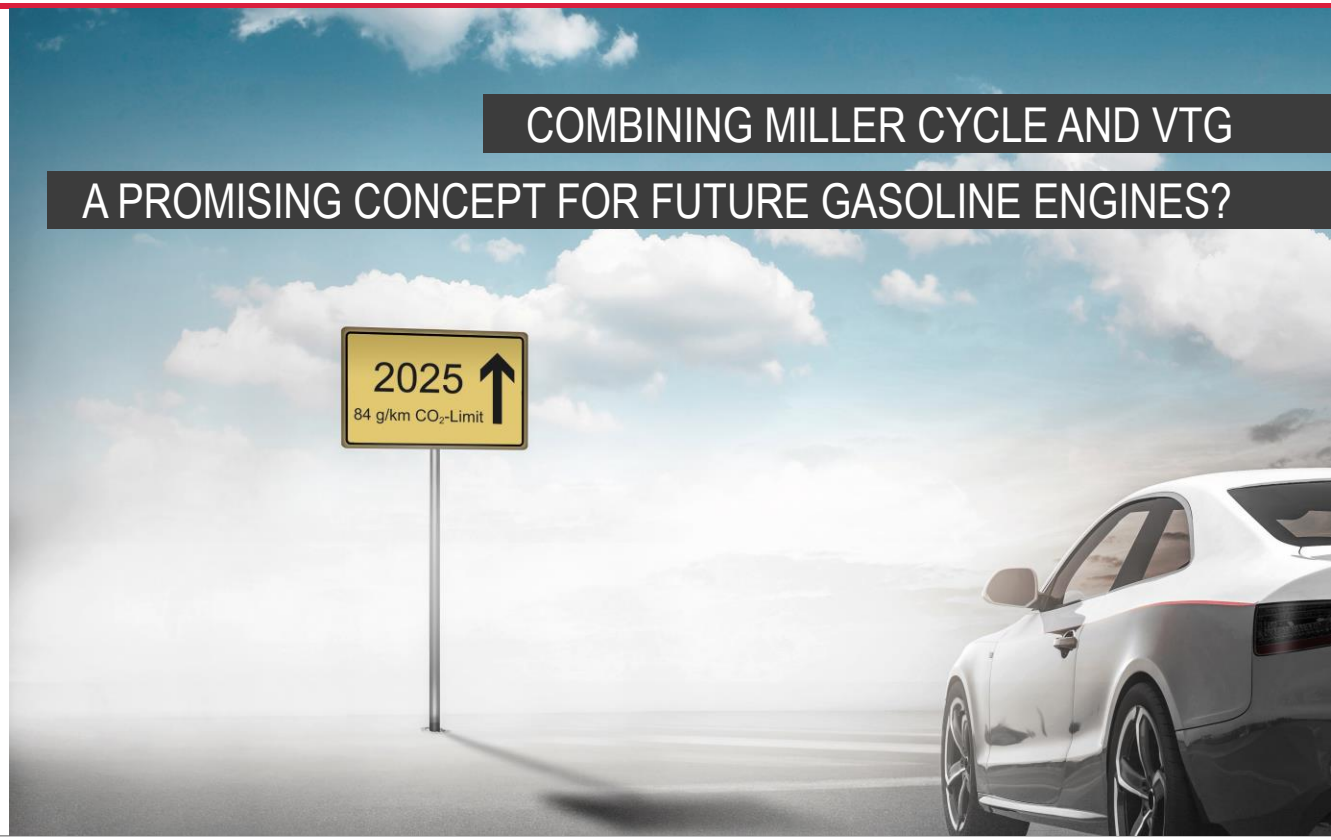
IAC 2016

COMBINING MILLER CYCLE AND VTG

A PROMISING CONCEPT FOR FUTURE GASOLINE ENGINES?

