Clean Cities Ozone Air Quality Attainment and Maintenance Strategies that Employ Alternative-Fuel Vehicles, with Special Emphasis on Natural Gas and Propane

By

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Fuels and Air Quality

Emissions Benefits (Costs) Vary by Type of Fuel Switch: Trade-Offs Often Exist and Must Be Addressed

In table, "+" is better, "-" is worse.

Type of Fuel Switch	Ozone Precursors: Hydro-Carbons	Ozone Precursors: Nitrogen Oxides	Partic-lates	Carbon Dioxide	Vehicle Cost	Fuel Cost
Natural Gas for Gasoline	+++	++/-	+	+/-	-	+
Natural Gas for Diesel	+	++++	++++++	+/--	-	+/-
Electric for Gasoline	+++	+++	++	+++/-	---	+
LPG for Gasoline	++	-	+	+	-	+
LPG for Diesel	+	+++	+++++	+/-	-	+/-
E85 for Gasoline	+/-	+	+	++	neutral	--

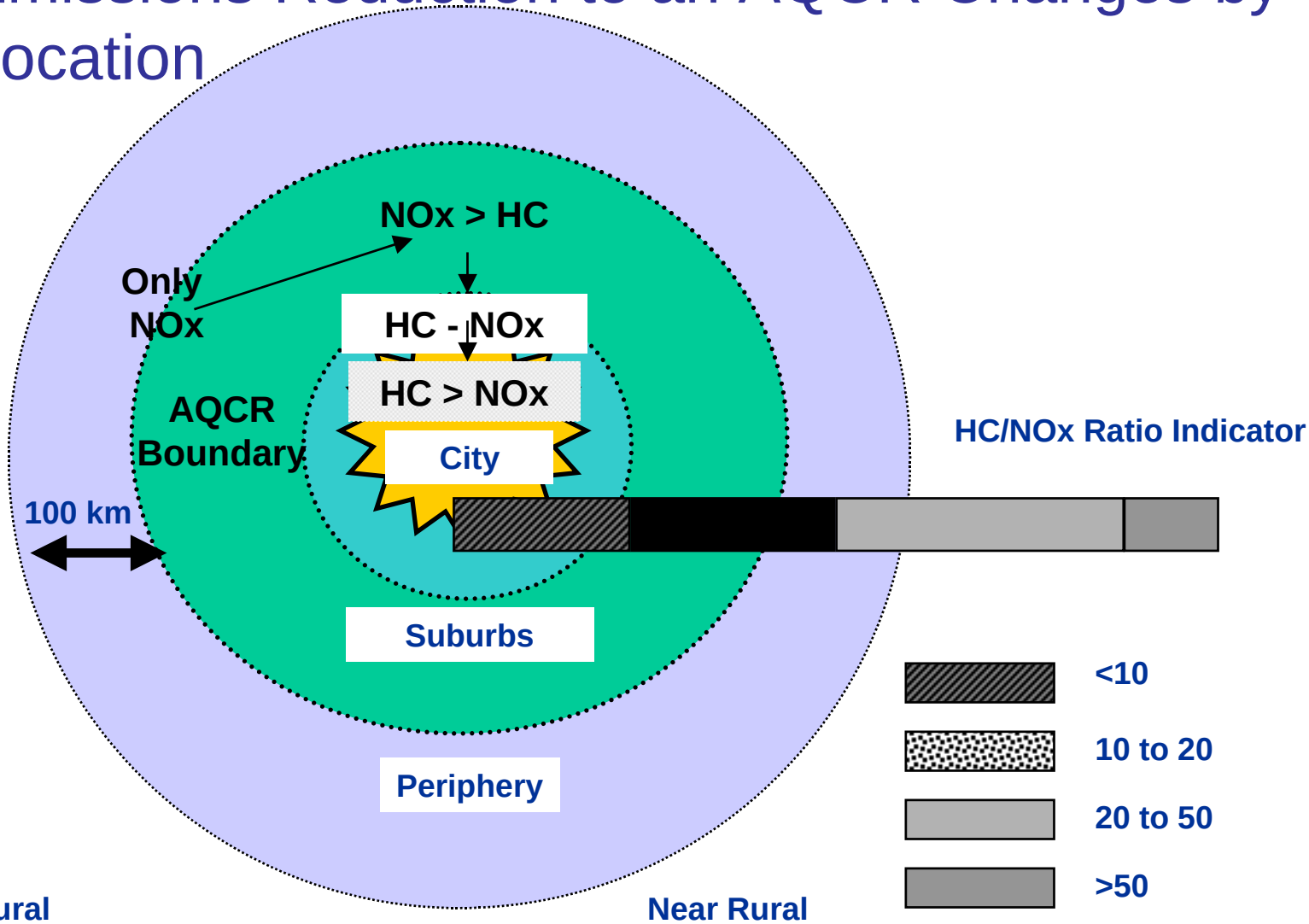
Ratings in table based primarily on the report GREET 1.0 - Transportation Fuel Cycles Model: Methodology and Use, by M. Q. Wang, Report ANL/ESD-33, Argonne National Laboratory (June 1996). Notes: For emissions comparisons, a plus means "better," indicating a reduction in emissions or cost. A minus has the opposite meaning. The number of pluses and minuses is related to the estimated percentage change and, where both pluses and minuses exist, to inconsistent data. A higher number of pluses or minuses indicates trend.

