An HCCI Engine Power Plant for a Hybrid Vehicle

U.S. Environmental Protection Agency

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Benefits of HCCI Engines

- High thermal efficiency
- Low NOx and PM emissions
- Potentially low incremental cost

Challenges of HCCI

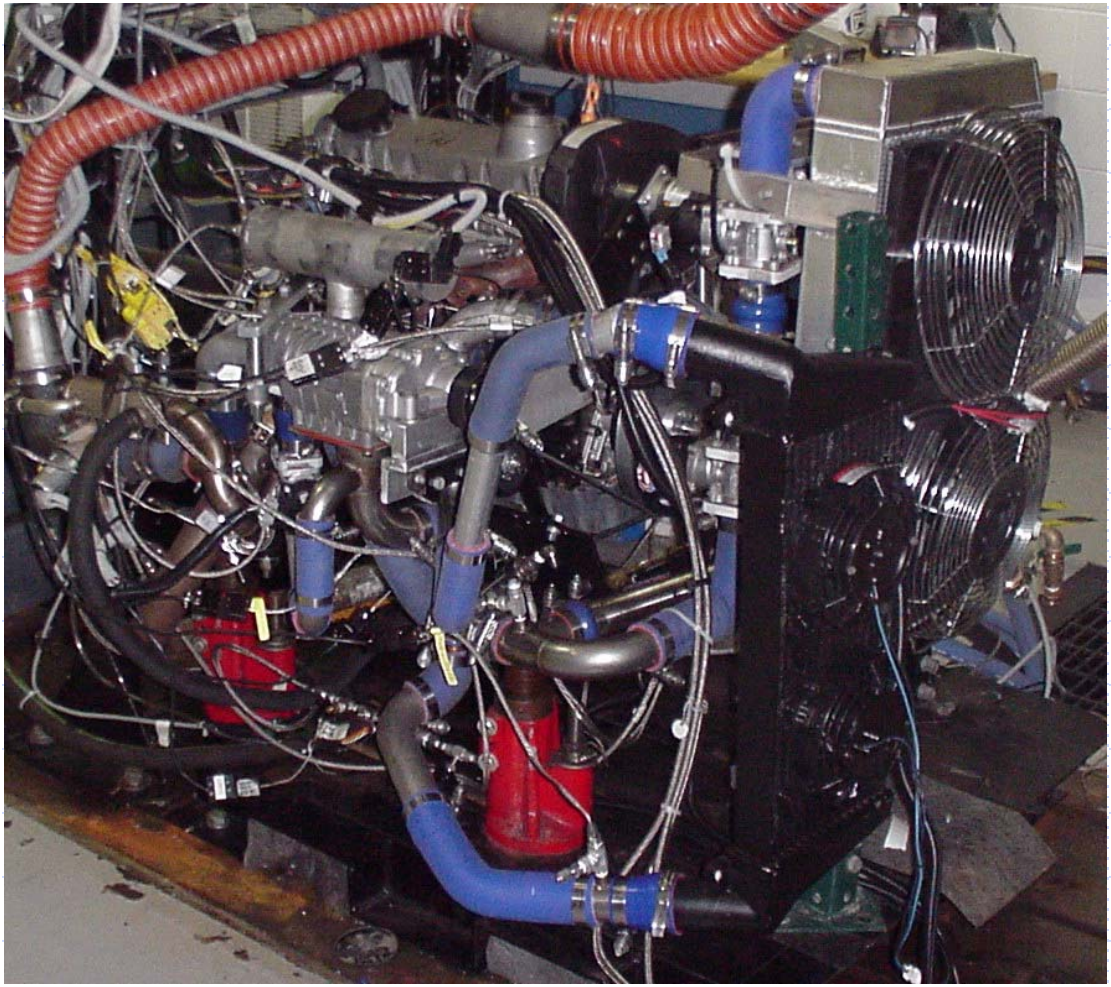
- Controlling Ignition and Combustion
- Expending Useful Operating Range
- Managing Transient Operation
- Reducing HC and CO emissions
- Finding Real World Applications

Program Objectives

- Explore operating range and performance of a multi-cylinder HCCI engine
- Study transient operation capabilities

Determine if an HCCI engine can be a suitable power plant for a hydraulic hybrid drivetrain (or any series hybrid)

Laboratory Setup of Test Engine



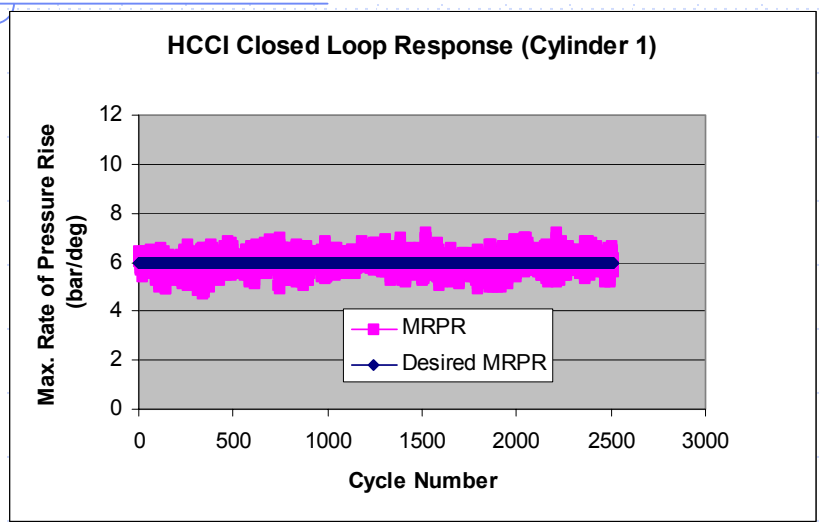
Control Strategy

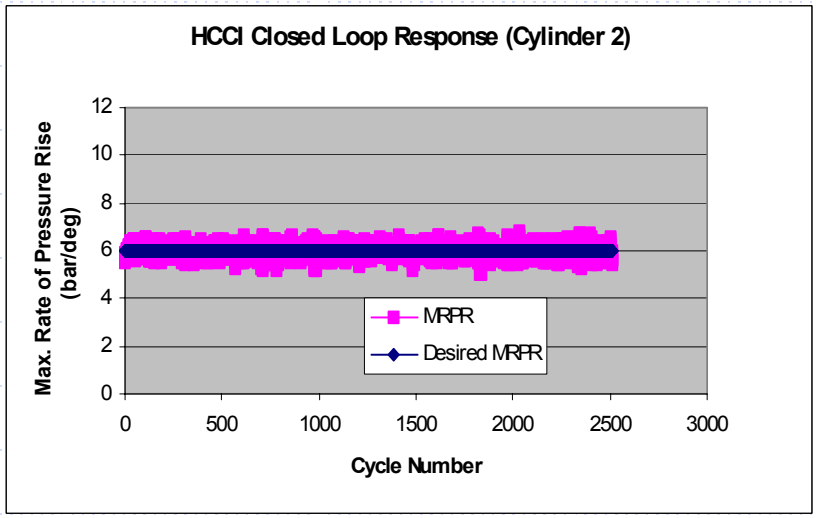
- Primary parameters were adjusted by the engine controller to maintain a single target combustion parameter.
- Primary parameters included the fueling rate, boost level, EGR, intake charge and coolant temperatures.
- Target combustion parameter was the maximum rate of pressure rise.