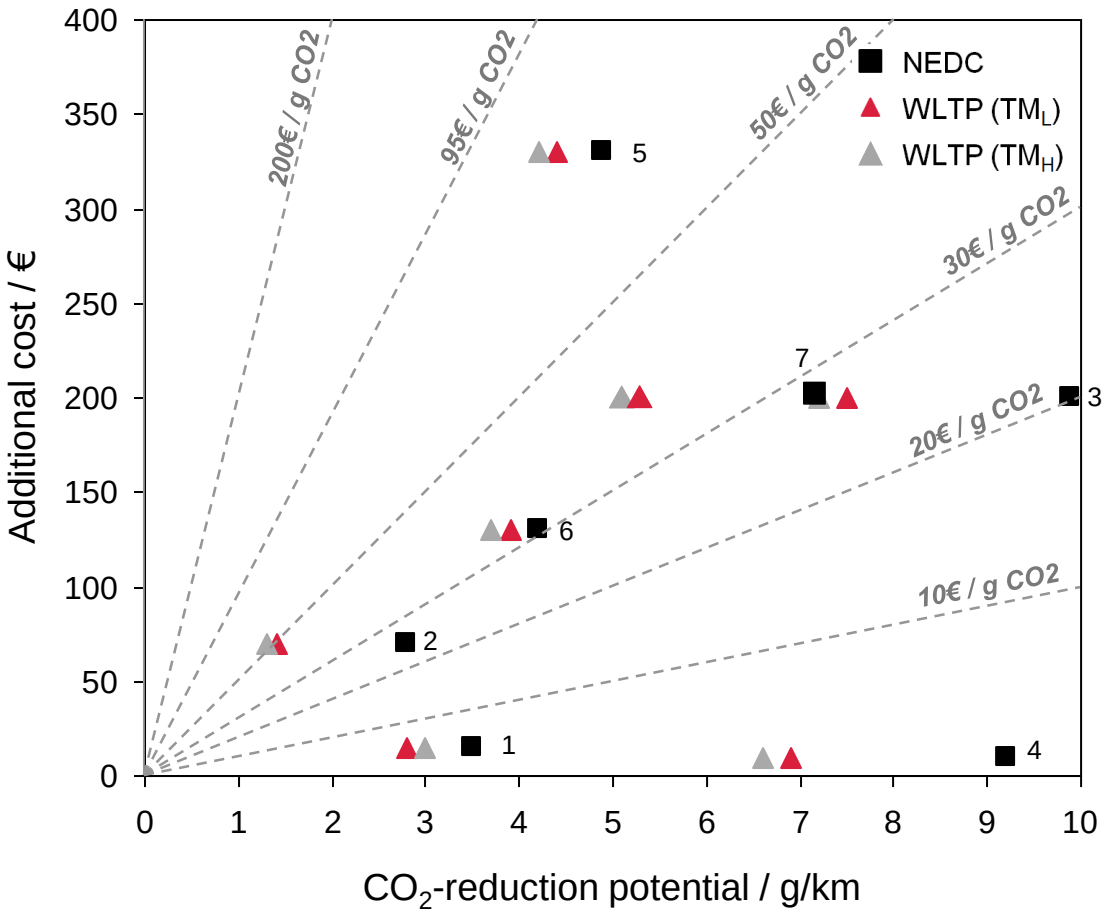


Shanghai, 30.11.2016

R. Aymanns, F. Xia, B. Franzke, D. Lückmann,T. Uhlmann, B. Höpke, R. Tharmakulasingam, Y.Yao

FEV view – “Best CO2/costs ratio with friction optimization, Miller cycle and 2-step VCR”

ASSESSMENT - COSTS VS EFFICIENCY (EXAMPLE CURRENT FEV DEVELOPMENT)



Base Powertrain
TC-GDI 1.0l 3 Cyl. max. torque 200 Nm, specific power 95 kW/l C-segment vehicle with 6 gear MT

#	Base Technology	Technology Change
1	Base friction	Optimized friction (base engine measures)
2	D-VVT	2-step VVL
3	Conventional cycle	Miller w. 2-Stage TC
4	Conventional cycle	Miller w. 1-Stage TC
5	Internal EGR only	cEGR w. 2-Stage TC
6	Internal EGR only	cEGR w. 1-Stage TC
7	No VCR	2-step VCR

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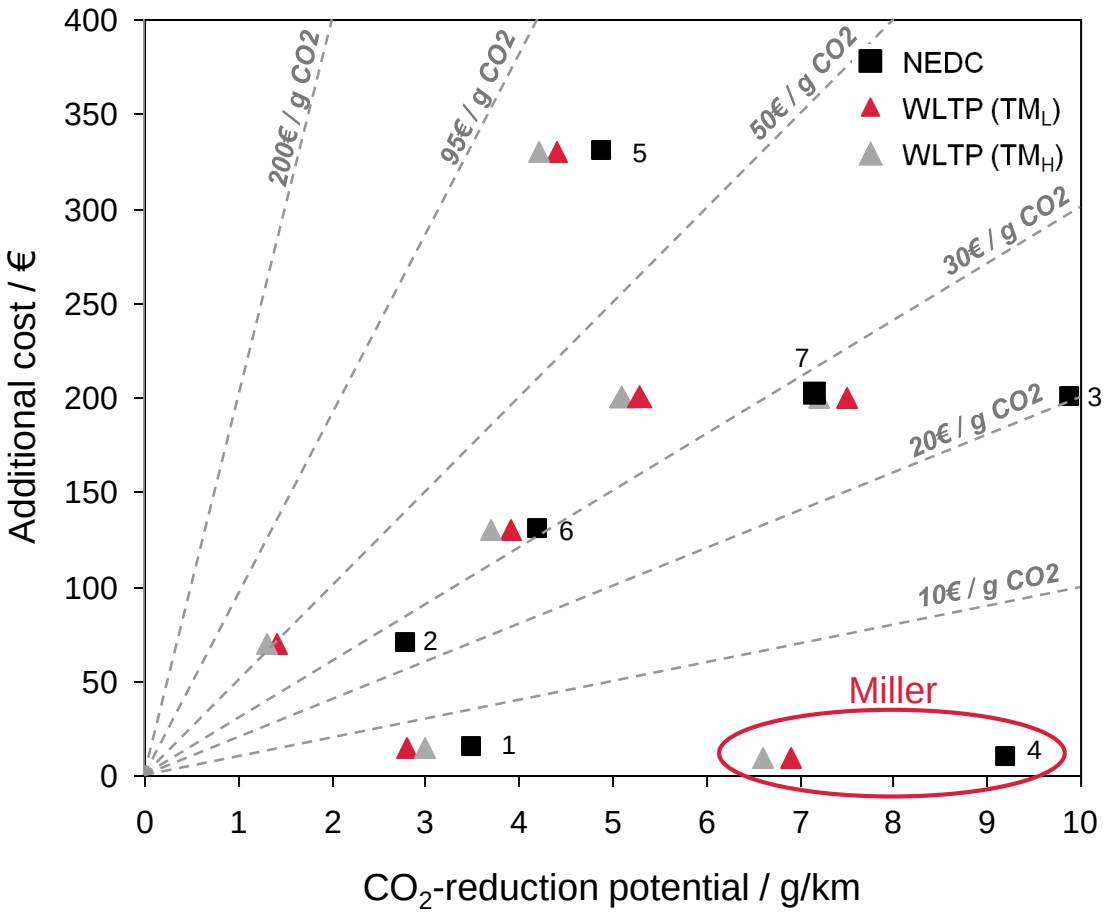

