Simulation of DPF regeneration strategies

GT-SUITE Users Conference

Frankfurt a. M., 20.10.2008

LMB
A. Schilling,
Dr. R. Röthlisberger

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Content

- **Introduction**
- **GT-Power simulation conditions**
- **Simulation-based study of regeneration strategies**
- **Results**
- **Conclusions and outlook**

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Content

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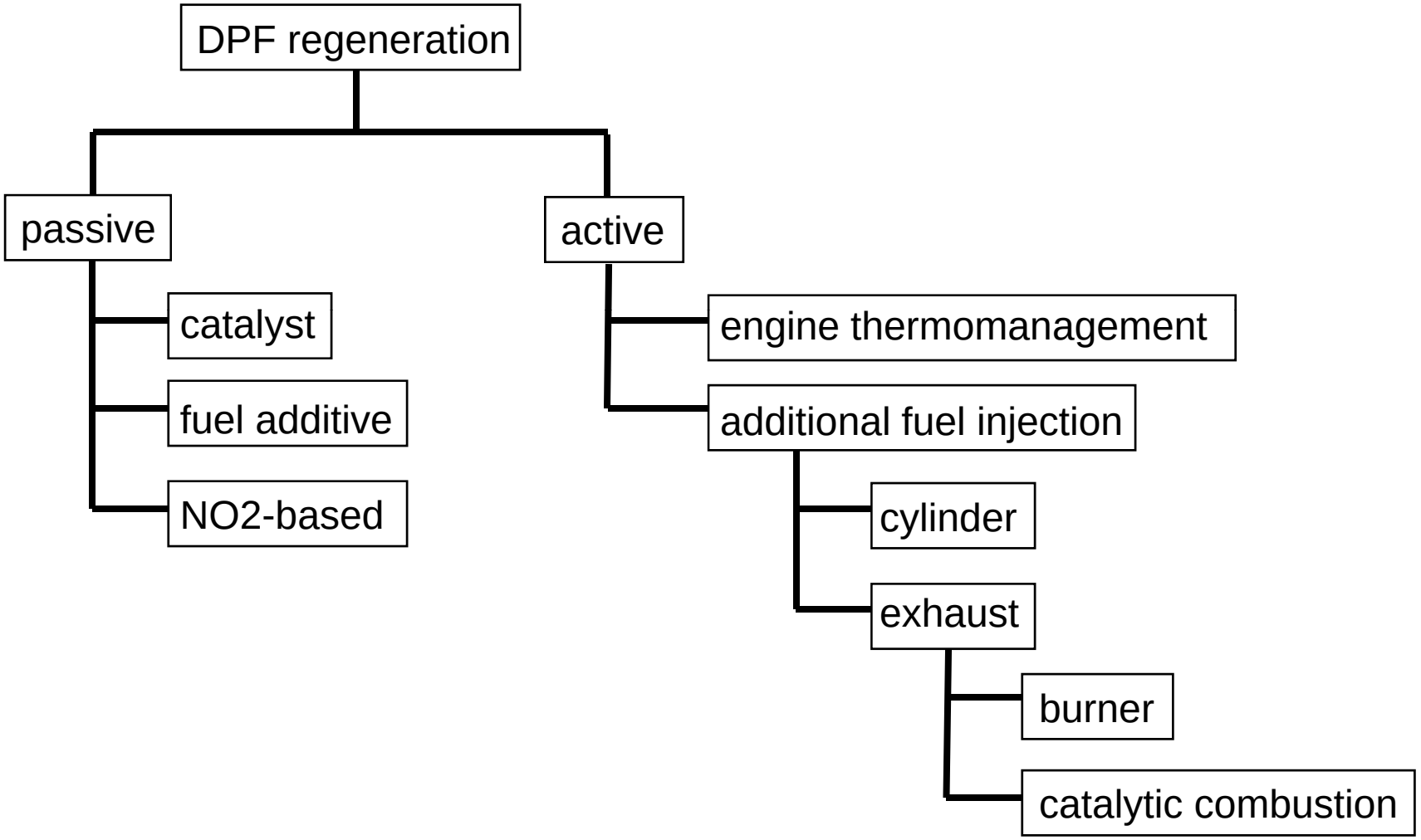
Introduction: DPF regeneration strategies overview



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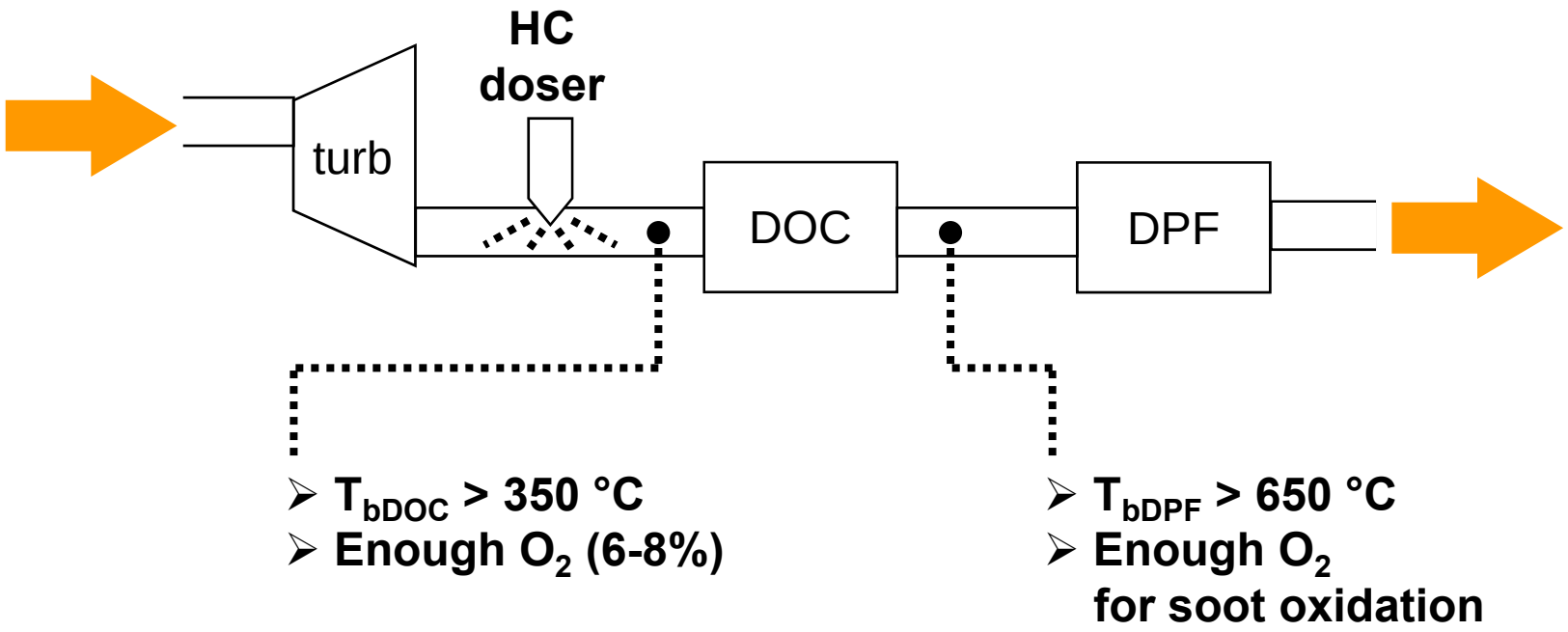
Introduction: Target conditions for regeneration

- Temperature before DOC
- Temperature before DPF
- Oxygen concentration



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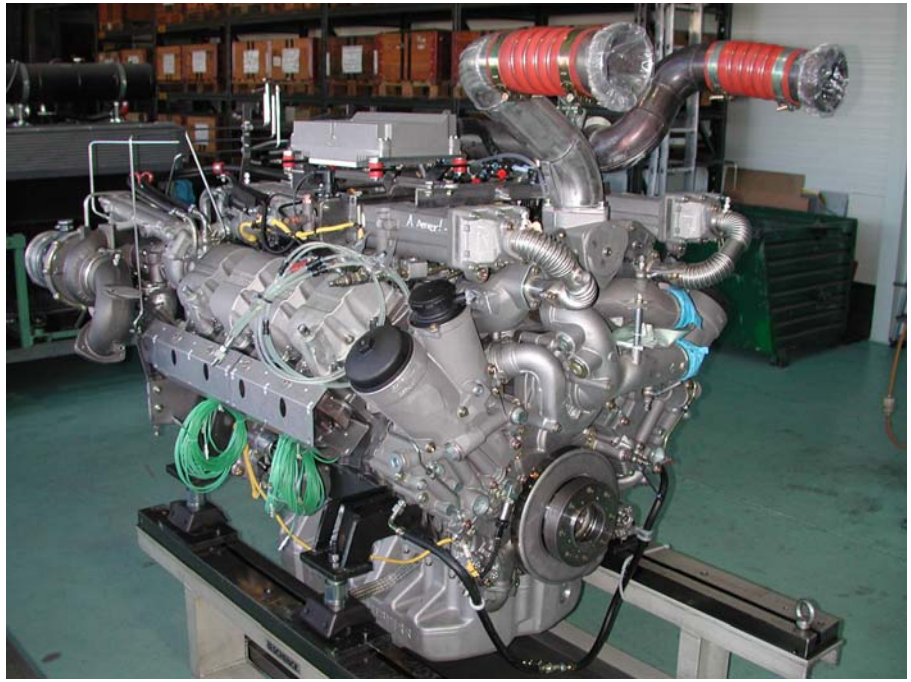
Engine considered

- **Name:** D9508
- **Cylinder:** V8
- **Power:** 500 kW
- **Emission level:** 3B
- **EGR system:** external
- **Turbocharging:** 2 stages, waste-gate
- **Injection:** direct, common-rail
- **DPF:** AC 200/12, 15’’ x 16’’



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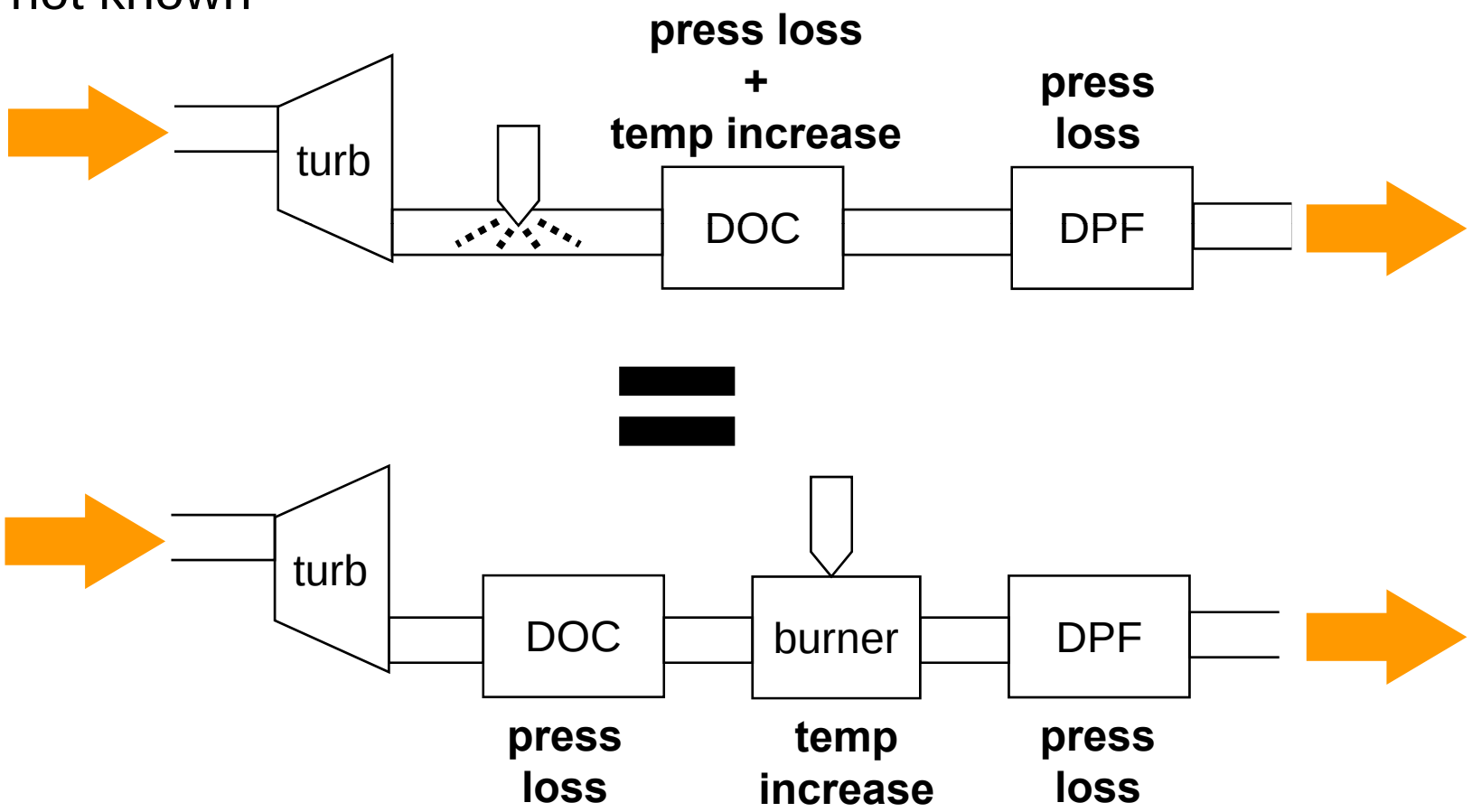
DOC + DPF modeling with GT-Power

