Overview of Light-Duty Vehicle Studies

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Washington, DC Workshop

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Sponsored by EERE

Transportation Cluster

Objective of LDV Studies Workshop

- This workshop is intended to be a working meeting for analysts to discuss findings and assumptions because a number of key studies on light-duty vehicles (LDVs) and biofuels have been completed in the past 5 years and the insight gained from their findings would be valuable.
- Outcomes:
  - common understanding of the effects of differing assumptions (today);
  - agreement on standard assumptions for future studies, where applicable (agreement on some assumptions today, follow-up discussions/meeting may be needed for others);
  - list of data/information gaps and needed research and studies (a complete list may not be achievable today, but a start is possible; a study plan with a schedule is the desired end-product).

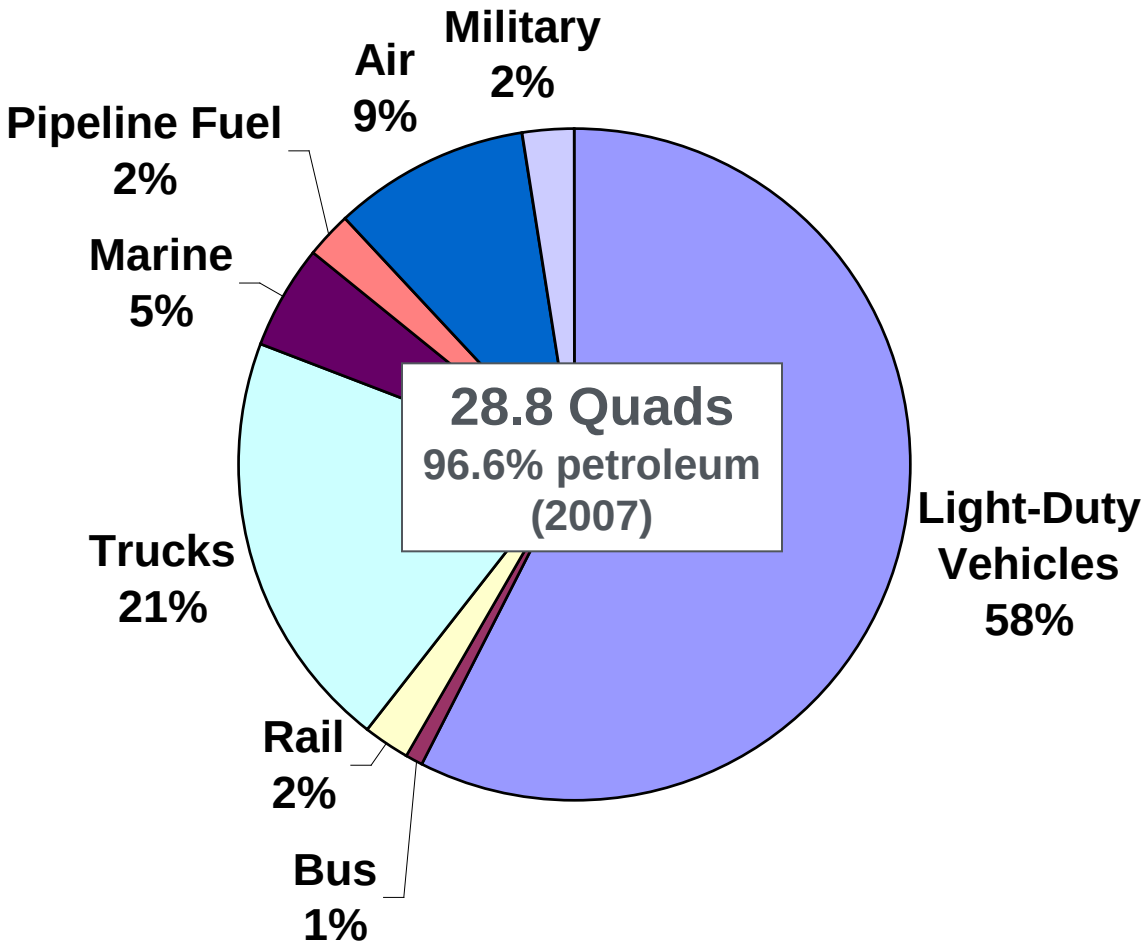
Introduction

Sam Baldwin

Chief Technology Officer

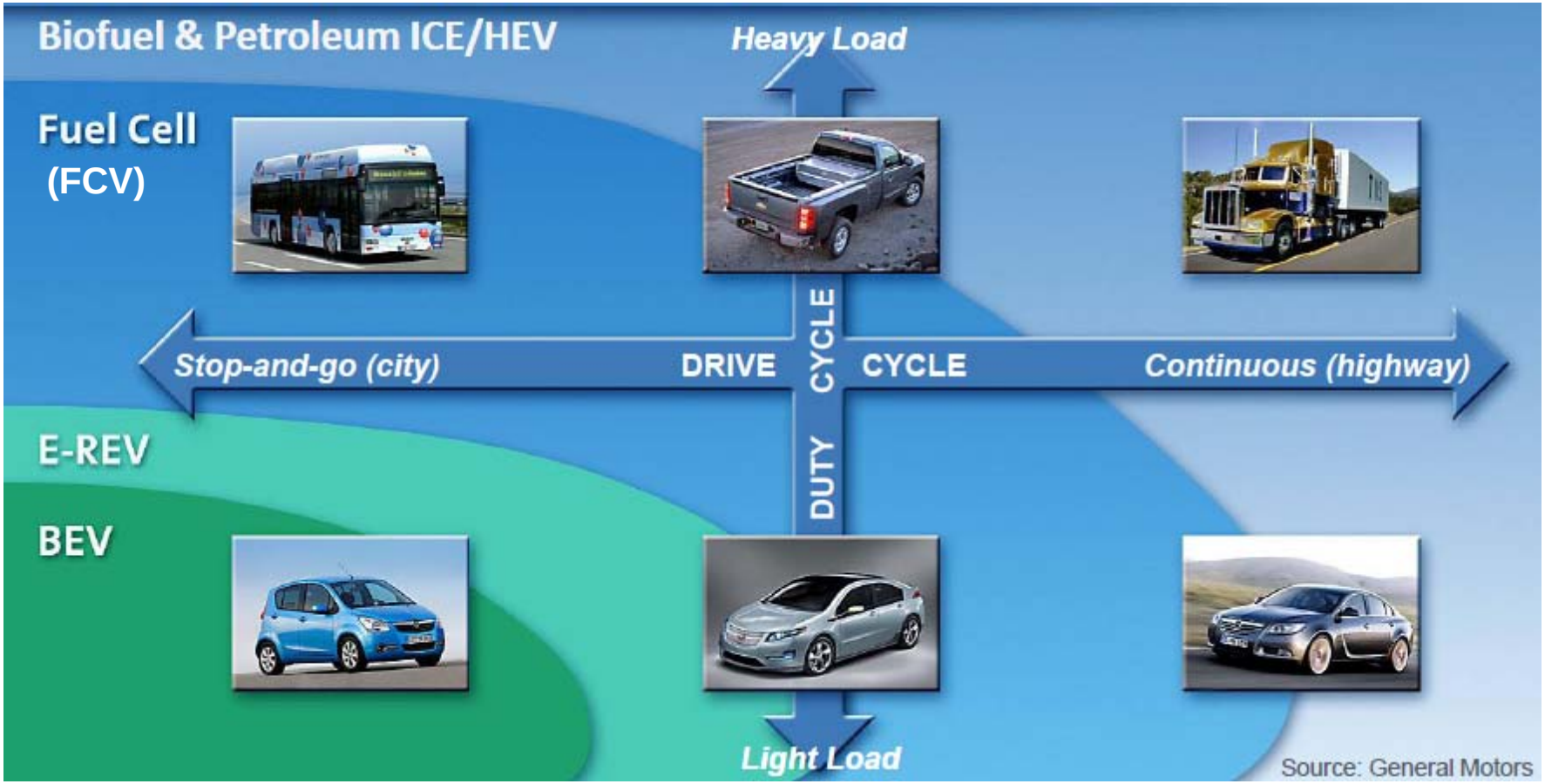
DOE EERE

Transport Energy Use



Light-Duty Vehicles
In the U.S. Transportation Sector

Different Vehicles for Different Use Patterns: no single answer



ICE: Internal Combustion Engine

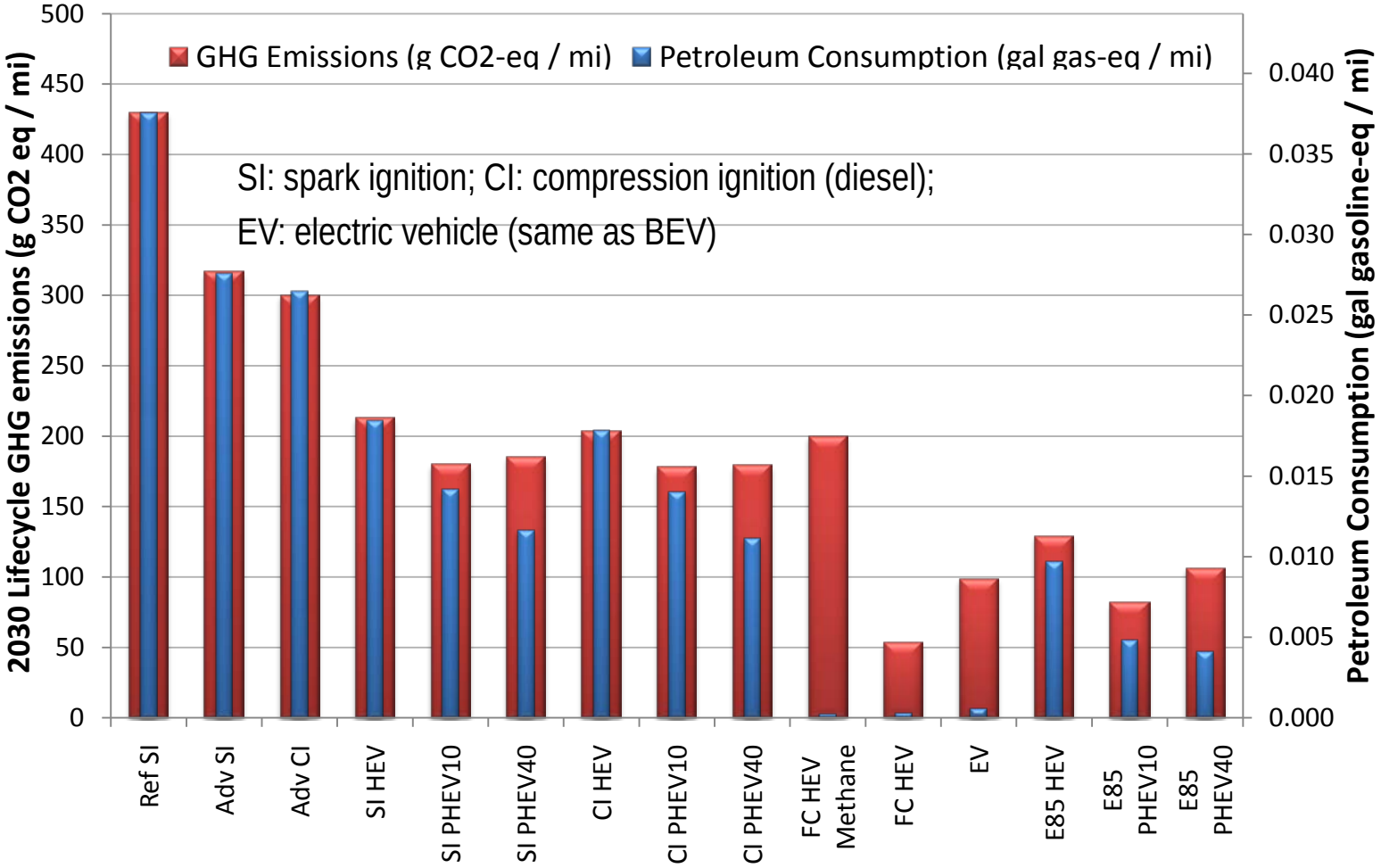
HEV: Hybrid Electric Vehicle

E-REV: Extended Range Electric Vehicle (PHEV)

