High Efficiency with Future Alcohol Fuels in a Stoichiometric Medium-Duty Spark Ignition Engine

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U. S. EPA

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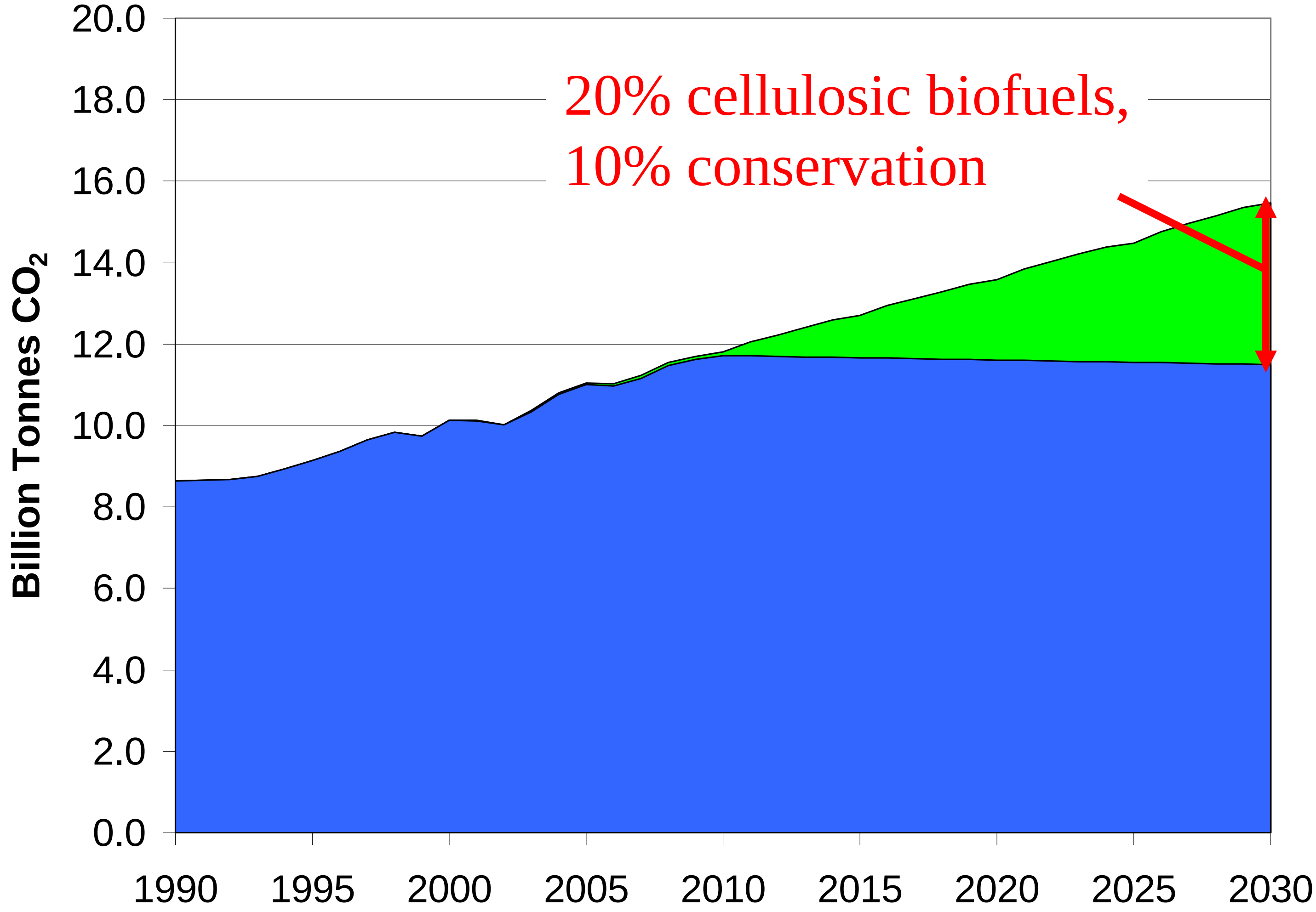
Holding the Line on CO_2 Emissions