- Equivalent modeling, since details of the DOC chemistry not known



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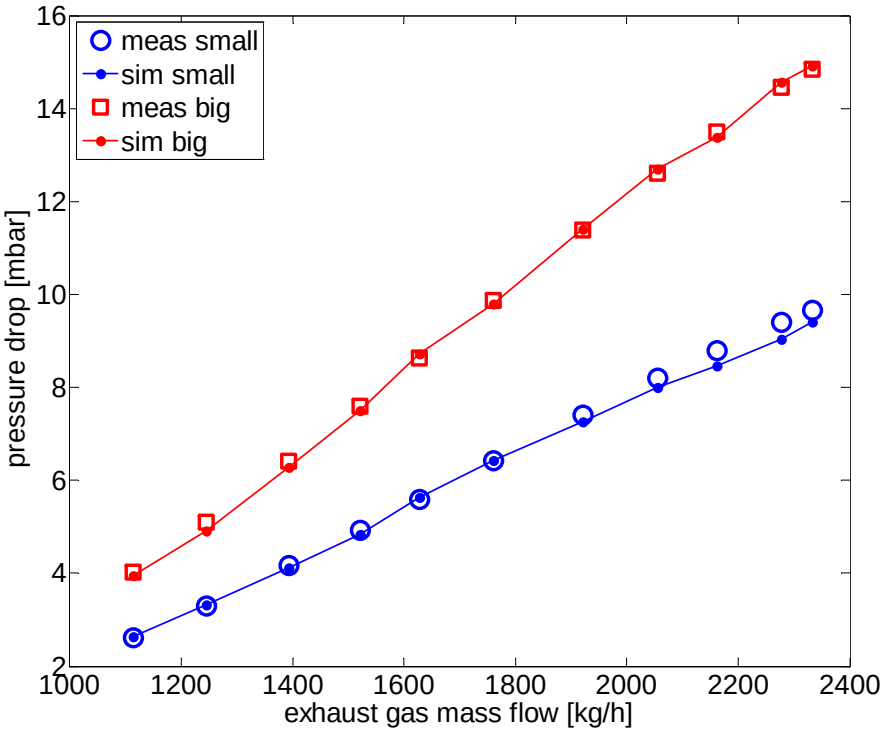
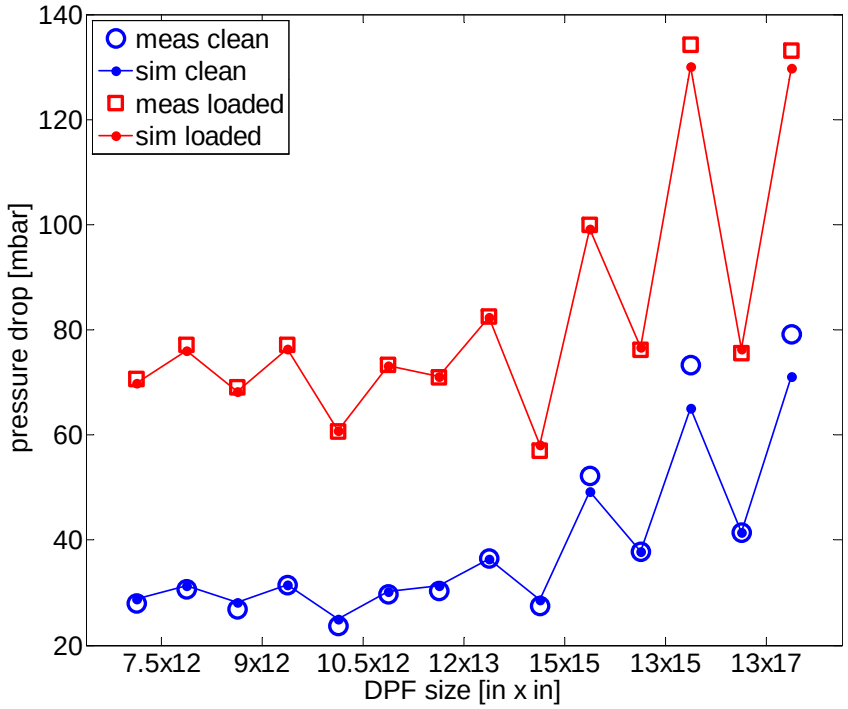
DOC + DPF modeling with GT-Power

- Pressure drop calibration results

DOC, various mass flows, comparison of two sizes



DPF, various sizes, comparison between clean and loaded



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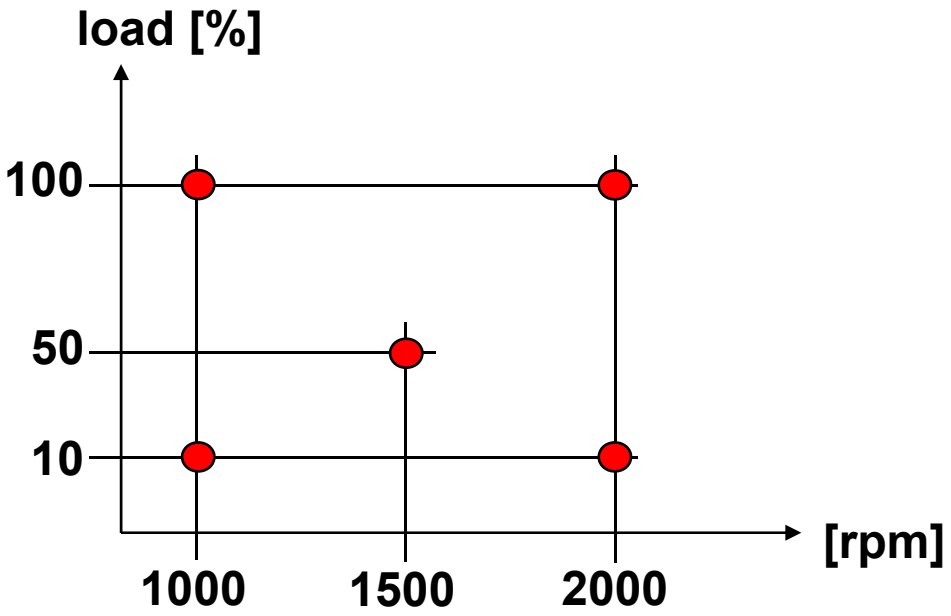
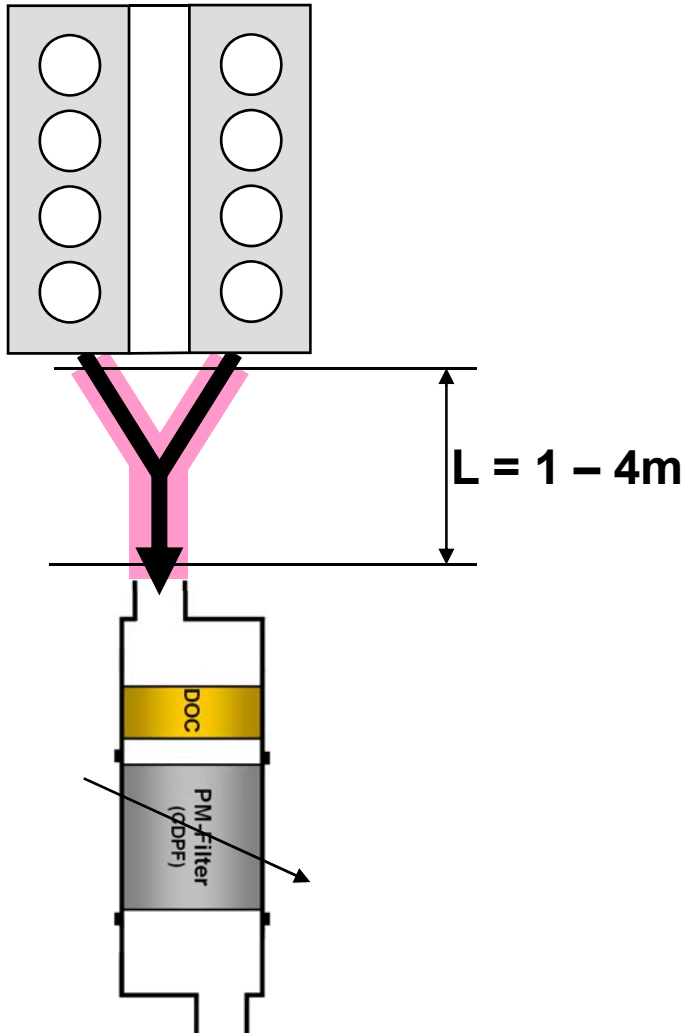
GT-Power simulation conditions

- 5 operating points
- 4 piping lengths
- With and without isolation
- DPF loaded with 3 g/l soot





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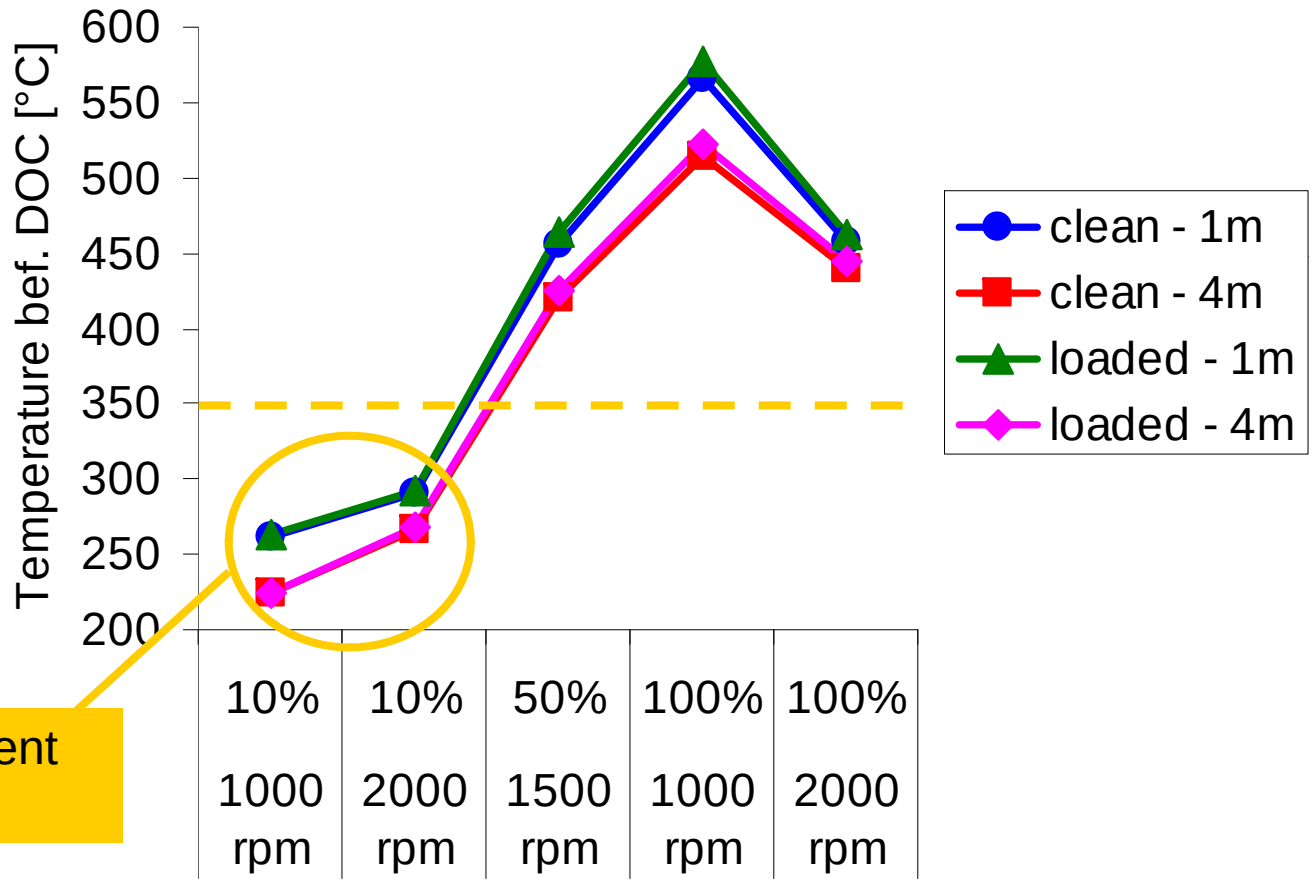
Characterization of the engine operation