Clean Cities & Alternative Fuels Are in Their Infancy - Not a Large Market Yet

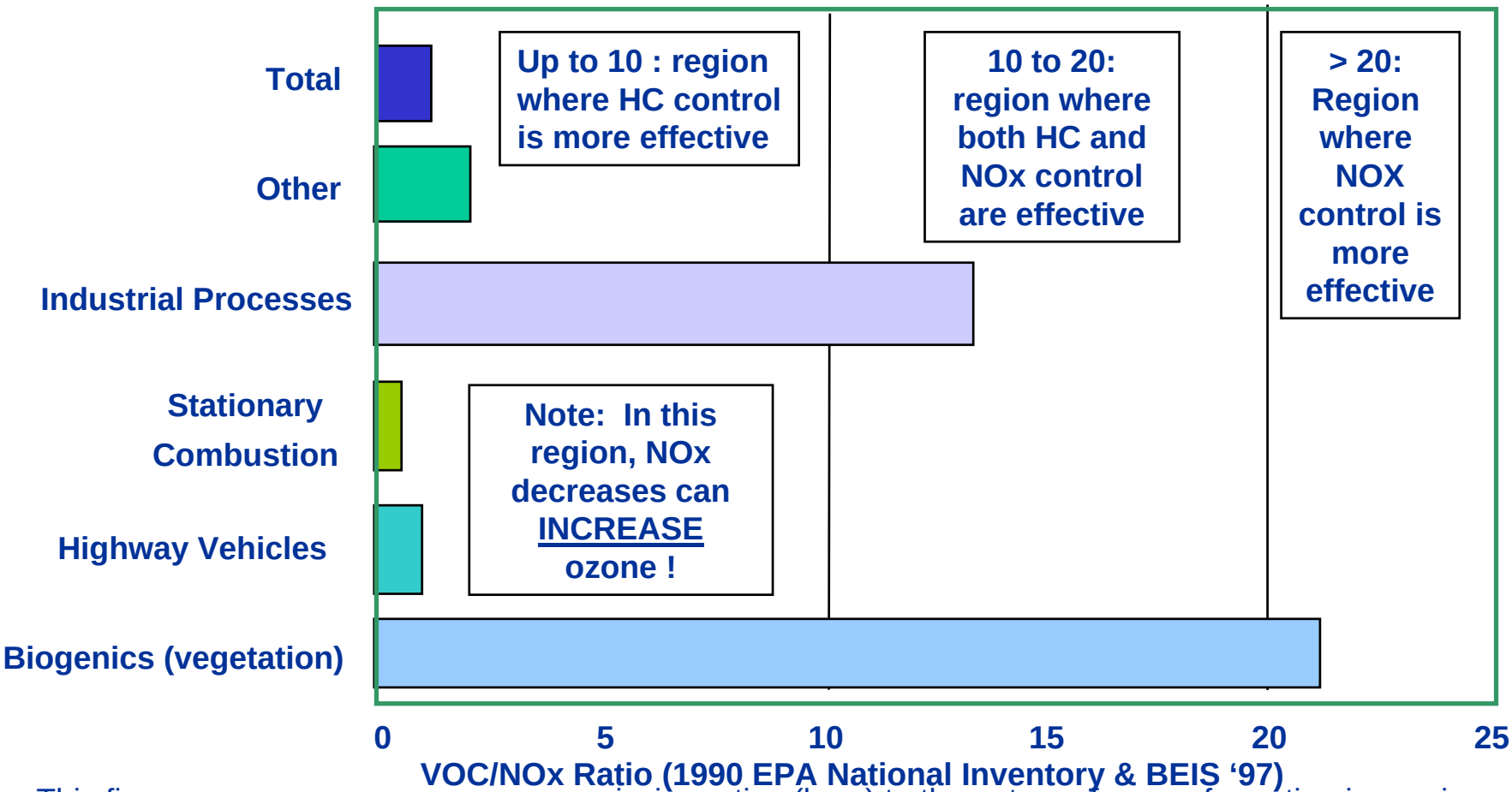
- EPA cannot spend same $ on clean fuels as on gasoline
- Yet regulations have to be met
- EPA tools now used for gasoline and diesel are far less accurate when applied to AFVs
- “Catch-22” can hinder AFV introduction
- Insistence on emissions performance being better than gasoline in all respects can hinder AFVs - air quality is the issue, not emissions

To Reduce Ozone, the "Real" Value of Emissions Reduction to an AQCR Changes by Location

Distant Rural: only CO_2 cuts have "value" to Clean Cities, but NOx cuts may be allowed in State OTAG SIPs

