Transportation Energy and Emissions: Reduction Opportunities and Policies Required to Implement Them

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Topics:

1. Implementing near-term fuel economy requirements
2. An “Action Plan for Cars”
3. Electrification of vehicles
4. Challenges inherent in 2050 GHG targets

An Important Requirement

Essential that targets and implementation policies are based on quantitative and robust analysis of the opportunties and their potential impacts.

Boston Consulting Group's EV Global Market Projections for 2020

	2020 Sales Millions[1]	2010 Sales Millions[2]	Annual Sales Growth[3], %
Hybrid	11	1	27
Plug-In HEV	1.5	0.1	31
Electric	1.5	0.1	31

[1]Values from Boston Consulting Group's Report: "The comeback of the Electric Car?" 2008. Total 2020 global sales volume 54 million.
[2]Assumed plausible 2010 sales volumes.
[3]Compounded annual sales volume growth required. Historical value for major technology change: about 10%.

Average Fuel Economy of New U.S. Light-Duty Vehicles

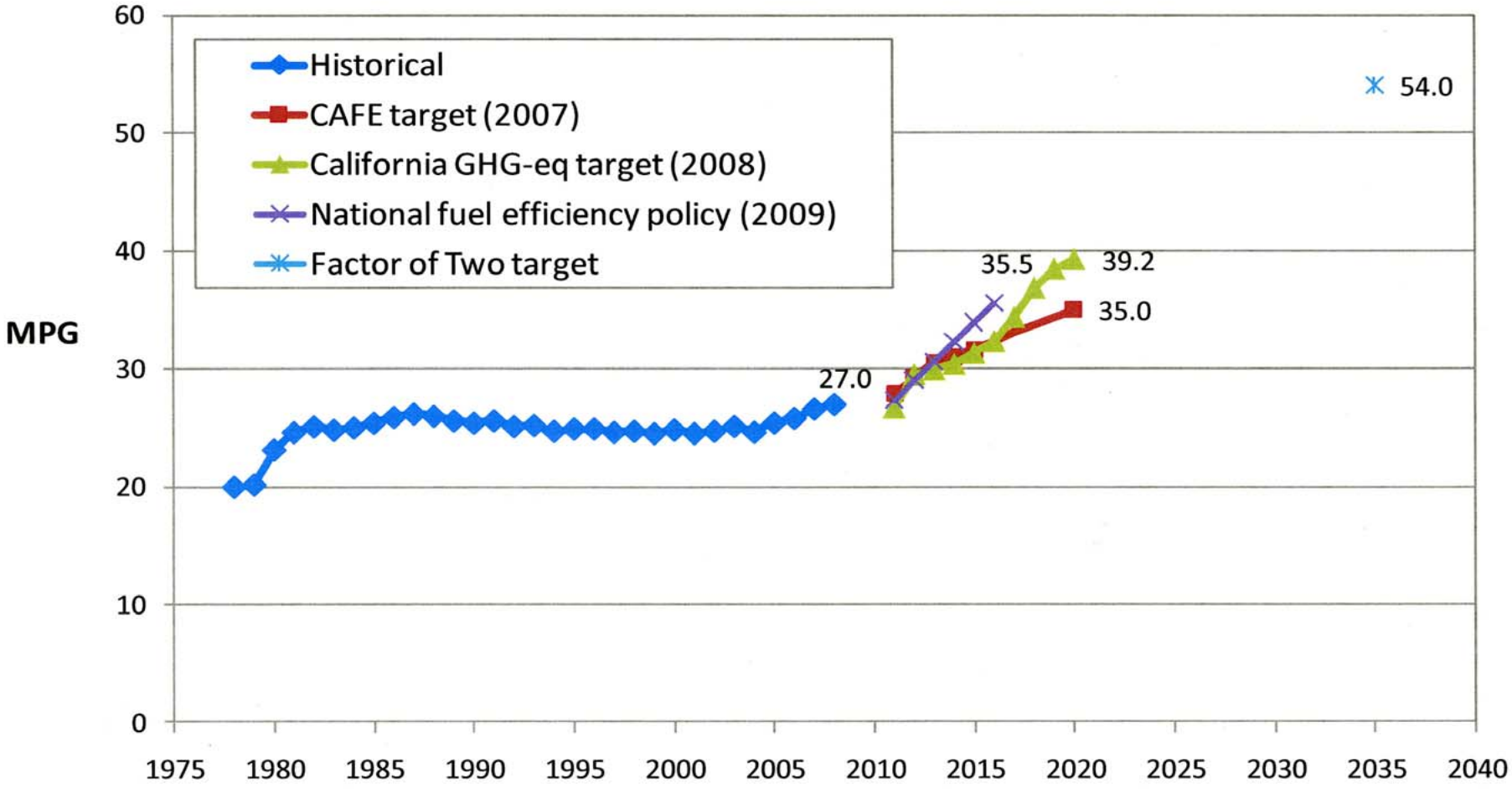


Chart shows unadjusted fuel economy values from NHTSA.