- Piping length 1m vs. 4m ➔ Effect on temperature before DOC



Thermomanagement needed

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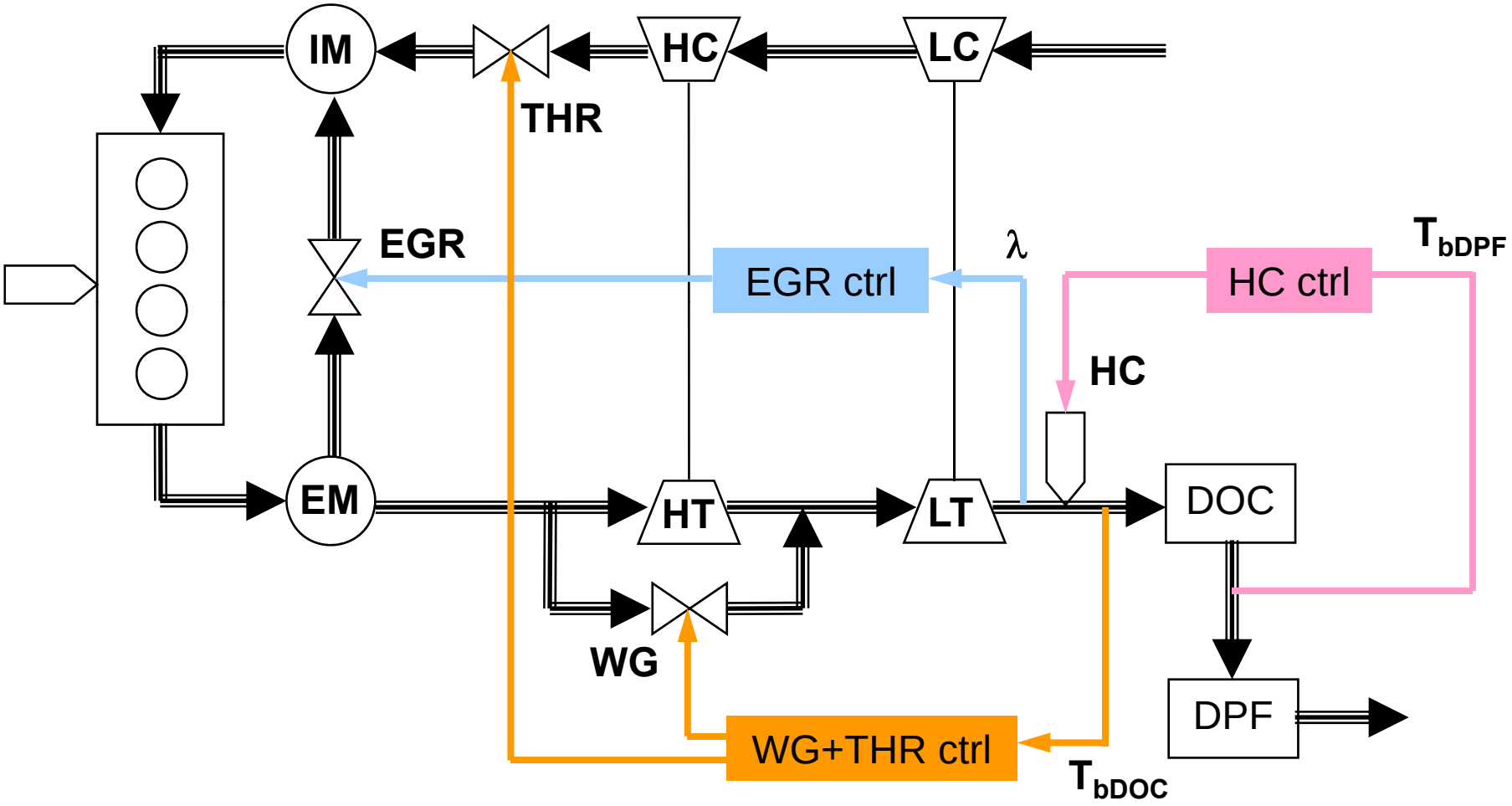
Engine control configuration



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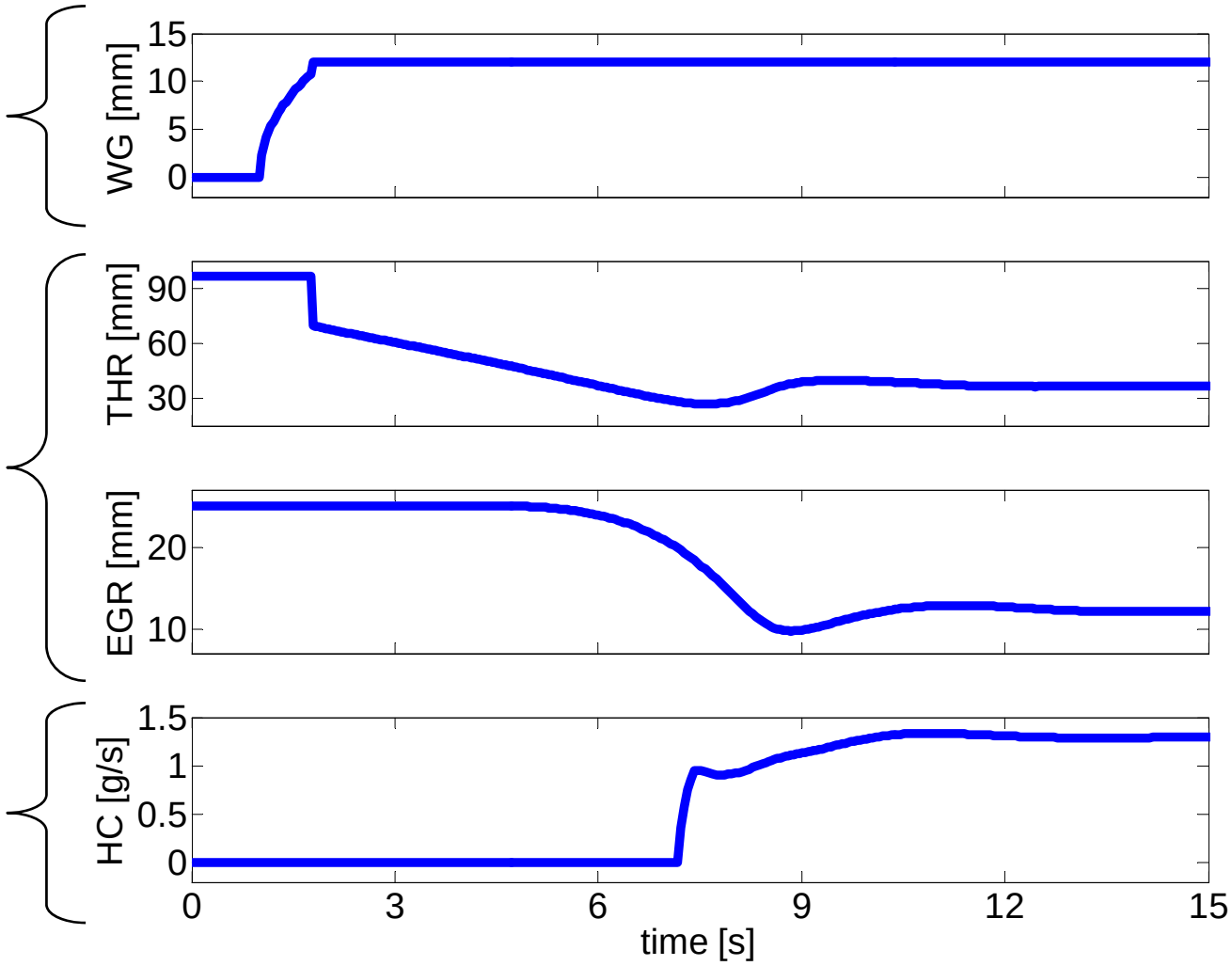
Example: Thermoman. + HC dosing at 2000 rpm, 10%

Opening of the WG

Coordinate control of EGR valve and THR to achieve control targets

HC dosing



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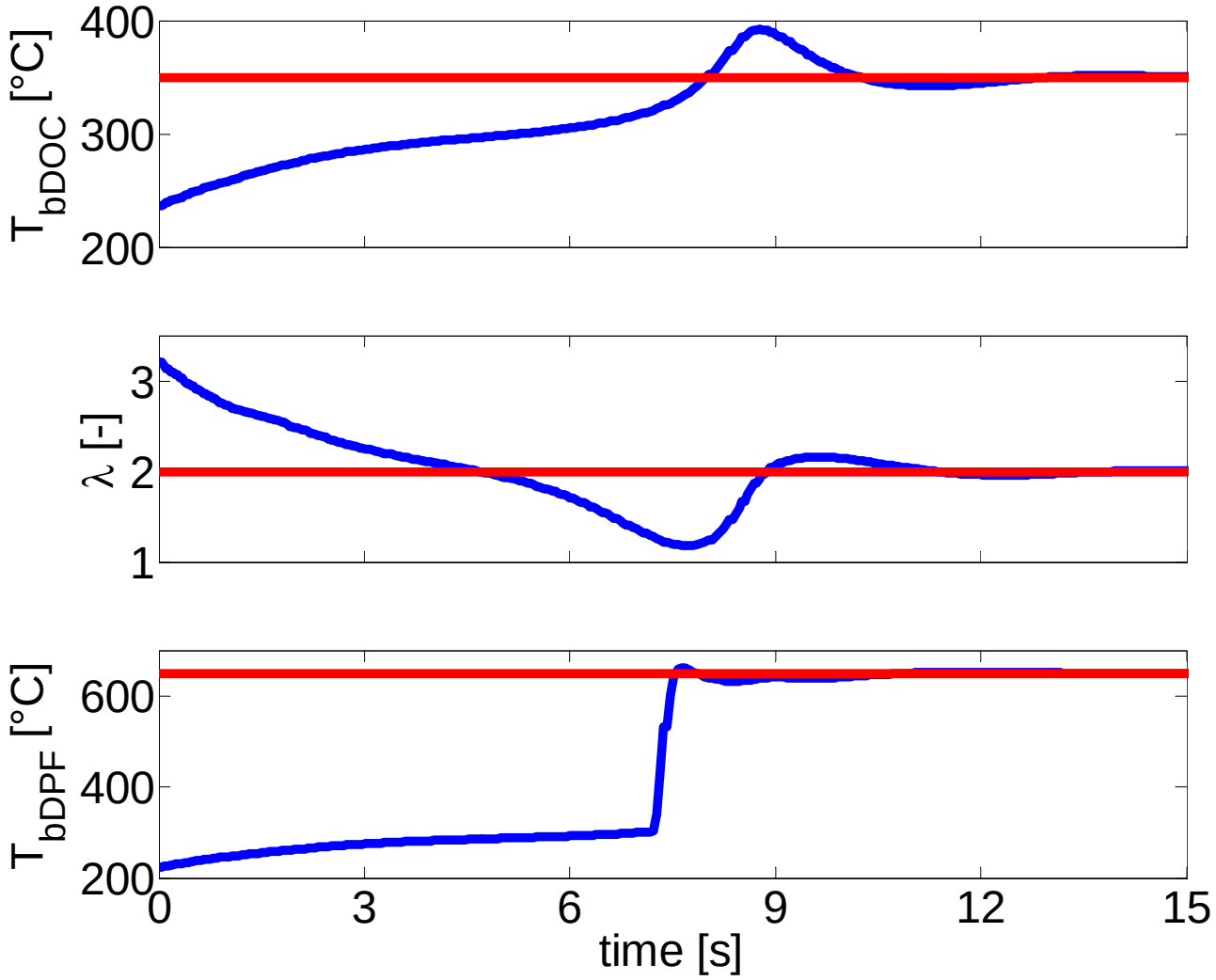
Example: Thermoman. + HC dosing at 2000 rpm, 10%



