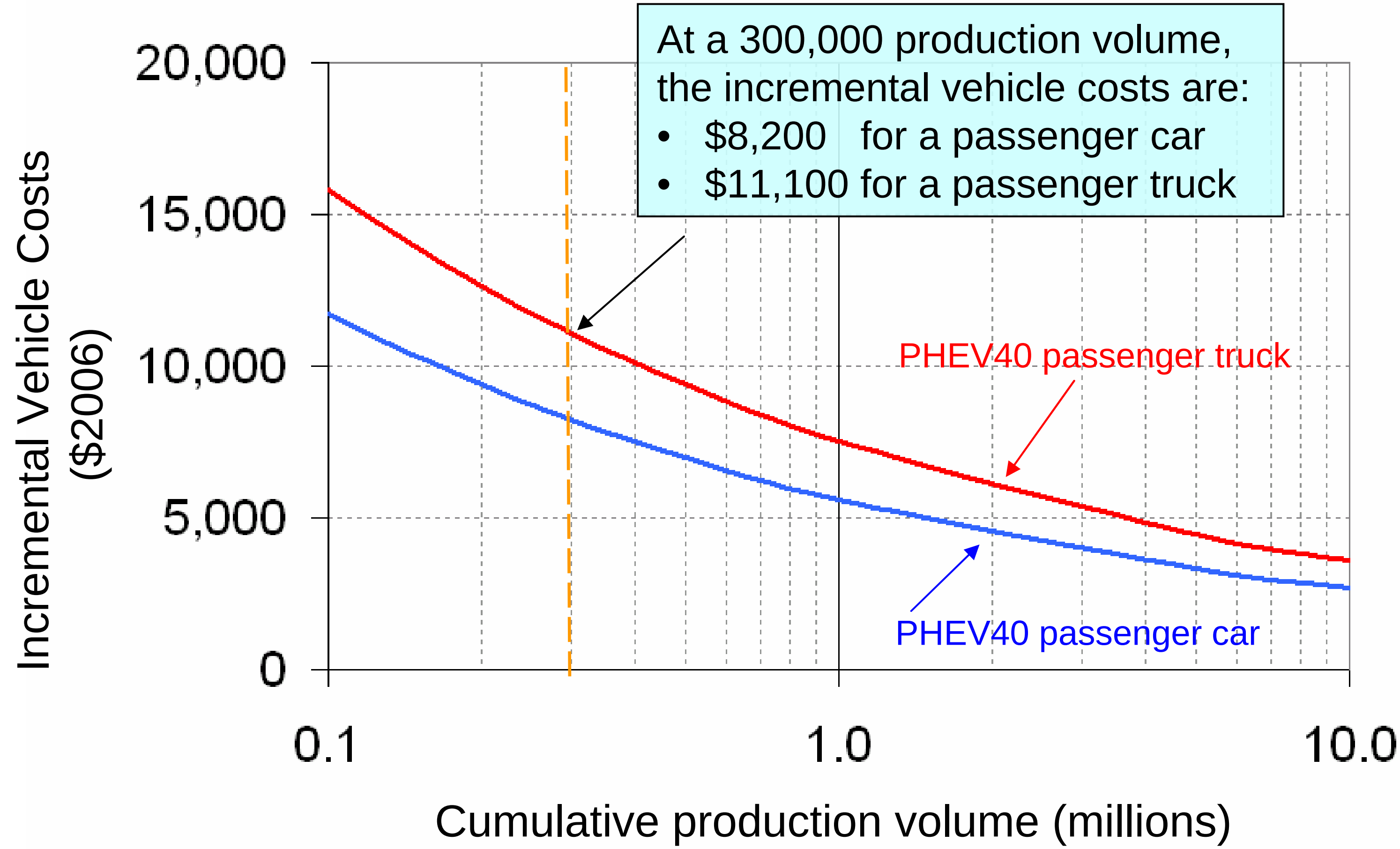
# Impact on GHG Emissions




| | 2030: % Reductions |
|---|---|
| HEVs | 4.8% |
| PHEVs | 5.4% |
| PHEVs+CCS | 8.1% |

