# Our New MIT Report: *On the Road towards 2050*

Sloan Automotive Laboratory


John B. Heywood

Sloan Automotive Laboratory, M.I.T.


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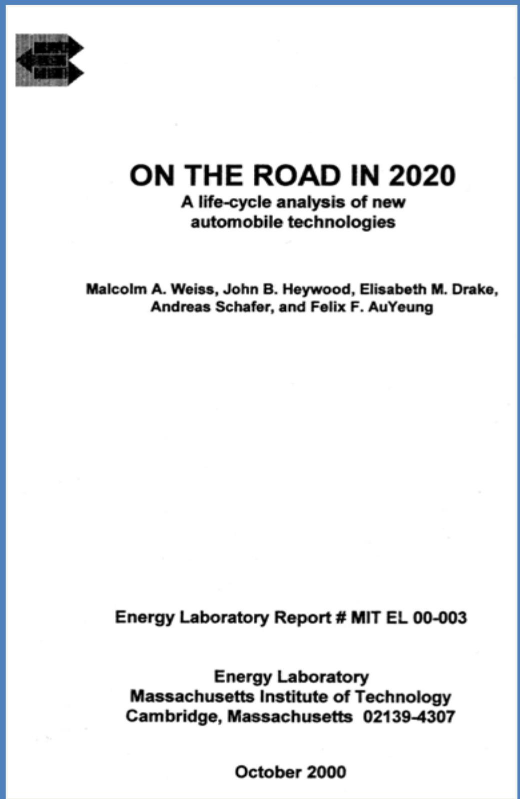
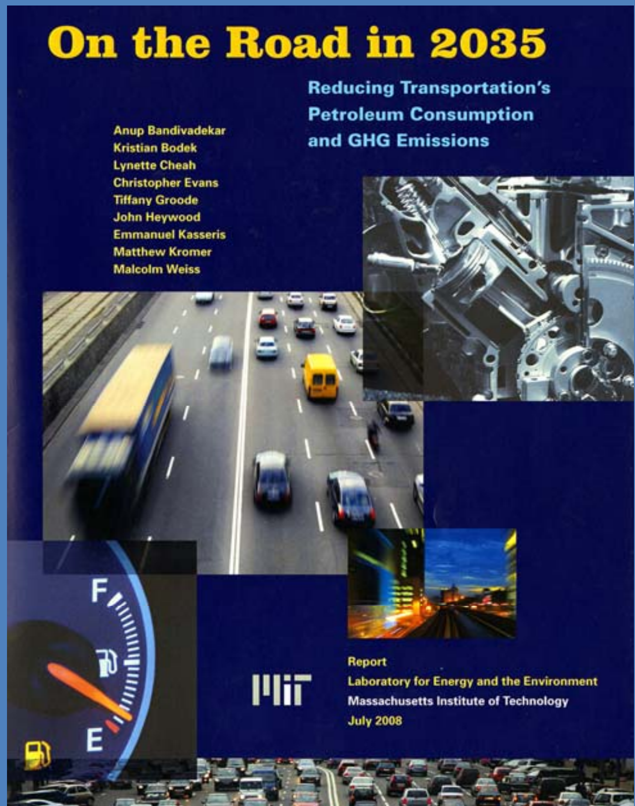
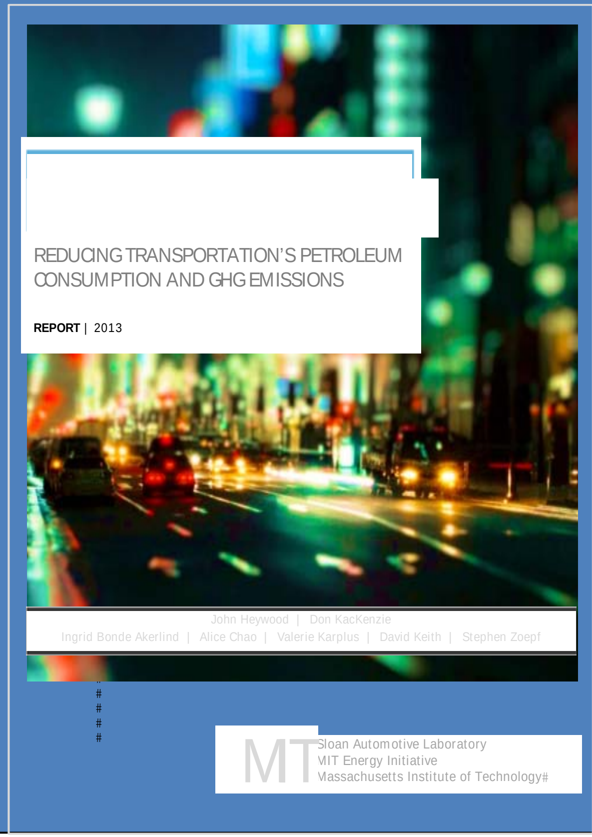
# Issued a Series of Reports