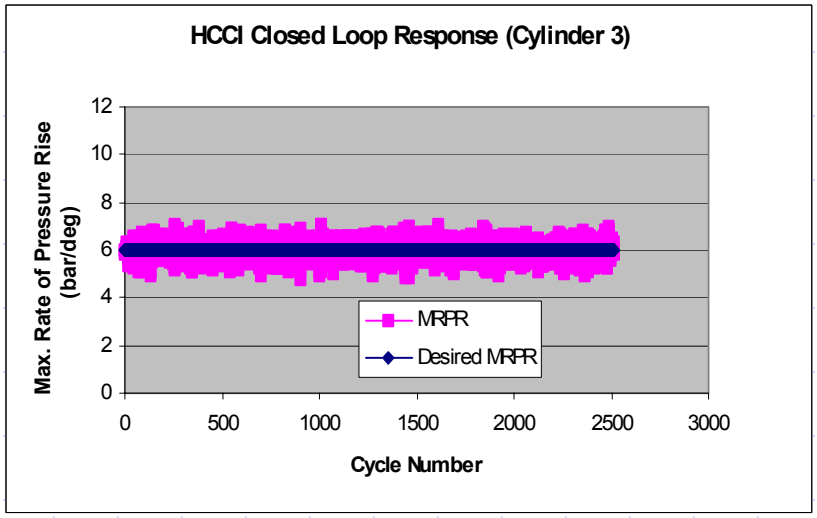
Control Strategy (continued)

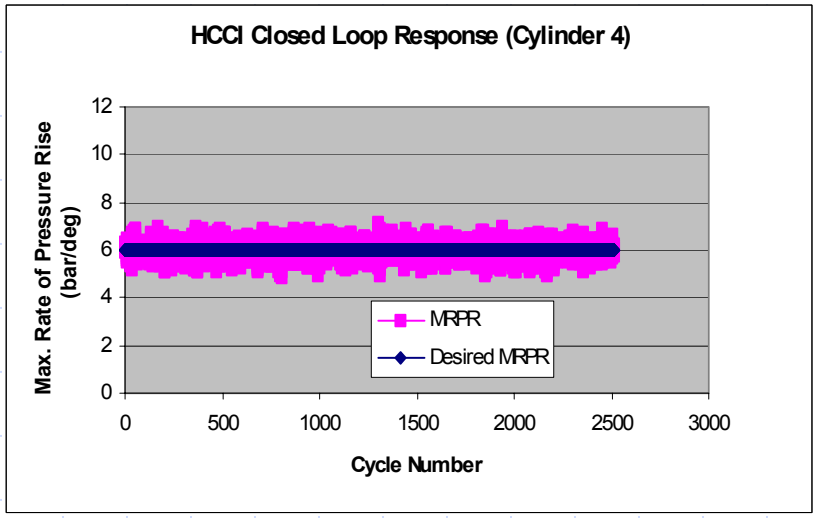
- Primary parameters mapped to yield/keep:
  - ***Best efficiency***
  - ***Stable operation*** (COV of IMEP < 3%)
  - ***Combustion noise not too high*** (MRPR ~ 6 bar/deg)
  - ***Low NOx emissions*** (NOx < 0.2 g/kWh)