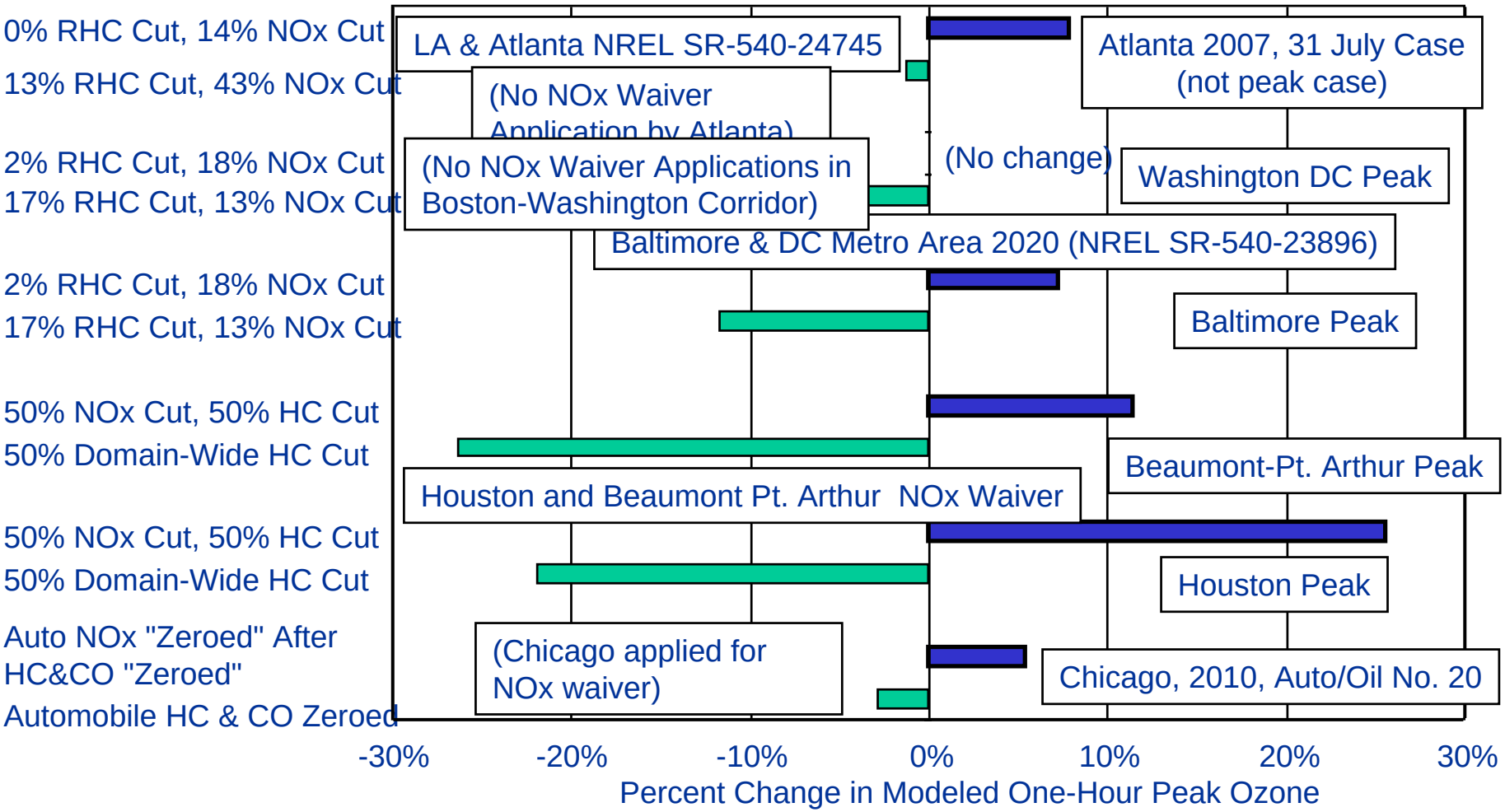


Ozone: HC (-VOC) cuts in core off a commercial or governmental metro area w/o industry should be best. In rural areas rich in vegetation, NOx cuts should be best.



This figure compares average source emission ratios (bars) to the nature of ozone formation in an air parcel with an ambient ratio of the same pollutants (grid lines and notes).

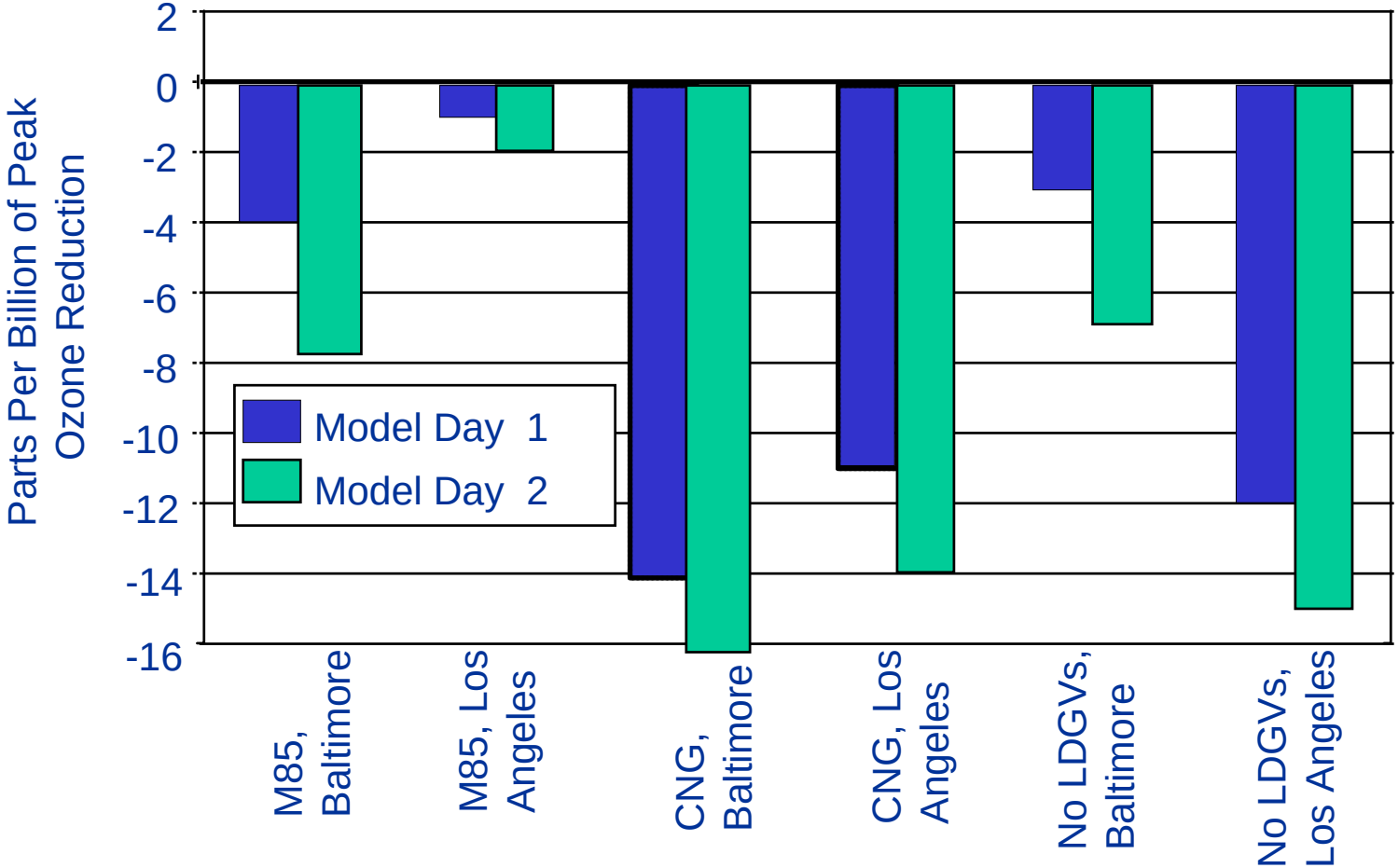
Reduction of NOx In Some Conditions and Locations Increases Peak Ozone: EPA Once Granted "NOx Waivers" to AQCRs Where this Condition is Modeled



Notes to Slide 6

- Note 1: Bottom bar in pair refers to “first cut,” always with more reactive hydrocarbon reductions than for the top bar. Relative to the bottom bar, the top bar shows effects of added cuts, with second round of cuts focusing more on NOx than reactive hydrocarbons. The ratio of NOx to reactive hydrocarbon reductions is always greater in the second set of emissions cuts, shown in the top bar.
- Note 2: Each of the studies cited includes examples of modeled emissions changes in which no ozone increase & NOx decrease combinations are shown, usually (not always) for a different metro area. On a percentage basis, peak ozone response to HC cuts is consistently greater than that for NOx cuts. NREL’st CNG simulations estimate much greater NOx emissions reductions than are estimated with the 1998 MY vehicles in this study.