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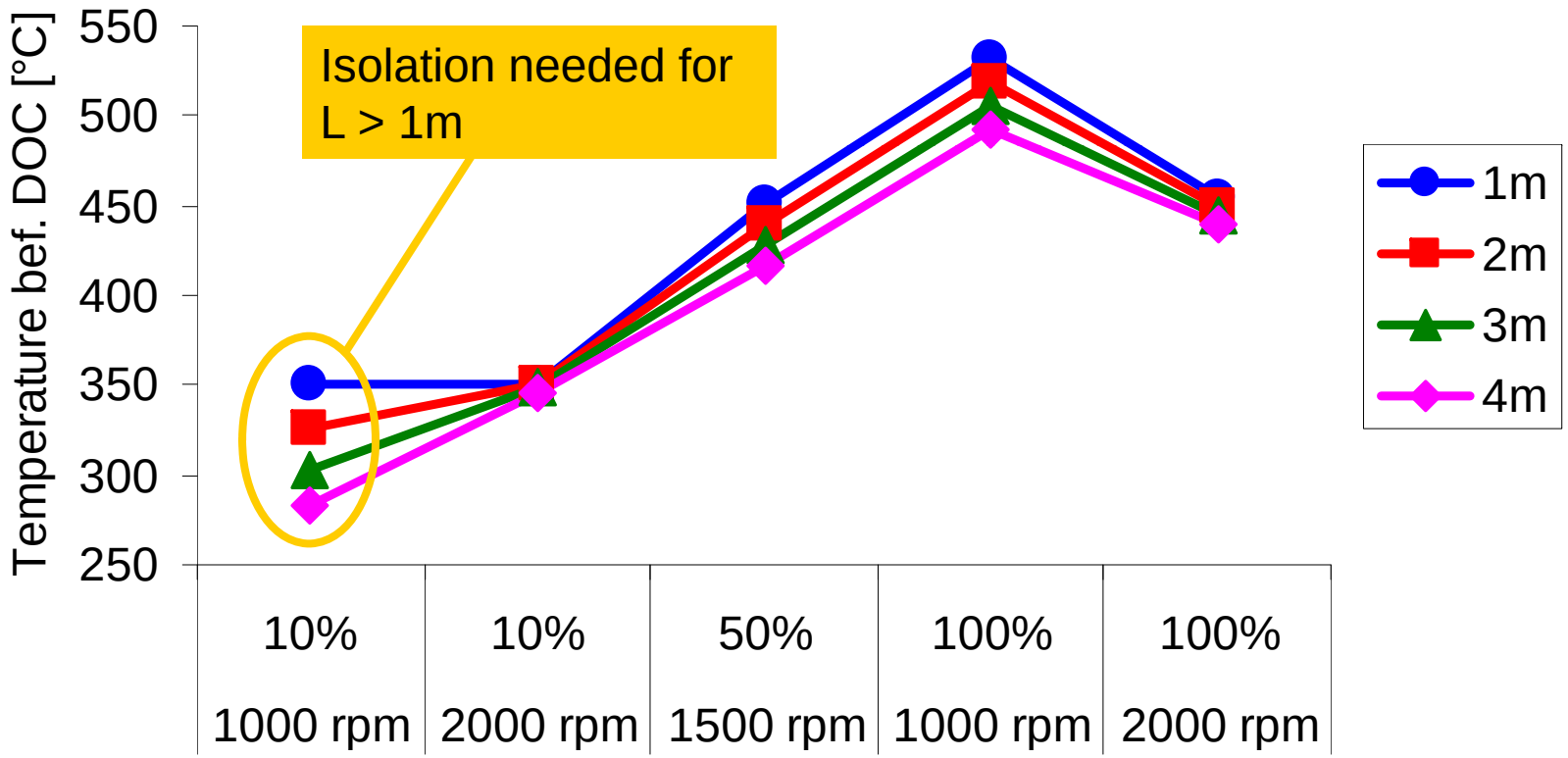
Exhaust piping isolation

- Question: Need for exhaust piping isolation?
- Answer: Test thermoman., variation of piping length 1m ➔ 4m



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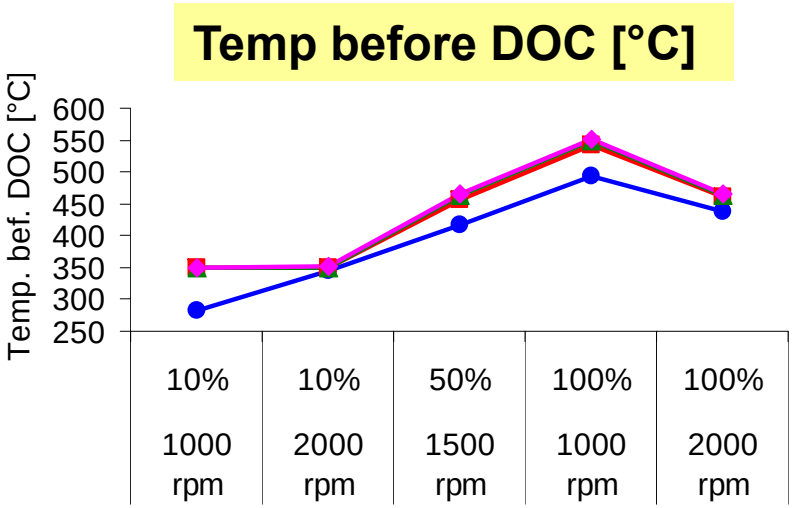
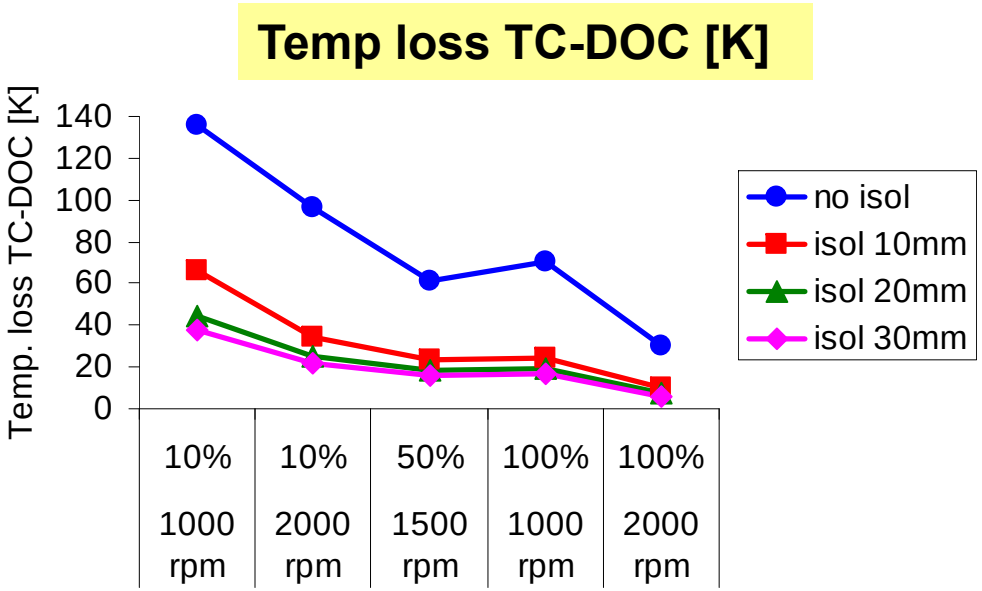
Exhaust piping isolation

- Question: Isolation thickness?
- Answer: Test thermoman., piping length = 4m, increasing isolation thickness





No more improvements by thickness > 20 mm

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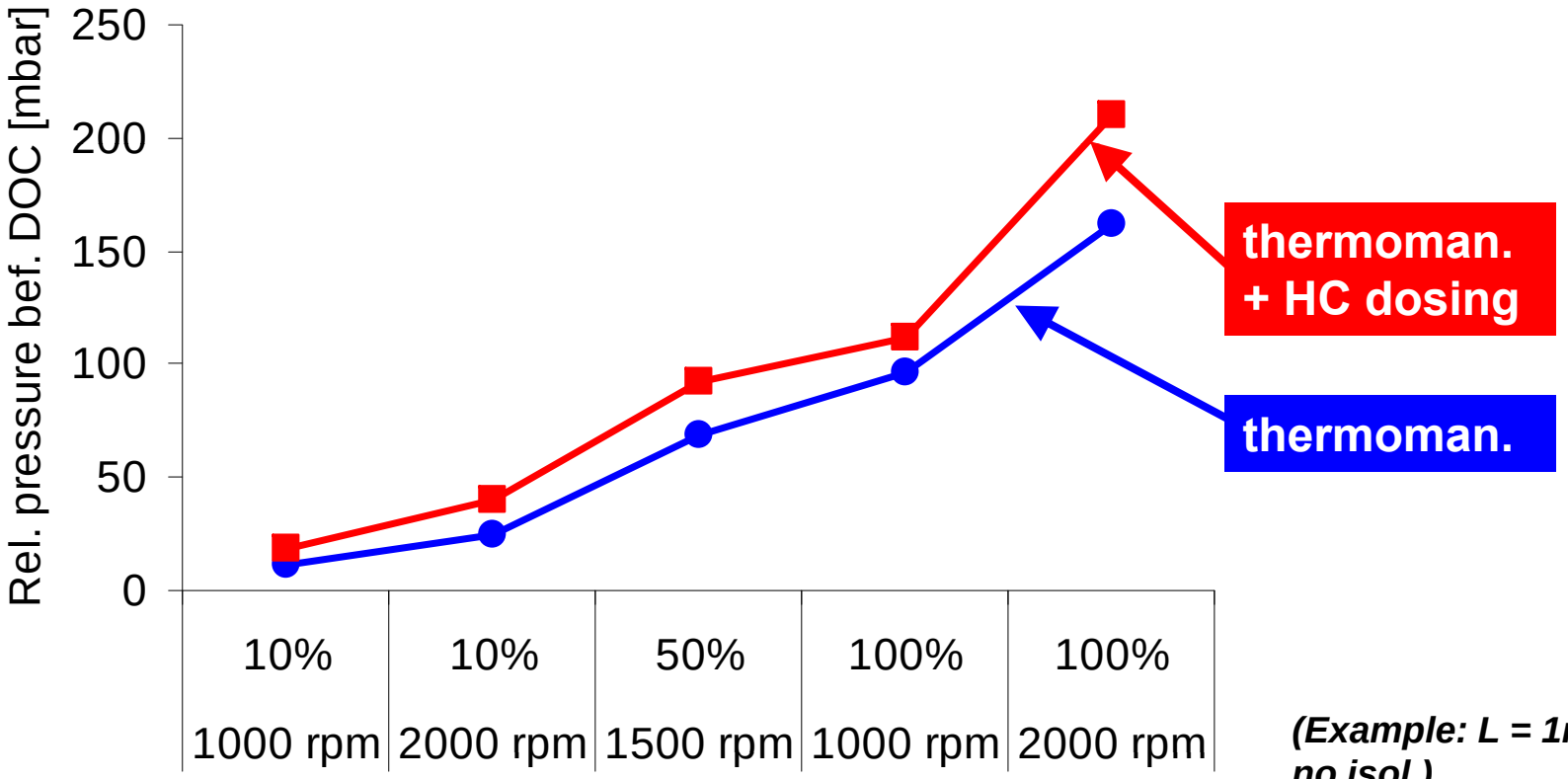
Feedback of HC dosing on thermomanagement

- Question: Feedback of HC dosing?
- Answer: Increased backpressure due to higher mass flow



(Example: L = 1m, no isol.)