# On the Road towards 2050: Report Status

1. New report: "On the Road Towards 2050": Potential for Achieving Substantial Reductions in Light-Duty Vehicle Fuel Use and Greenhouse Gas Emissions.

2. Contributors: John Heywood and Don MacKenzie (also editors), Ingrid Bonde Akerlind, Parisa Bastani, Kandarp Bhatt, Alice Chao, Eric Chow, Valerie Karplus, David Keith, Michael Khusid, Eriko Nishimura, Stephen Zoepf.

3. M.I.T. Energy Initiative Report, 2015.

# Report Status

Ch. 1 Introduction

Ch. 2 Overview of Options

Ch. 3 Propulsion and Vehicle Technologies

Ch. 4 Vehicle Weight and Size Reduction

Ch. 5 Fuel Consumption

Ch. 6 Fuel and Energy Pathways Forward

Ch. 7 Deploying Improved and New Vehicle Technology

Ch. 8 Opportunities in Traveler and Driver Behavior

Ch. 9 Scenario Analysis and Results

Ch. 10 A Comprehensive Policy Approach

Ch. 11 Overall Findings and Implications

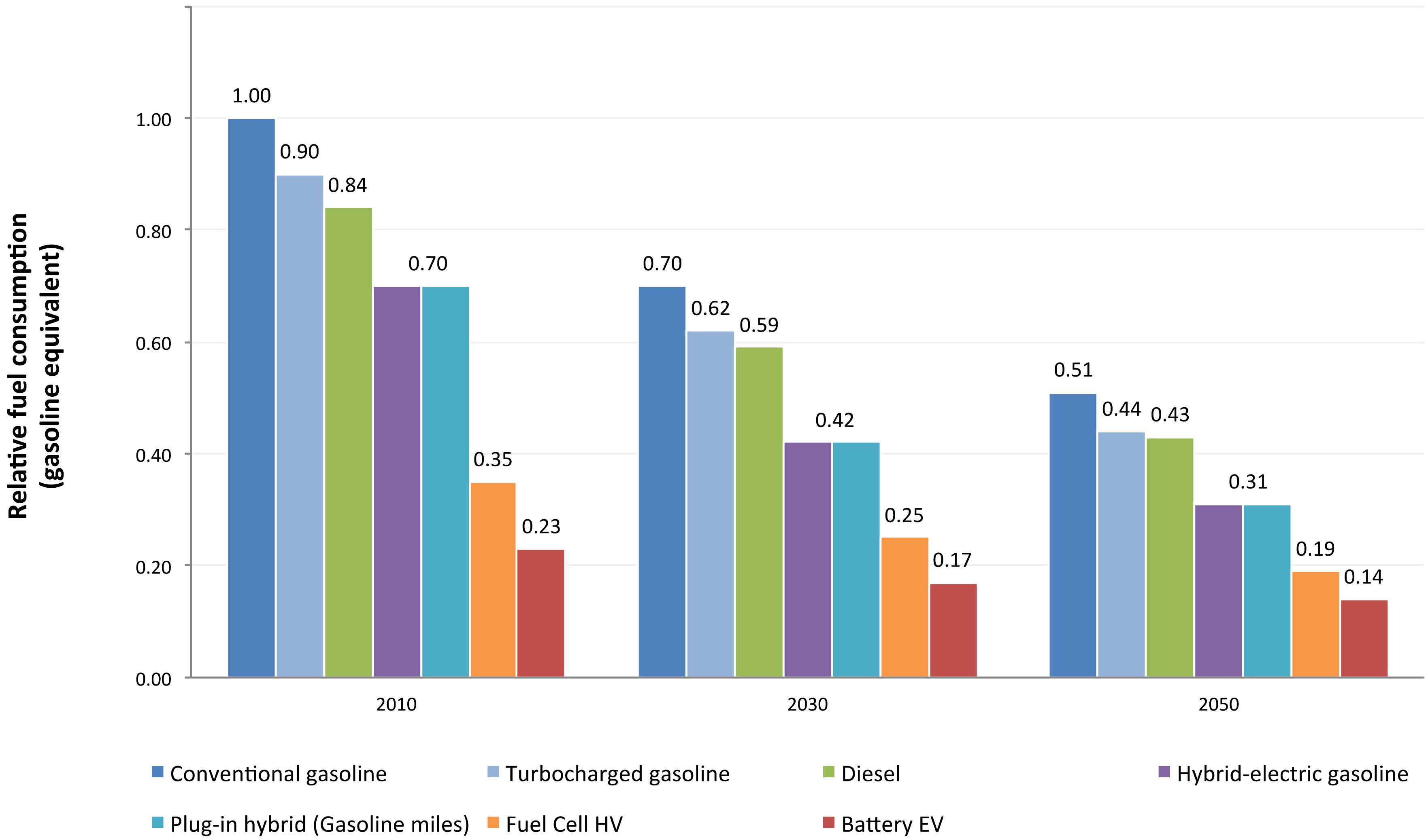
# Three Important Energy and GHG Emissions Paths Forward