According to a 1997 NREL study, CNG vehicles are about as good for peak ozone as no vehicles (EV?). Results show air quality effects of AFVs do differ.



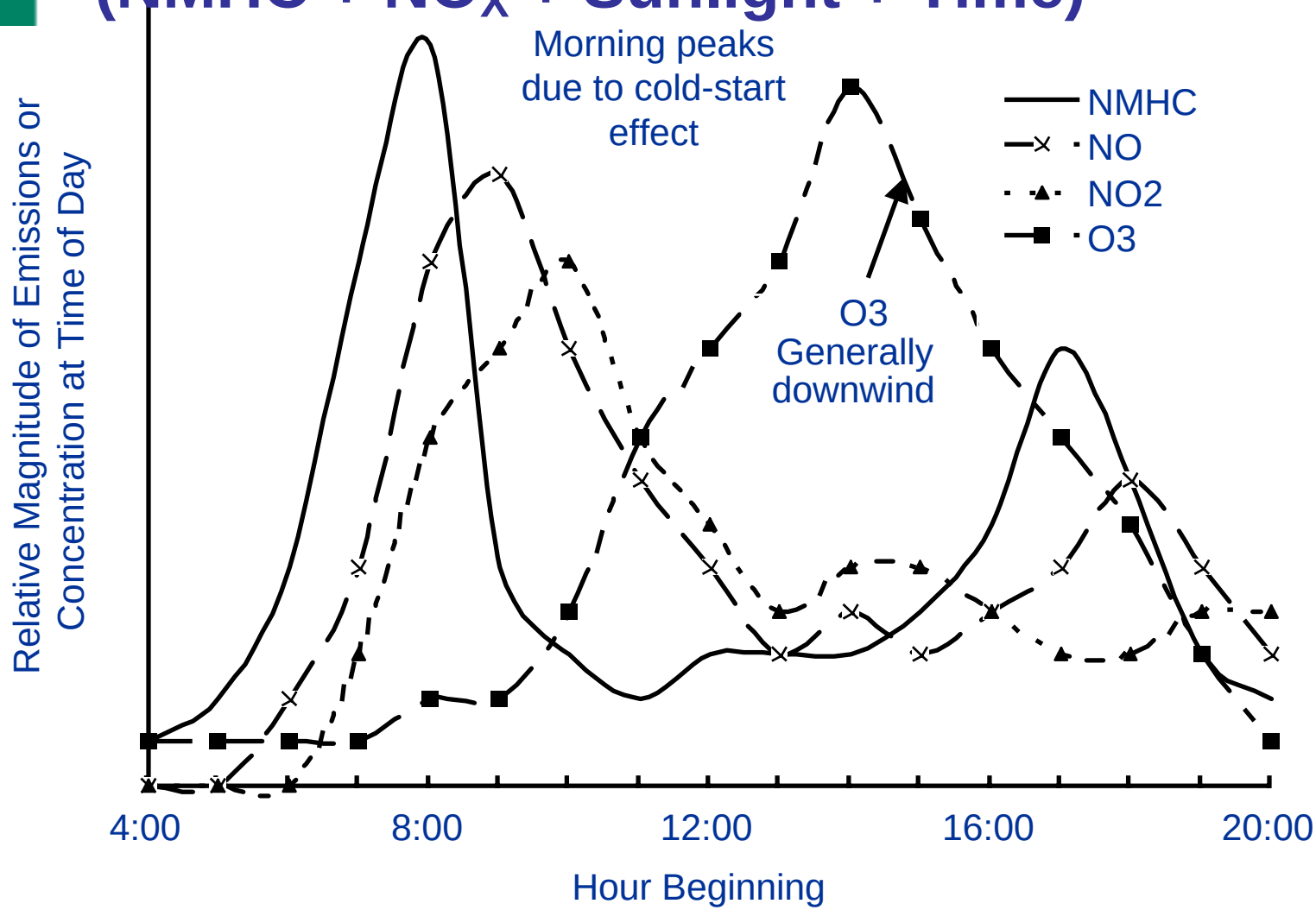
Reduction in Future Year (2020) Ozone By LDGV Replacement

Source: Guthrie et al. (1997), Air Quality Effects of Alternative Fuels: Final Report NREL/SR-540-23896

Some Key Details To Determine AFV-Caused Air Quality Changes

- Estimate amounts and locations of AFV and and replaced conventional vehicle fuel-cycle emissions
  - By county or grid squares occupied
  - By altitude (power plant emissions of EVs)
- Break out timing of AFV and replaced conventional vehicle fuel-cycle emissions
  - By hour, by day (weekend vs. weekday), by season, by year