Steady State – **Combustion Stability**

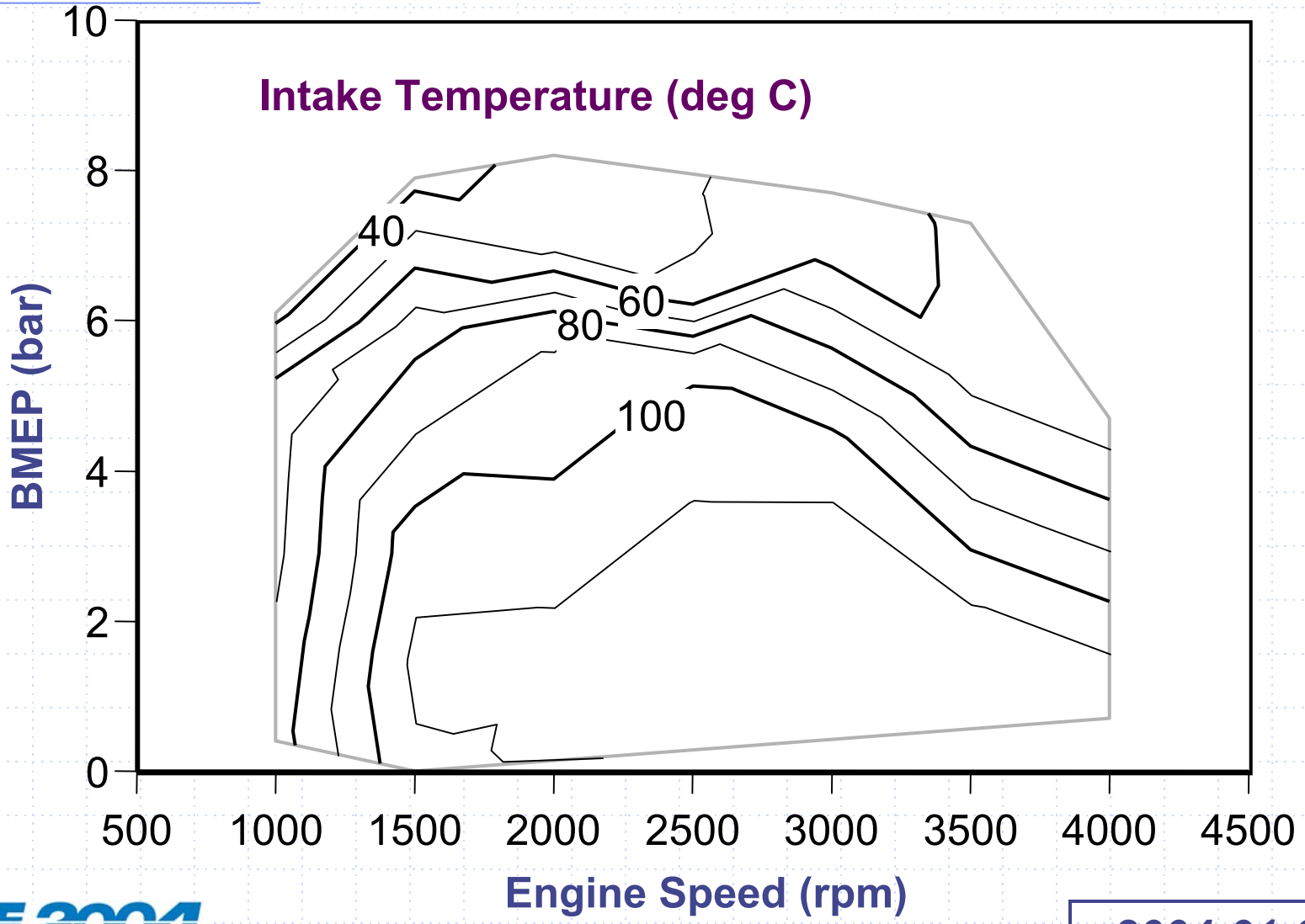








Steady State – **Intake Temperature**



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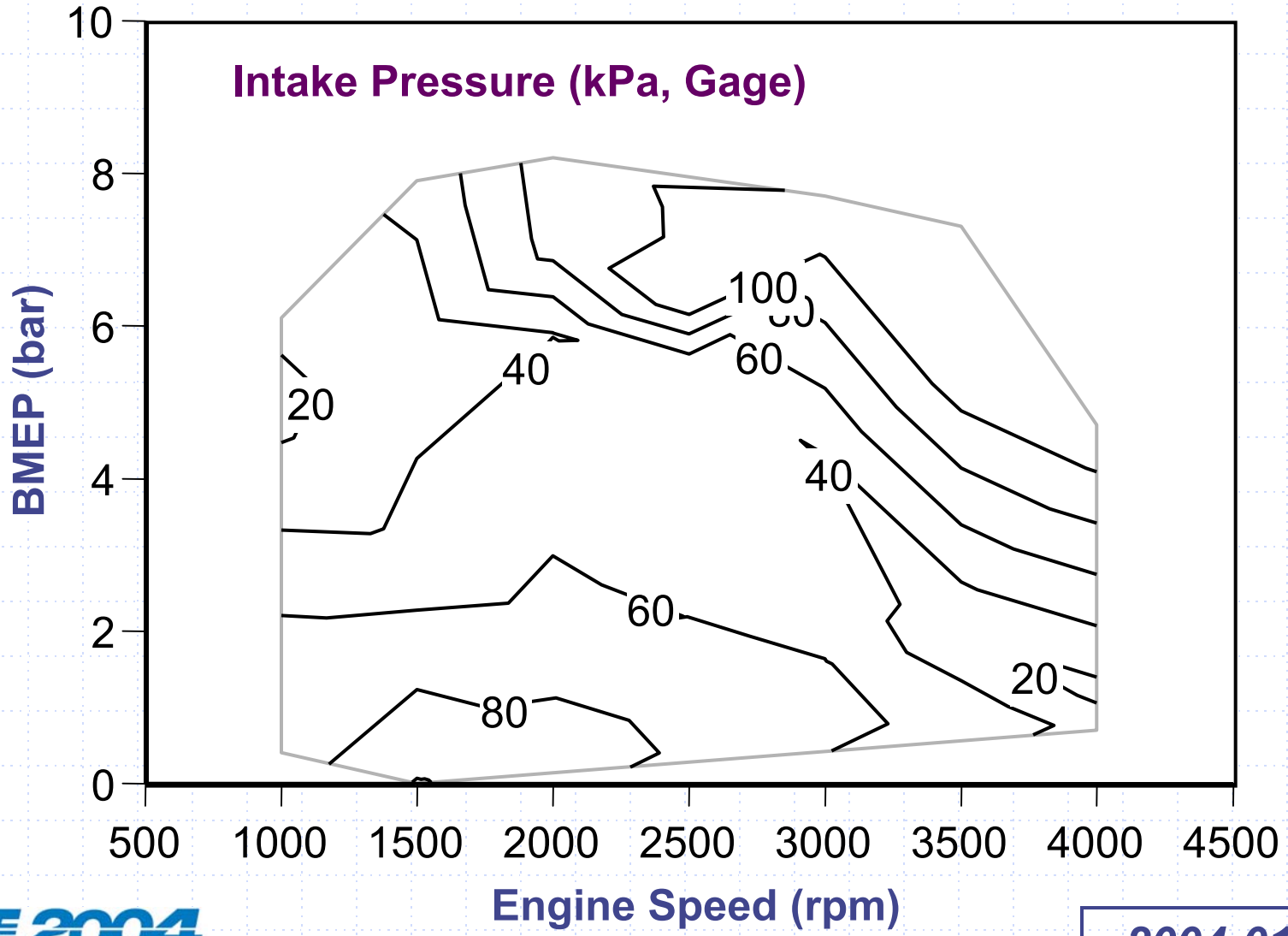
Steady State – **Intake Pressure**