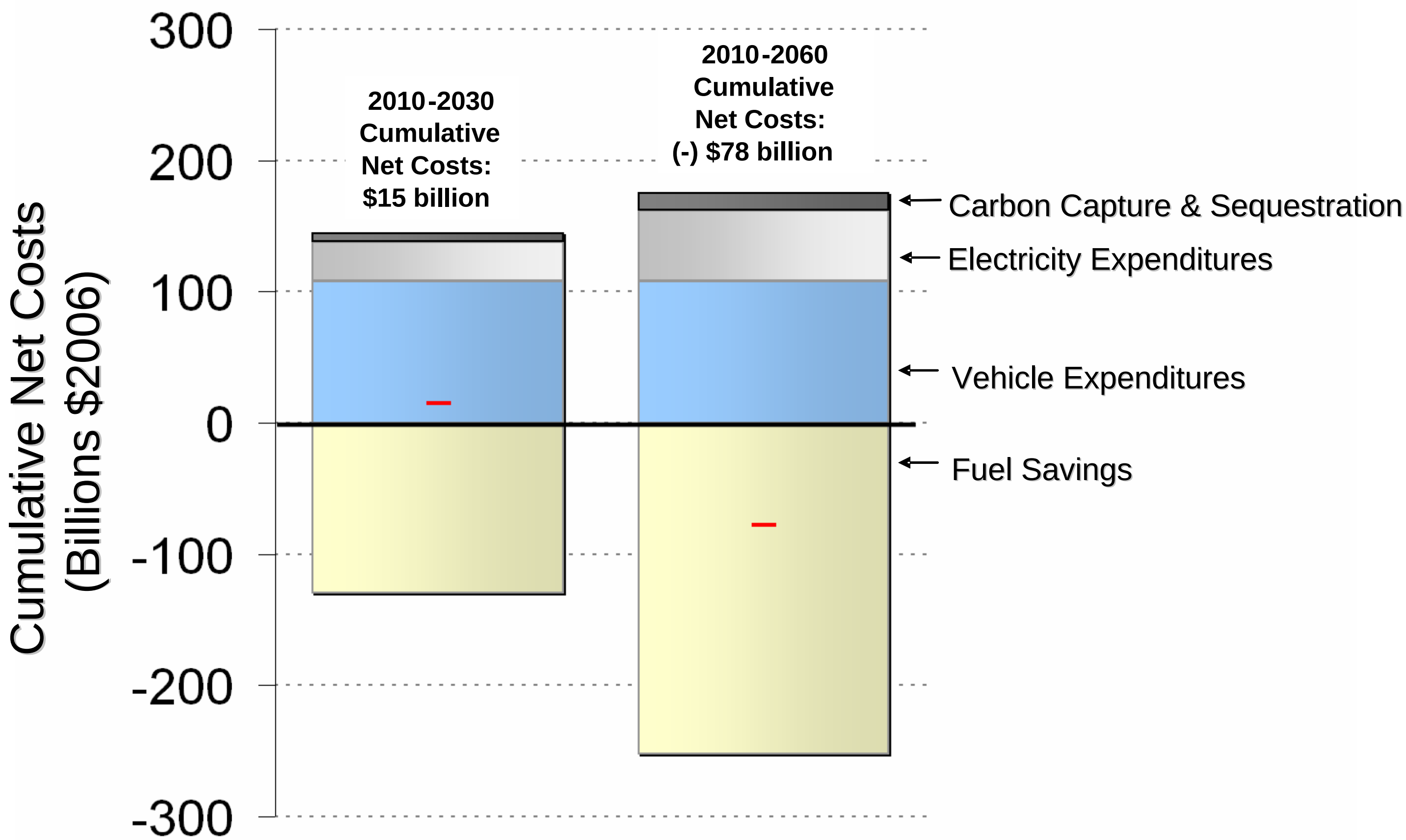
- PHEVs lower GHGs compared to conventional gasoline-powered vehicles
- Marginal GHG benefits for PHEVs compared to “Conventional Hybrids” Scenario
- Reductions in GHG emission increase by 50% with low emitting electricity source (e.g., coal with Carbon Capture and Sequestration)

# PHEV Experience Curves




- Key assumption: Each doubling in PHEV volume reduces costs by 20%
- Predicting incremental costs challenging, also considered 10%, 30%