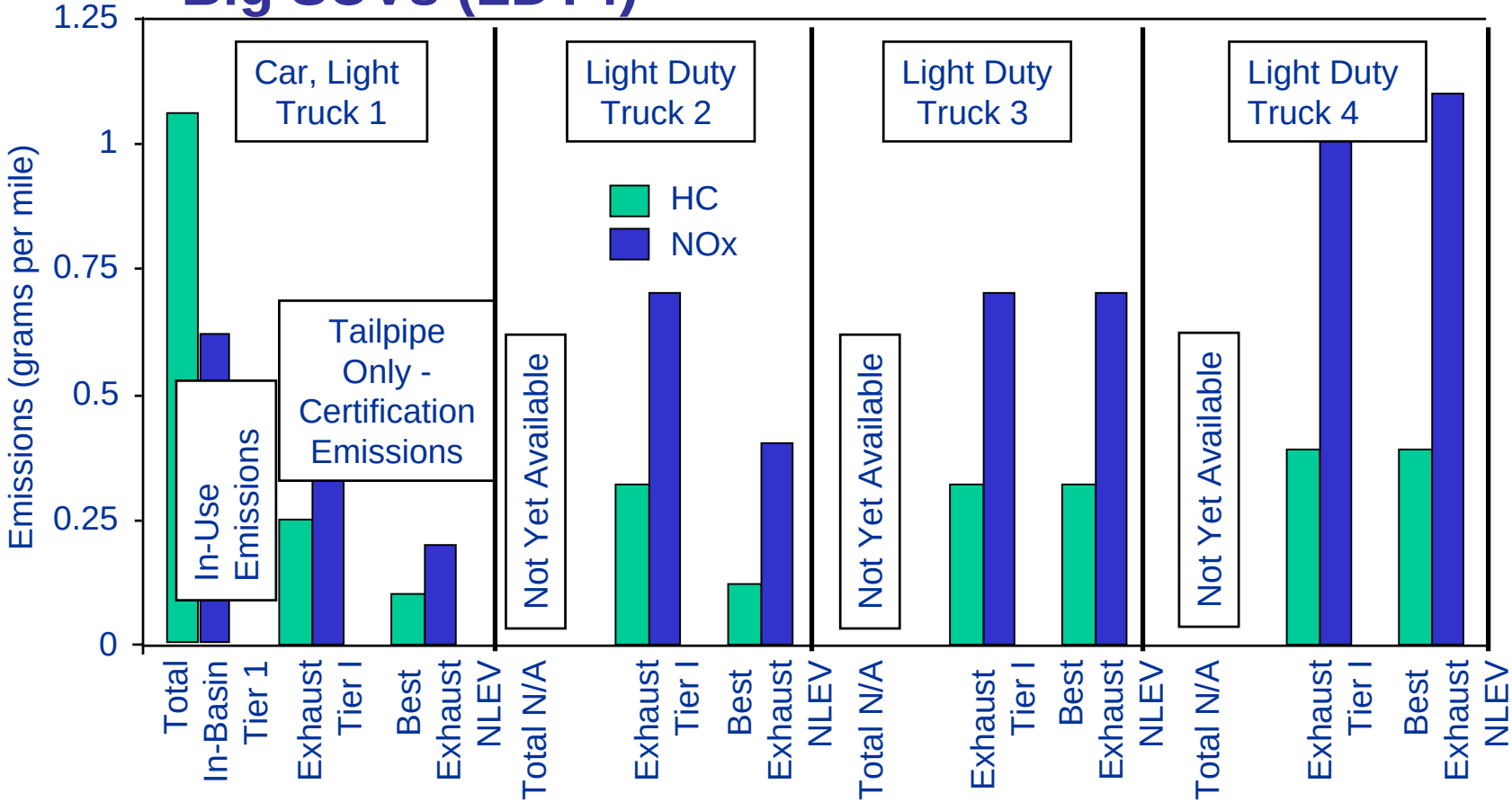
Classical Chronology of Ozone Formation: (NMHC + NO_X + Sunlight + Time)



Emissions Reductions Are Sometimes Needed In Areas Meeting Standards

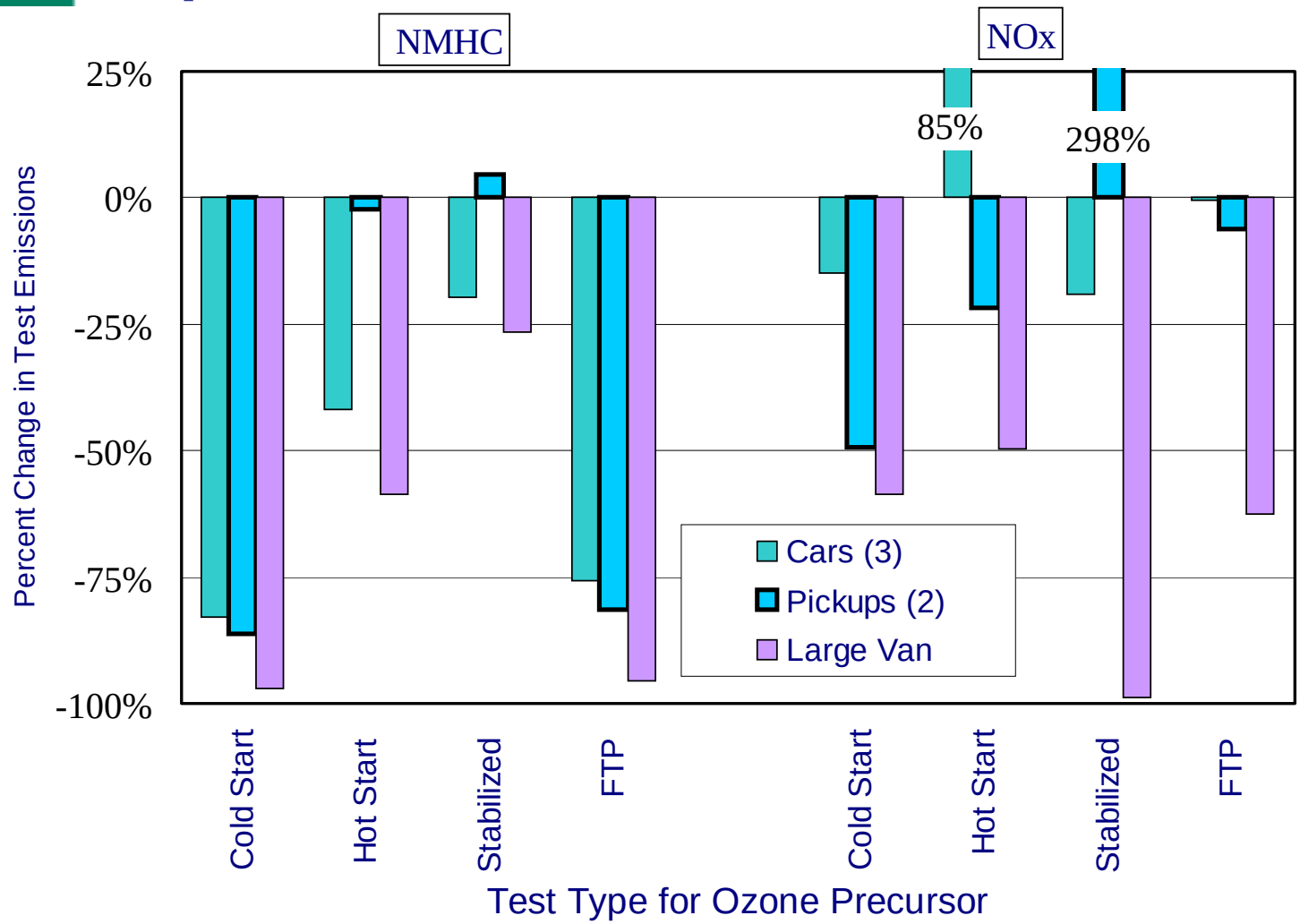
- “Conformity” for areas near air quality violations requires submissions to EPA concerning an emissions budget for the metro area
- When a metro area emissions budget is tight, major new construction projects may be required to “find” emissions cuts to offset construction-induced increases