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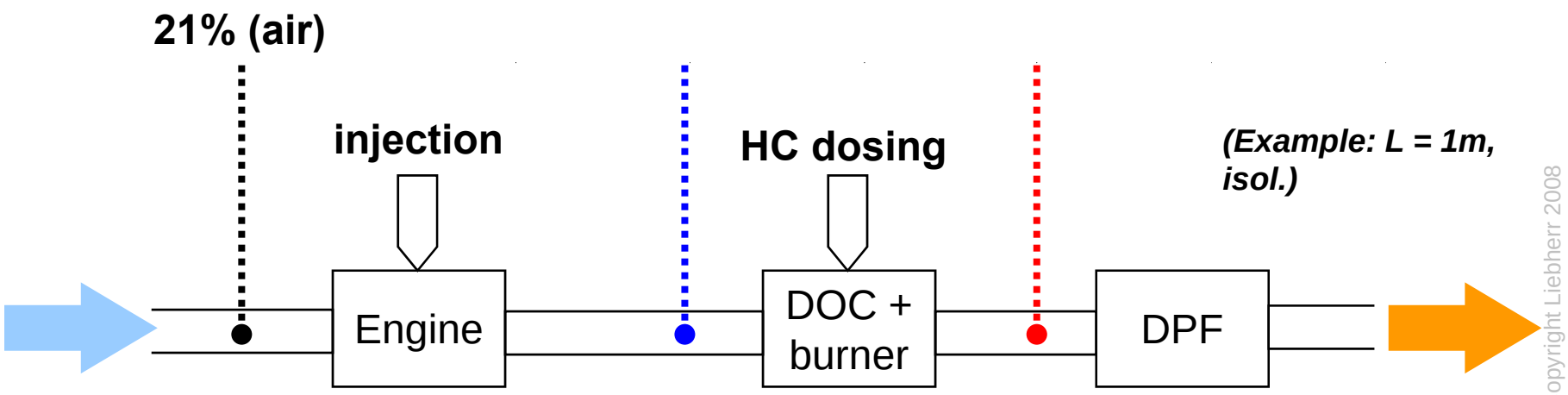
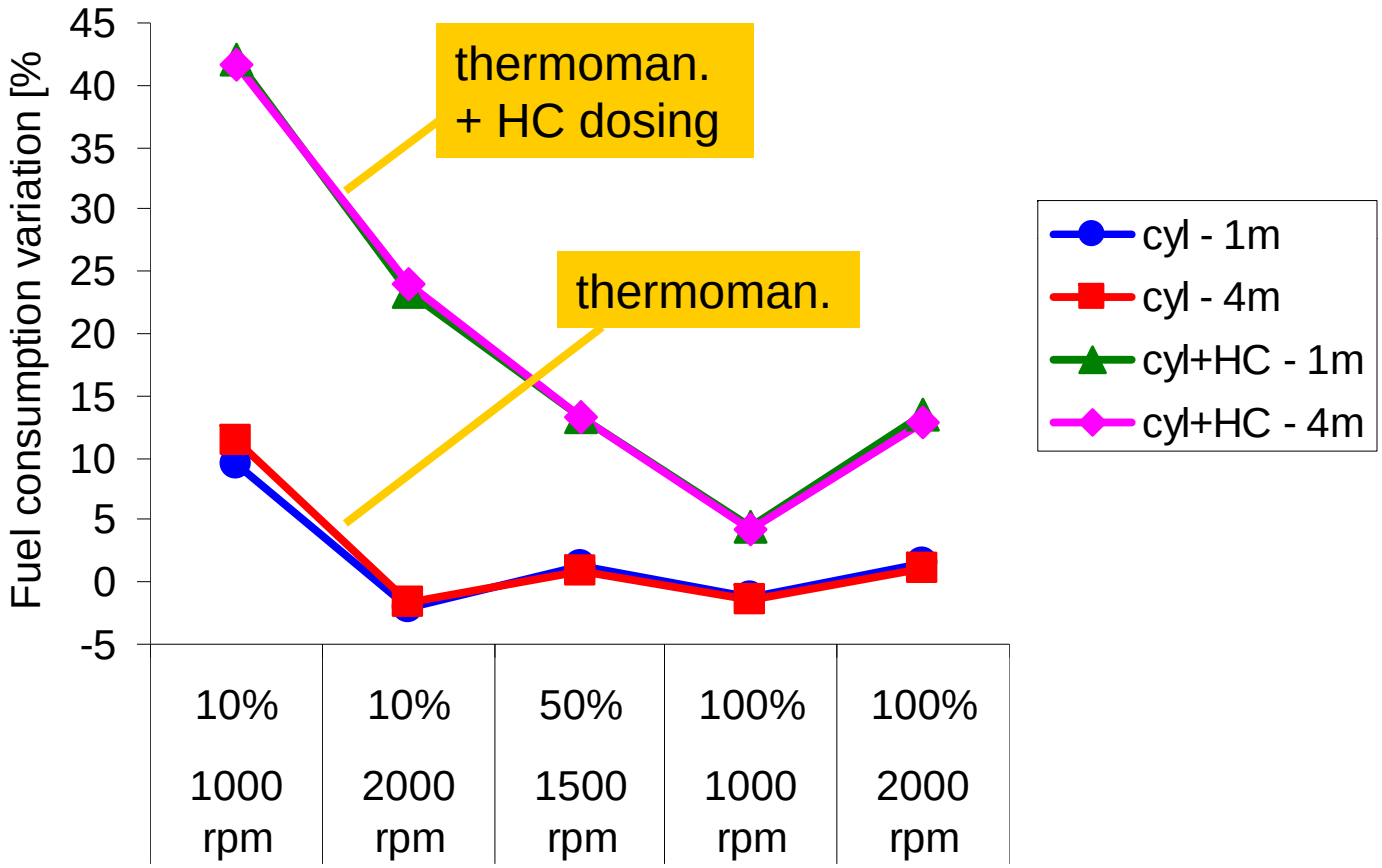
Oxygen concentration analysis



Fuel consumption variation during DPF regeneration

- Question: Fuel consumption increase during regeneration?



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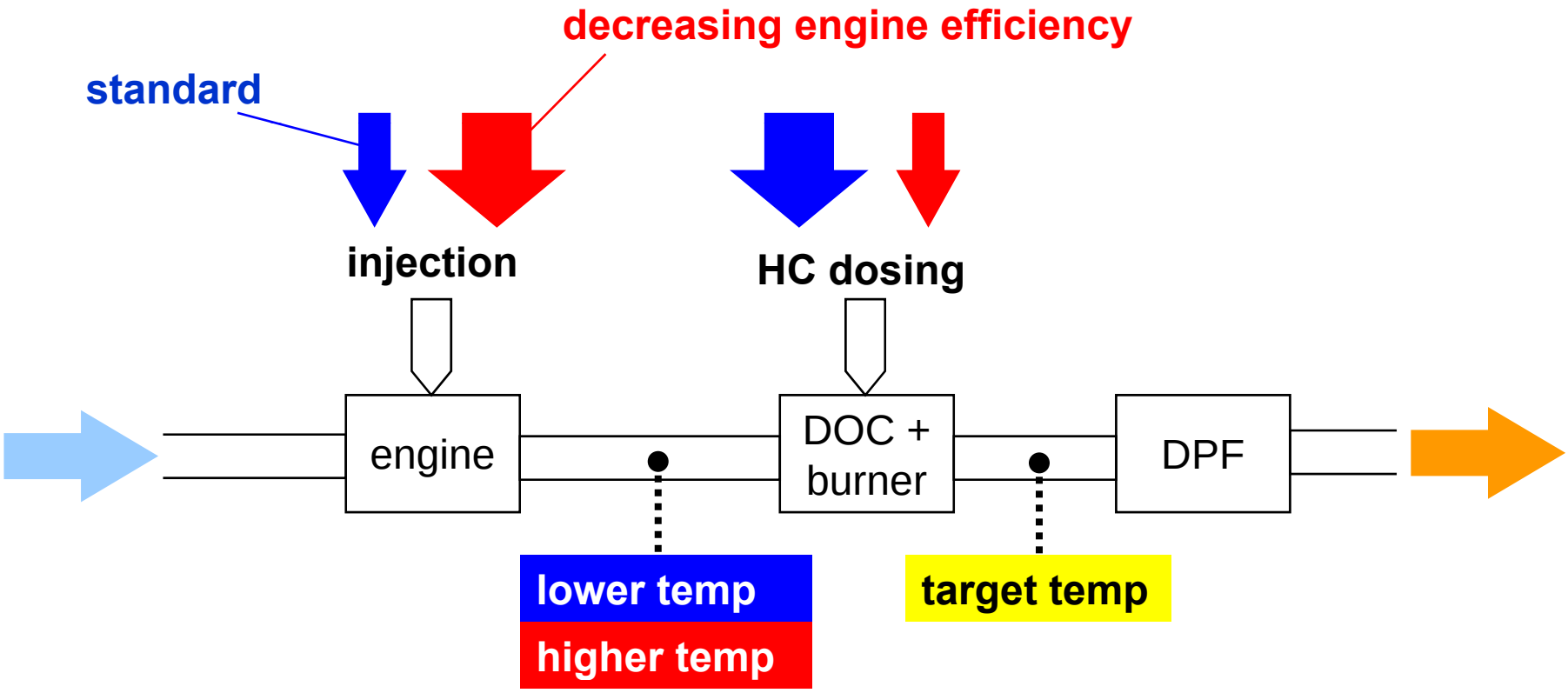
Total fuel consumption optimization

- Question: Is there an optimal strategy for fuel injection splitting between engine and HC doser to achieve the target temperature before DPF?



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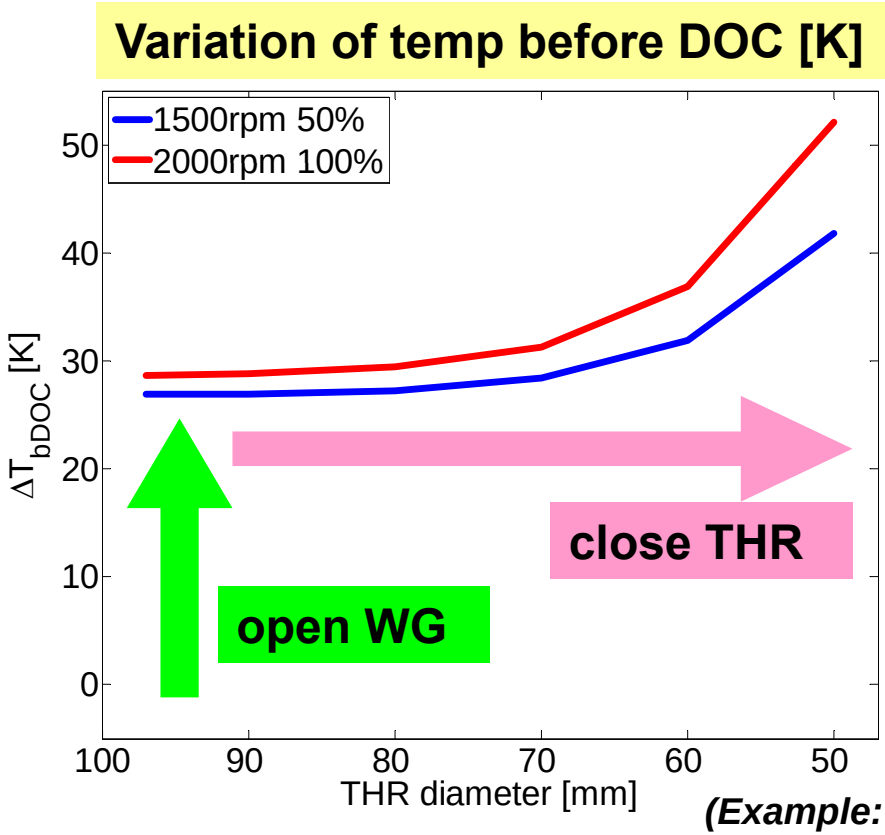
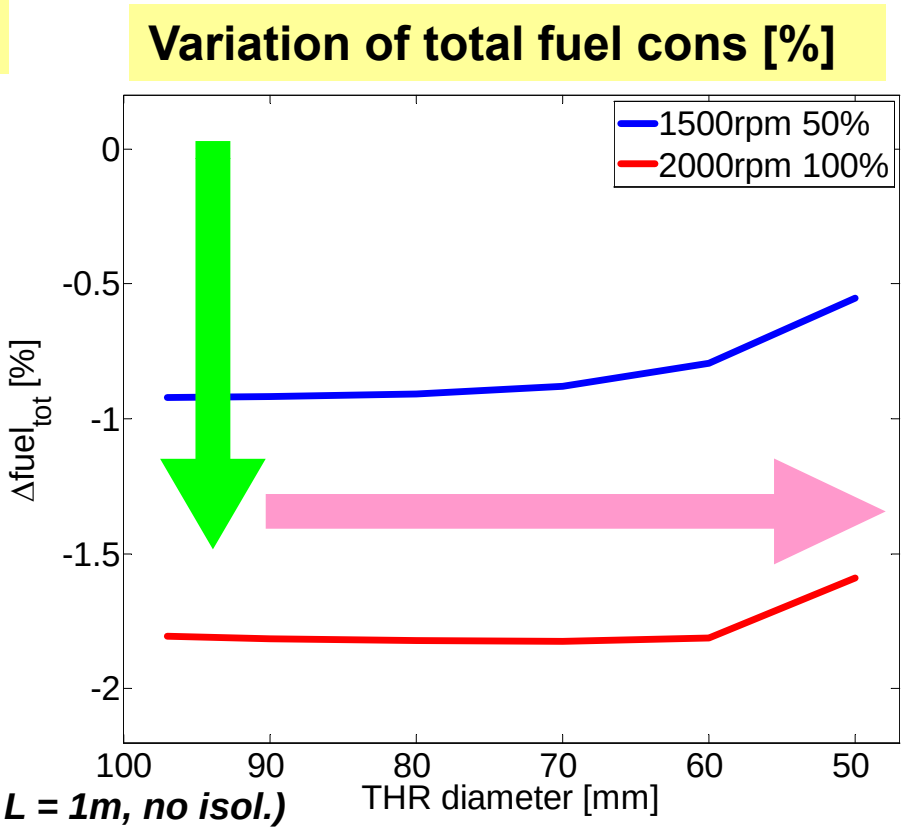
Total fuel consumption optimization

- Answer: Investigation of the effects of WG opening and THR closing (thermoman. not necessary at these 2 operating points)





(Example: L = 1m, no isol.)