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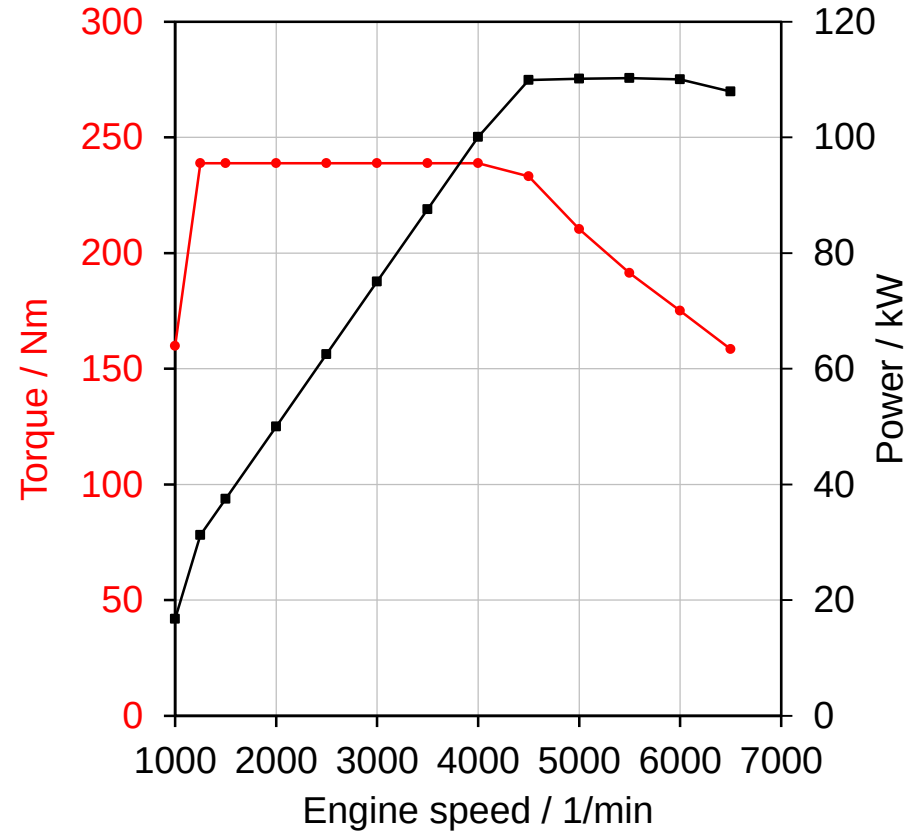
Engine targets and design parameters

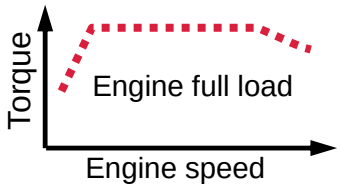
Parameter	Unit	Value
Displacement	l	1.5
Cylinder number	-	3
Compression ratio	-	11.4
Bore/stroke	-	82 / 94.6
Max. torque	Nm	239 @ 1250 1/min
Max. power	kW	110 @ 5500 1/min
Max. Miller ratio	with earliest IVO = 20 °CA bTDC (ref. 1 mm lift)	1.23 / 1.05

$$\text{Miller ratio} = \frac{V_{\text{H, expansion}}}{V_{\text{H, compression, effective}}}$$