1. **Improve:** increase the fuel efficiency of mainstream transportation vehicles and develop alternative liquid hydrocarbon fuel sources which can displace petroleum and reduce GHG emissions.

2. **Conserve:** reduce the demand for energy intensive personal and freight transportation services.

3. **Transform:** explore how to shift transportation's energy requirements (and propulsion technologies) to alternatives with much lower GHG emissions.

# Relative Fuel Consumptions (Tank to Wheels):



# Well-to-Wheels GHG Emissions Data: Average New U.S. Car in 2030

| Vehicle Propulsion System/fuel | $CO_2$/fuel Energy $gCO_2e/MJ$ | $gCO_2e/km$ | $CO_2$/km Ratio |
|---|---|---|---|
| Gasoline NASI | 93 | 213 | 1.0 |
| Turbo SI Gasoline | 93 | 191 | 0.9 |
| Diesel | 99 | 194 | 0.91 |
| HEV | 93 | 133 | 0.62 |
| PHEV (10) – (30)[a] | | 103 – 77 | 0.48 - 0.36 |
| FCEV[b] | 200 – 100 | 150 – 74 | 0.7 – 0.35 |
| BEV[c] | 164 – 88 | 87 – 47 | 0.41 – 0.22 |
| Natural gas NASI | 74 | 169 | 0.79 |
| Corn ethanol NASI | 73 | 167 | 0.78 |
| Sugar cane/Forest waste ethanol | 34 – 39 | 78 – 89 | 0.37 – 0.42 |
| Tar sands gasoline | 105 | 240 | 1.13 |

[a]Dependent on the % miles electrical and electrical supply system
[b]FCEV – Lower number with Clean $H_2$ (with CCS or "green" electrolysis)
[c]Dependent on the $CO_2$ intensity of electricity

# Summary of Potential at the Vehicle Level

1. Improving mainstream engine, hybrid, technology and vehicle light-weighting have potential for up to 50 percent reduction in vehicle fuel consumption (gasoline equivalent) by 2050.
2. Greenhouse gas emissions reduction potential, full life-cycle analysis, is somewhat less—about 40 percent.
3. Charge-sustaining HEV vehicles likely to grow as fraction of sales: relative benefit will usefully improve.
4. Plug-in hybrid technology significantly more promising path to increased electrification than BEVs: battery performance and cost, range and recharging time are major barriers.
5. Fuel cell hybrid technology and hydrogen appear to be lowest cost longer-term propulsion and fuel alternative: low GHG emitting hydrogen supply and distribution major barriers.
6. Biofuels: Useful though likely limited in scale by land impacts.

