Greenhouse Gases and Light-duty Vehicles

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Many technology options available to reduce Light Duty vehicle GHGs

- Tendency is to focus on the “big hitters”
  - Hybrids (and PHEVs) like the Prius, “2-Mode”, and the Volt
  - Advanced Clean Diesels
- However, there are many “small hitters” that remain available to the fleet to reduce vehicle GHGs at very affordable costs
  - Better **engines** (for efficiency, not just improved performance)
  - Advanced **transmissions**
  - Improved **vehicle and accessories**

Care must be taken when combining these technologies, so appropriate benefits are predicted

Vehicle Technologies available to reduce GHGs from Light Duty

- Engines
  - Reduced Engine Friction & Improved Lubricants
  - Variable valve timing and lift
  - Cylinder deactivation
  - Gasoline direct injection
  - Turbocharging with engine downsizing
  - Clean Diesels
- Transmissions
  - 6-speed automatic
  - Automated manual
- Hybrids (“mild”, “medium” and “full” – electric, plug-ins and series hydraulic)
- Vehicle and Accessories
  - Reduced aerodynamic vehicle drag, through design
  - Improved low rolling resistance tires
  - Weight reduction
  - Halting or rolling back the “performance race”
  - Improved alternators, electrical & A/C systems and other accessories
  - Electric power steering

LD Technologies Entering Fleet

	1998	2008
Multi-valve engine	40%	77%
Variable valve timing	negligible	58%
Cylinder deactivation	0%	7%
Turbocharging	1.4%	2.5%
Manual transmission	13%	7%
Continuously variable trans	0%	8%
Hybrid	0	2.5%
Diesel	0.1%	0.1%

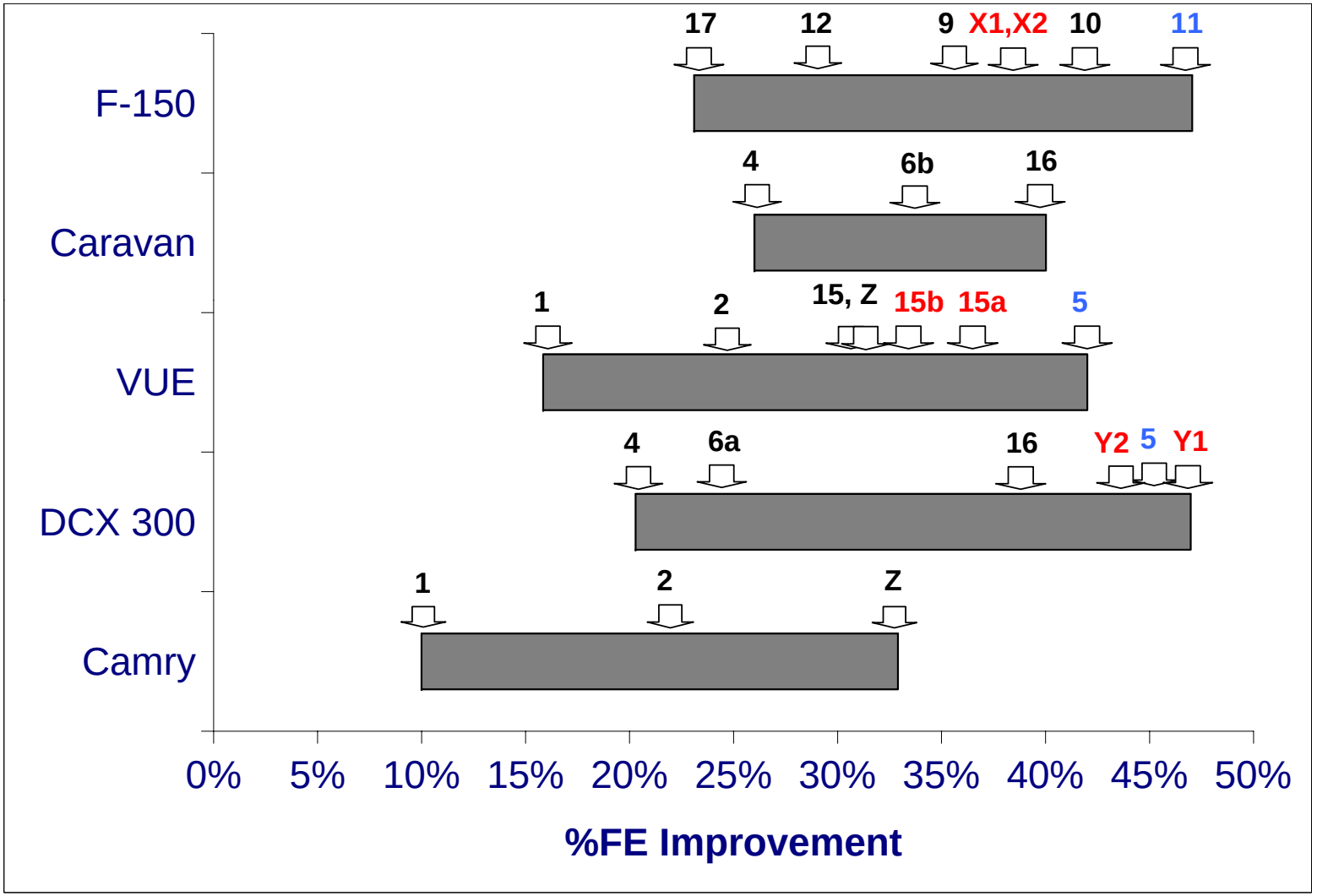
Using Vehicle Simulation to predict the additive potential of these "small-hitters"