BEV: Battery Electric Vehicle

FCV: Fuel Cell Vehicle

Advanced Technologies Can Help to Reduce Oil Use and GHGs Emissions



- **Assumes a future electric grid with carbon emissions at 6% of the current U.S. grid's emissions. Hydrogen is generated from: 52% natural gas (SMR), 22% coal w/ CCS, 25% biomass w/ CCS, and 1% electrolysis. Vehicles modeled with Argonne National Lab's model, the Powertrain Systems Analysis Tool (PSAT).**

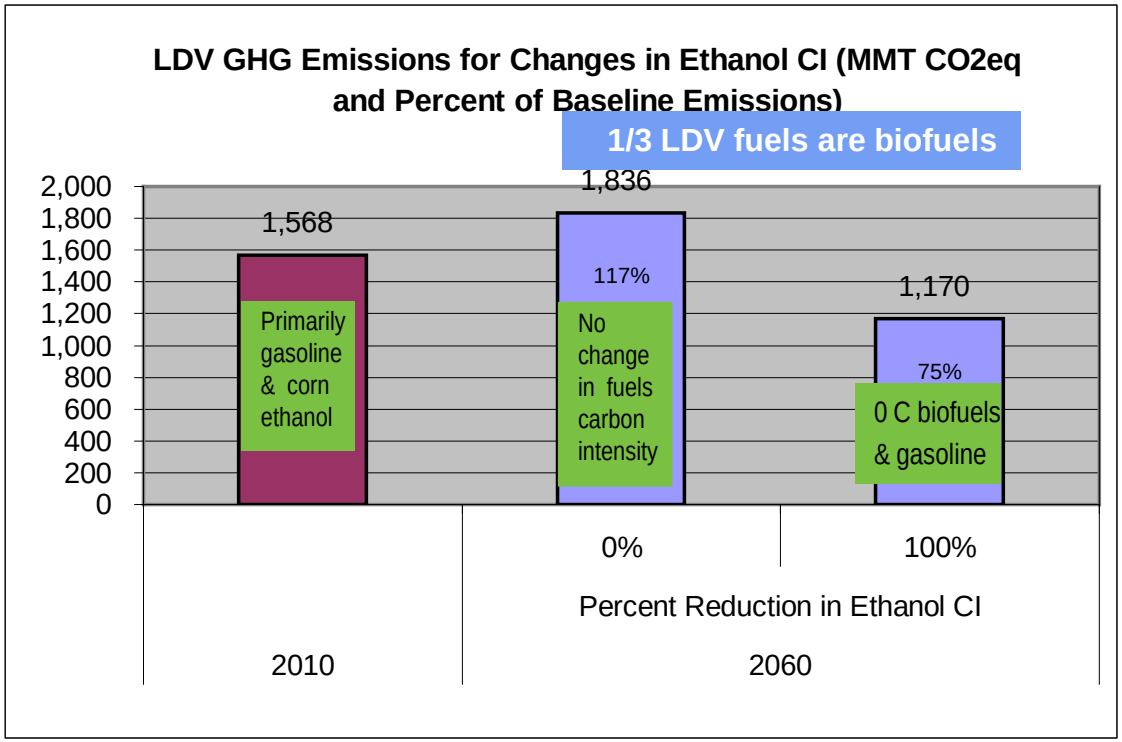
Where Are We Now?

- 1,570 million metric tons (M MT) GHGs/year from LDVs from 9 million barrels per day (M bpd) of gasoline and corn ethanol
- 9 M flexible fuels vehicles (gasoline/E85) and 1.4 M HEVs on the road; more advanced LDVs at pre-commercial stage
- Renewable Fuels: 12 billion gallons of renewable ethanol/yr or 0.6 Mbpd gasoline-equiv. gallon (gge) now (biodiesel volume is much smaller and not mentioned here); (Renewable Fuels Standard or RFS mandates 36 billion gals/yr of renewable fuels or 1.6 Mbpd gge in 2022[1])