Since Large Vehicles Are Allowed to Emit More, Fixed % Reductions = More Ton Cuts in Pickups & Big SUVs (LDT4)



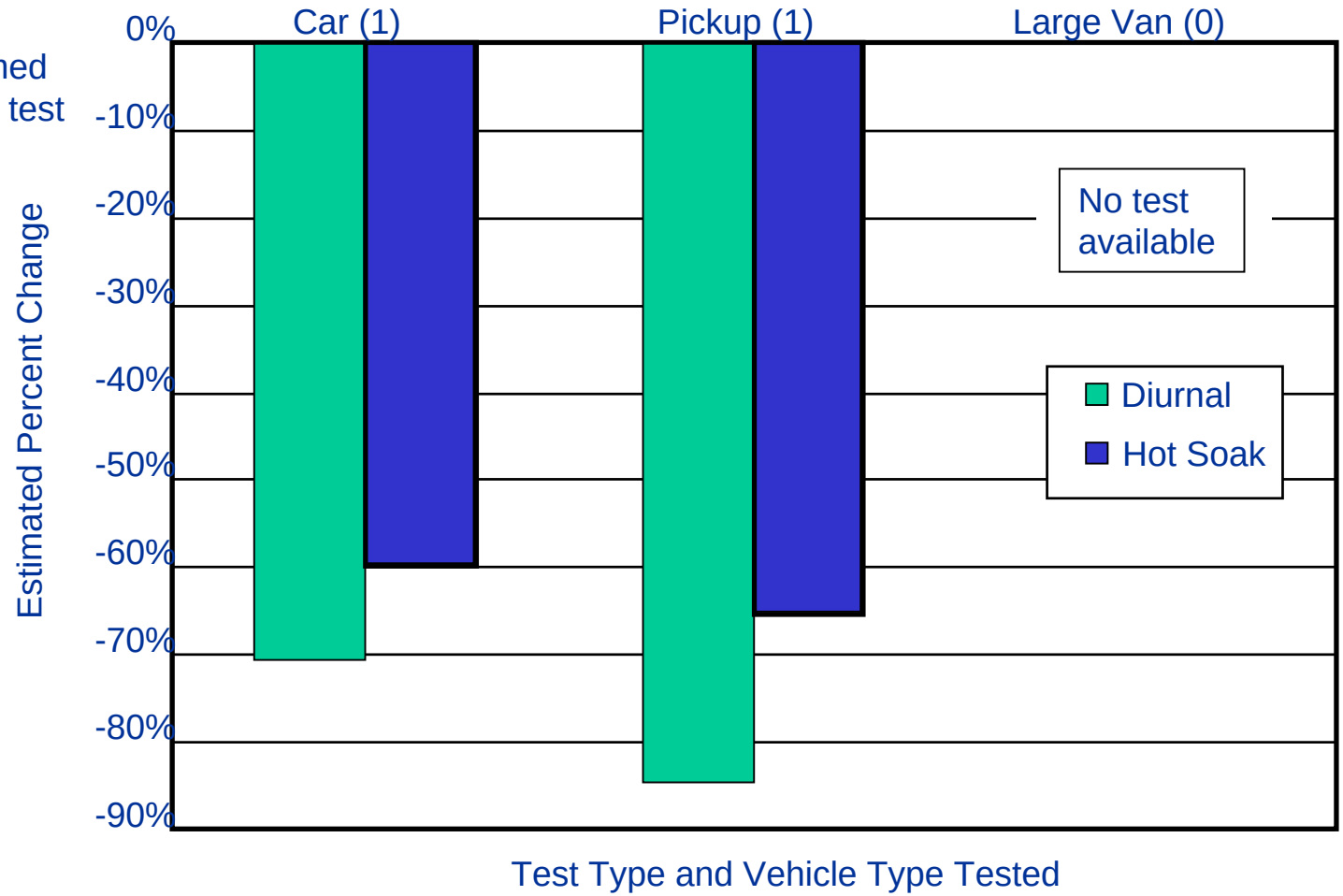
Notes: NLEV does not apply to LDT 3 & 4. Mobile 5a has only one category for LDT 3 & 4 (LDGT2), though separate tailpipe standards exist. "Not Yet Available" means these classes were not examined. No EVs are available in the LDT 3& 4 classes; CNG models are.