- Five vehicles selected for vehicle simulation were chosen to be representative for a class and were anticipated to see no significant technology package changes before MY2010
  - Toyota Camry - Standard Car
  - Chrysler 300 - Full Size Car
  - Saturn Vue - Small Multi-Purpose Vehicle
  - Dodge Grand Caravan - Large Multi-Purpose Vehicle
  - Ford F-150 - Large Pickup Truck

- Twenty six technology packages
  - Representative of a range of options manufacturers might pursue to reach ~25% CO2 reduction.
  - Applied the same package to different classes, where vehicle attributes might affect benefits (e.g., power-to-weight ratio)
  - 28 different vehicle technologies considered
  - Conventional gasoline/diesel vehicles; **no HEVs**

- Evaluated to achieve equivalent drivability performance
  - 0-60 mph, launch, passing and gradeability performance

Summary of Results from Vehicle Simulation



Summary of Results from Vehicle Simulation Report

- Significant GHG reductions and vehicle efficiency improvements are available without depending on hybrid technologies
- Performance and vehicle attributes (size, weight, utility) can be preserved using these technologies
- Technologies are proven and available in current production
  - (with exception of HCCI and camless)

- Technology packages delivered 11-47% GHG reductions
  (depended on vehicle class and technology compatibility)

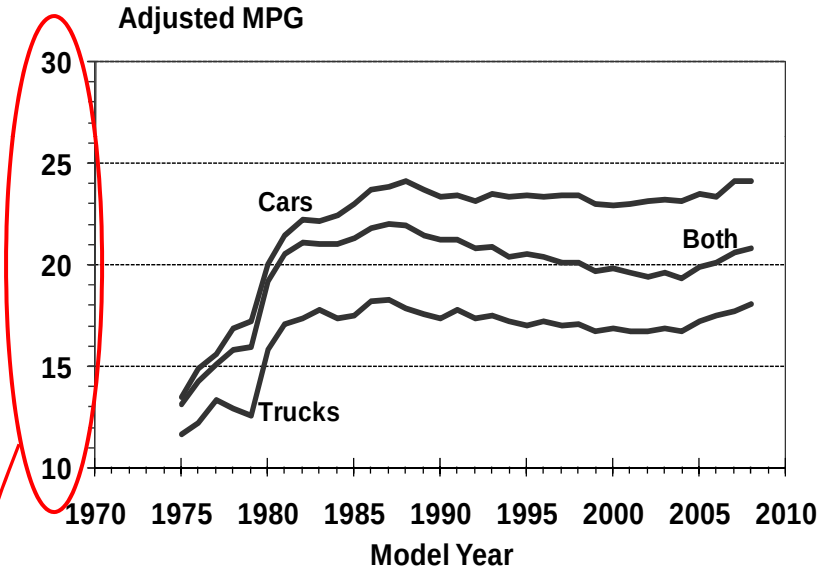
- Details & cost projections for technologies in the packages can be found in *Staff Technical Report: Cost and Efficiencies Estimates of Technologies Used to Reduce Light-duty Vehicle Carbon Dioxide Emissions* (EPA420-R-08-008, March 2008)