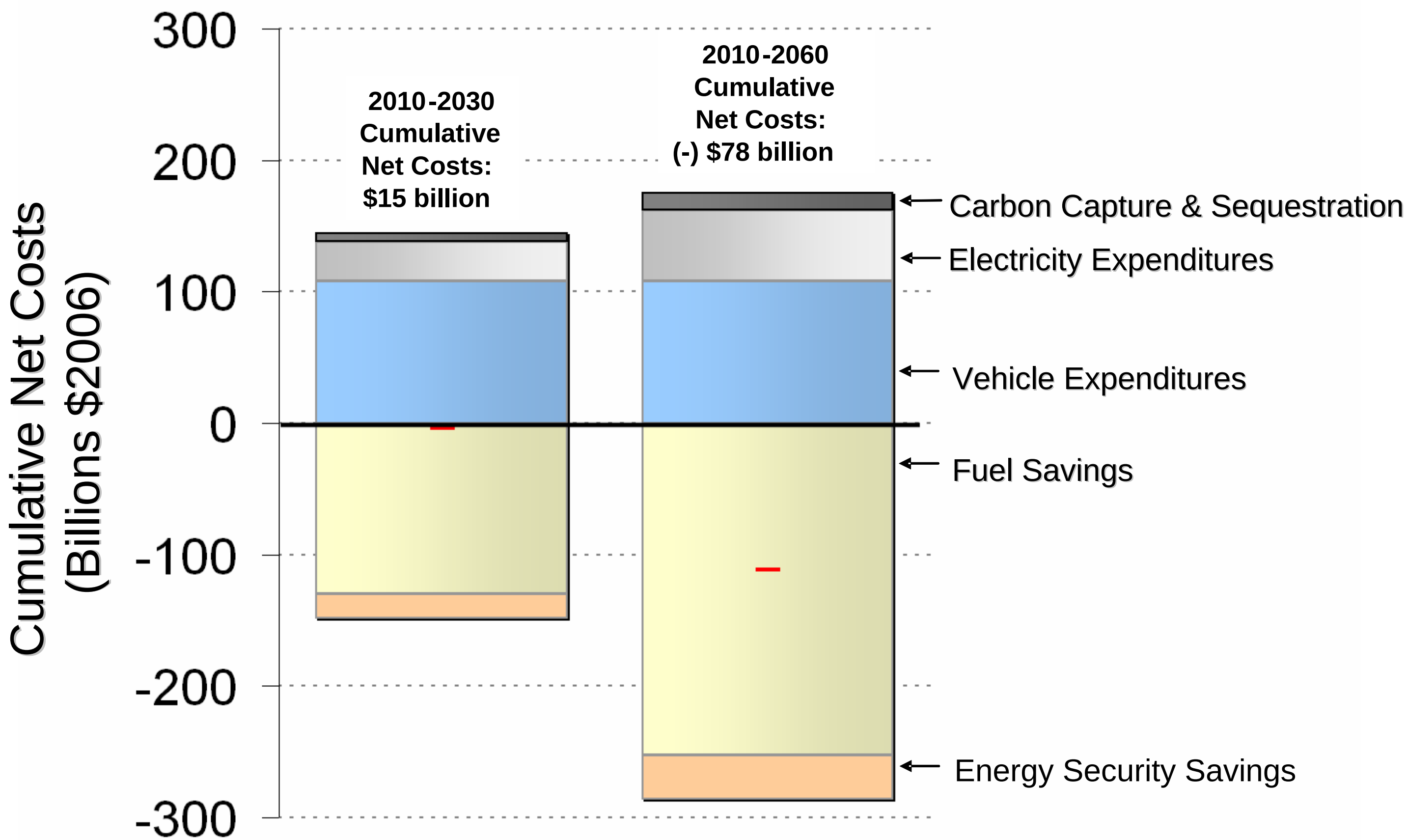
# Social Costs of PHEV Scenario




- Using a 3% discount rate, AEO 2008 reference world crude oil price forecast ($70/barrel in 2030), and 8.7¢/kWh electricity, CCS cost: $35/ton of $CO_2$ reduced*
- Does not include social costs of carbon, energy security benefits, or environmental externalities

*IPCC Special Report on Carbon Dioxide Capture and Storage (2005)