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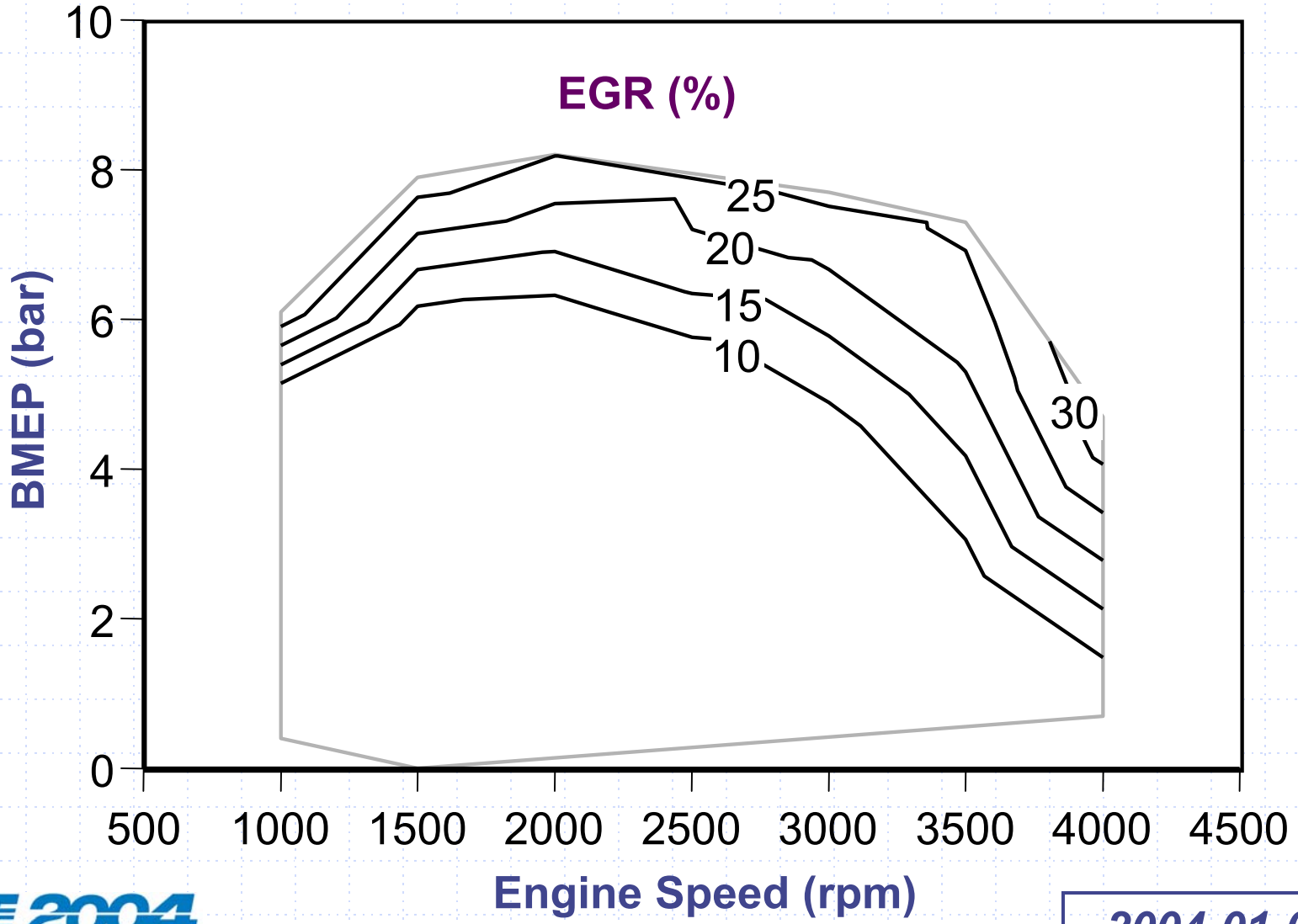
Steady State – **EGR Rate**



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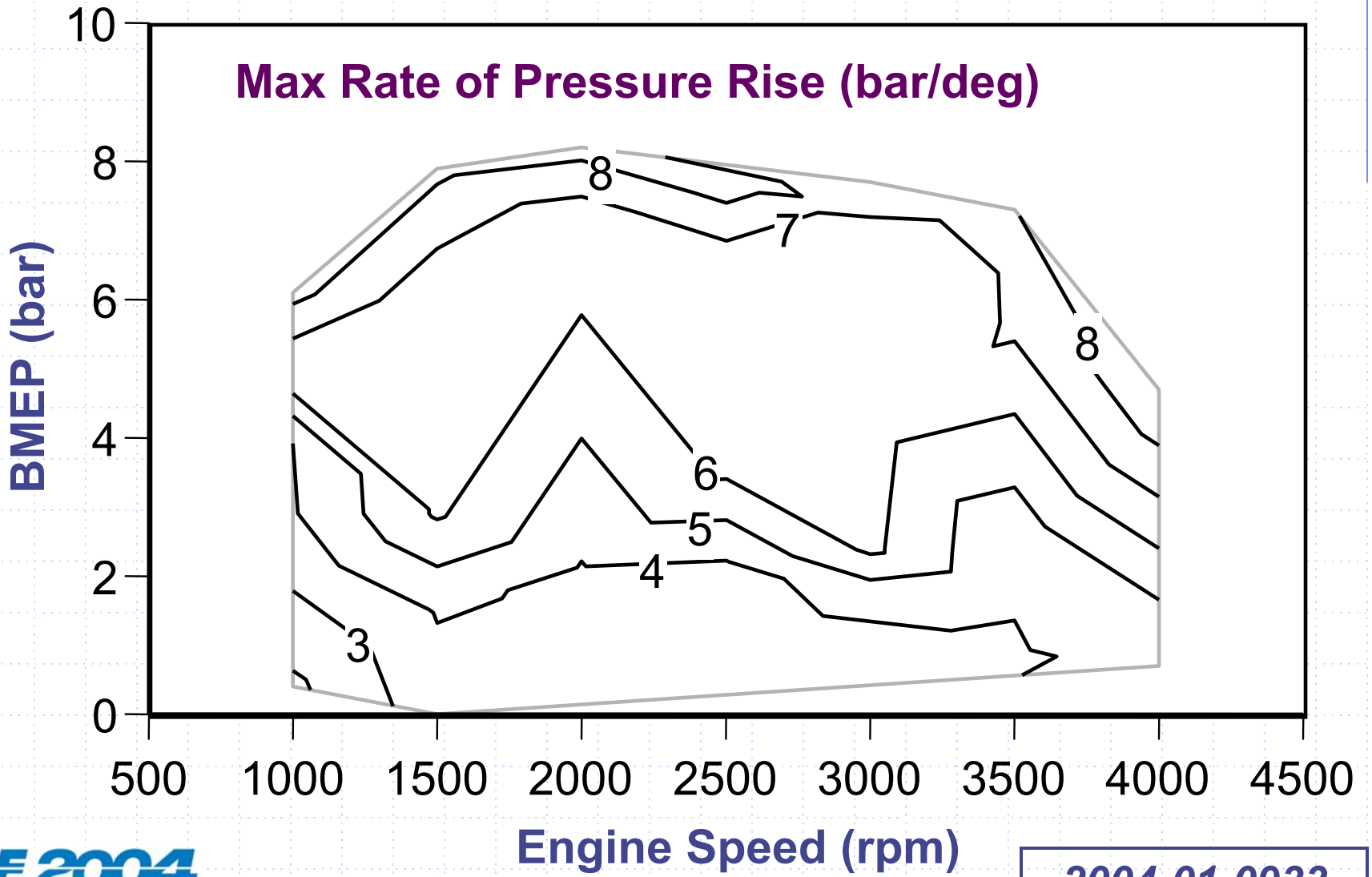
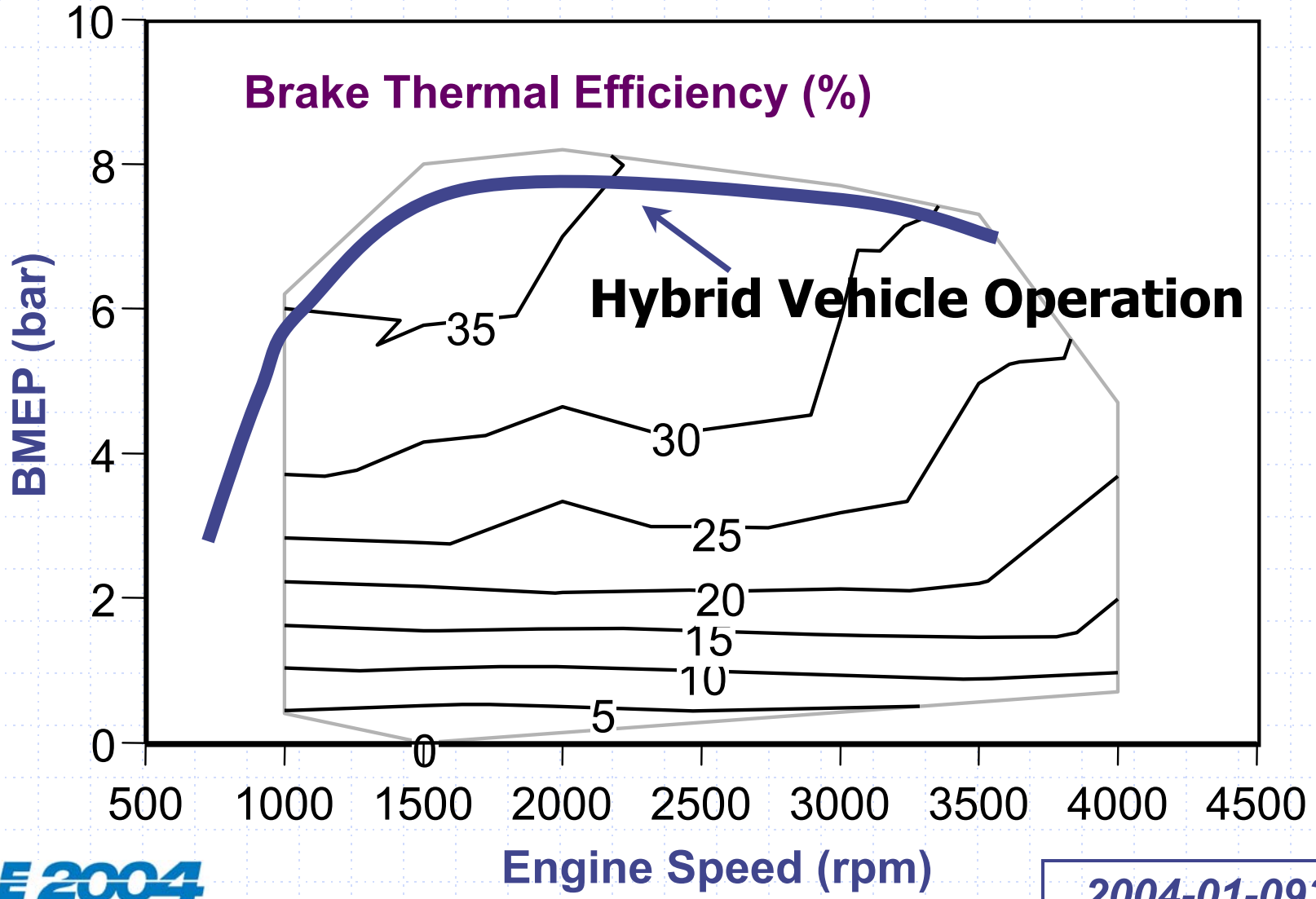
Steady State – **Combustion Phasing**



