EXPECTED IMPACTS OF ADVANCED COMBUSTION REGIMES AND ALTERNATE FUELS ON EMISSIONS CONTROLS

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Acknowledgement: Se Oh, Wei Li, Paul Najt

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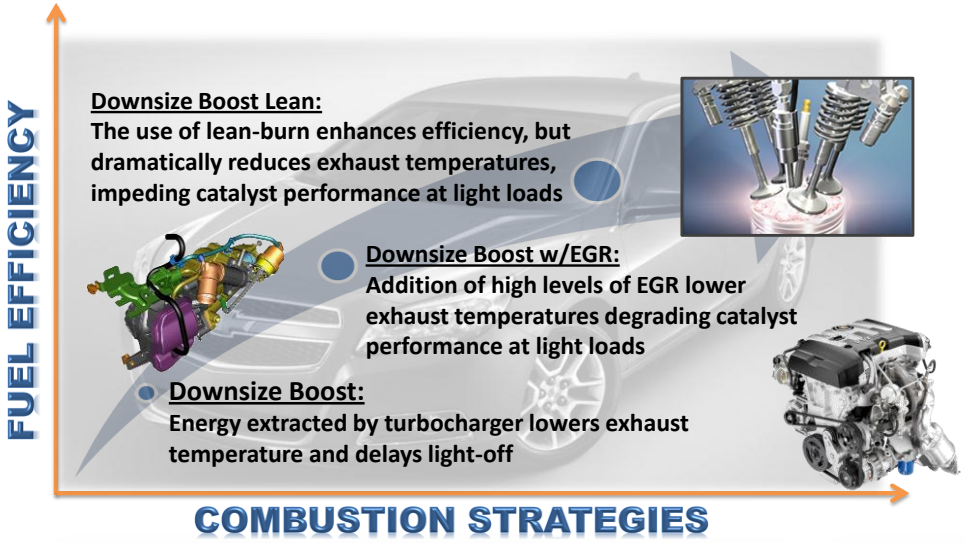
ADVANCED COMBUSTION AND FUELS USED IN US



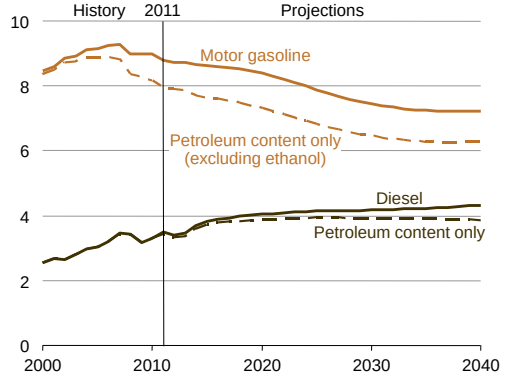

gasoline

diesel

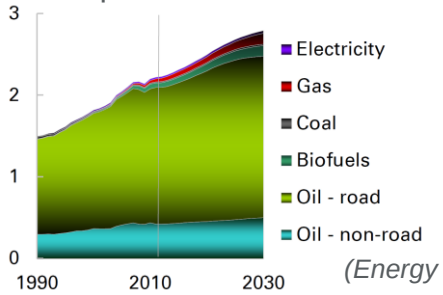
E85


Bi-fuel (CNG)

eia U.S. motor gasoline and diesel fuel consumption, 2000-2040 (MB/day)



bp Outlook on Global Energy Demand for Transportation

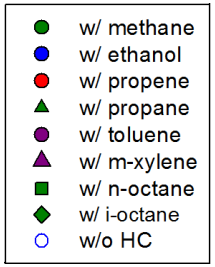


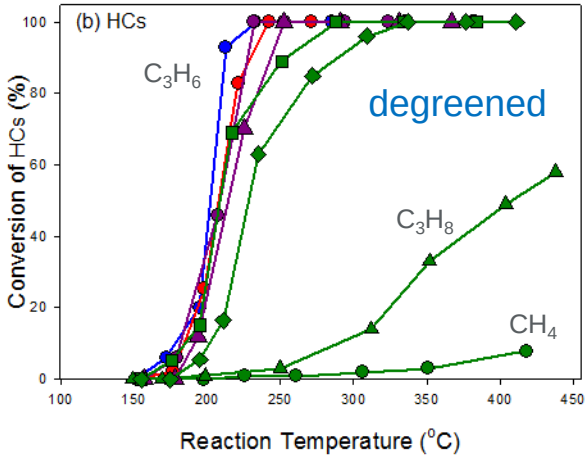
(Energy Outlook 2030)