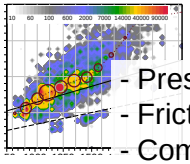


Turbocharger matching process with “FEV TC Tools” for optimized layout

Engine Targets

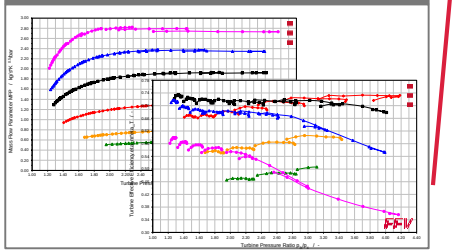


FEV Engine Database

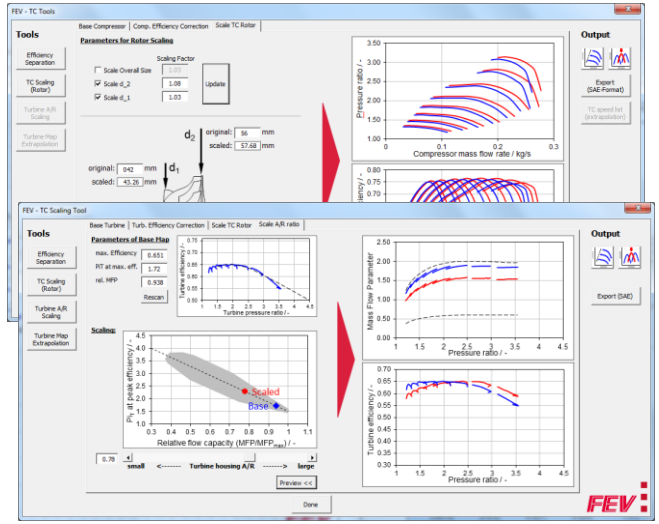


- Pressure losses
- Friction losses
- Combustion profile
- GT-Power models

TC Base Maps



FEV TC Toolkit

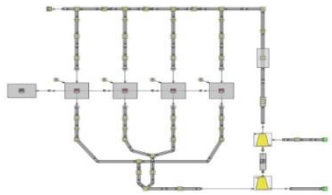


Features

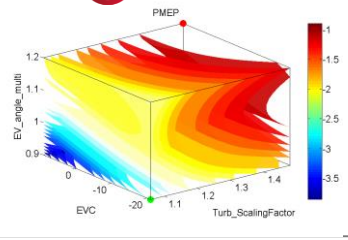
- Efficiency correction
  - heat transfer
  - friction
- Scaling
  - global scaling
  - housing variation
- Map extrapolation
  - incl. VGT