# Develop and Analyze Scenarios of Future Light-Duty Vehicle Developments and their Impacts

1. Average new vehicle level:
   - Different mainstream and alternative propulsion systems and their fuels
   - Quantify their fuel consumption, acceleration performance, size/weight, GHG emissions, cost
   - Estimate improvements in these attributes over time

2. In-use vehicle fleet level:
   - Vehicle type and propulsion system sales mix over time
   - Sales volume, annual vehicle mileage/kilometers

3. Approaches/methodologies
   - Engineering analysis of engine-in-vehicle options
   - Recent sales data trends and plans
   - Assumptions, comparisons, judgments

# Our Recent LDV In-Use Fleet Scenarios

1. On the Road in 2035, MIT LFEE Report, U.S. and Europe, 2008. (Anup Bandivadekar et al.).
2. "The effect of uncertainty on US transport-related GHG emissions and Fuel Consumption out to 2050," Trans. Res. A, 2012. (Parisa Bastani et al.).
3. U.S. CAFE STANDARDS: Potential for Meeting Light-duty Vehicle Fuel Economy Targets, 2016-2025, MITei Report, 2012 (Bastani, Heywood, Hope).
4. "Potential of Electric Propulsion Systems to Reduce Petroleum Use and GHG Emissions in the U.S. Light-Duty Vehicle Fleet," MS Thesis, MIT, 2010 (Michael Khusid).

# Our Recent LDV In-Use Fleet Scenarios – Continued

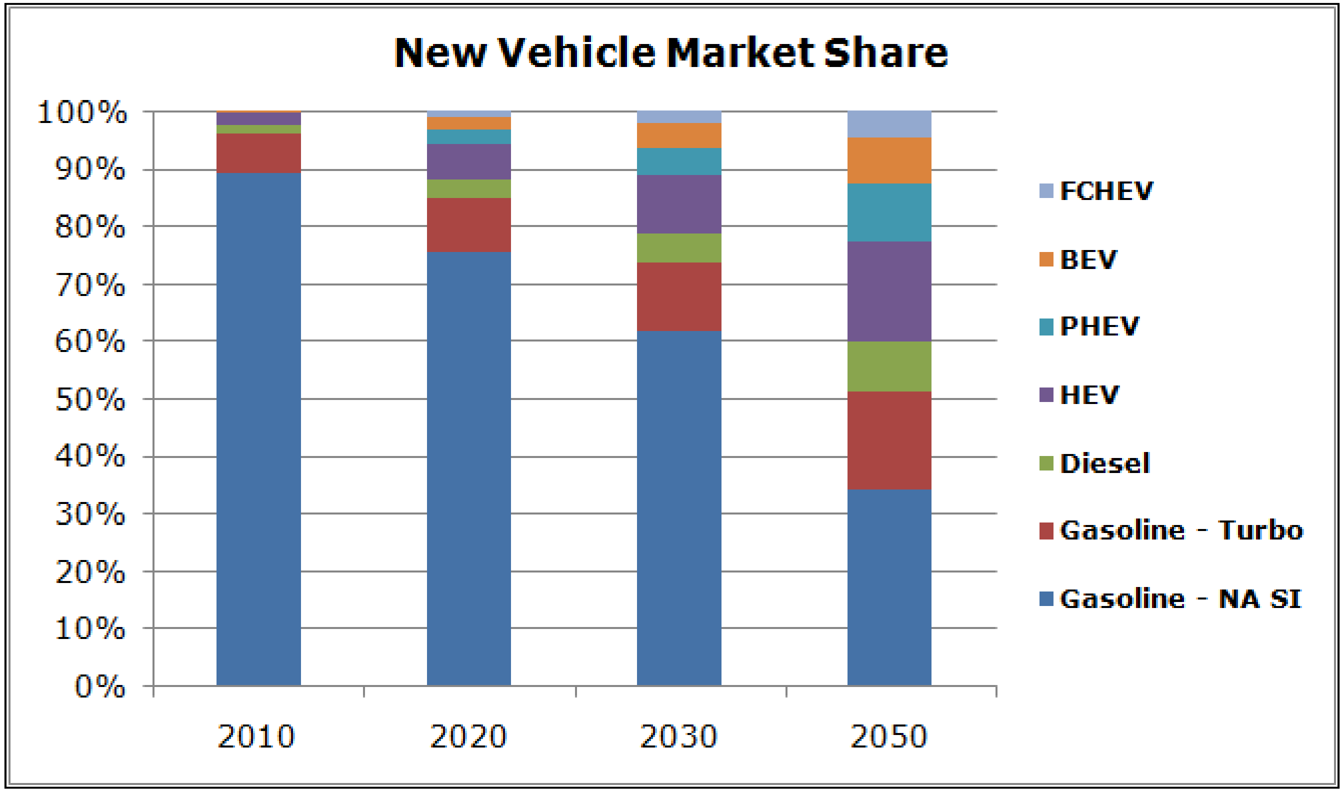
5. "Potential for Meeting the EU New Passenger Car $CO_2$ Emissions Targets," MS Thesis, MIT, 2010 (Kandarp Bhatt).