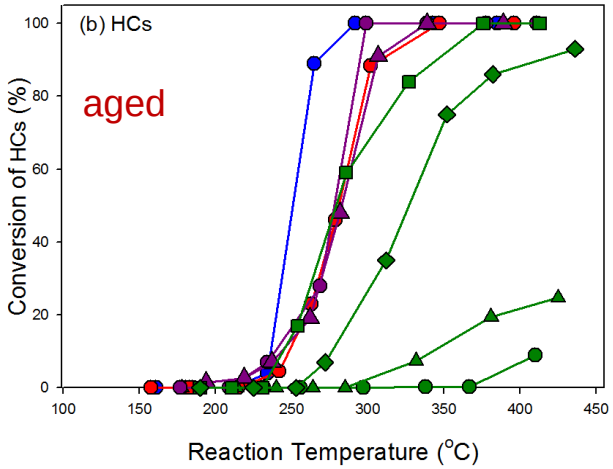
OXIDATION OF VARIOUS HC SPECIES OVER TWC

Reactor SV: 100,000 h^{-1}
Feed:
1% CO
0.3% H_2
500ppm NO
1% O_2
10% CO_2
10% H_2O
1500ppm CH_4
750 ppm C_2H_5OH
500 ppm C_3H_6
500 ppm C_3H_8
220 ppm C_7H_8
190 ppm m-C_8H_{10}
190 ppm n-C_8H_{18}
190 ppm i-C_8H_{18}
Balanced in Ar

Commercial TWC



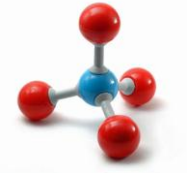


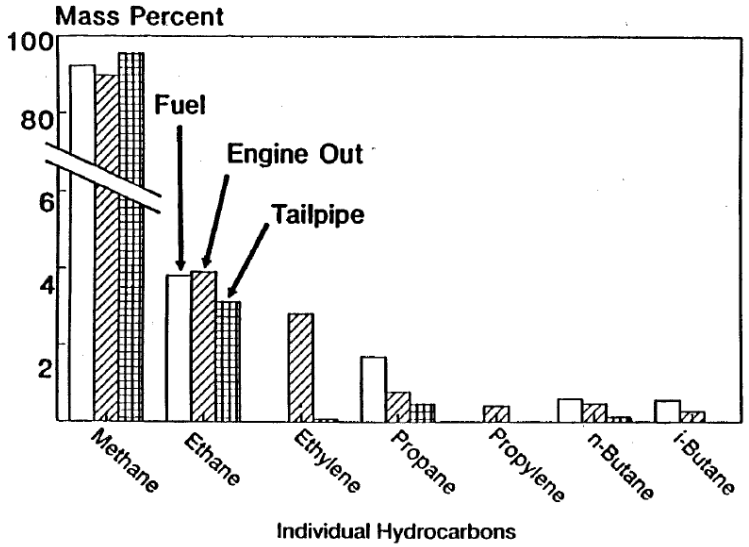


(I.S. Nam et al., Catalysis Today 2014)