Percent Change in FTP Total and Bag-Specific Emissions, '98 CNG vs. Gasoline

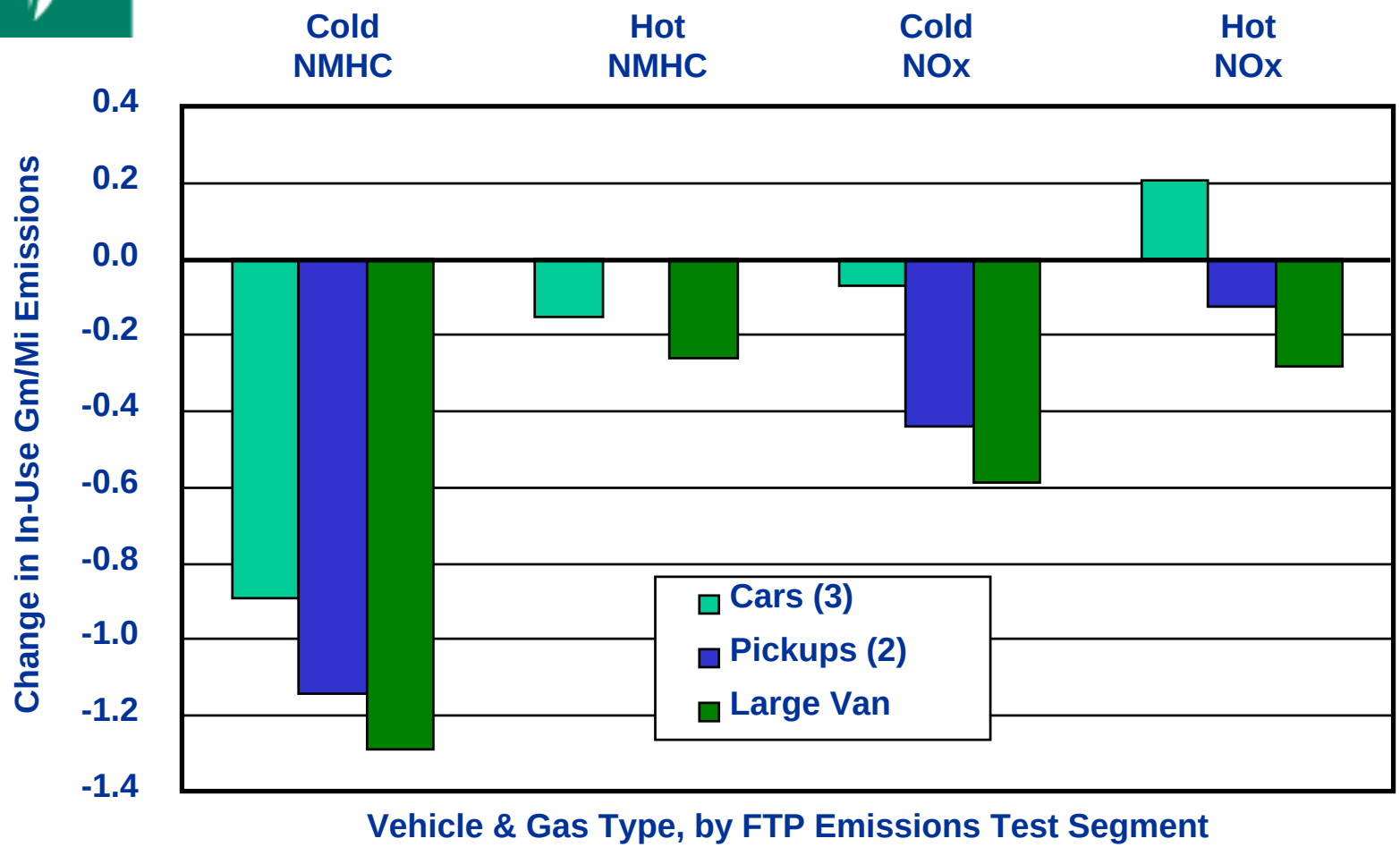


Estimated NMHC Percent Emissions Reductions Per Test, Diurnal & Hot Soak, CNG-for-Gasoline Switch

Note: It was assumed that 5% of reported test THC emissions for CNG were NMHC emissions.