Steady State – **Engine Efficiency**



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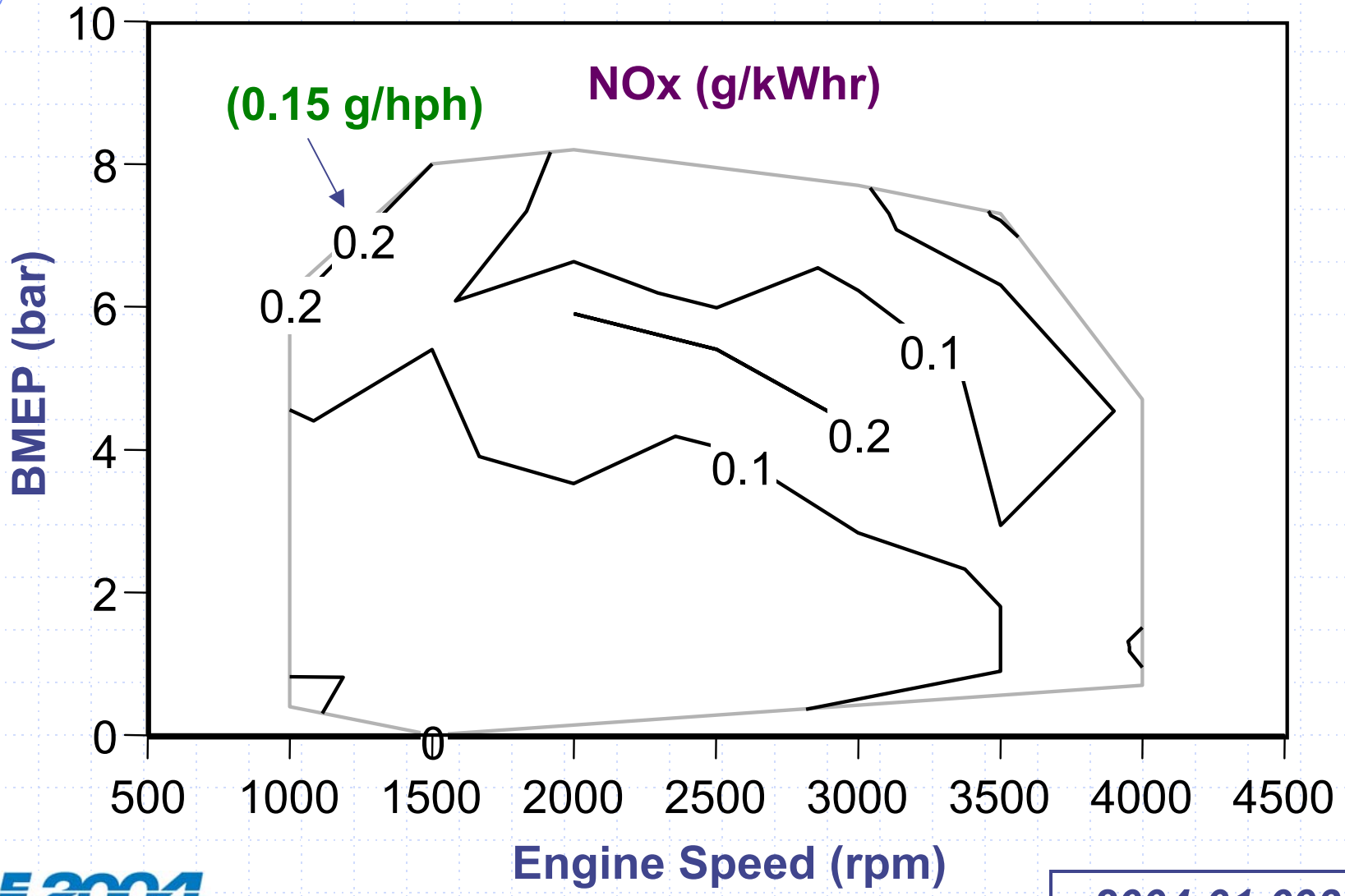
Steady State – **NOx Emissions**