METHANE EMISSION FROM CNG

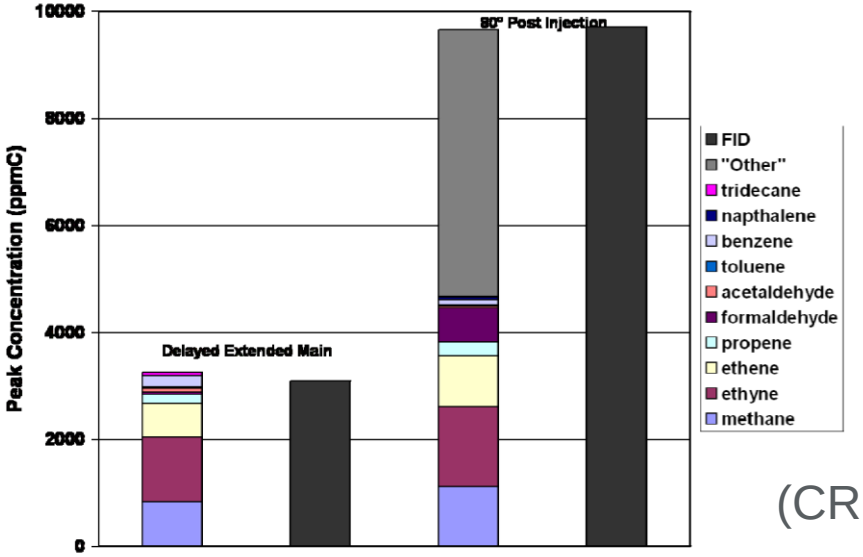
- Methane is typically 5% of the hydrocarbons emitted from gasoline engines but may be more than 20% in the tailpipe
- Methane is the most difficult hydrocarbon to oxidize
  - Methane's C-H bonds are extremely strong/stable
  - Methane is known for very weak adsorption on precious metal catalysts or zeolites





DIESEL ENGINE OUT HC SPECIES

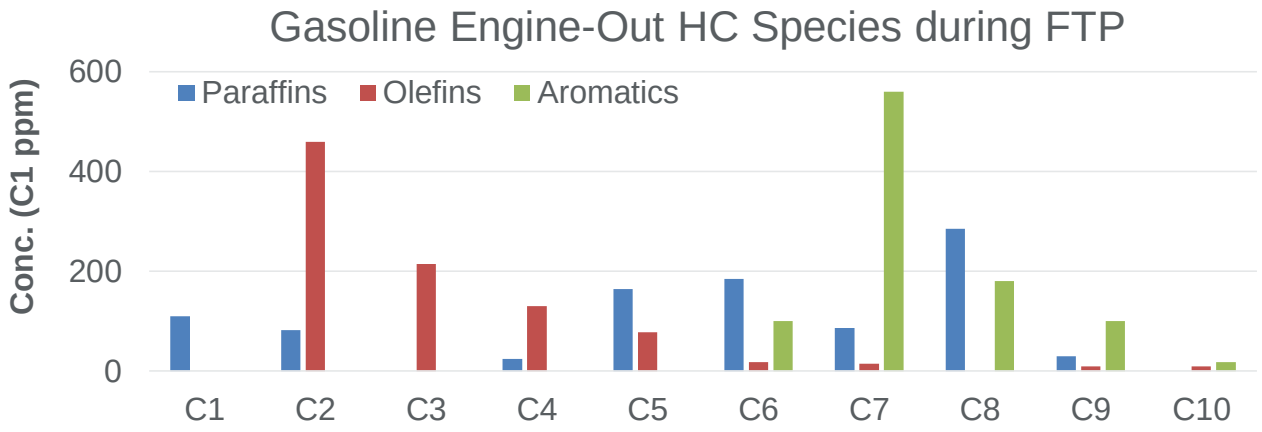
- Majority of HC from diesel engine is typically unburned heavy HCs resulted from delayed and/or post injections
- Propylene and Ethylene are major species among light HCs



(CRC Report AVFL-10b2, 2005)

CONVENTIONAL GASOLINE ENGINE OUT HC SPECIES

- Gasoline fueled engine generates more paraffins (saturated hydrocarbon) than that with diesel fuel