6. "Assessing the Fuel Use and GHG Emissions of Future Light-Duty Vehicles in Japan," MS Thesis, MIT, 2011 (Eriko Nishimura).

7. "Driving Change: Evaluating Strategies to Control Automotive Energy Demand Growth in China," MS Thesis, MIT, 2013 (Ingrid Bonde Akerlind).

8. "Benefits of a Higher Octane Standard Gasoline for the U.S. Light-Duty Vehicle Fleet," SAE paper, 2014-01-1961 "Economic and Environmental Benefits of Higher-Octane Gasoline," Env. Sci. Tech., V. 48, 2014. (Eric Chow, Ray Speth, John Heywood et al.).

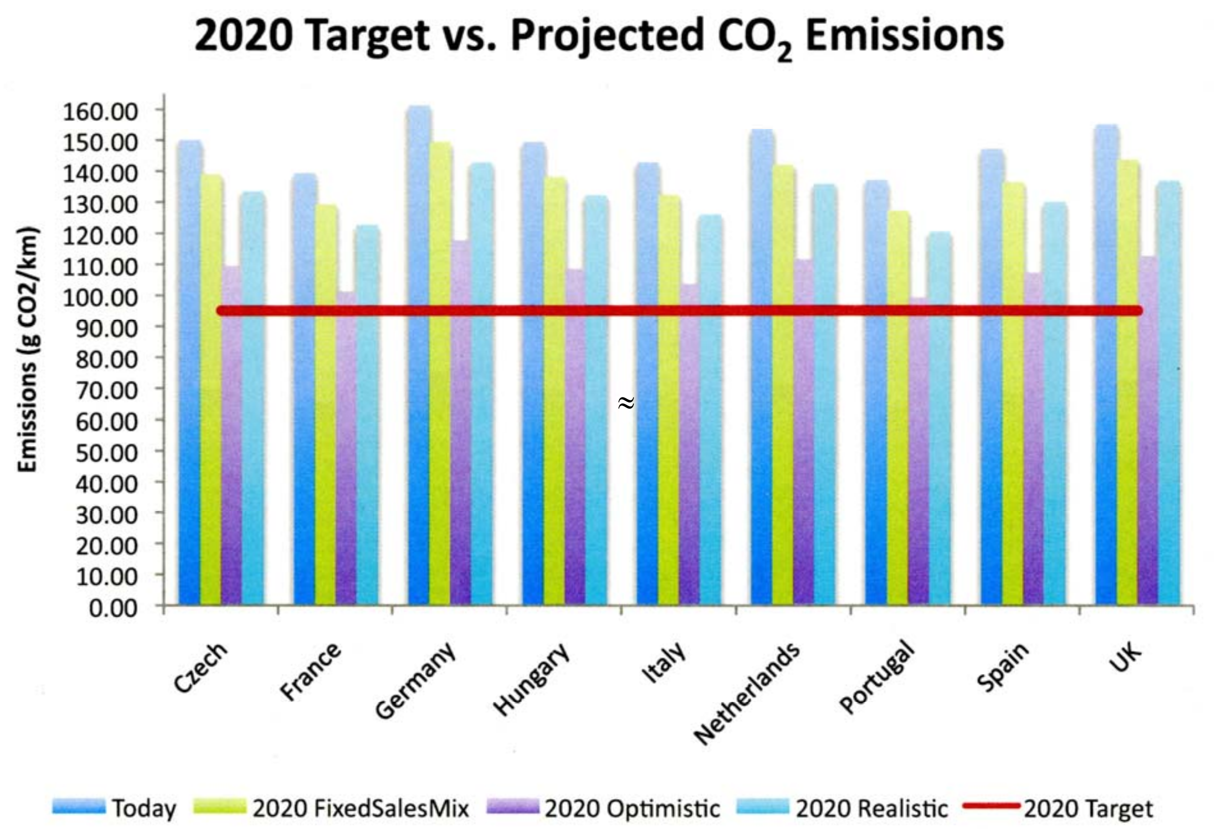
# Technology Market Deployment Over Time (U.S.)




