RAND INFRASTRUCTURE, SAFETY, AND ENVIRONMENT

Environmental, Security, and Economic Issues of Electricity as a Transportation Fuel

Constantine Samaras

March 15, 2010

Image: www.consumerreports.org

What Are the Issues Surrounding Electrifying Transportation?

- Considerable policymaker interest in reducing oil imports and greenhouse gas emissions
- One avenue to achieving these goals is plug-in hybrid electric vehicles (PHEVs)—passenger vehicles that use electricity for a portion of travel
- As part of this panel, we will review the potential benefits and challenges of this pathway and discuss policy options

Acknowledgements

- Presentation summarizes analyses undertaken over past five years
- Collaboration with the Design Decisions Laboratory at Carnegie Mellon University
  - Including Professor Jeremy Michalek, Dr. C.S. Shiau, and Ph.D. Candidates E. Traut and K. Meisterling
- RAND is continuing to analyze issues surrounding transportation electrification as well as other alternative electricity and fuel technologies

What Are the Range of Vehicle Technology Options?

- **PHEV-20**: Plug-in hybrid with a battery capacity allowing user to drive 20 miles in all-electric mode
- **PHEV-40**: Plug-in hybrid with a battery capacity allowing user to drive 40 miles in all-electric mode
- **RE-EV**: Range-extended electric vehicle that uses small onboard gasoline engine to recharge the battery if needed
- **EV**: electric vehicle; no gasoline engine—range is limited by battery capacity

What Are the Range of Vehicle Technology Options?