Annual worldwide CO_2 emissions (AEO): liquid fuels



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Source: EIA (AEO), EPA staff estimates

EPA Biofuels Test Program

Alternative SI FUELS
Renewable, feasible and sustainable

Efficient POWERTRAINS
Low-CO2 and criteria pollutant emissions, equal or better performance

SI Biofuels

Ethanol
Methanol
Butanol
Hydrogen

Engines

Gas Engine Improvements
Clean Diesel
Variable Displacement
Variable Compression
DI Gasoline
HCCI engine
Alcohol engine
Fuel Cell
Free Piston Engine
HyTEC

Drivetrains

Dual Clutch AMT
Electric Hybrids
Hydraulic Hybrids

SAE®

Future Low-GHG Fuels for SI Engines

- Conversion of Biomass into High-Octane Fuels: Pathways
  - Fermentation/Distillation
  - ➡ Ethanol
  - Gasification/Synthesis
  - ➡ Methanol
    - Fischer-Tropsch gasoline
    - Hydrogen

GHG reductions*: Ethanol

Feedstock	% GHG Reduction
Corn	21.8
Sugar Cane	56.0
Cellulosic Biomass	90.9

*-Source: EPA report EPA420-F-07-035, April 2007

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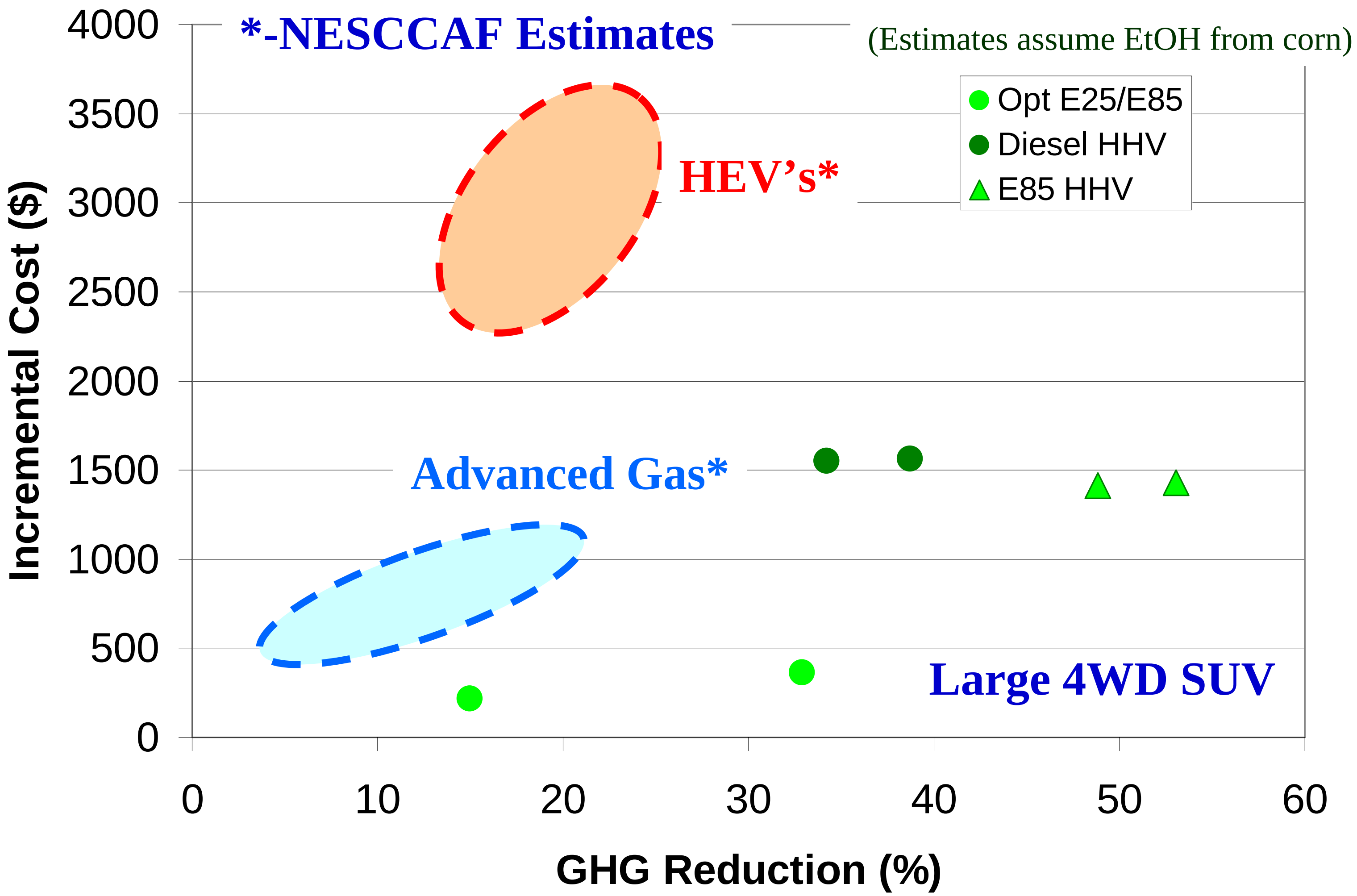
Cost-effective, low-GHG technologies