[1] *USDA assumed that 3 additional billion gals/yr will be corn ethanol and 21 additional billion gals/yr will be advanced biofuels (530 advanced biorefineries to be built by 2022)*
USDA Biofuels Strategic Production Report, June 23, 2010

Perspective 1: Future with Only Extreme Biofuels Success

If zero-carbon biofuels accounted for 1/3 of LDV energy in 2060, GHG emissions would be 1,170 M MT/yr or 75% of 2010 emissions, assuming no radical change in LDV technologies beyond CAFE requirements and a very moderate ramp-up of hybrid electric vehicles (HEVs). - For comparison, if the carbon intensity (CI) of new biofuels was the same as today's corn ethanol, GHG emissions would increase to ~1,840 M MT/yr, or almost 120% of 2010 emissions.



Hypothetical Illustration!

Perspective 2: Extreme Biofuels Success & Better HEV Success

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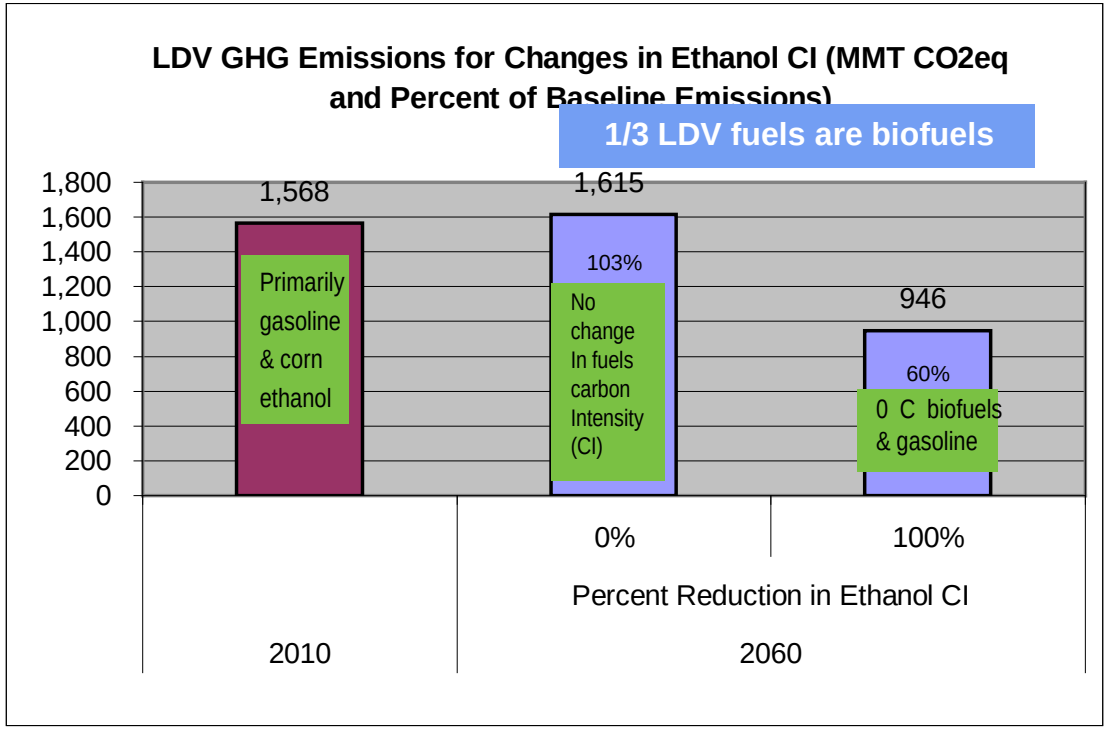
In 2060, if 60% of LDVs were HEVs and the same kind of biofuels success was assumed (1/3 or slightly more of LDV energy is zero carbon), GHG emissions would be ~950 M MT/yr, i.e., 60% of 2010 emissions. - For comparison, if the carbon intensity (CI) of new biofuels was the same as today's corn ethanol, GHG emissions would increase to ~1,610 M MT/yr, i.e.,103% of 2010 emissions.



Hypothetical Illustration!