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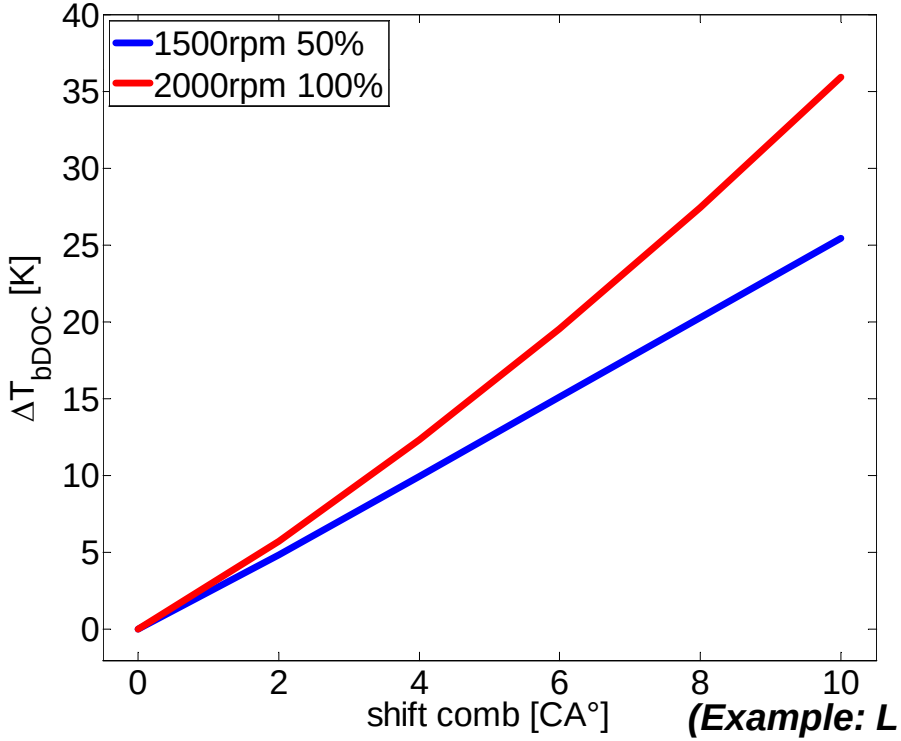
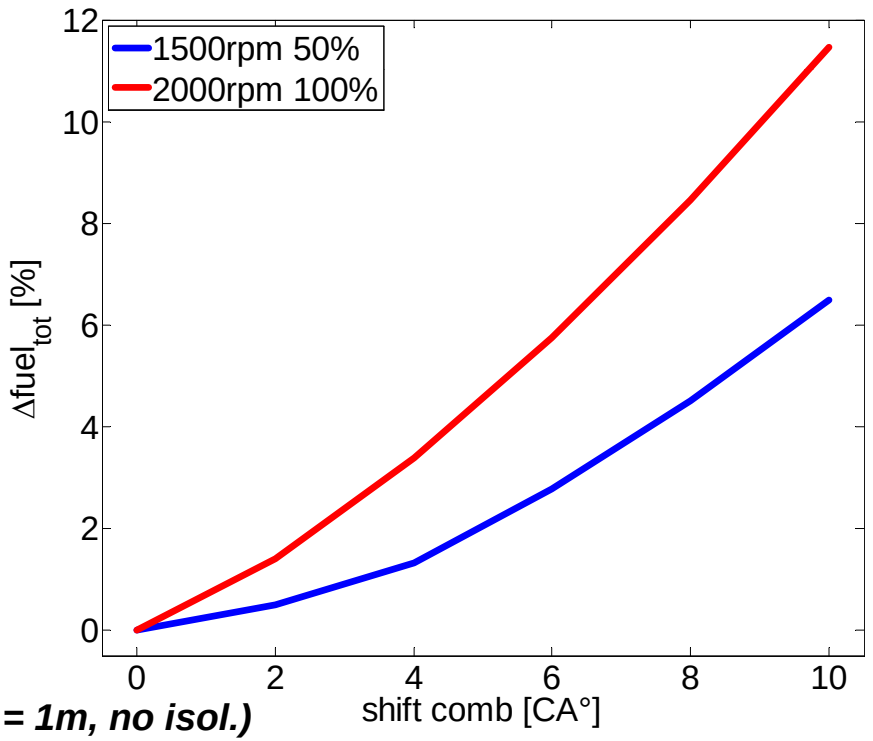
Total fuel consumption optimization

- Answer: Investigation of the effects of shifting combustion to late
- Could be a possibility to reduce NOx during regeneration!

Variation of temp before DOC [K]



Variation of total fuel cons [%]



(Example: L = 1m, no isol.)

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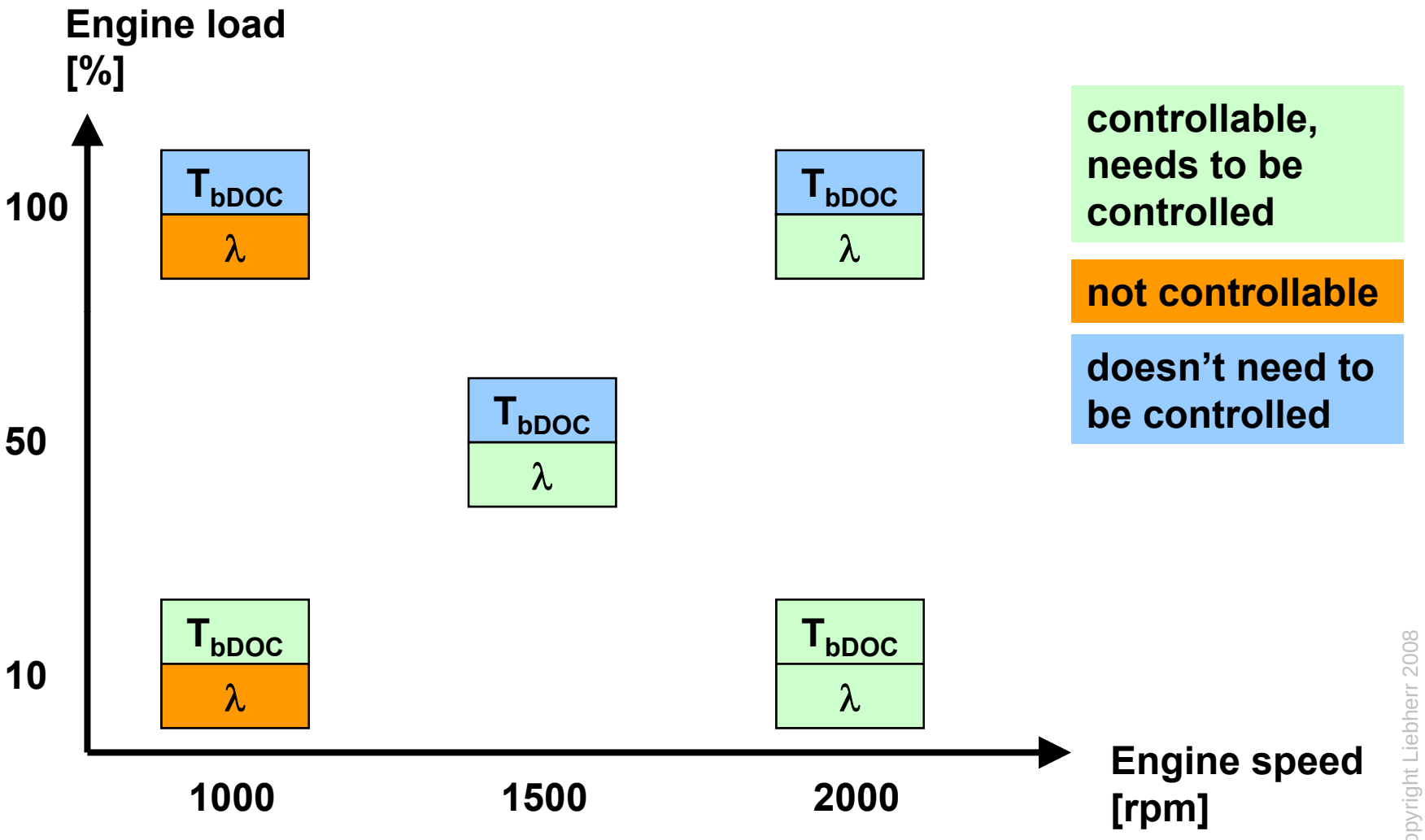
Overview thermomanagement



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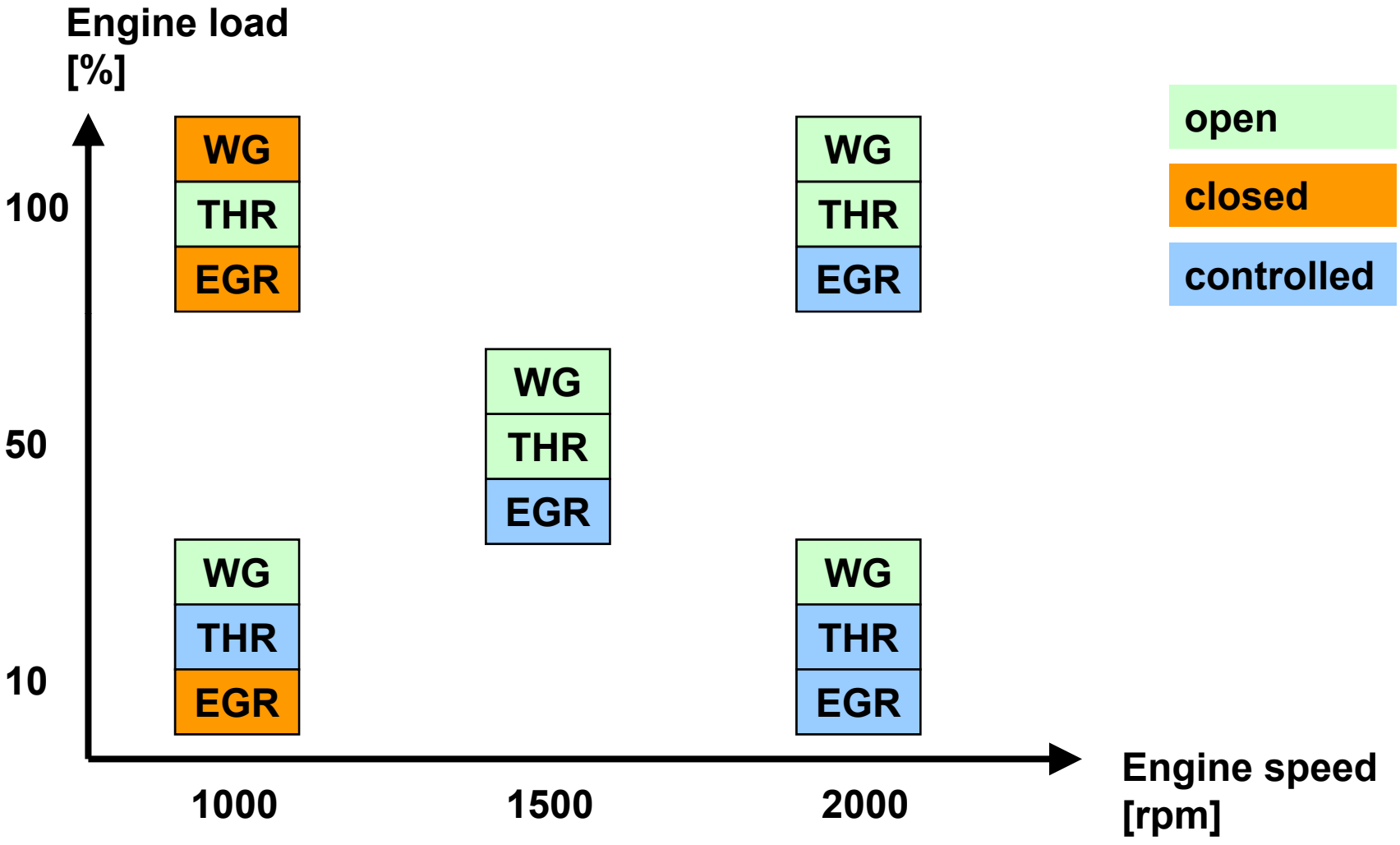
Overview thermomanagement