Methodology for Determining LDV Sales Mix Needed to Meet Various CAFE

We have estimated, versus model year:

1. Efficiency of future powertrain options (naturally-aspirated gasoline, turbo DI gasoline, low-emissions diesel, hybrid, PHEV, BEV, fuel cell).

2. Average vehicle weight reduction (materials substitution, redesign, size shift).

3. Increase in vehicle performance (power/weight ratio, 0 to 60 mph time): Emphasis on Reducing Fuel Consumption, % ERFC.

4. Sales mix characteristics required to meet average miles per gallon target.

Vehicle scenarios

Scenario	% ERFC	Avg. new vehicle weight (kg)	% light trucks (vs. cars)	% Market share by powertrains					
				NA SI	Turbo SI	Diesel	HEV	PHEV	Total adv. powertrain
2008	-	1,870	48%	90.9%	4.6%	1.7%	2.8%	0.0%	9.1%
2015 Federal CAFE target = 31.6 MPG									
-Lightweight	75%	1,514	40%	73%	13%	4%	9%	0%	27%
-Downsize	75%	1,502	30%	82%	9%	3%	6%	0%	18%
- Adv. Powertrain	75%	1,554	40%	67%	16%	5%	10%	1%	33%
- Combination	75%	1,528	35%	73%	13%	4%	8%	0%	27%
2016 National Fuel Efficiency Policy target = 35.5 MPG									
-Lightweight	75%	1,480	40%	26%	37%	12%	23%	1%	74%
-Downsize	75%	1,530	30%	26%	37%	12%	23%	1%	74%
- Adv. Powertrain	75%	1,580	40%	14%	43%	14%	27%	1%	86%
- Combination	75%	1,520	35%	26%	37%	12%	24%	1%	75%

Average new vehicle weight reported includes effect of downsizing/shift towards cars

2020 Scenarios that will meet CAFE 35 MPG target

	% ERFC	% Veh. weight reduction	% Market share by powertrains				
			NA SI	Turbo SI	Diesel	Hybrid	Total adv. powertrains
2020 limit	100%	17%	-	-	-	-	50.0%
Adjust ERFC, weight, adv. Powertrains	99%	16%	51.5%	24.3%	7.8%	16.5%	48.5%
Low ERFC	75%	17%	42.9%	28.5%	9.1%	19.4%	57.1%
Lower ERFC	50%	17%	32.4%	33.8%	10.8%	23.0%	67.6%
Improve avg. powertrain efficiency by +10%	75%	17%	75.9%	12.1%	3.9%	8.2%	24.1%

Assumptions:
- Market share of light trucks (vs. cars) = 50% in all scenarios
- Ratio of Turbo SI : Diesel : Hybrid is fixed at 3 : 1 : 2
- 17% avg. light-duty vehicle weight reduction = -320 kg = -710 lb

An Action Plan for Cars

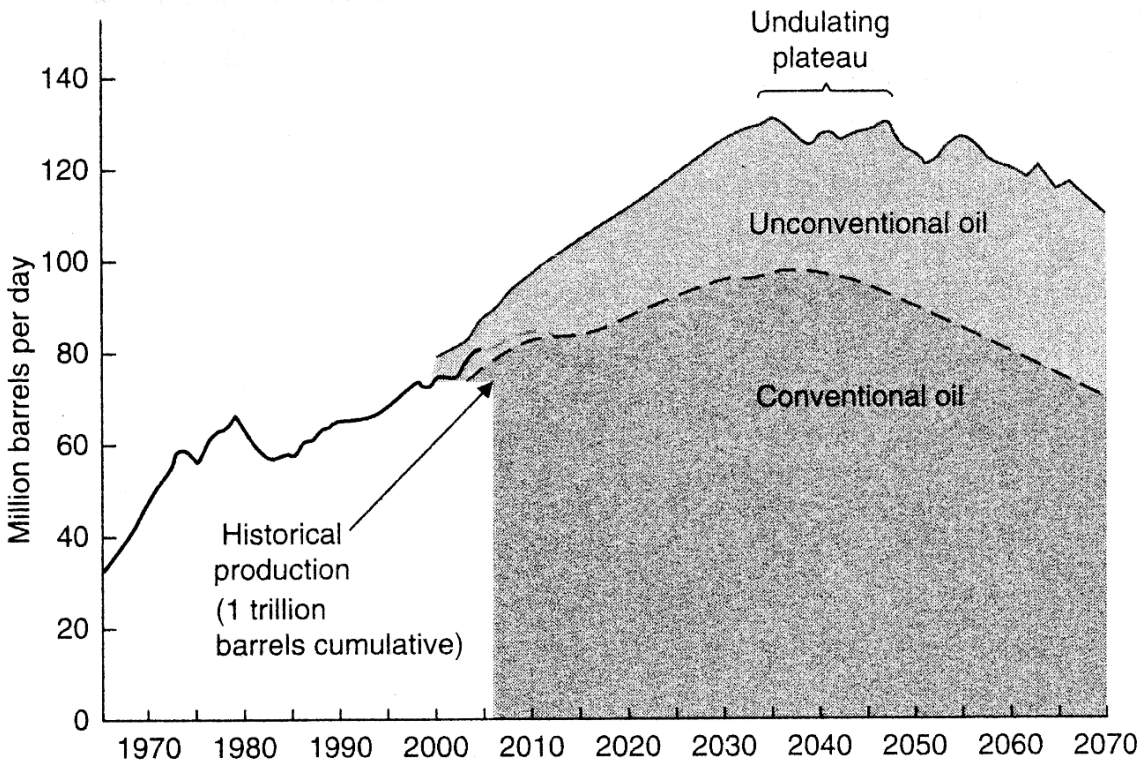
1. John Heywood, with team of 12 colleagues and students, has developed this "Action Plan": The set of policies needed to reduce U.S. LDV petroleum consumption and GHG emissions.