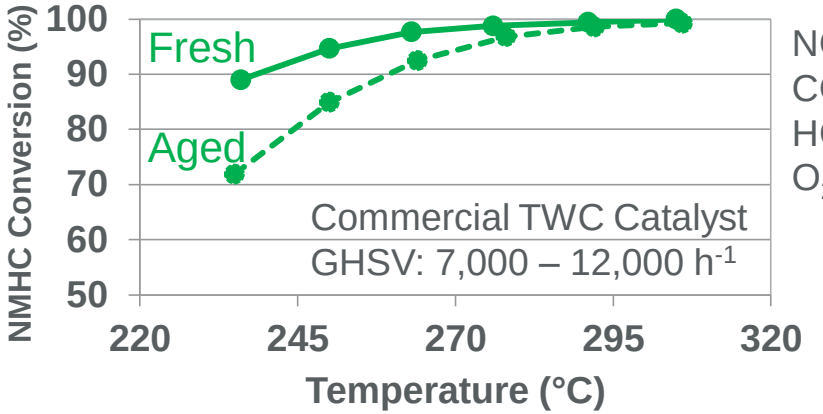


(Source: SAE Paper 2001-01-0660, Toyota)

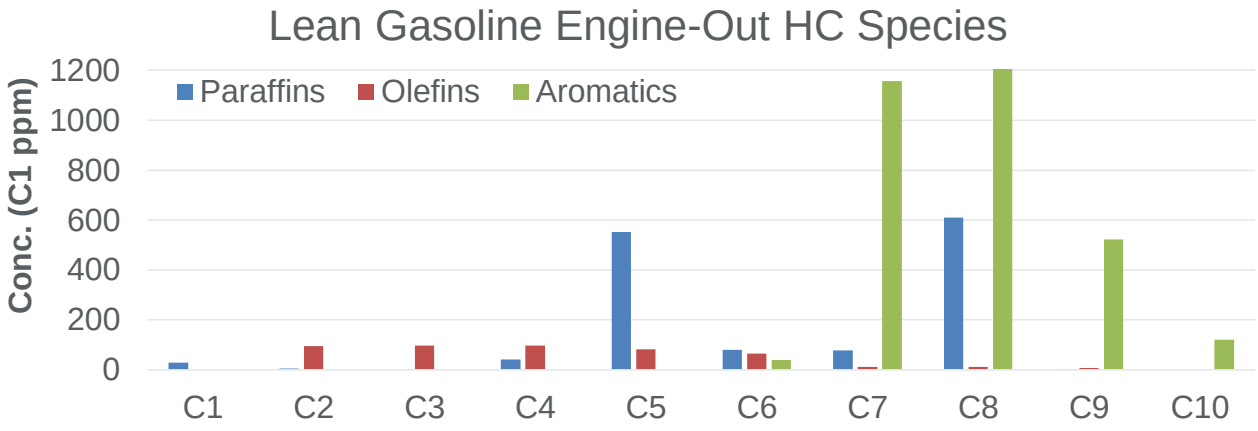
CHALLENGE ON LEAN GASOLINE AFTERTREATMENT

The use of lean-burn enhances efficiency, but dramatically reduces exhaust temperatures, impeding catalyst performance at light loads

Via GM Hydrocarbon Speciation Method (Loo, Olson, Mulawa, SAE 2000-01-2950)



NO: 100 ppm
CO: 1700 ppm
HC: 4500 ppm
O_2: 10 %



SUMMARY

1. Engine out hydrocarbon species are different depending on the types of fuels while the level of HC emission would be closely linked to the engine control
2. The oxidation performance over conventional gasoline three-way and/or diesel oxidation catalyst are different per types of HCs
3. Diesel engine emission includes a large fraction of unsaturated and heavy HCs, which is relatively more active than saturated and light HCs at low temperatures (< 300 °C)
4. For the case of gasoline engine, more branched C5 and C8 saturated HCs were observed, and a modern TWC had difficulties in converting those HC species to meet 99+% conversion at below 300 °C even with excessive O_2 (>5%) in the exhaust stream
5. It will be crucial to develop low temperature catalysts that are insensitive to HC species in harmonizing with advanced combustions for improved fuel efficiency