EPA Alcohol Engine Test Program

- Engine Platform: International 4.5L V6
  - Modified for PFI, SI

Displacement, Bore x Stroke	95mm x 105mm
Power, Torque rating	130 kW @2600 rpm, 650 N-m@1500 rpm
Injection System	PFI, 2 injector/cylinder
Fuel Type	E85, M85
Ignition System	Spark Ignition, Multiple spark
Air Induction System	Twin single-stage VTG
Geometric Compression Ratio	16.3:1 (fixed)
Exhaust Aftertreatment	Stoich, Three-way catalyst

Test Fuels

	Gasoline	Methanol	Ethanol
Chemical Formula	$C_nH_{1.83n}$	CH_3OH	C_2H_5OH
Relative Energy Density	1.0	0.49	0.67
AKI (R+M)/2	87	99	98
Heat of vaporization [kJ/MJ]	~8.0	56.0	31.2
RVP [psi]	7.0	4.6	2.3
CO_2 Emissions [g/MJ]	74.2	69.8	71.1

High flow injectors

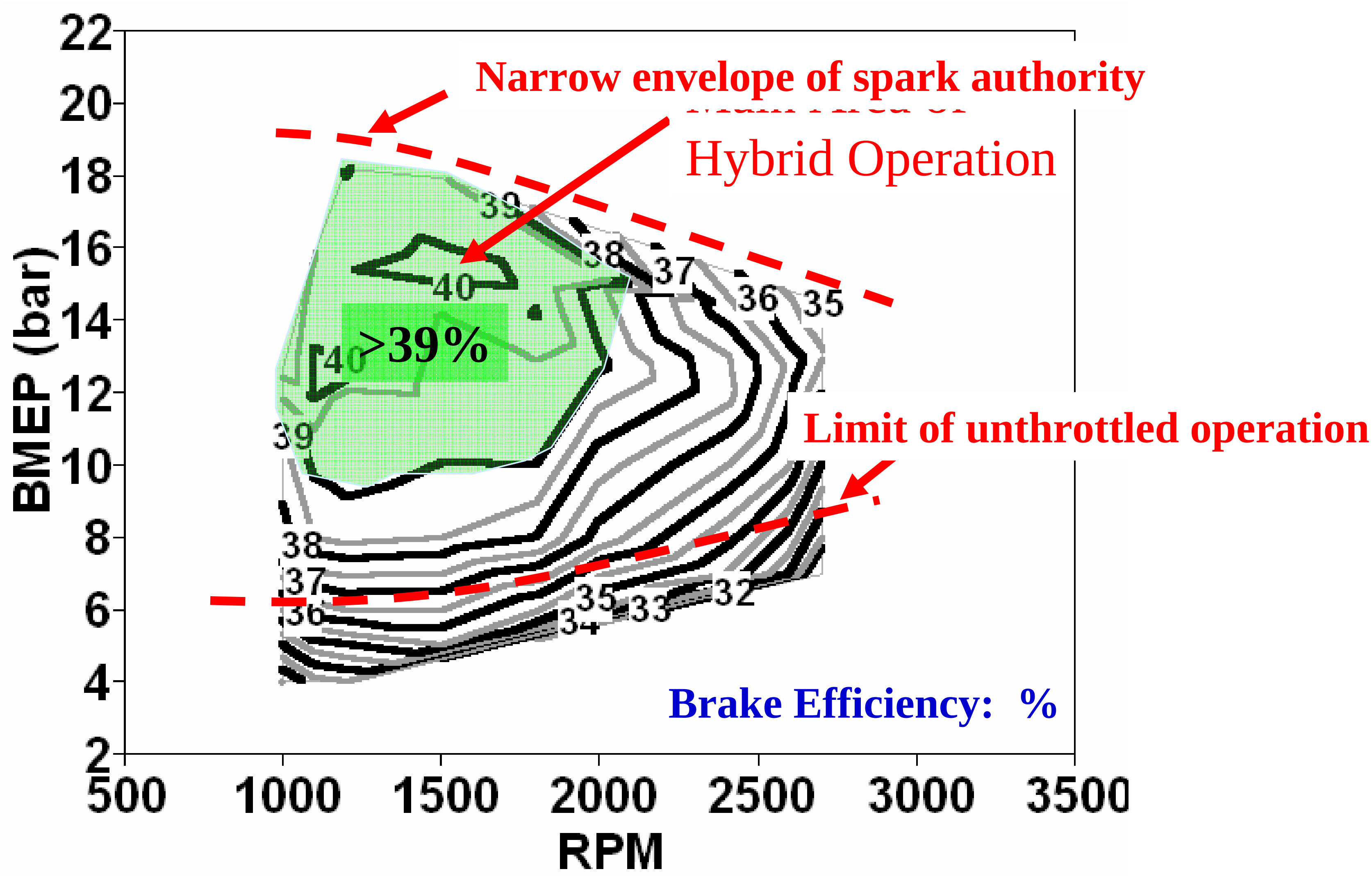
Enables high CR

Reduces comp work

Cold start concerns

Lower CO2 in exhaust

E85 Brake Thermal Efficiency



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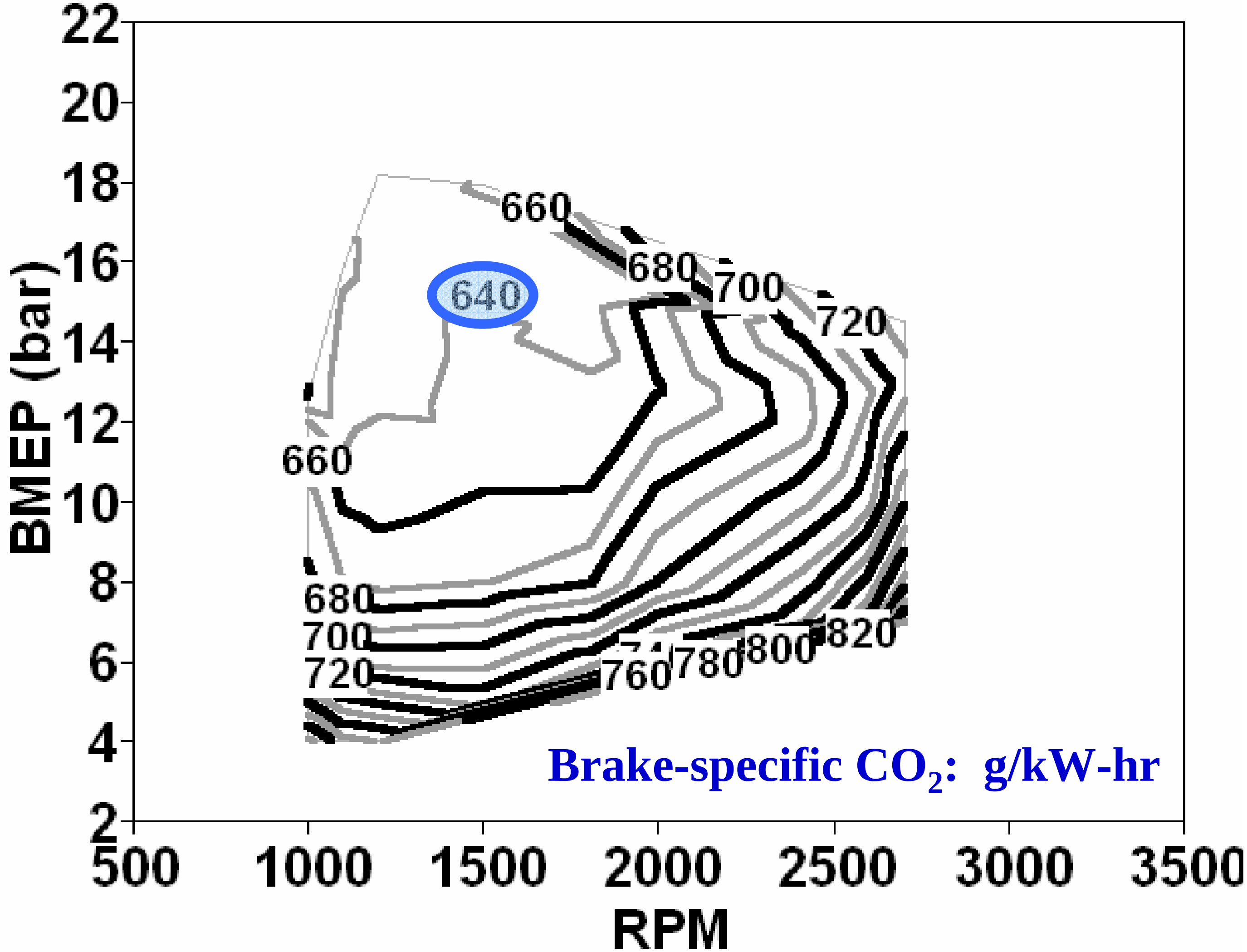
E85 Specific CO_2 emissions