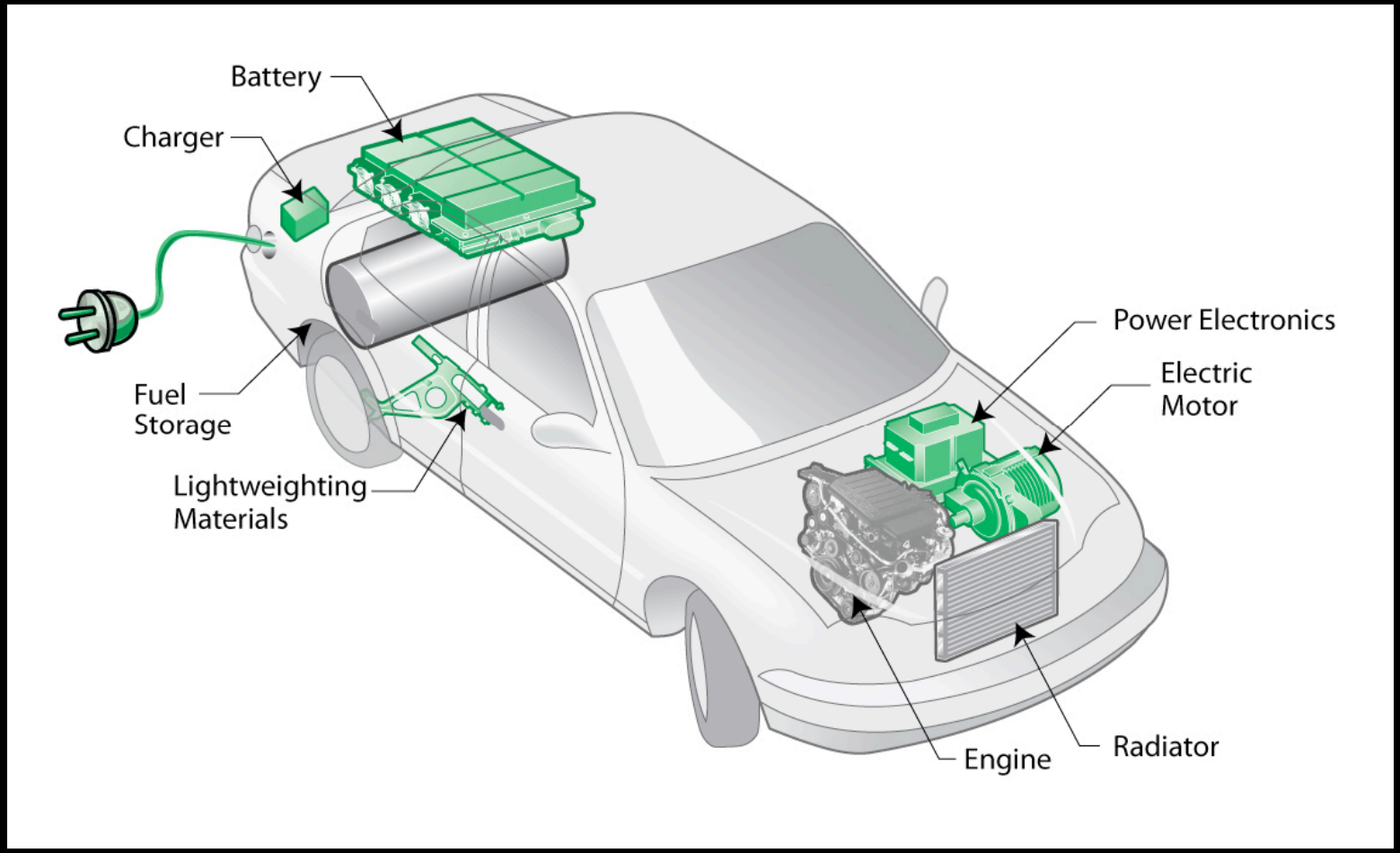


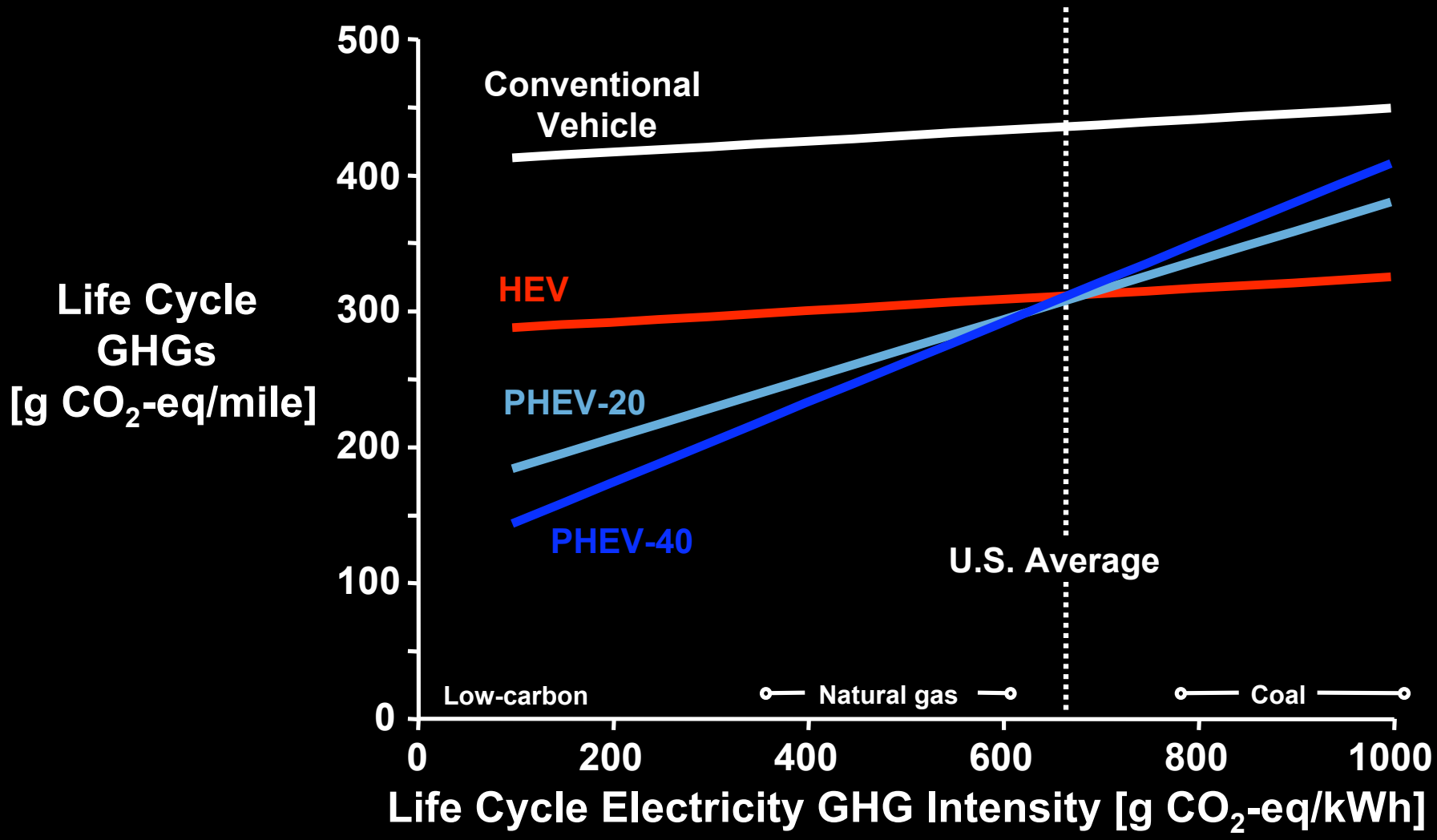
Image: Argonne National Laboratory

What Are Drivers of GHG, Security, Economic Impacts from Plug-in and Electric Vehicles?

- GHG intensity of electricity, fuels and materials
  - Renewables and other low-carbon options
- Share of travel on electricity versus fuels
  - Battery size, efficiency, travel patterns, charging
- Larger battery allows more electric range, but increases costs and material impacts
  - Extra weight and can degrade fuel economy by up to 5%

Source: Shiau, C.-S.N., Samaras, C., Hauffe, R., Michalek, J.J., 2009. Impact of battery weight and charging patterns on the economic and environmental benefits of plug-in hybrid vehicles. *Energy Policy*, 37(7) 2653-2663.

Electrified Transportation Has Large GHG Benefits with Low-Carbon Electricity



Source: Samaras, C., Meisterling, K., 2008. Life Cycle Assessment of Greenhouse Gas Emissions from Plug-in Hybrid Vehicles: Implications for Policy. *Environ. Sci. Technol.* 42(9), 3170-3176.

RAND

Low-Carbon Electricity Grid Is Critical to Large GHG Reductions in Long-Term

- For every 10 million PHEV-40s in the fleet:
  - Reduces GHGs by 5-20 million metric tons each year
- Decision time horizons in electric power sector are a lot longer than automobile sector
  - Power plants are long lived capital with lasting GHG impacts
- Could match new electric loads with low-carbon generation via renewable energy credits or portfolio standards
- Electrified transportation may initially be more successful as a regional strategy