Sales market share modal inputs to 2050

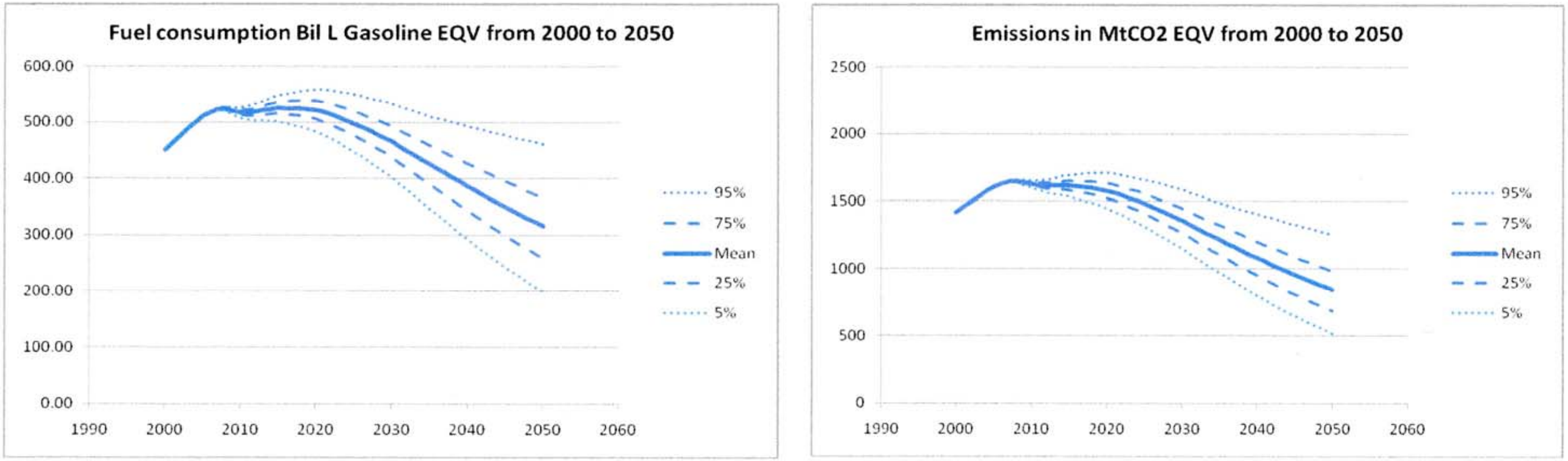
Source: Bastani, Heywood, Hope (2012)

# European Union: Projected Sales Mix $CO_2$ Emissions, by Country, vs. Target, 2020




Projected $CO_2$ reduction, 15-25%: Targets require $\approx$33%

# U.S. LDV Fleet Fuel use and GHG Emissions out to 2050




U.S. in-use fleet fuel consumption (bil liters gasoline equivalent per year) and GHG emissions (Mtonnes $CO_2$ equivalent per year): mean values and uncertainty

Source: Bastani, Heywood, Hope (2012)

# Summary: Where Are We?

1. Improving the mainstream internal combustion engine (gasoline and diesel) light-duty vehicle is the most effective way to reduce in-use LDV fleet GHG emissions in the nearer term.

2. By reducing the HEV cost premium and increasing its benefits, the HEV sales fraction can continue to increase steadily over time, yielding additional reductions.

3. The potential for reducing vehicle weight, and thus reducing fuel consumption, is significant, important to pursue, but has limits.

4. The other propulsion system options (alternative fuels, EVs and electricity, fuel cells and hydrogen) need to be explored and developed further, and their feasibility assessed.

# Summary: Where Are We? – Continued

5. Biomass-based fuels contribution likely limited by source constraints. Miscibility and octane important issues.

6. BEVs are inherently limited, so important to expand PHEV sales, from the increasing HEV market, so electricity can provide a growing fraction of transportation's energy.

7. The GHG emissions from the electricity supply system must be substantially reduced in parallel.

8. Which of these alternative energy sources is the most promising is, as yet, unclear, though fuel cells and hydrogen are moving up.

# Summary: Where Are We? – Continued

9. Policies will need to be implemented to prompt these changes on both the supply and demand side. e.g.,

   - More stringent GHG requirements beyond 2025
   - Increases in fuel/carbon taxes (for several reasons)
   - Joint efforts between government, auto industry and petroleum/energy industry to implement needed infrastructure changes
   - Actions that reduce the demand for private vehicular travel significantly