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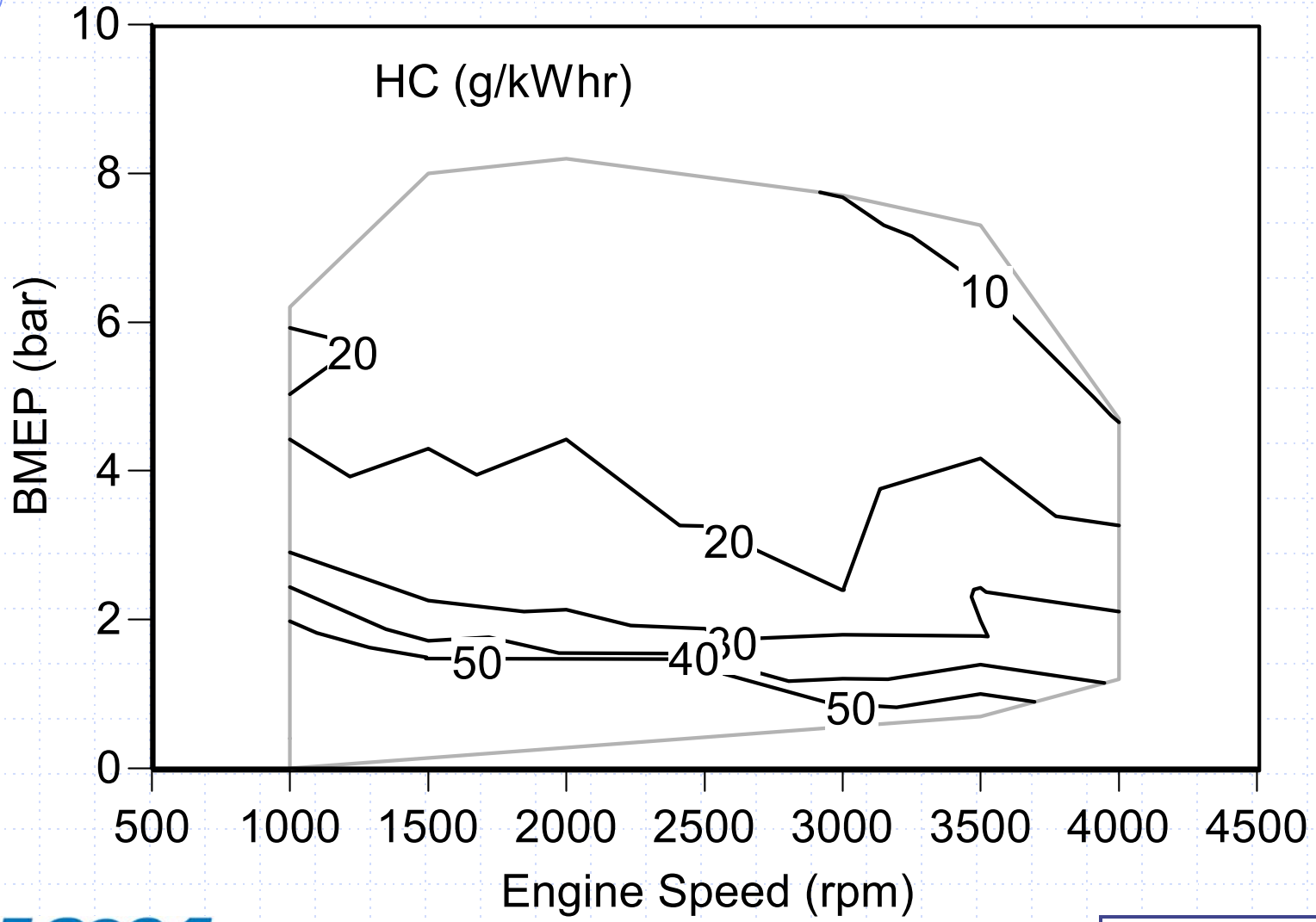
Steady State – **HC Emissions**



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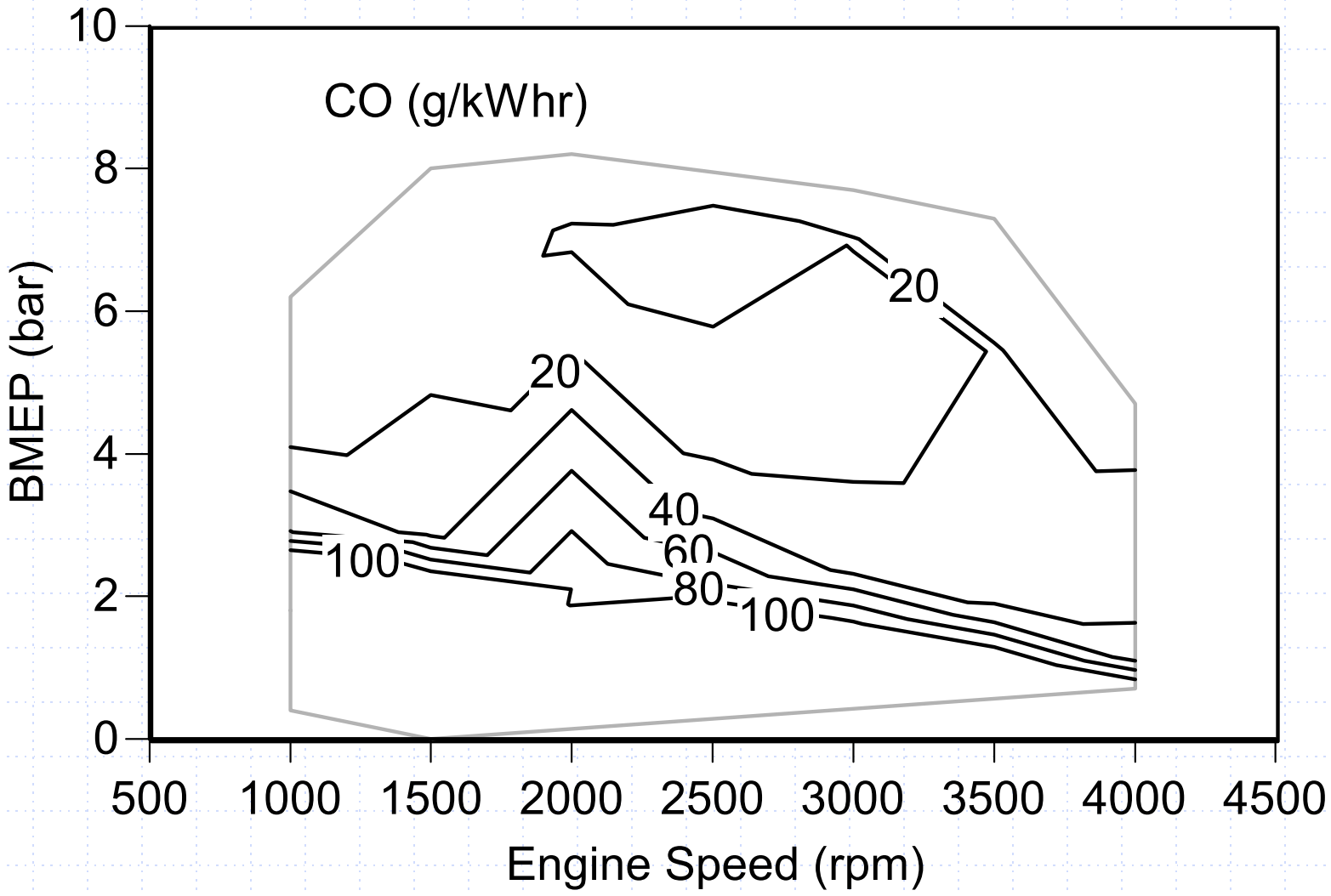
Steady State – **CO Emissions**