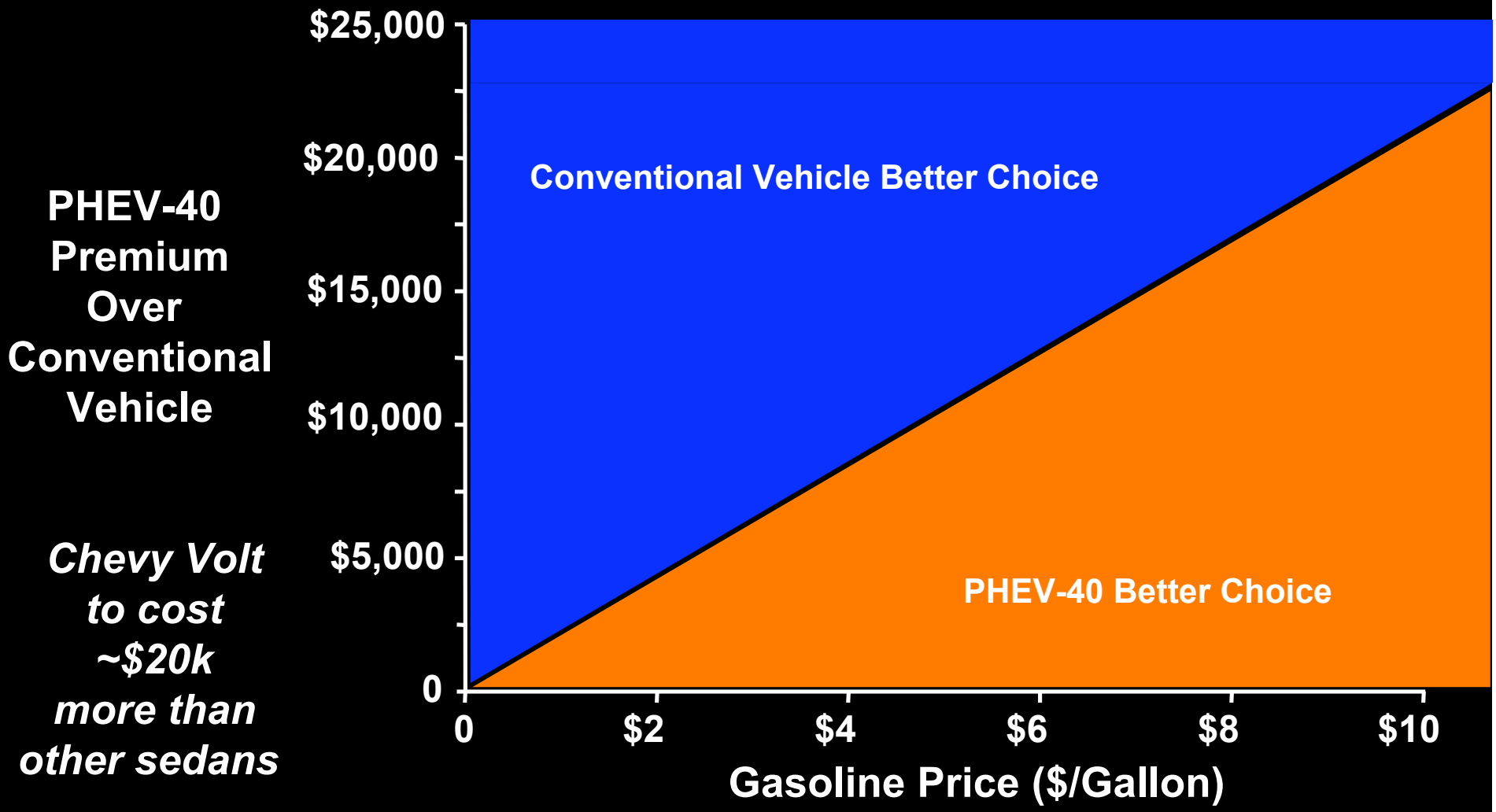
Electric Range and Infrastructure Investments Determine Oil Displacement

- **For every 10 million PHEV-40s in the fleet:**
  - **Displaces about 5-8 million gallons per day of gasoline**
- **PHEV-40 displaces about 2,200-3,700 gallons of gasoline over lifetime**
- **Electric Vehicle displaces about 3,200-4,800 gallons of gasoline over lifetime**

What Are the Challenges for Plug-in Hybrid and Electric Vehicles?

- **Because of the cost of batteries, PHEVs are substantially more costly than conventional vehicles and can be more costly than traditional hybrids**
- **Net reductions in GHGs compared to conventional hybrids depends on GHG intensity of electric power**
- **Charging infrastructure and electricity grid impacts**