Low GHG Air-Conditioning

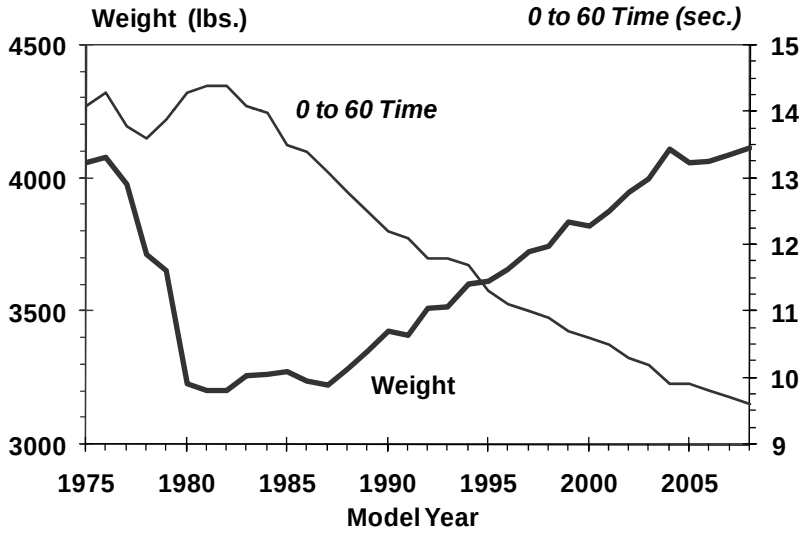
- Historically no incentive to reduce A/C HFC refrigerant leakage or A/C-related CO2
  - Thus, significant opportunities for cost effective reduction using available or near term technologies
- Leakage reduction: Tighter seals, less permeable and more durable materials/designs, electronic monitoring
- A/C-related CO2: Variable-displacement compressors, system layout and controls
- Overall, potential for about 5% CO2-equivalent reduction
  - About $110/veh ($70/veh for leakage reduction and $40/veh for A/C-related CO2)
- Longer term potential for reducing both leakage and CO2 with alternate refrigerants

Efficiency, Weight and Performance

Adjusted Fuel Economy by Model Year (Annual Data)



Weight and Performance (Annual Data)



"Adjusted MPG" is EPA's Window Sticker fuel economy that reflects "real world" driving conditions. Recall manufacturer's meet today's 27.5 mpg CAFE.

CAFE fuel economy is a "laboratory number" that is much higher than EPA's label – "CAFE of 35 mpg in 2020" will be 27-28 mpg "real world" economy.

Full-Series Hydraulic Hybrids Vehicles

- **Under development at EPA**
  - Similar to an Hybrid Electric Vehicle, but uses hydraulics
  - Extremely efficient power transmission, particularly well suited for pick-ups, SUVs and medium-duty trucks
  - 30-40 % CO_2 reduction for $800-1300

Series-Hydraulic Hybrid an a Ford Expedition

Projected Design Examples

Large 4WD SUV	*Medium Engine Package*	*Small Engine Package*
Diesel Engine	**3.8-liter** (170 kw)	**1.9-liter** (95 kw)
Accumulators	**15 gals**	**22 gals**
Weight Increase	**360 lbs** (163 kg)	**125 lbs** (57 kg)
	Fuel Economy – label values	*Fuel Economy – label values*
City	**32 mpg**	**33 mpg**
Highway	**22 mpg**	**23 mpg**
Combined	**27 mpg**	**28 mpg**
	Performance	*Performance*
0-to-60 mph acceleration (at test weight)	**8.9 seconds**	**11.4 seconds**
Max sustained speed (at GVWR)	**108 mph**	**90 mph**
Max sustained grade (at 70 mph at GVWR)	**9.1%**	**3.5%**
GVWR plus towing (at 65 mph at 3% grade)	**12,000 lbs**	**6,900 lbs**

Substantial vehicle GHG reductions remain untapped

- GHG reductions will be realized as just some of these “small hitter” technologies are applied to the LD fleet to meet EISA
- The known and proven “big hitter” technologies remain available for significant further GHG reductions
- A changing LD fleet mix (smaller-size, lower-weight, “just maintaining” performance) provides potential for much more GHG reduction
  - The market response to $4/gal fuel demonstrates the lack of resistance to these changes
- Beyond HEVs and Clean Diesels, other vehicle technologies are being aggressively explored and considered by OEMs -- for even greater petroleum consumption reductions and potential GHG reductions
  - Plug-In Hybrid Electric Vehicles (PHEVs)
  - Battery only Electric Vehicles
  - Series Hydraulic Hybrid Vehicles
  - Dedicated alternative-fuel vehicles (E85)