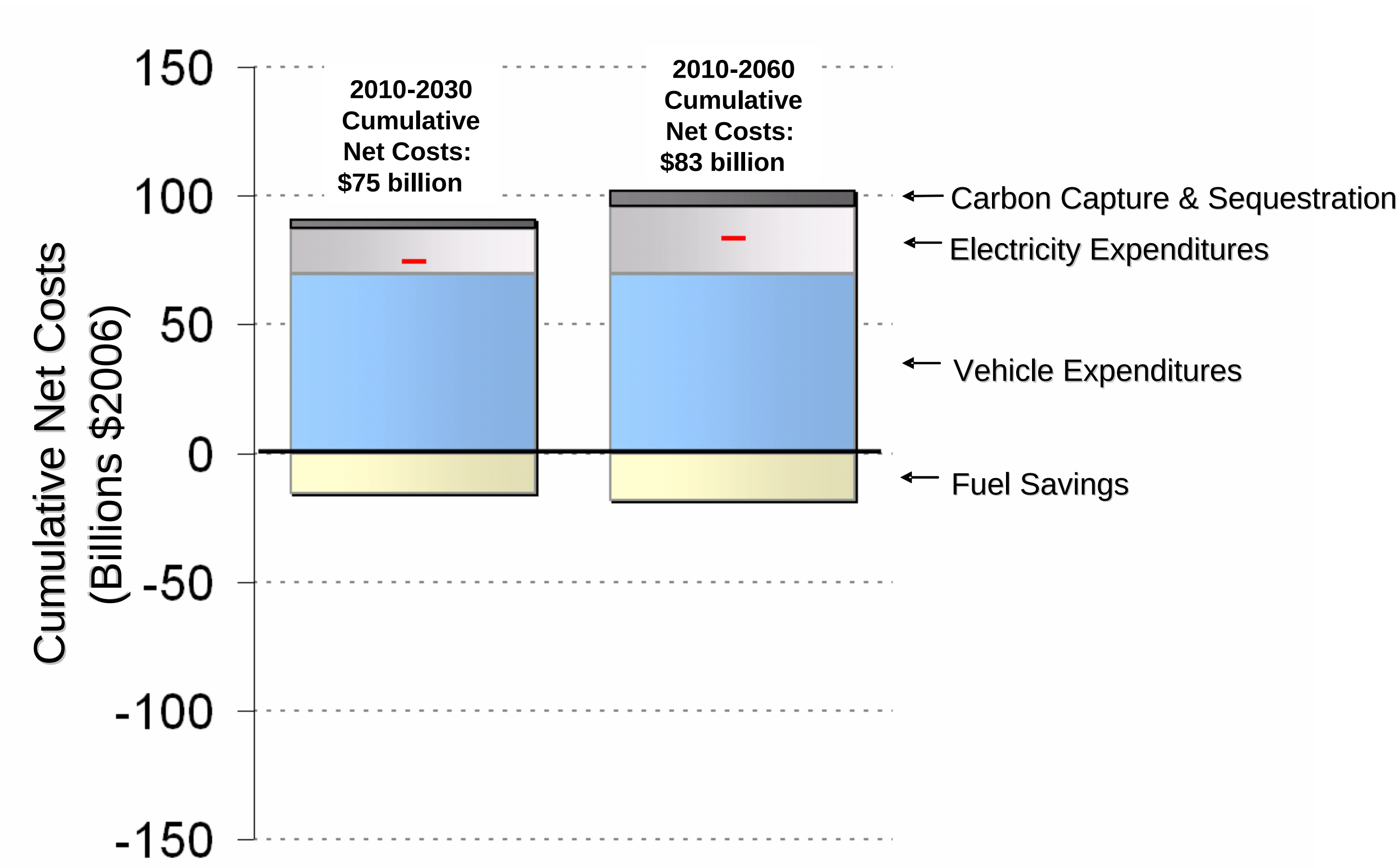
# Social Costs of PHEV Scenario




- Energy security benefit of $34 billion over lifetime if $12.40/bbl energy security premium employed ($2006)
- Sensitivity analysis on social cost of carbon of $1, $10, $50 per tonne of $CO_2$ considered, yielding additional savings from $1.2, $12, to $60 billion respectively.

*IPCC Special Report on Carbon Dioxide Capture and Storage (2005)

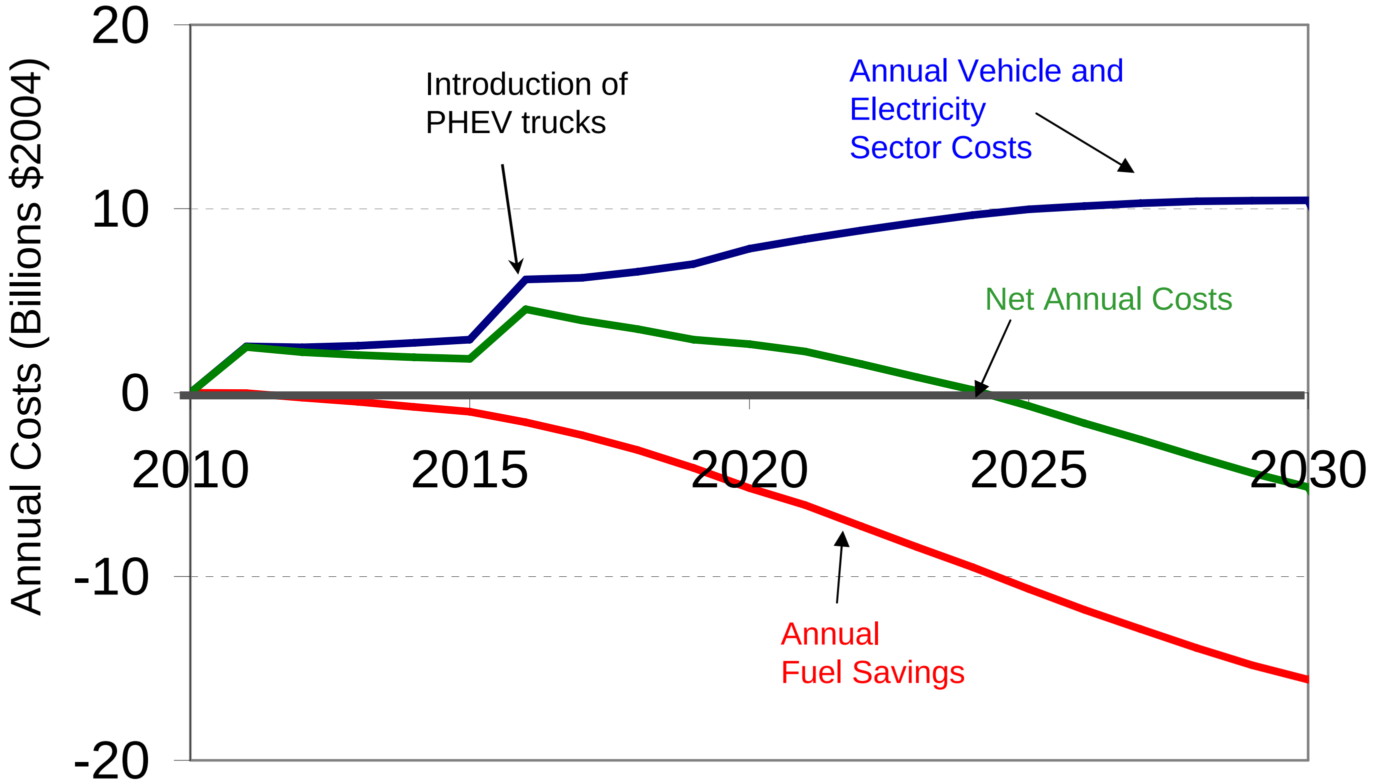
# Consumer Costs of PHEV Scenario




- Using a 20% discount rate on gasoline fuel savings, AEO 2008 reference world crude oil price forecast ($70/barrel in 2030), and 8.7¢/kWh electricity, CCS cost: $35/ton of $CO_2$ reduced*