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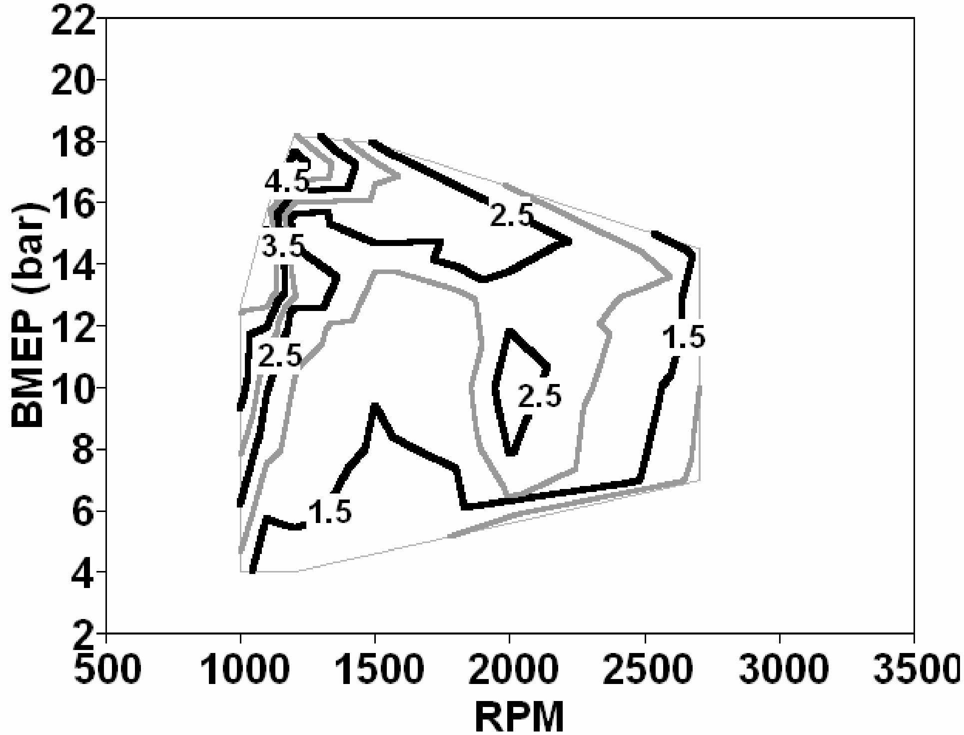
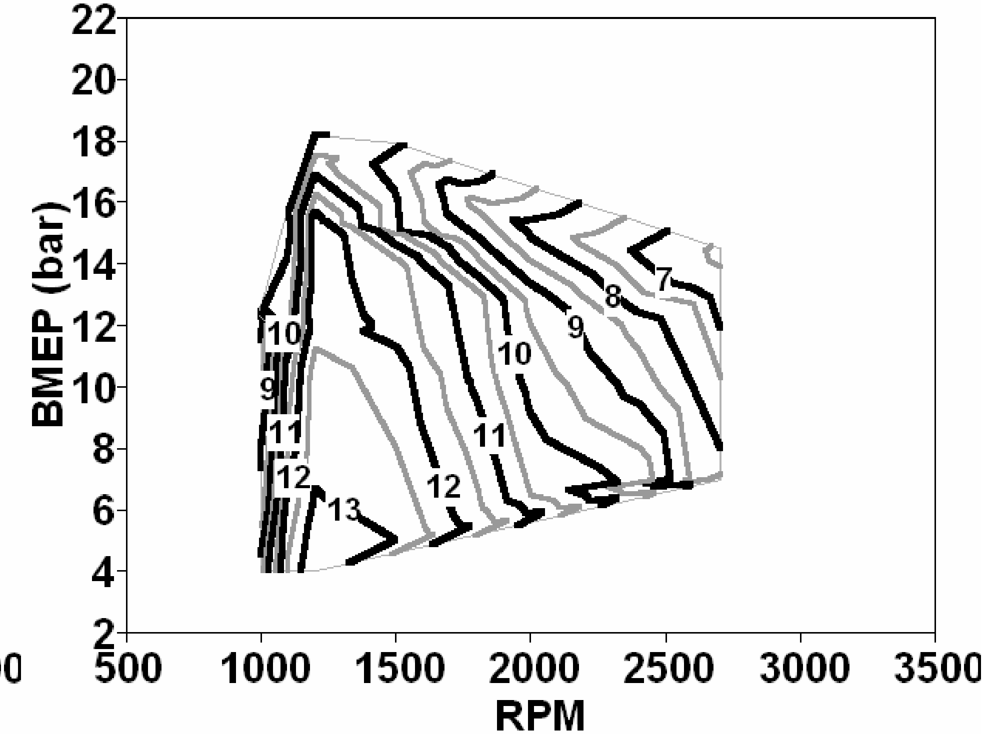
E85 Criteria Pollutant Emissions