Economics Are Attractive with Low Battery Prices and High Gasoline Prices



Chevy Volt to cost ~$20k more than other sedans

RAND

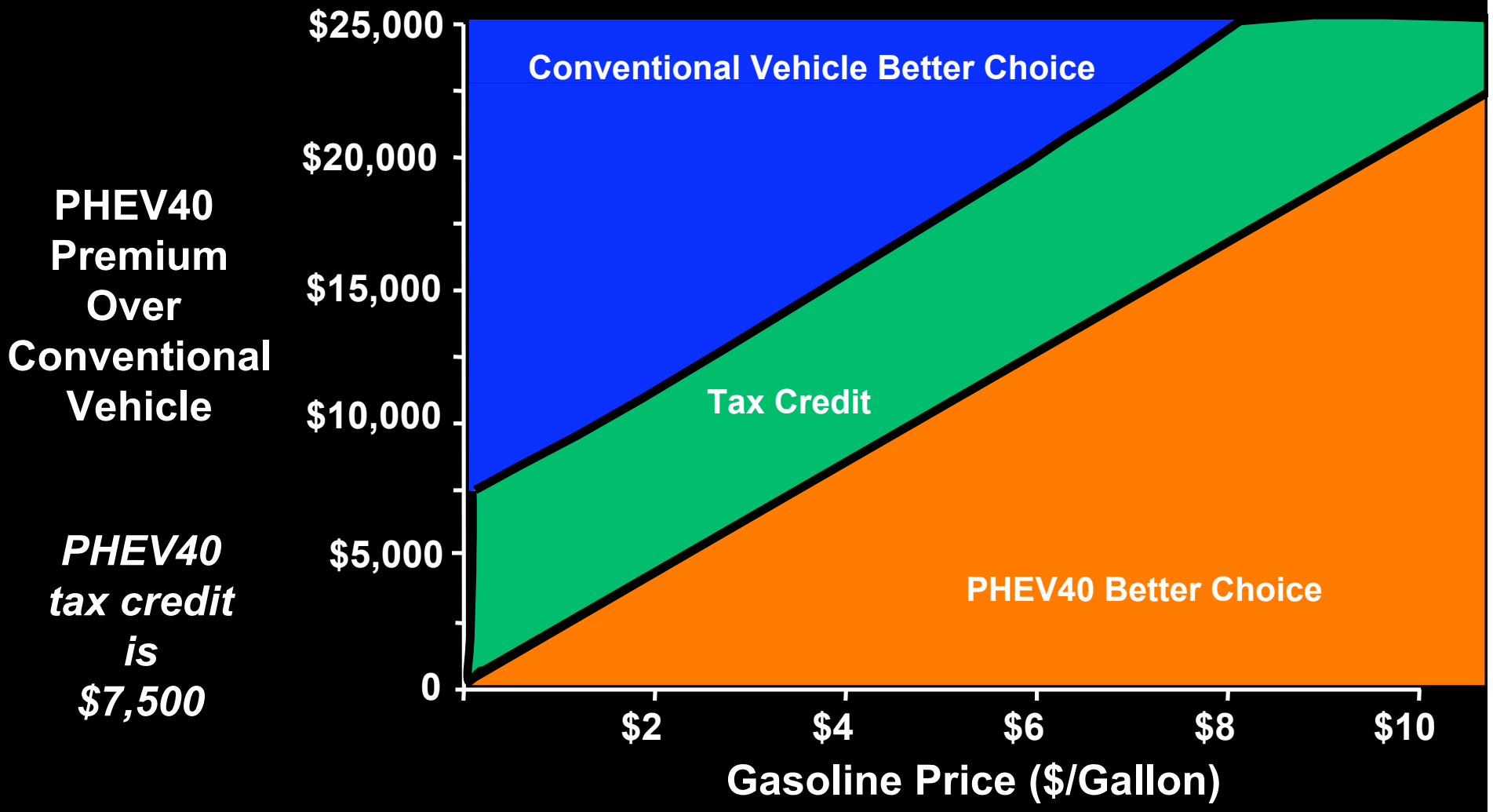
Current Tax Credit Policies Likely Insufficient

Current PHEV tax credits

- **$2,500 for first 4 kWh of battery capacity**
- **$417 for each additional kWh; Max of $7,500 total**