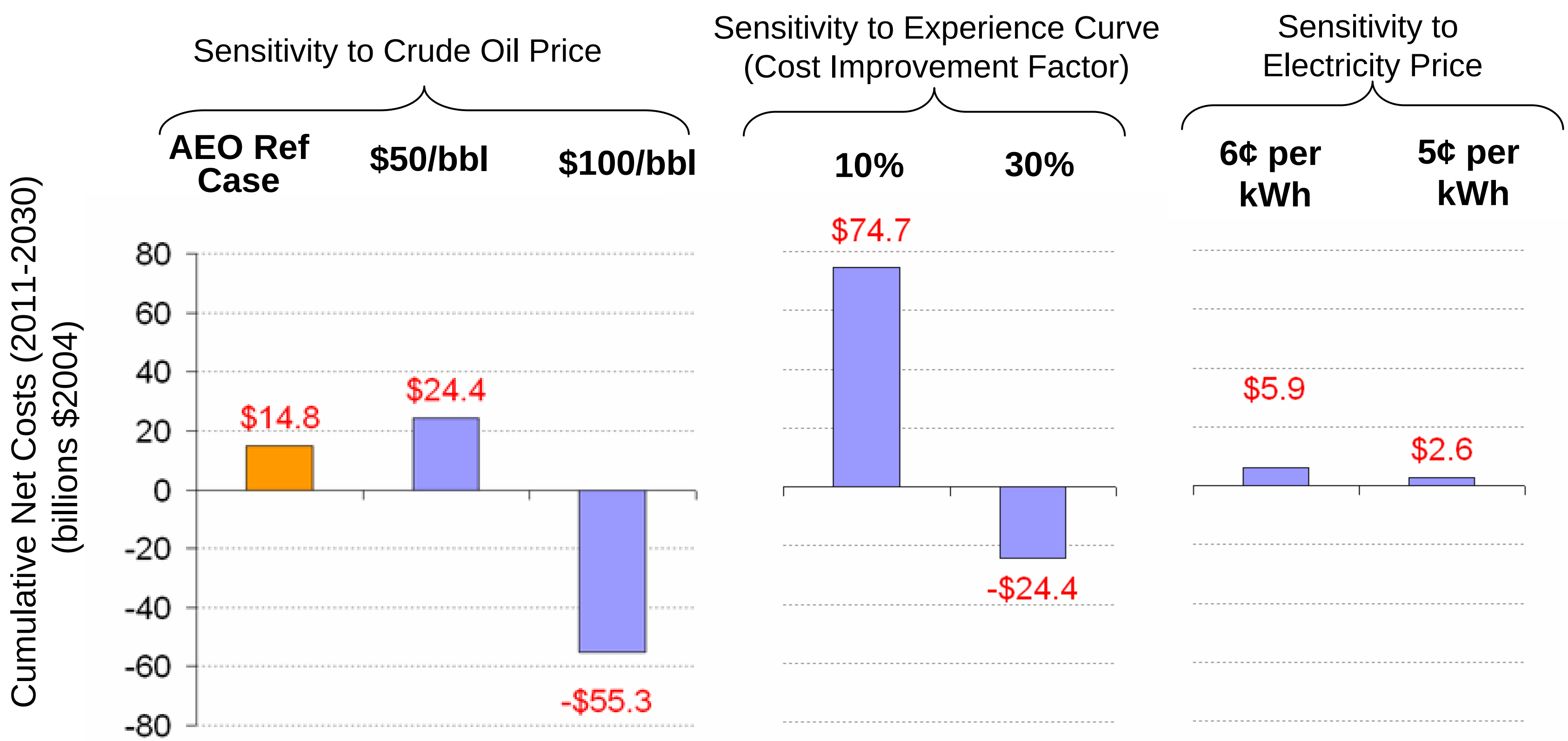
*IPCC Special Report on Carbon Dioxide Capture and Storage (2005)

# Annual Costs of PHEV Scenario




- In near-term, vehicle costs exceed fuel savings
- PHEVs begin to payback in 2024 (annual fuel savings exceed other annual costs)
- In 2024, incremental vehicle costs are $3,800 for PHEV40 cars and $6,500 for PHEV40 light trucks