- Engine-out emissions
- Stoichiometric operation: three-way catalyst





Brake-specific NO_x: g/kW-hr

Brake-specific HC: g/kW-hr

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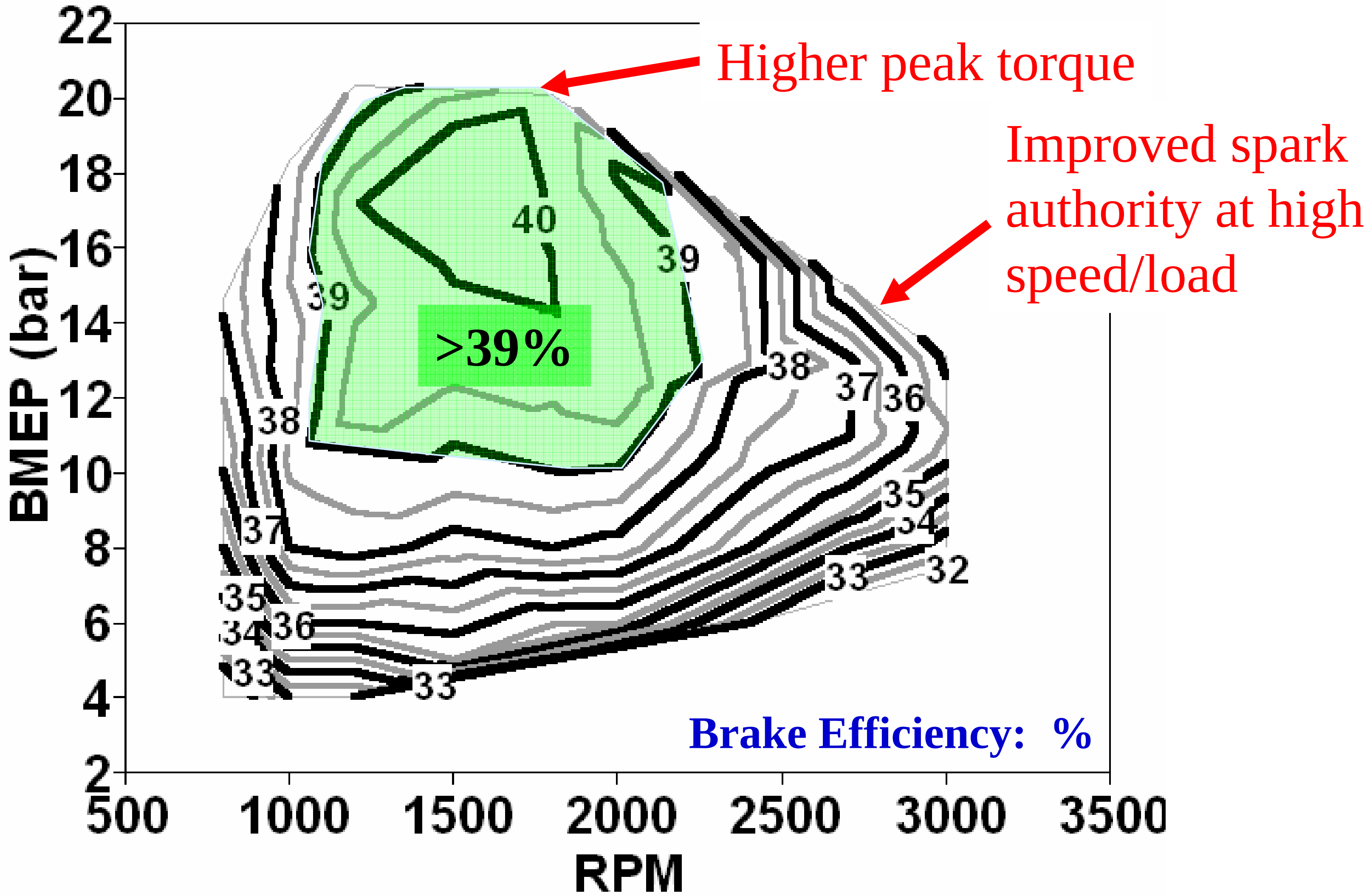
M85 efficiency