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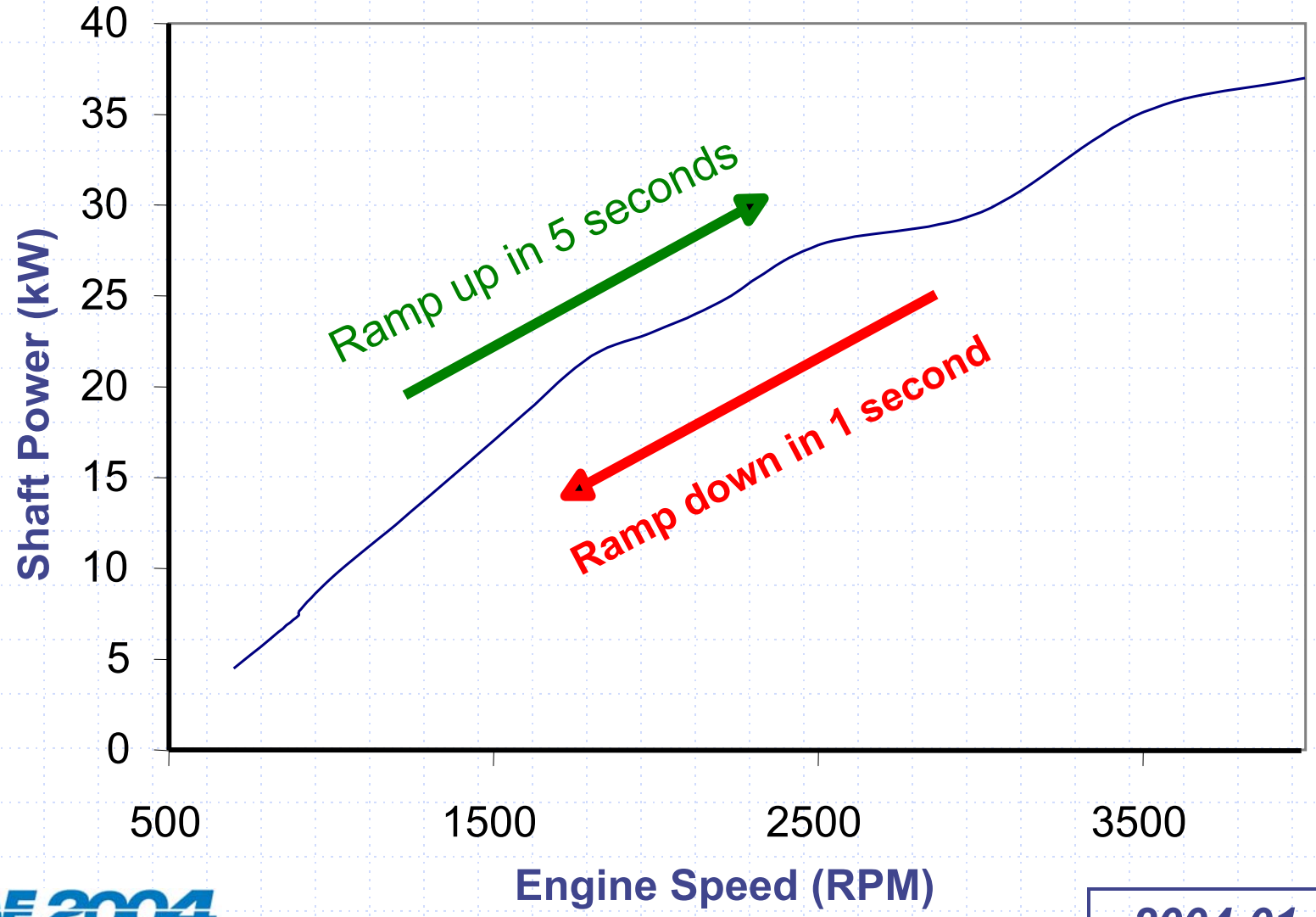
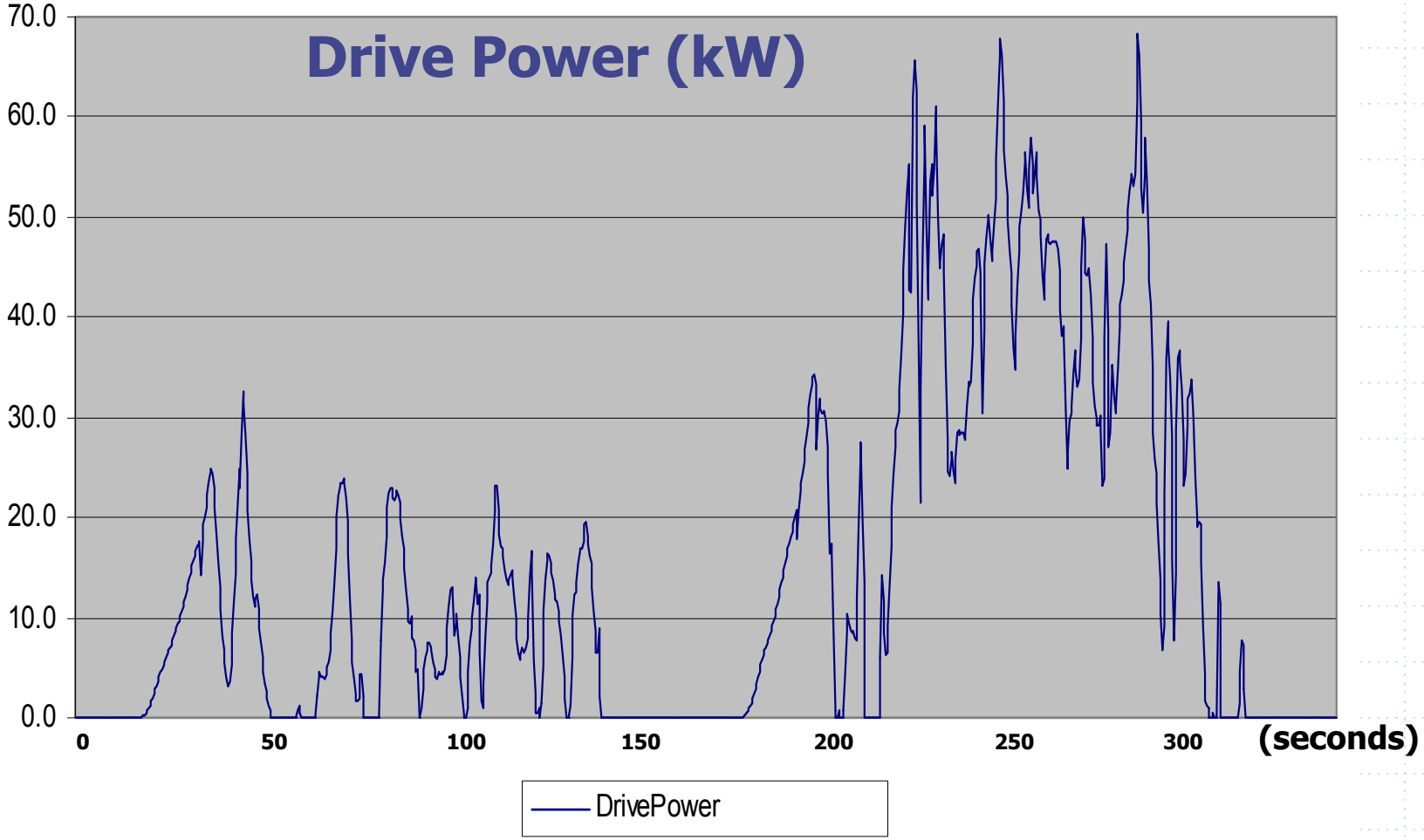
Transient Operation