# Cost Sensitivity Analysis

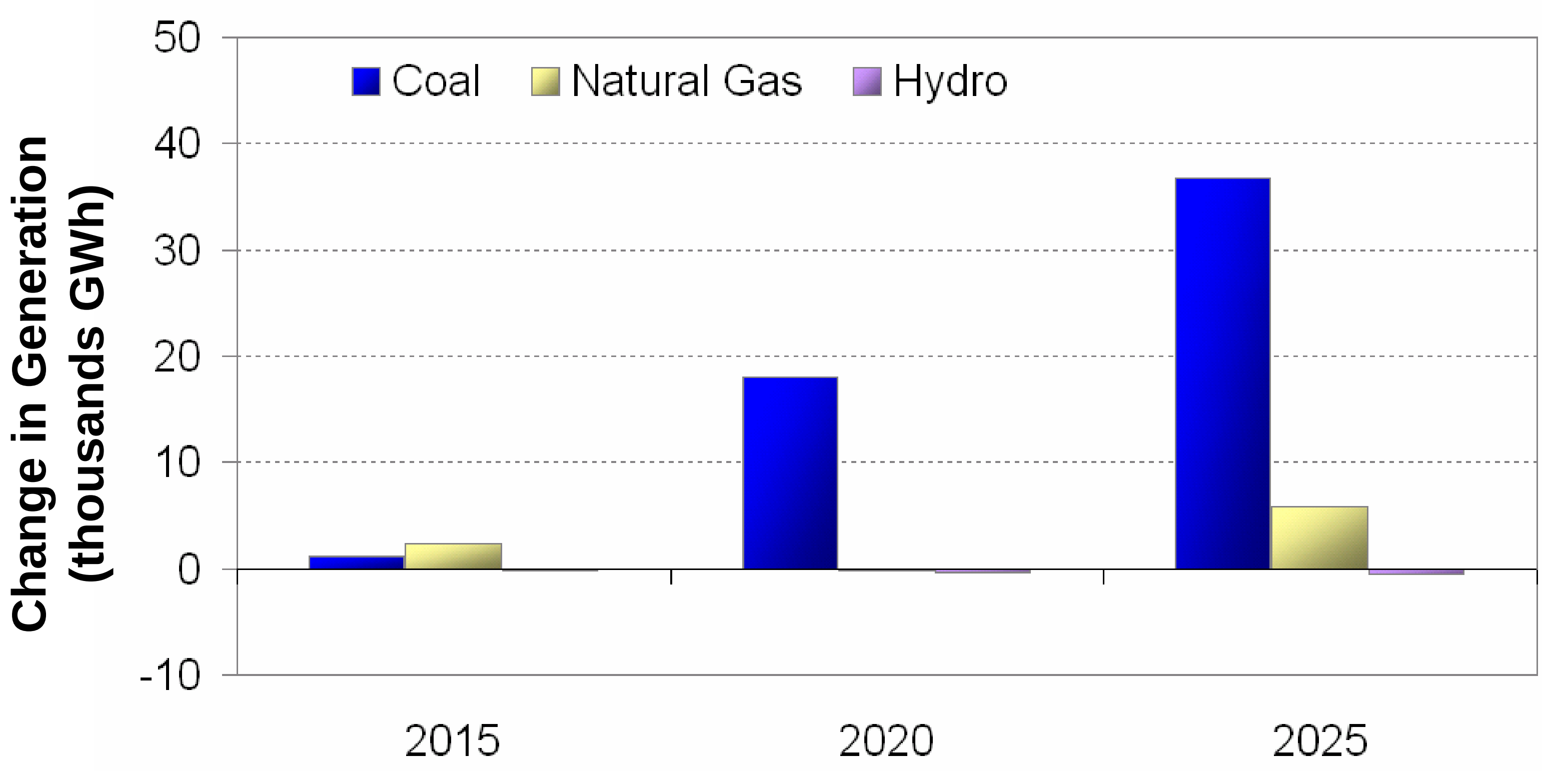


# Conclusions

- As part of a suite of vehicle technological possibilities, PHEVs have considerable potential
- PHEVs are a promising option for reducing U.S. petroleum consumption/oil imports
- GHG impacts depend on amount of electric operation and source of electricity
  - If coal is primary fuel source for electricity, GHG emissions benefits from PHEVs are likely to be modest if no/low GHG electricity sources power the PHEVs (*compared to conventional hybrids)*
- No need for large new energy supply infrastructure investments
- Cost is the largest single barrier – high capital costs precede large fuel savings