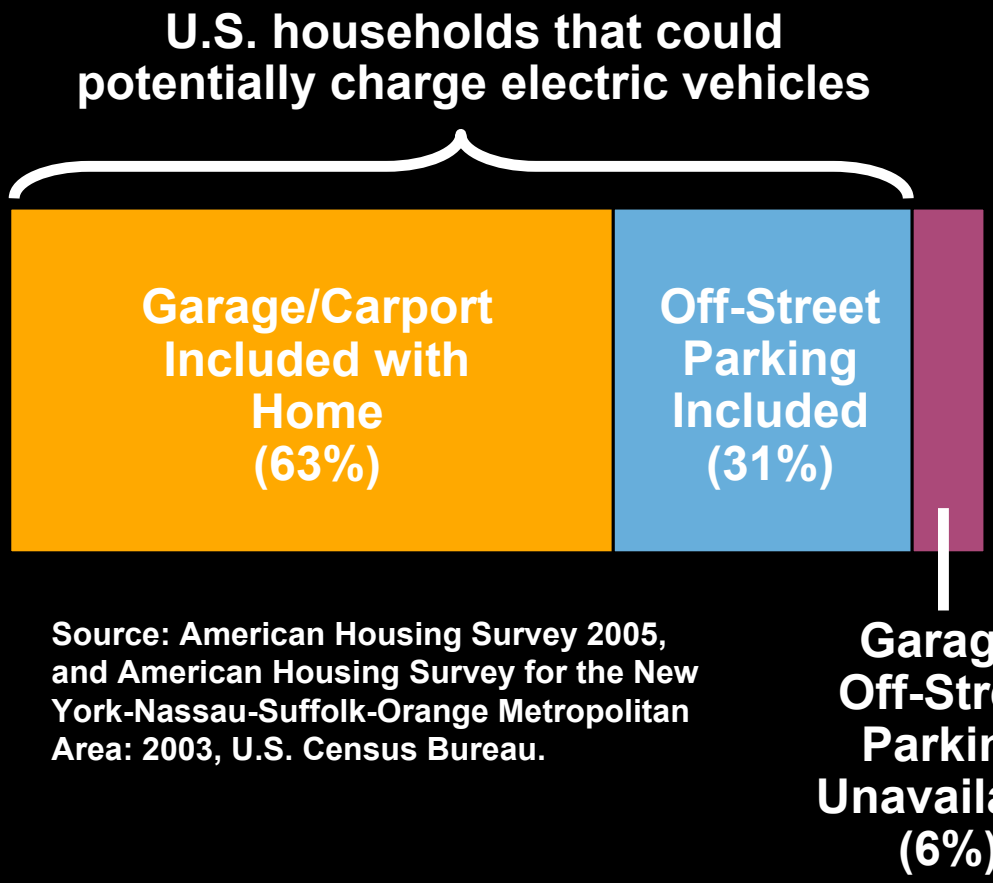
- **To be competitive at $3–$6 per gallon with credits:**
  - **PHEV-20 premium can't exceed ~$6,000–$17,000**
  - **PHEV-40 premium can't exceed ~$12,000-$21,000**
- **Even $100/ton CO_2 price does not change economics using electricity resembling the national average**

Economics Are Attractive with Low Battery Prices and High Gasoline Prices



RAND

Charging Is Feasible at Home Electrical Outlets



Source: American Housing Survey 2005, and American Housing Survey for the New York-Nassau-Suffolk-Orange Metropolitan Area: 2003, U.S. Census Bureau.

- Charging could occur at around 94% of U.S. homes
- There is variation across the various regions in the U.S.
- Electricity system impact manageable with proper planning

Large-Scale Adoption Depends on Economic Viability of PHEVs and EVs

- Consumers historically prefer immediate sales tax exemptions rather than credits for hybrid vehicles
- Widespread use of PHEVs may require household installation of 220V outlets and other upgrades
  - Tax credits for upgrading homes probably less effective than rebates to utility companies
- Continue battery R&D to reduce costs and improve life
- Policies should be evaluated for effectiveness and against other options

Key Findings

- PHEVs and EVs can have large life-cycle emissions reductions compared to traditional vehicles
- Large potential oil displacements enhance economic security
- Near-term battery cost challenges are critical
- Policies needed for large adoption and emissions reduction with PHEVs and EVs

Contact Information:

Constantine Samaras
RAND Corporation

E-mail: csamaras@rand.org

Tel: +1 412 683 2300 x4666

Web: www.rand.org

INFRASTRUCTURE, SAFETY, AND ENVIRONMENT