List of Studies and Presenters

- Hydrogen Transition Study: David Greene & Paul Leiby – Oak Ridge National Laboratory (ORNL). *ORNL was assisted by car companies, NREL, DTI, LCA, TIAX & Energetics*
- National Research Council (NRC) Study of Transition to Hydrogen/Biofuels/Highly Efficient Conventional & Hybrid Electric Vehicles/Plug-in HEVs: Mike P. Ramage – National Academy of Engineering, Exxon Mobil Research & Engineering (ret.) & Joan Ogden – University of California at Davis
- NRC Study of Liquid Fuels from Coal and Biomass: Mike P. Ramage
- Biofuels Feedstock Assessment: Zia Haq – DOE EERE
- LDV Multi-Path Study: Steve Plotkin – Argonne National Laboratory
- LDV Well-to-Wheels Study: Michael Wang & Amgad Elgowainy - ANL
- Carbon and Oil Reduction for LDV Pathways: Patrick Serfass for Sandy Thomas – National Hydrogen Association
- PHEV and BEV Market Studies: Anant Vyas – ANL

Agenda

8:15 – 8:25	Introduction	Sam Baldwin
8:25 - 8:50	Scopes of Studies	Jake Ward & Tien Nguyen
8:50 – 9:25	Hydrogen Transition Study	David Greene & Paul Leiby
9:25 – 10:25	NRC Studies on Transition to Hydrogen/Biofuels/Highly Efficient Conventional and HEVs/Plug-in HEVs	Mike Ramage & Joan Ogden
Break (10 minutes)		
10:35-11:10	NRC Study on Alternative Liquid Fuels from Coal & Biomass	Mike Ramage
11:10 – 11:50	USDA/DOE Biofuels Feedstock Assessment	Zia Haq
Lunch (50 minutes)		
12:50 – 01:25	Light-Duty Vehicles (LDVs) Multi-Path Study	Steve Plotkin
01:25 – 02:00	Well-to-Wheels Study of Advanced LDVs	Michael Wang & Amgad Elgowainy
02:00 – 02:35	Carbon and Oil Reduction for LDV Pathways	Patrick Serfass
Break (10 minutes)		
02:45 – 03:25	PHEV and BEV Market Studies	Anant Vyas
03:25 - 04:10	Round Table	All
04:10 – 04:30	Wrap-up and Action Items	Jake Ward & Tien Nguyen

Logistics

- For lunch, restaurants and coffee kiosks are located on the Promenade (P) Level of L'Enfant Plaza. Coffee and snacks can be obtained there throughout the day if needed.
- The East side elevators descend directly to the P level. The West side elevators descend to the lobby where escalators take you to the P level.
- Olympic Coffee Shop, Oh's Café, Potomac Café, Au Bon Pain, Everything Yogurt, Gourmet II, McDonald's…

Attributes of LDV Studies

- Studies used vetted data sources such as: (a) GREET - the ANL vehicle greenhouse gases & energy model, (b) MIT & ANL modeling results of fuel economy and costs of future vehicles, etc. Where study authors chose to deviate, they documented the reasons
- Only the NRC study of transition to hydrogen/biofuels included a proposed multi-year RD&D budget
- The two NRC transition studies, the DOE Multi-path Study and the study by Clean Car Options (Sandy Thomas) estimated the costs of policies
- The study by Clean Car Options shows a comparison of the other vehicles with the battery electric vehicle (BEV). The ANL market study also looked at BEV and PHEV.

Chronology & Linkage - 1

- **2006-08. ORNL et al. Transition to Hydrogen Study**
  - Postulated accelerated transition & required policy
  - Developed FCV cost reduction trajectory with proprietary auto industry's input
  - Analyzed the following issues:
    - How fast can LDVs transition to hydrogen if the needed policy is in place?
    - What are the transition costs and is the new infrastructure affordable?
    - What if FCV cost targets could not be reduced down to DOE goals?
- **2007-08. National Research Council (NAS/NAE)'s Study of Transition to Hydrogen/Biofuels/Highly Efficient ICEVs & HEVs**
  - In 2005 Congress requested an investment roadmap to achieve a hydrogen economy by 2020. Assuming RD&D success for biofuels and advanced conventional and hybrid electric vehicles, NRC estimated the benefits that would accrue over the next 3 decades
  - To estimate additional benefits, NRC used a transition scenario from the ORNL study. NRC estimated the maximum practical penetration rate for FCVs; identified needed policies; estimated infrastructure & incentive costs; and proposed a multi-year RD&D budget.