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Conclusions

- Thermomanagement: Needed at low load
- Isolation:
  - Needed for exhaust piping length > 1m
  - No more improvements by thickness > 20mm
  - Almost same total consumption for all piping lengths 1m - 4m
- 1000 rpm 10% most critical: At L = 4m temp-bef-DOC > 350 °C obtained only with isolation and with very small margin
- Optimal fuel injection splitting: As less fuel as possible in the cylinders, as much as needed in the HC doser

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Outlook

- Simulation of post injection and late-post injection ➔ Injection system model and predictive combustion model needed
- Effect on NOx ➔ Predictive combustion model needed

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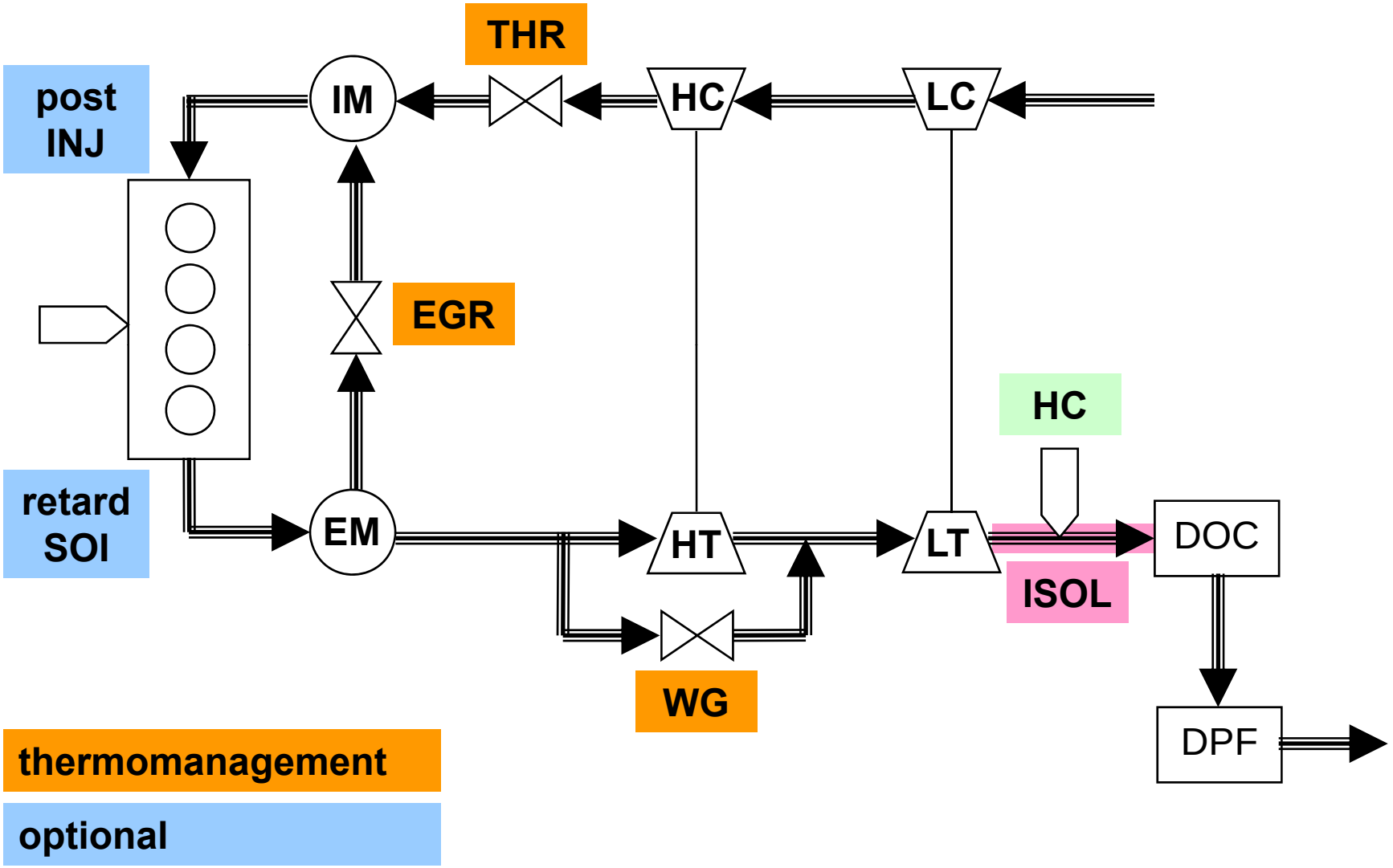
Thank you for your attention!

Do you have questions?

Simulated engine system configuration



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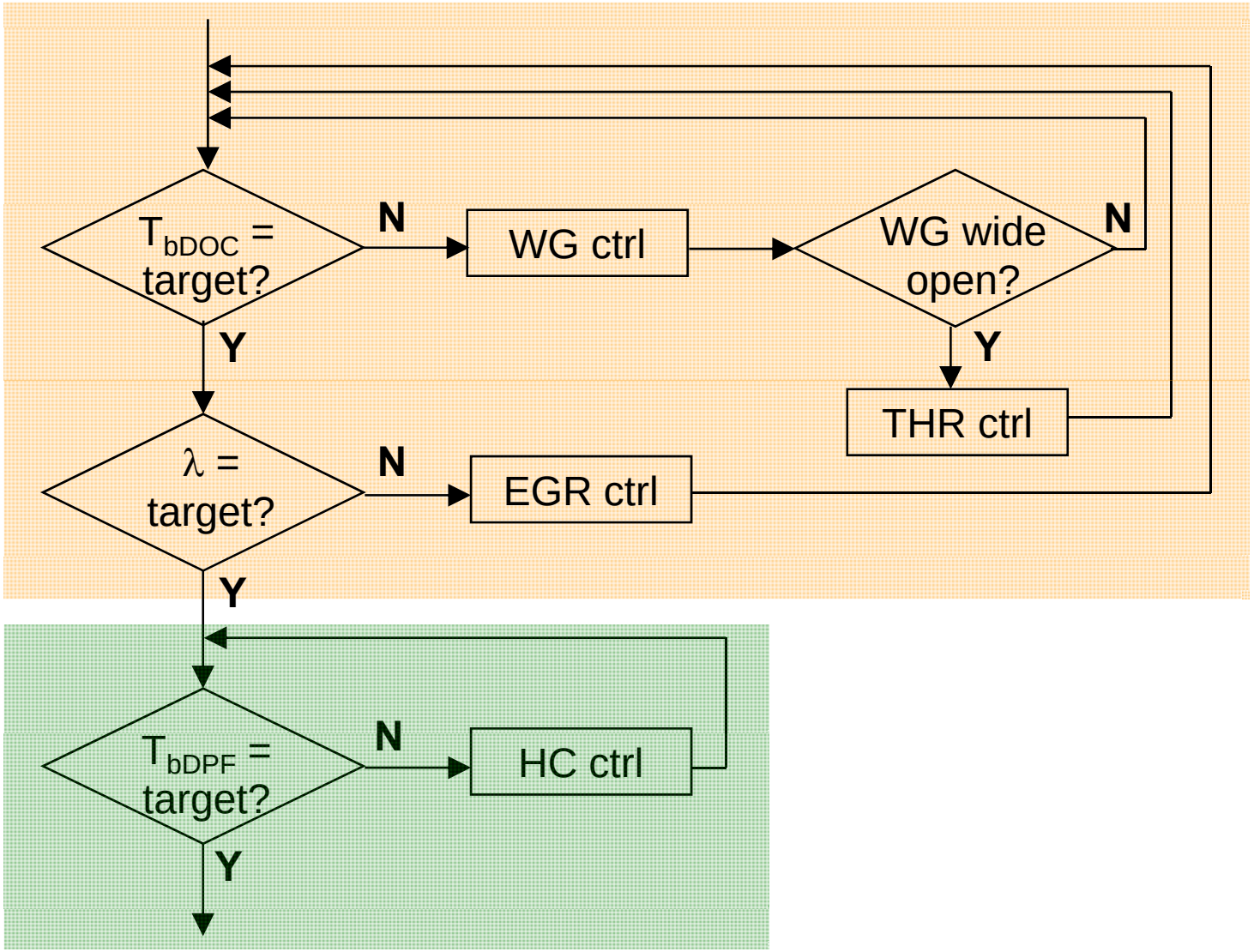
Thermomanagement + HC dosing: Control strategy



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- **Modeling of the aftertreatment system**
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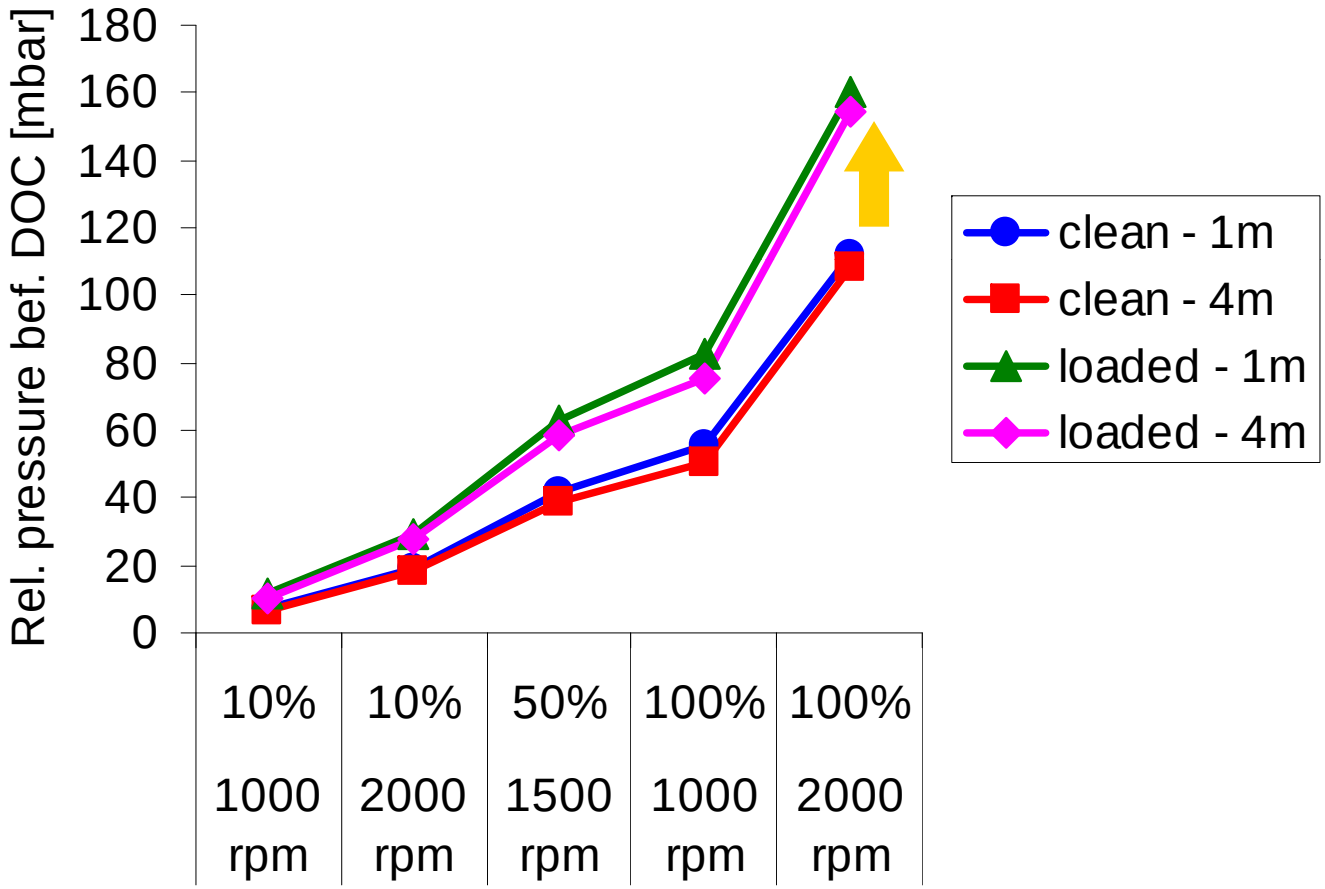
Characterization of the engine operation