DOE Optimization

GT-Power

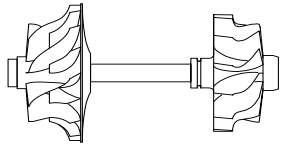


FEV TOPEXPERT

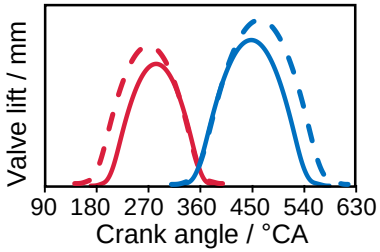


Optimized Matching

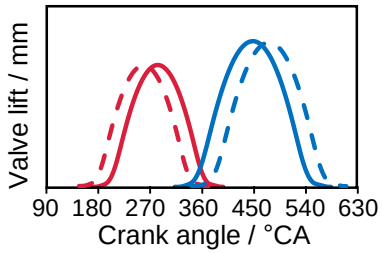
TC layout



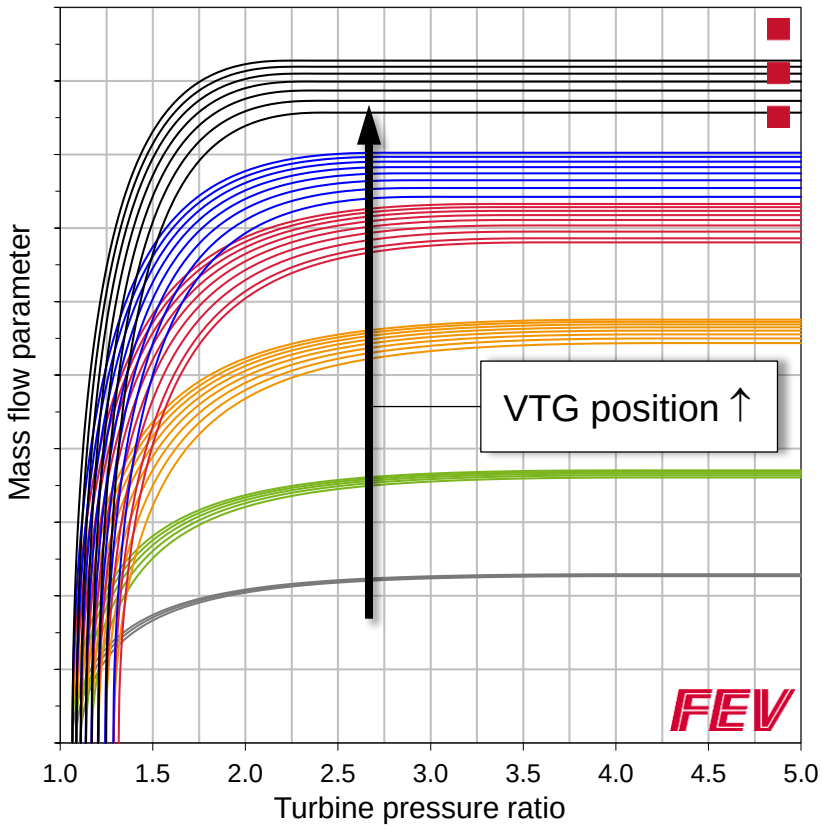
Valve layout

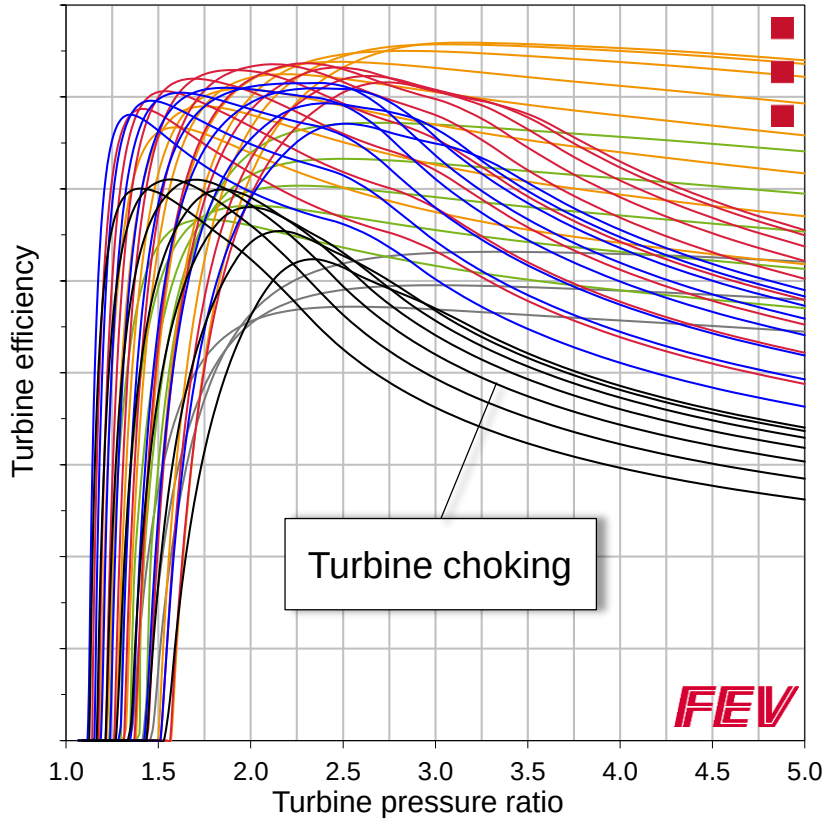


Valve timing

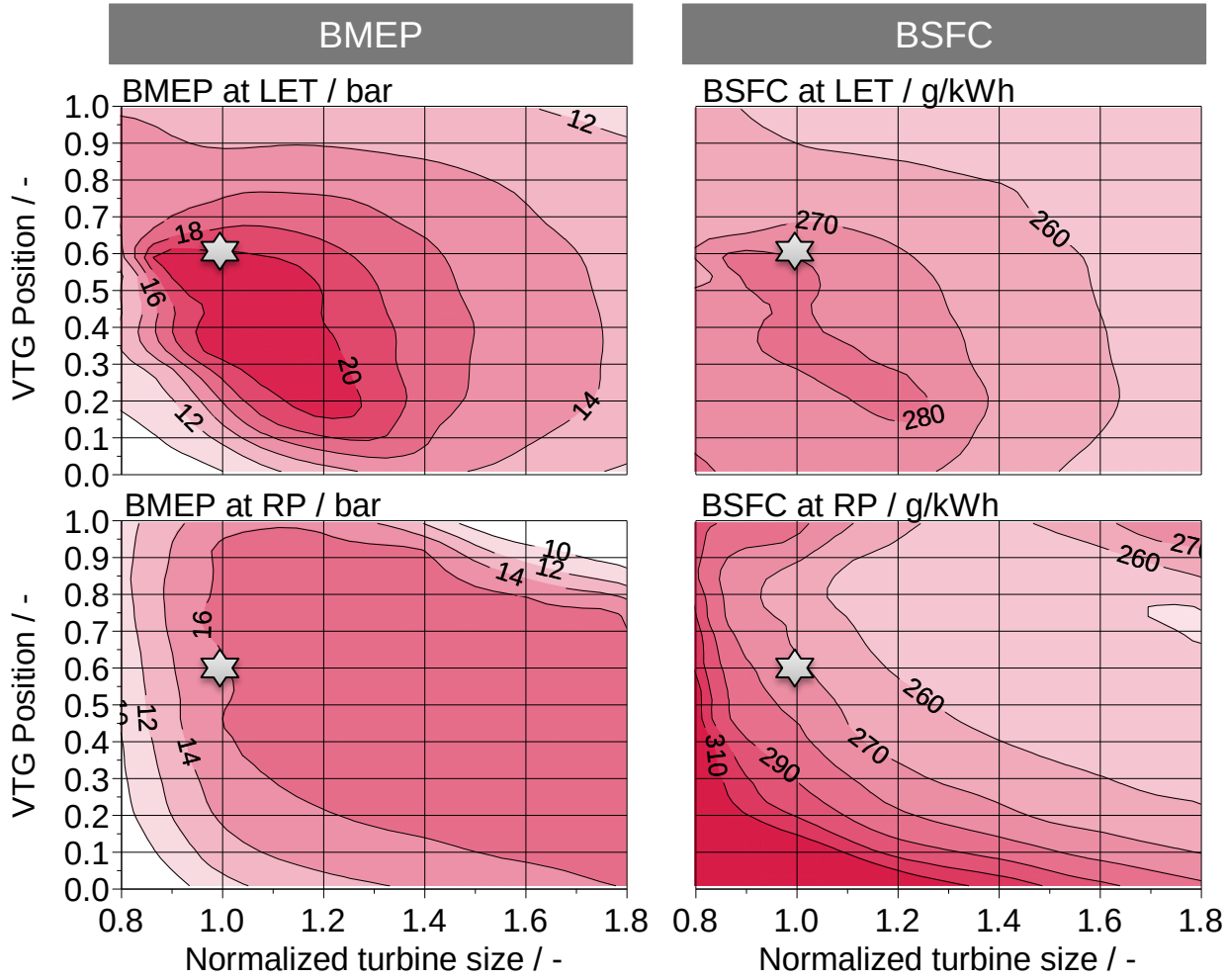


“FEV TC Tools” – Full extrapolation of turbine maps (incl. VTG)