# Appendix

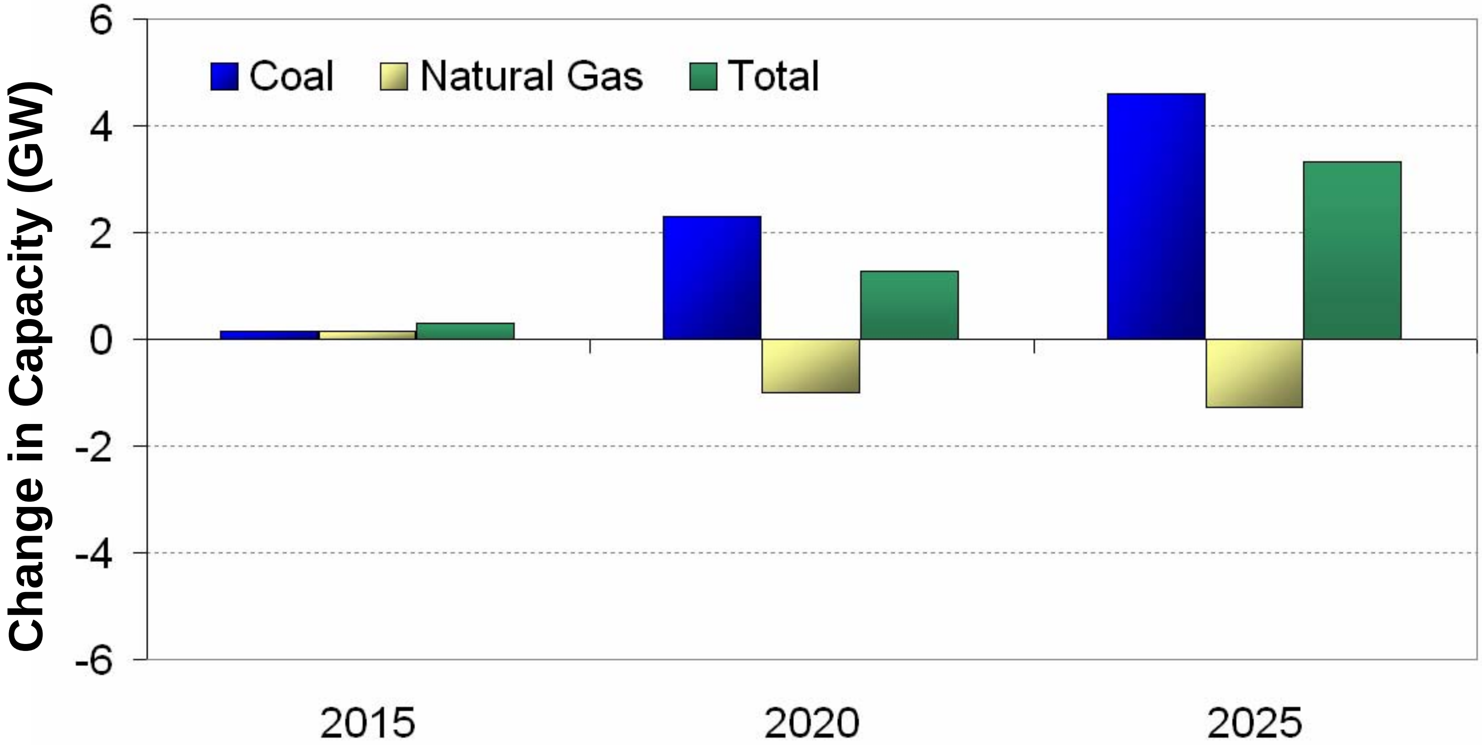
# Additional Electricity Generation for PHEVs (25% Day-Time Case)




- Day-time case results in slightly more natural gas, but coal is still dominant

Model: IPM

# Capacity Changes for PHEVs (25% Day-time Case)




Model: IPM

- Electric utilities still build more coal, but less natural gas capacity is retired
- Net increase in capacity rises to 3330 MW by 2025

* 2025 change in coal capacity includes a 0.15 GW decrease in expected retirements;
2025 change in natural gas capacity includes a 0.19 GW increase in expected retirements

# 75 mpg in 2050

A target of 75 mpg by 2050 represents the average fuel economy for the entire light duty vehicle stock (rather than just new vehicles) necessary for vehicles to do their proportionate share in meeting the IPCC stabilization scenario of 450 ppm CO2.

75 mpg CAFE equates to a combined city-highway fuel economy label value of 56 mpg.