- Clean vs. loaded DPF ➔ Effect on backpressure



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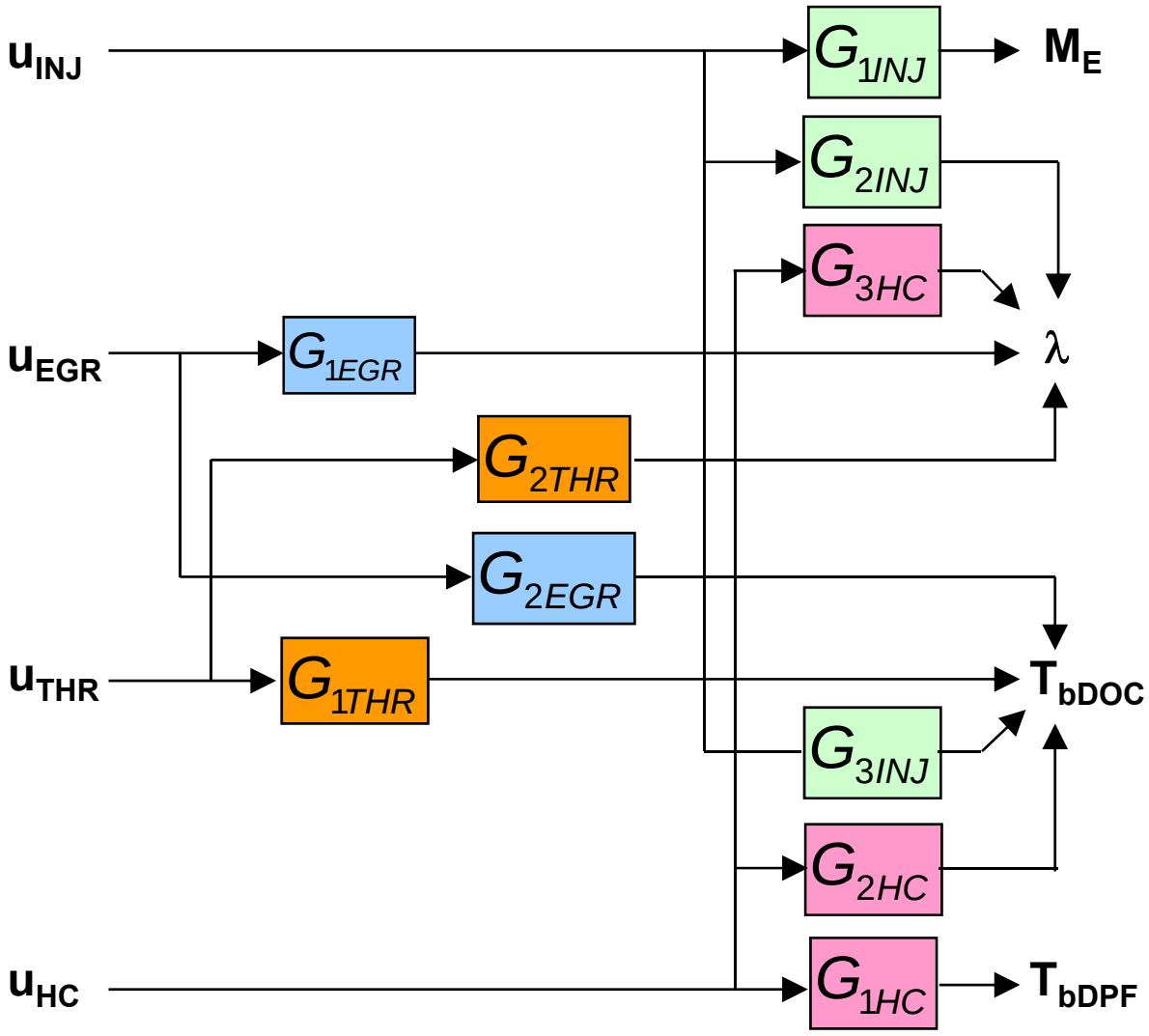
Plant input/output characterization



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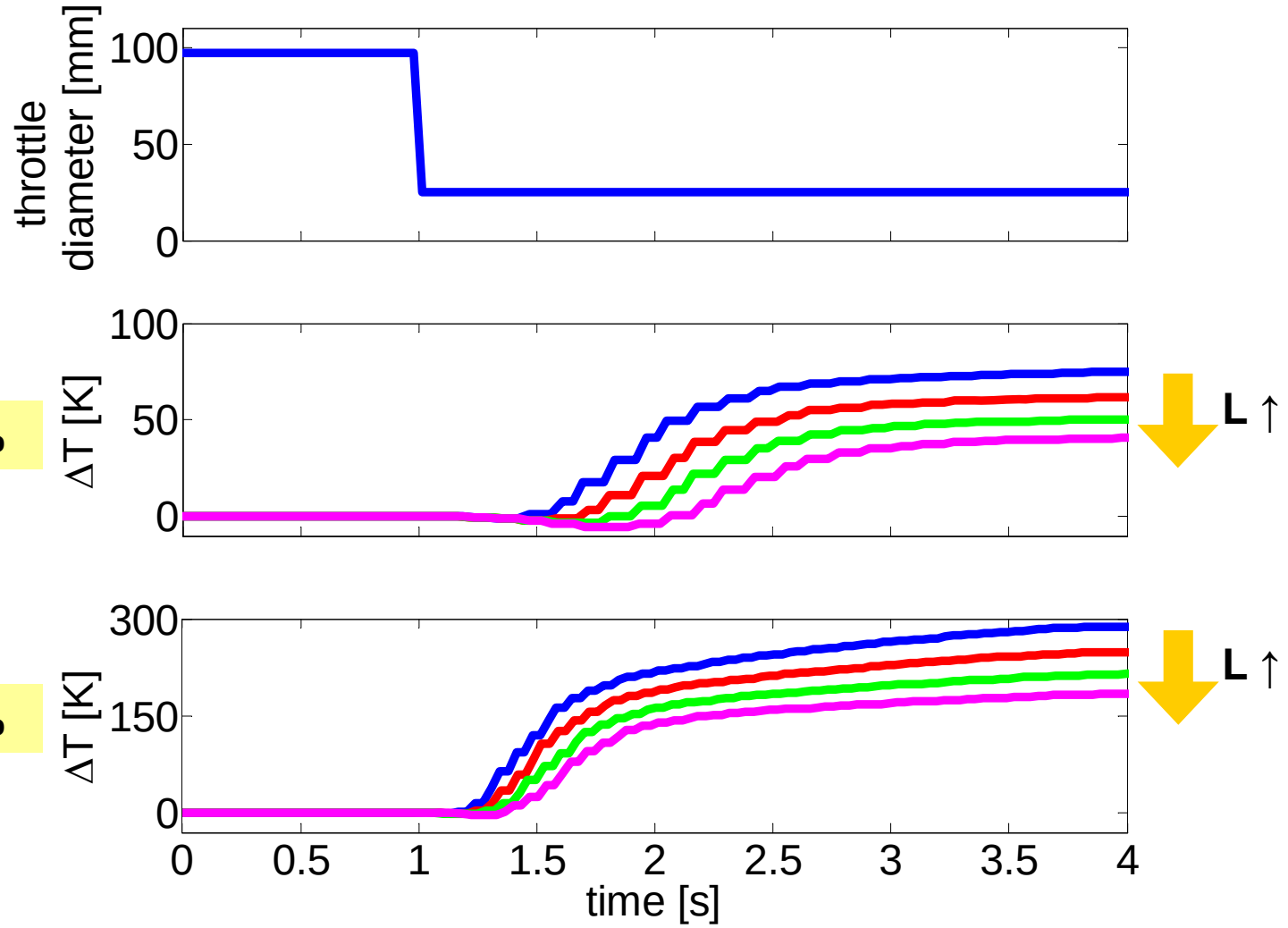
Example: Plant u_{THR} ➔ T_{bDOC} for piping length 1m to 4m

1000 rpm, 10%

2000 rpm, 10%



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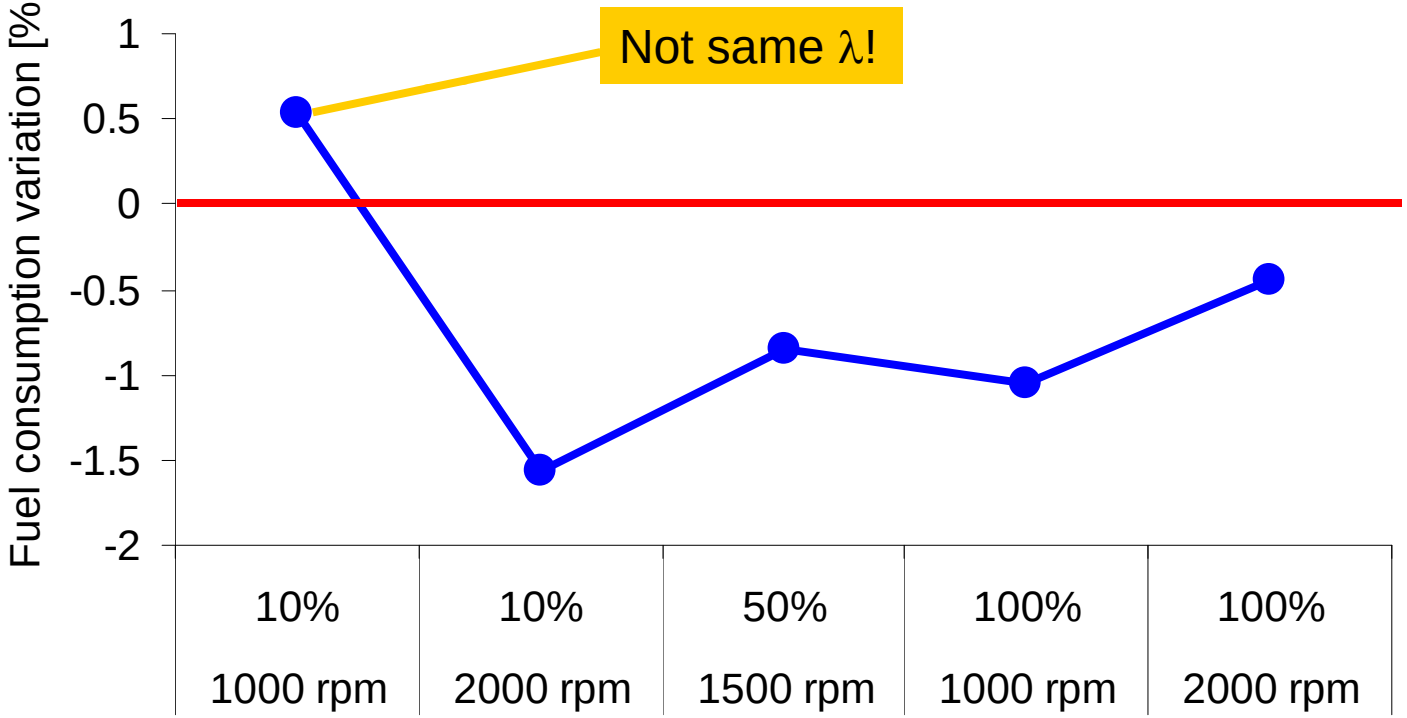
Exhaust piping isolation

- Question: Influence of isolation on total fuel consumption?
- Answer: Test at piping length = 1m (isolation not absolutely necessary at this piping length)



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