Turbocharger matching results for three turbine configurations

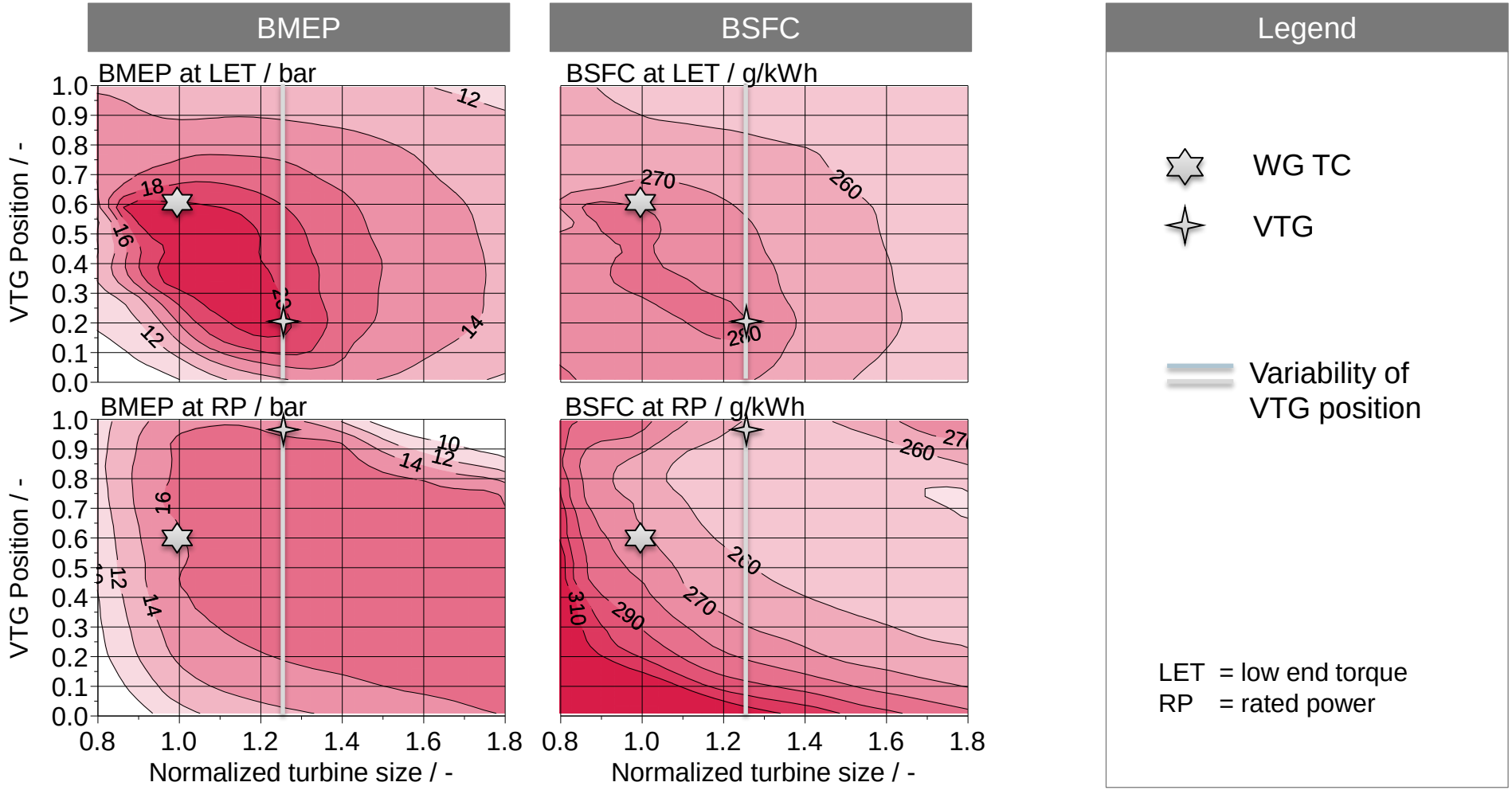


Legend

WG TC

LET = low end torque
RP = rated power

Turbocharger matching results for three turbine configurations



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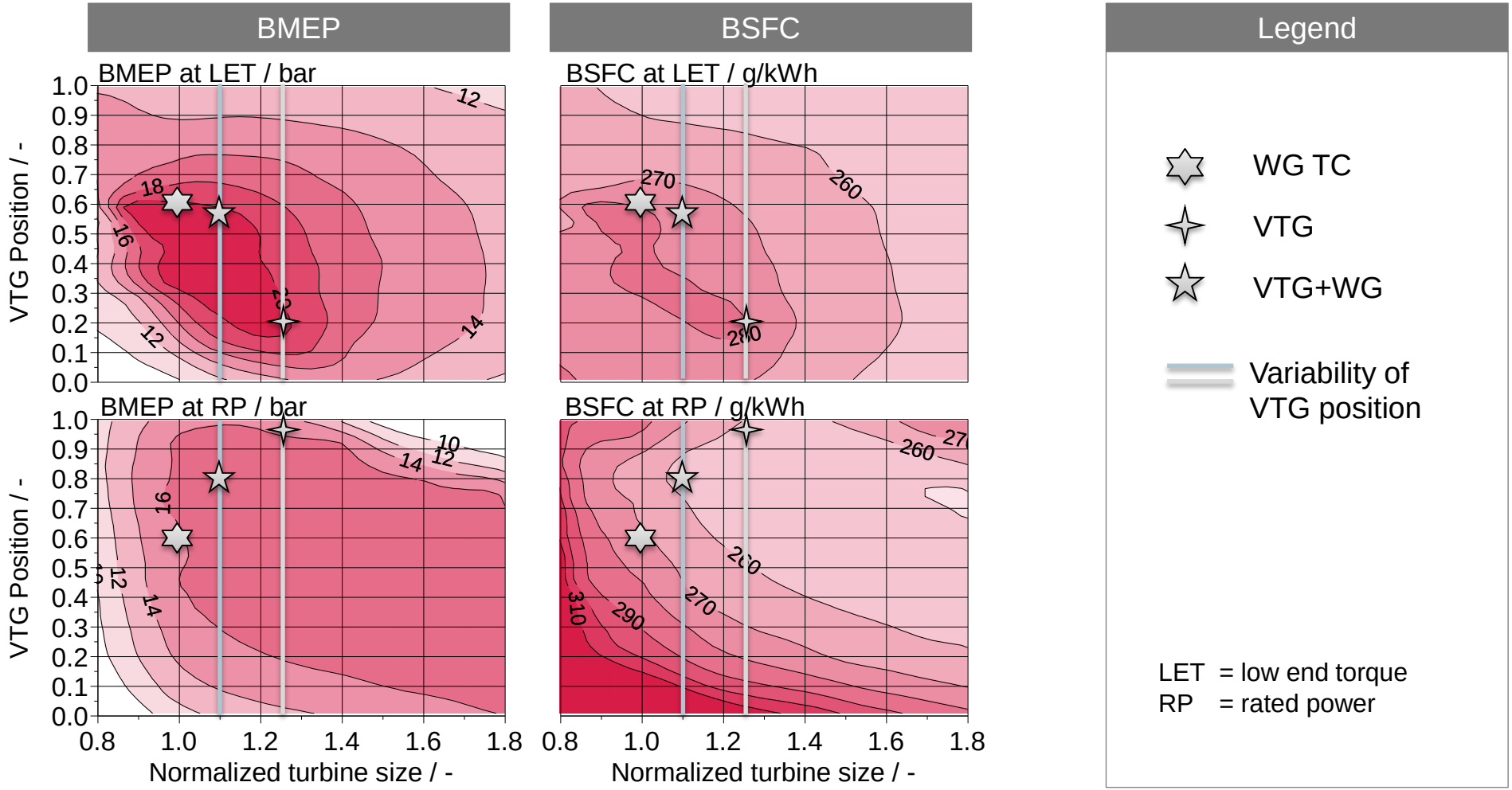