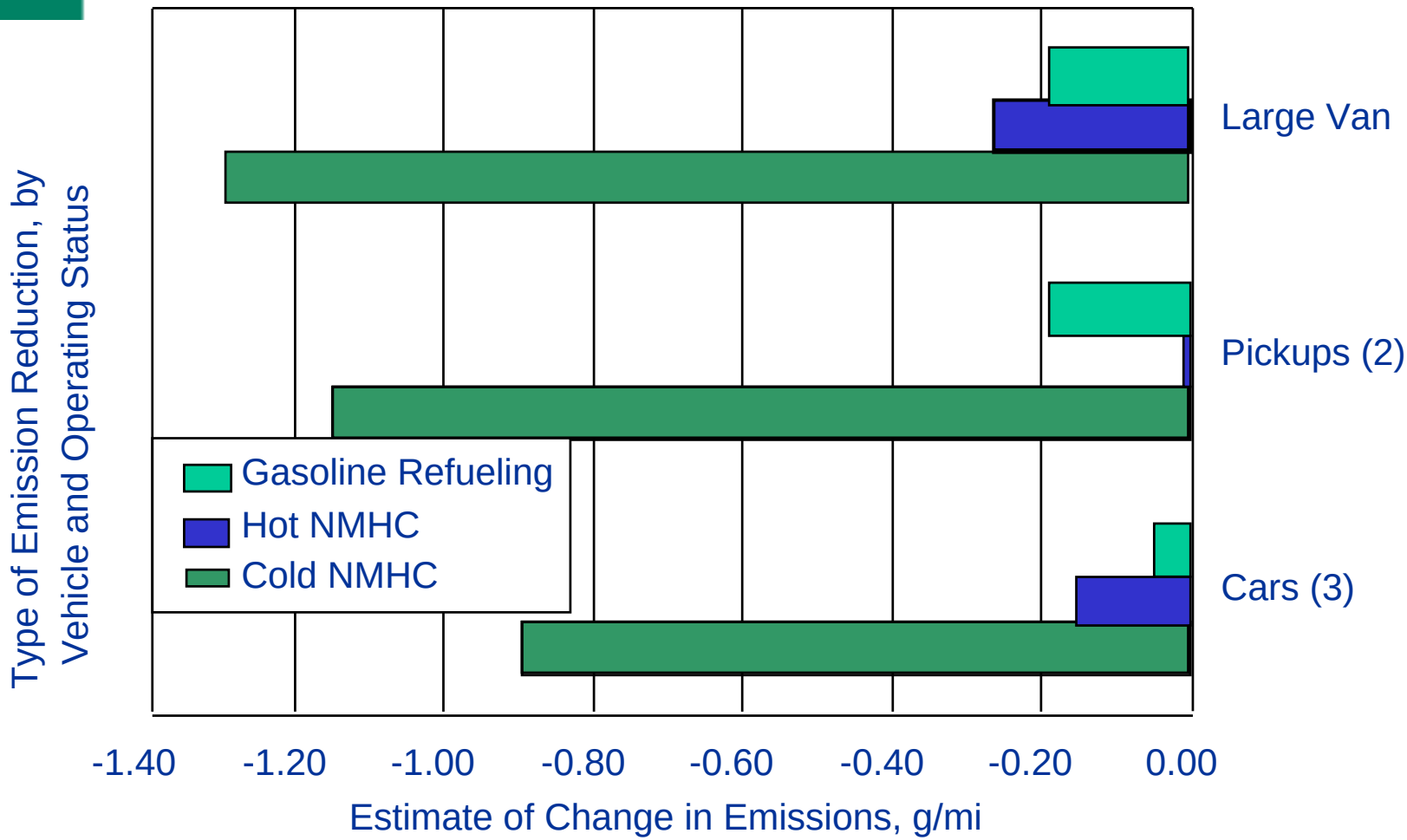


Estimated Mean Change in Per-Mile In-Use Tailpipe Emissions: CNG-for-Gasoline Switch



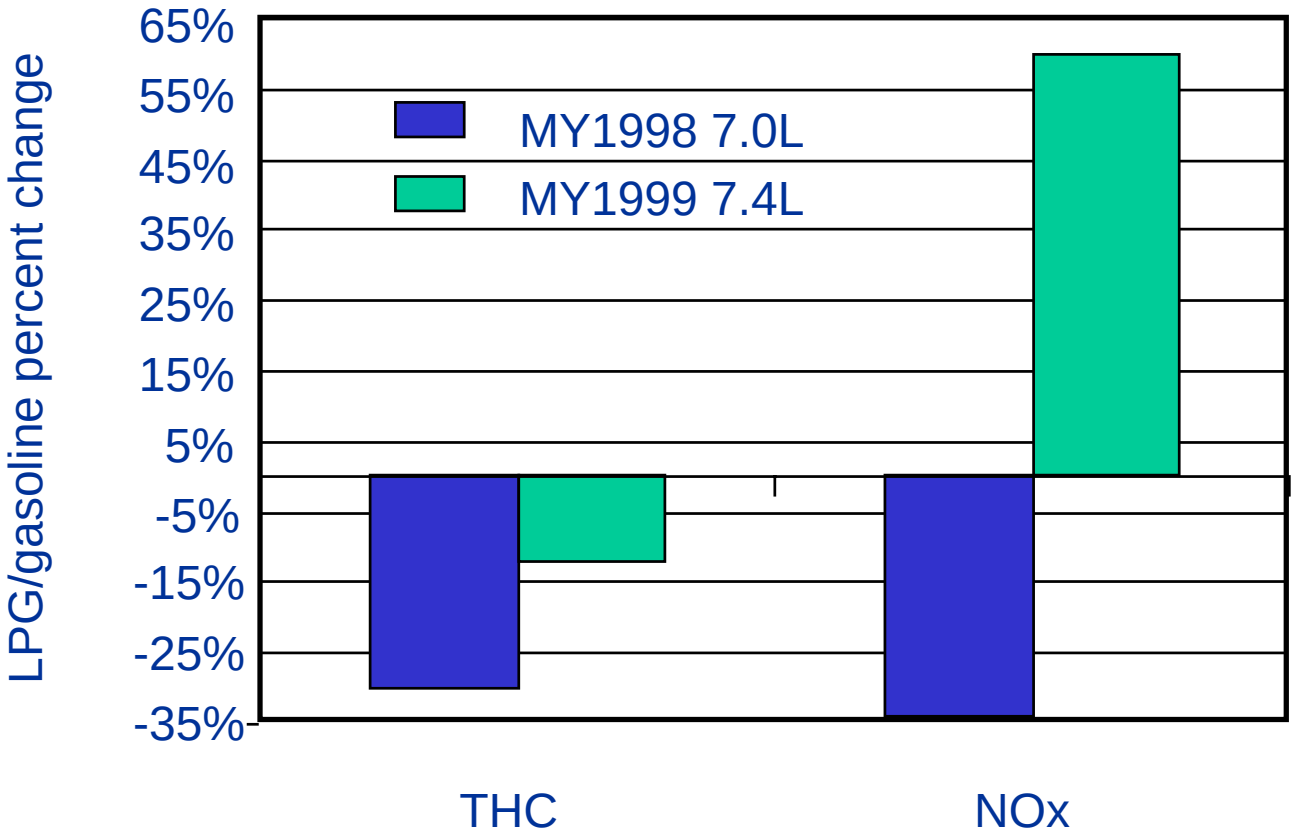
Note: Using Mobile 5a class-specific gasoline emissions estimates for an ozone event day in St. Louis, urban driving. Cold or hot start in Mobile 5a, as applicable. Includes exhaust, evap, running & resting emissions. 1999 MY. CNG totals = gasoline Mobile 5a results x % changes estimated for FTP bag1 (cold) or bag3 (hot).

Elimination of Gasoline Refueling NMHC Losses Should be Added to CNG Benefits



Note: Our Mobile 5a estimates of gasoline vehicle refueling losses did not vary with cold and hot start.

Ford LPG Medium Heavy Duty LPG vs. Gasoline Certification Results, 2 Model Years



EPA 50,000 Mi. Certification Emission Comparisons for LPG

Conclusions

- Need to address ozone is immediate
- Gaseous fuel and electric AFVs can help now
- NOx and HC both down for EVs
- CNG available, marketable
- NMHC cold-start and total down sharply for CNG
- Value of CNG NMHC reduction for O_3 varies:
  - Location
    - Rural [0] exurban [small], suburban[moderate], urban[high]
  - Ratio (urban NMHC/NOx < 5-6 means NMHC best)
  - Timing (high urban morning cold-start benefit)
- Method for SIP credit under VMEP proposed