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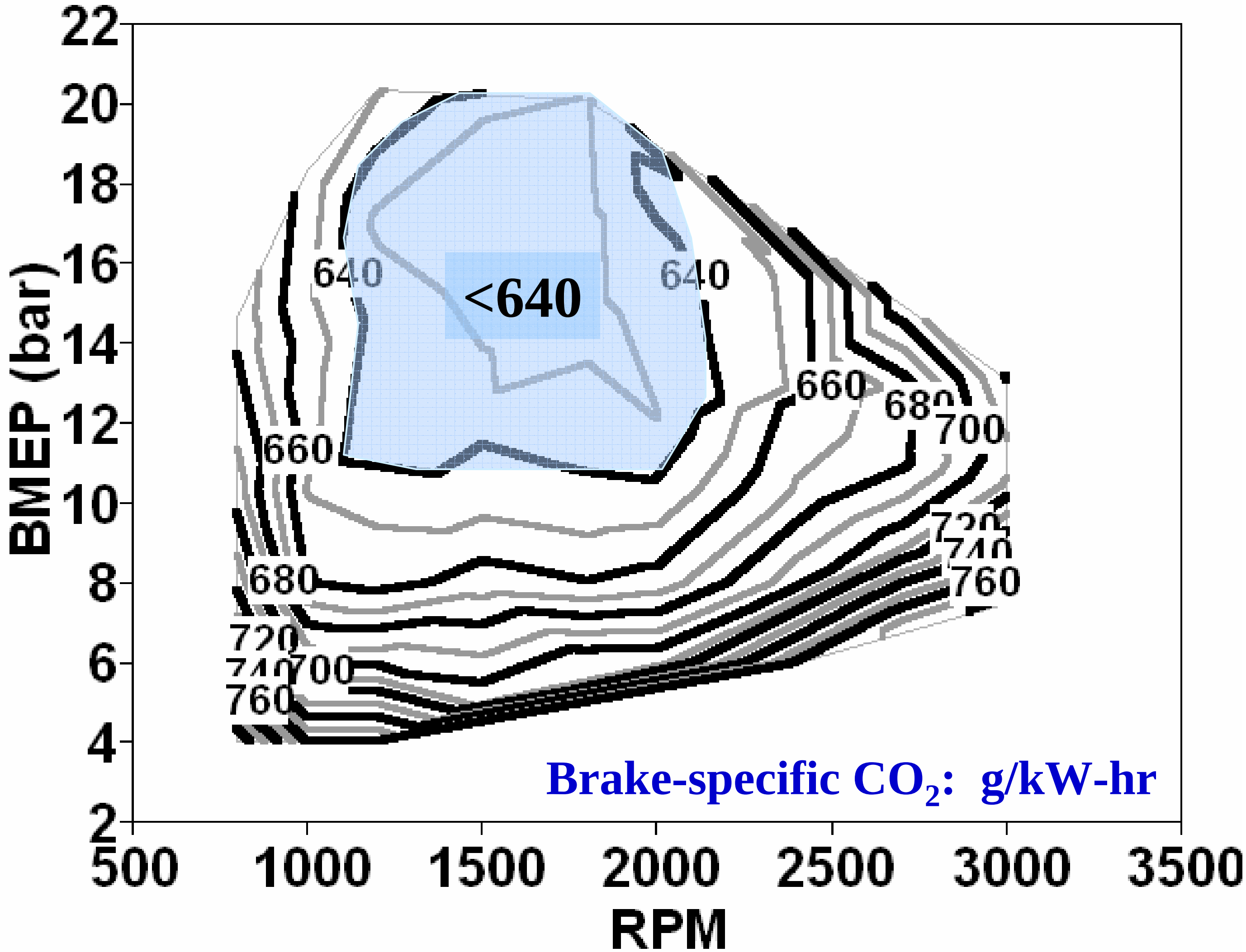
M85 CO2 emissions



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Summary/Conclusions

- Ethanol and methanol are both attractive SI fuels for achieving high efficiency at near gas-engine costs
  - Better-than-diesel efficiency with PFI-SI alcohol engines
  - Stoichiometric operation with a standard TWC
- Alcohol fuels offer potentially ultra-low GHG emissions when produced from biomass
  - Specific CO2 emissions: metric for comparing the effectiveness of engines operating on various fuels.
- Future attempts to cap GHG vehicle emissions depend on <u>conservation</u> and <u>biofuels</u>
  - EPA option: E85 with a Hydraulic Hybrid Vehicle

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THANK YOU!!!

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