Method to Determine the Target

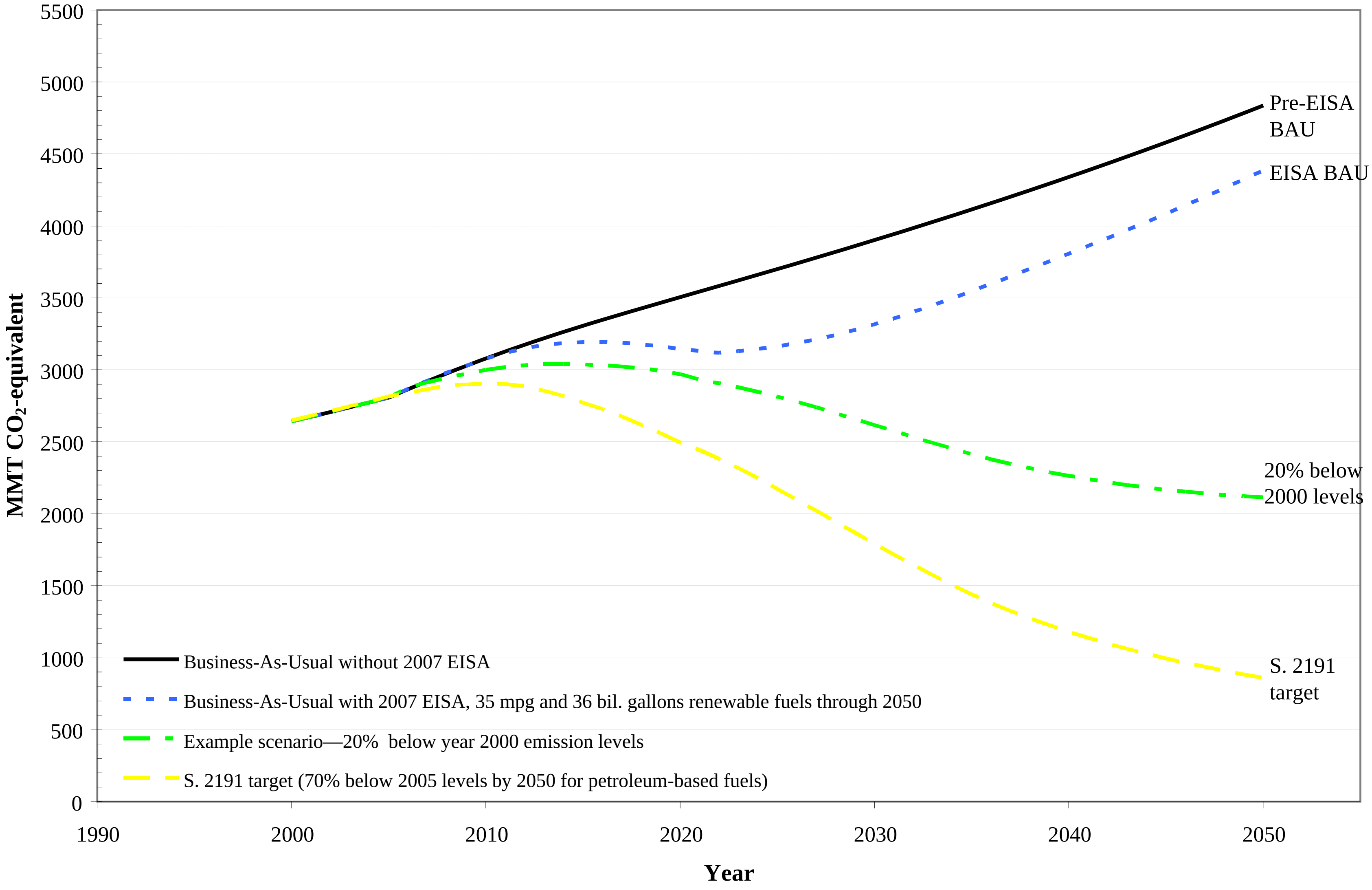
- We begin with a stabilization goal of 450 ppm atmospheric CO2 in 2050
  - This corresponds to about a 3 degree C temp rise
  - IPCC projects that this would require 2050 emissions to be 20% lower than 2000 emissions
- Total light duty vehicle emissions of GHGs were 1400 MMT in 2000, including emissions from the entire fuel lifecycle
- For light duty vehicles to do their proportionate share, the 2050 target for US light duty vehicle emissions would be 1120 MMT
- Under business as usual, total GHG emissions from US light duty vehicles are projected to reach 2300 MMT in 2050, assuming that:
  - Fuel economy under EISA increases to 35 mpg CAFE by 2020 (a 40% increase from today's levels), and stays at 35 mpg thereafter (ie EPA does not attempt to project further CAFE increases that the National Highway Transportation Safety Administration would promulgate under EISA).
  - Renewable fuels reach the EISA requirements of 36 billion gallons in 2022 and remain at the same percentage of the fuel pool thereafter
  - US growth in total vehicle miles traveled is 1.7% per year, including growth in both new vehicle sales and VMT per vehicle
- The 2050 target of 1120 MMT is, therefore, just over a 50% reduction from 2050 BAU emissions
- Using the same assumptions for VMT and renewable fuels in 2050 as above, the fuel economy of the fleet needs to reach 75 mpg CAFE to reach the 2050 goal of 1120 MMT

Example technology pathways to reach 75 mpg for the in-use fleet in 2050

1. All vehicles are plug-in hybrids with batteries to supply 40 miles of all-electric range (PHEV-40). At all other times, the PHEV would operate like a normal hybrid.
2. Half of all vehicles are PHEV-40s with advanced lightweight materials and optimized engines that run on E85 made from cellulosic feedstocks and average over 100 mpg CAFE. The other half of the fleet is made up of conventional hybrids or diesels with advanced lightweight materials that average about 65 mpg CAFE.
3. Similar to #2, but 70% of the fleet is made up of PHEV-40s averaging over 100 mpg and 30% are conventional hybrids or diesels that average about 50 mpg CAFE. Note that we have some hybrids and diesels today that are at or near 50 mpg CAFE (equating to about 40 mpg for the fuel economy label).

# U.S Transportation GHG Emissions Projections

(including fuel production and end-use combustion emissions of transportation fuels)



# Non-LD GHG Emissions Compared to Sector Targets

(including fuel production and end-use combustion emissions of transportation fuels)