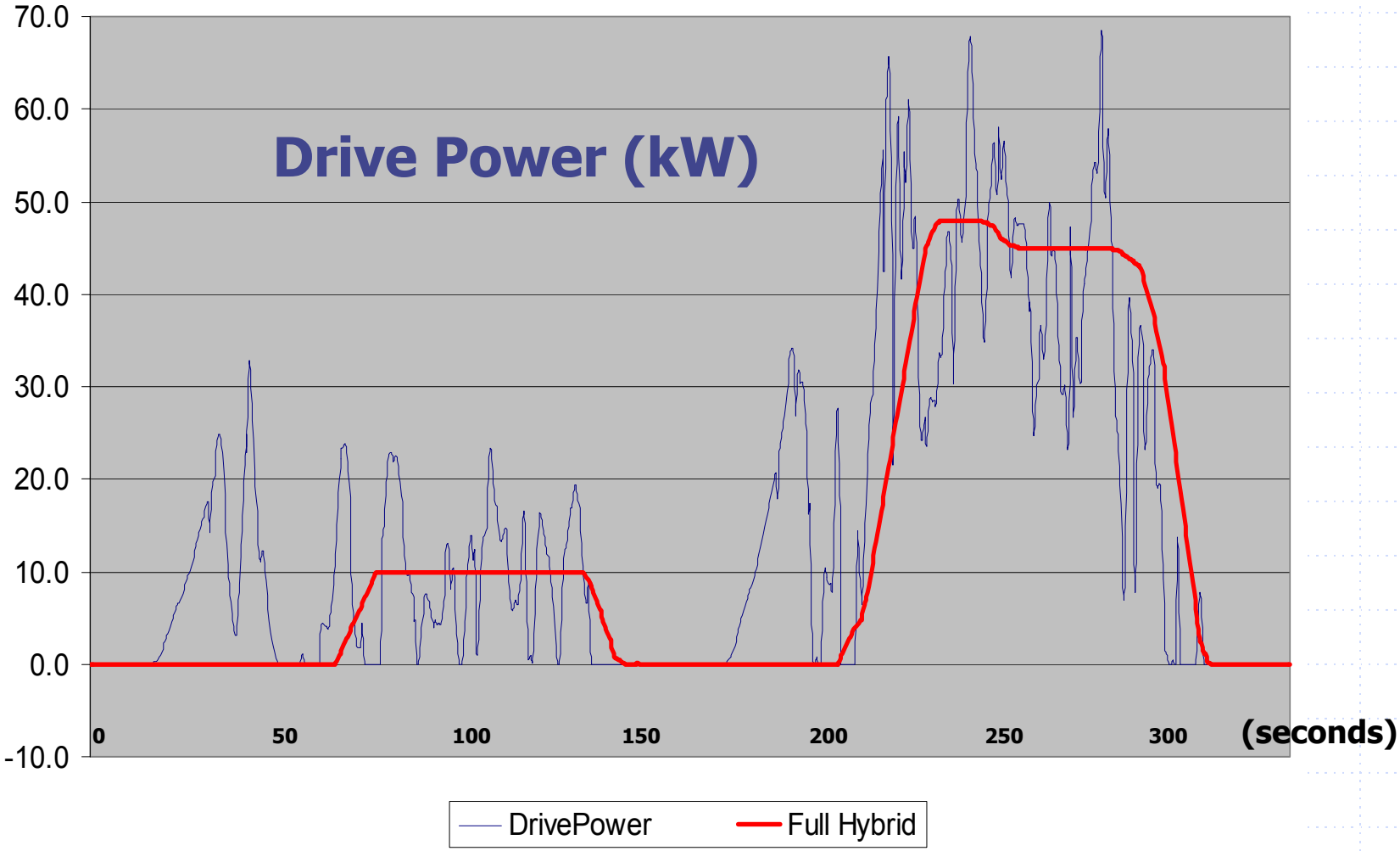
Conventional Vehicle

Power Demand (kW)



Series Hydraulic Hybrid Vehicle

Power Demand (kW)



Conclusions

1. An HCCI engine with mostly current production components can operate over a wide range of conditions with low NOx emissions and good thermal efficiencies.
2. The engine can make transitions along a preset power curve.
3. The engine shows potential as a power plant for a hybrid vehicle.

Future Tasks

- Developing a better matched boost system to improve power density and efficiency
- Improving the control logic for better transient response
- Reducing engine out HC and CO and testing aftertreatment devices
- Starting directly in HCCI mode when engine is cold
- Testing the engine in a hybrid vehicle

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