2. This set (for vehicles) comprises:
   a. Specifying fuel economy targets for CAFE beyond 2020
   b. Increasing fuel taxes by 10¢/gallon each year for at least 10 years
   c. Implementing a fuel-consumption-based "feebate incentive system" at time of vehicle purchase
   d. Establish driver education programs focused on "high fuel economy driving" behavior
   e. Improve the fuel consumption labeling provisions on new (and used) vehicles

An Action Plan for Cars - Continued

3. Recommendations related to fuels are:
   a. Develop the knowledge base and analysis procedures for full life-cycle GHG accounting for fuels
   b. Develop a robust U.S. national strategy in the transportation fuels area
   c. Based on that strategy, identify the incentives and policies needed to increase the supply and effective use of the more promising fuels

Oil Supply Scenario



Source: Cambridge Energy Research Associates, 60907-9, Press Release, November 14, 2006 (graph adapted by Sperling, D., and Gordon, D., Two Billion Cars, 2009).

Optimistic/Pessimistic Assessments

Concept of **degrading factors** useful in assessing impact potential:

1. Deployment of new “better” technology is limited (unlikely to be 100%).

2. Operating conditions where benefits are real are “duty cycle” constrained.

3. Overlapping benefits with already developing alternative approaches must be discounted.

Example: HCCI combustion engines: Doesn’t work at higher loads, when engine is cold. Benefit degraded by 0.8 x 0.8 = 0.64!

HEV, PHEV, BEV Deployment Issues

1. Need for “prototype production” phase, with volumes in tens of thousands, which lasts 5-10 years.

2. Initial costs of these vehicles are significantly higher (e.g. currently HEV ~ $5,000, PHEV (30 mile range) ~ $10,000, BEV ~ $15,000 depending on range).

3. Long-term projections suggest these price differentials may reduce by factor of 2.

4. Impact of BEV range limitation on vehicles’ attractiveness is major uncertainty.

HEV, PHEV, BEV Deployment Issues – Cont.

5. Many pragmatic issues:
   - Availability of recharging locations
   - Recharging power requirements for “fast recharge”
   - Cumulative impact on electricity grid over time
   - Battery performance, weight, and cost issues
   - Near-term: we need to slow down and develop the technology

6. Electricity as viable longer-term energy option?
   - Systems analysis of an evolving transportation electricity supply option needed
   - GHG emissions of future electric grid, and of electricity used in transportation, a major question

What will it take to reduce GHG Emissions 75%

1. Will require significant reduction in impacts in 5 to 10 separate independent areas: e.g., vehicle technology, alternative fuels, vehicle usage, etc.

2. Note that:

$$0.8 \times 0.8 \times 0.8 \times 0.8 \times 0.8 \times 0.8 = 0.26$$

3. Six independent factors each achieving a 20% reduction yield at 75% reduction.

Achieving a 70 - 80% Reduction in Transportation's GHG Emissions by 2050

Meeting these 2050 GHG emission targets will need:

- Major improvements in powertrain and vehicle efficiency
- Major vehicle size and weight reduction
- Stronger emphasis on fuel consumption reduction over performance and other attributes
- Substantial build-up of alternative green (low CO_2) sources of transportation energy
- Reductions in mobility impacts through mode shifts and conservation
- Extensive management of transportation infrastructure and its several modes
- Changes in urban land-use patterns
- And other "transforming" changes

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