Chronology & Linkage - 2

- **2008-09. National Research Council's PHEV Transition Study**
  - Using an approach that is comparable to the first NRC study, NRC estimated the maximum practical penetration rate for PHEVs and transition costs and benefits
  - NRC compared these to the benefits associated with the RD&D success scenario for biofuels and advanced conventional and hybrid electric vehicles
- **2008-09. NRC Study of Liquid Transportation Fuels from Coal and Biomass**
  - The study is part of the NRC America's Energy Future project. NRC assessed the technological status, costs, and environmental effects of alternative transportation fuels, and estimated the potential supply of these fuels if the needed federal activities were initiated as soon as possible. The biomass supply estimate is slightly more conservative than that in the NRC Transition to Hydrogen/Biofuels Study
- **2005-08. USDA/DOE Biofuels Feedstock Assessment**
  - A joint USDA/DOE report that provides research recommendations to address constraints surrounding the availability of biomass feedstocks. The report includes an economic assessment linked to an analysis of the GHG emissions and sustainability of biofuels from agriculture and forestry resources.

Chronology & Linkage - 3

- **2006-08. ANL LDV Multi-path Study**
  - The study estimated advanced vehicles/fuels potential under 2 technology cost scenarios and alternative policy scenarios. The study looked at ethanol, hydrogen, and electricity, with advanced internal combustion engine vehicles, HEVs, PHEVs, and FCVs. BEV cost and performance were characterized, but BEVs did not achieve significant market penetration in modeled scenarios
- **2008-10. ANL Well-to-Wheels Study**
  - The study focused on comparisons of GHG emissions and oil use between advanced vehicle/fuel combinations such as PHEVs on gasoline and ethanol, FCVs on H_2, etc. relative to gasoline ICEVs and HEVs, and how the electric grid's mix of generation technologies impact the benefits of using electricity for transportation
- **2009. National Hydrogen Association/Clean Car Options' study**
  - The study looked at transition to HEVs vs. PHEVs vs. BEVs (battery electric vehicles) vs. FCVs, assuming biofuels RD&D success in several of the cases. The study estimated infrastructure costs for BEVs and FCVs and the costs of transition policies. PHEV (blended mode) results from the ANL Well-To-Wheels study (Phase 1) were used
- **2006-09. ANL BEV and PHEV Market Studies**
  - ANL analyzed the markets for different PHEV types, i.e., all-electric range of 10 miles, 20 miles, 30 miles and 40 miles. The BEV was also analyzed.

Potential Action Items after Workshop

- Questions/answers during briefings and round table session at the end will likely generate a list of action items
- As a minimum, the discussions can cover:
  - Standardization of assumptions (where applicable)
  - Web-accessible data base of assumptions similar to EIA-provided query capabilities for Annual Energy Outlook data
  - Risks and uncertainties
  - Additional sensitivity analyses and new studies to address uncertainties (additional discussions/meeting may be needed)
  - Options to mitigate risks (may not be able to complete today)
  - Schedule for a plan of future studies and other needed activities

Uncertainties - example

- Fuels: cost and availability of low-carbon/sustainable biofuels, electricity and H_2
  - Non-food biomass feedstock and costs of converting to fuels
  - Renewable/nuclear generation ramp-up rates and costs
  - Costs of electricity storage to mitigate intermittency of electricity generation
  - Cost and timing of carbon capture & sequestration
  - Costs of upgrading home circuits for charging vehicles
  - Public fueling station costs (PHEVs, BEVs and FCVs)
  - Costs of transporting biomass feedstock or hydrogen fuel
- Vehicles: costs of batteries, fuel cells and on-board H_2 storage
- Policies to overcome infrastructure barriers and initial high costs of advanced vehicles & fuels