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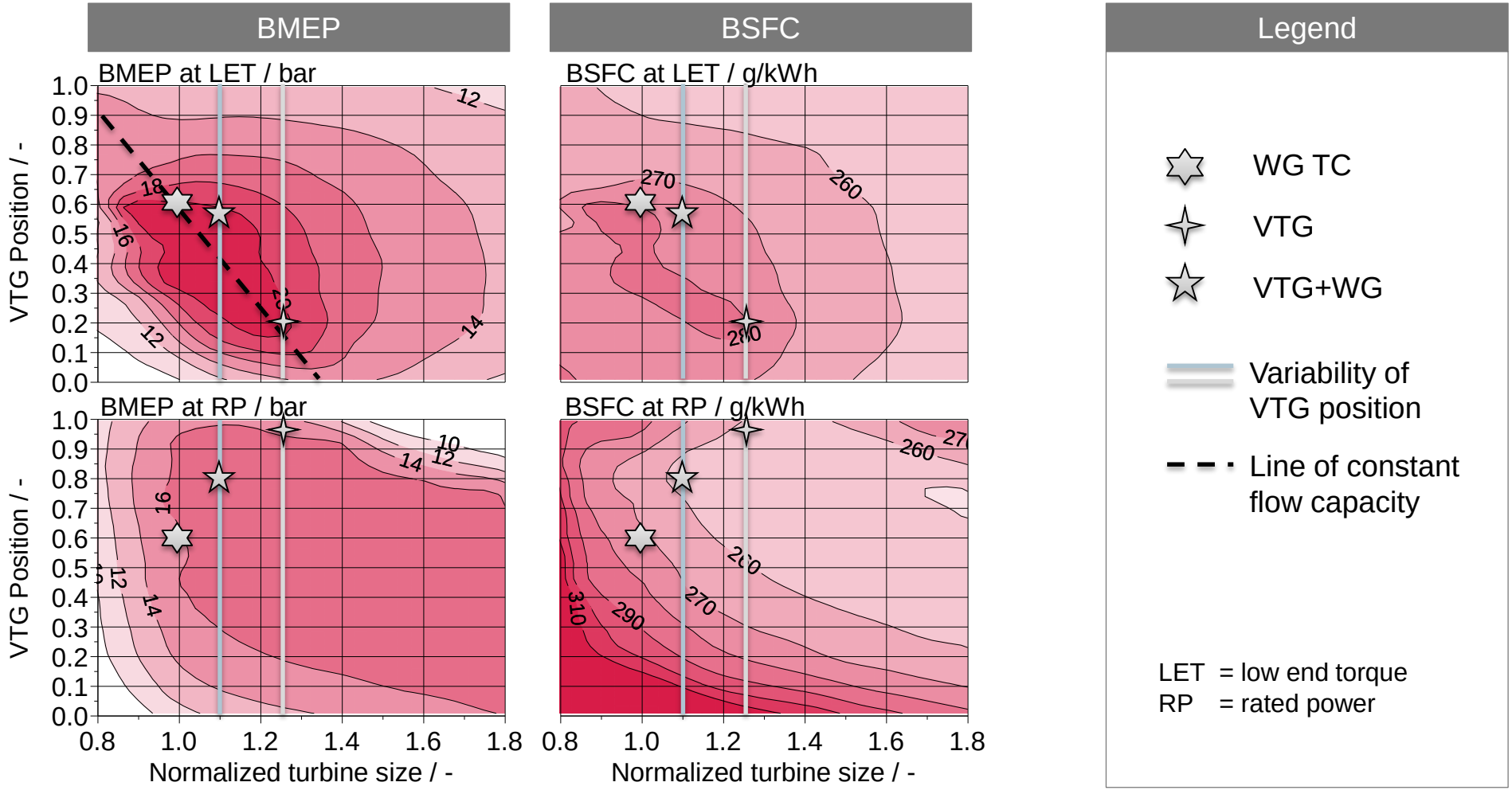
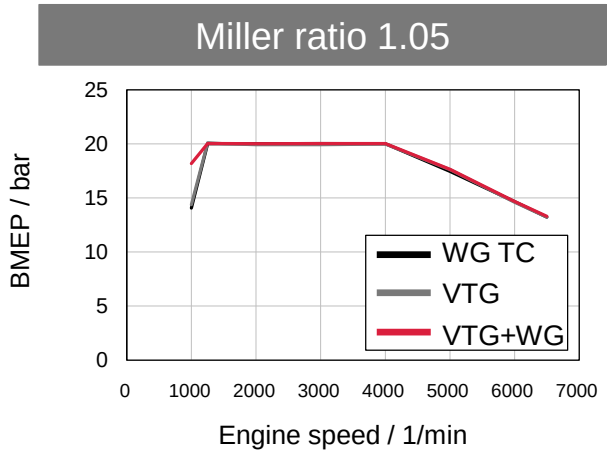


Engine performance results at full load operation



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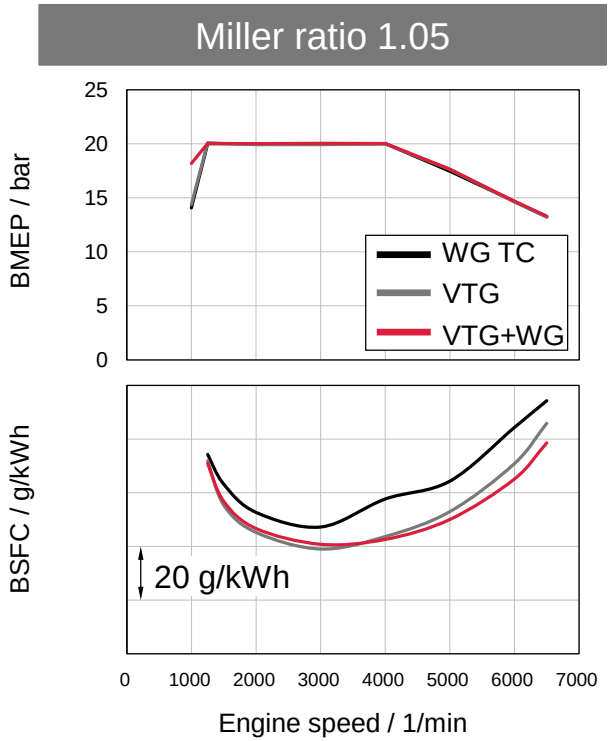

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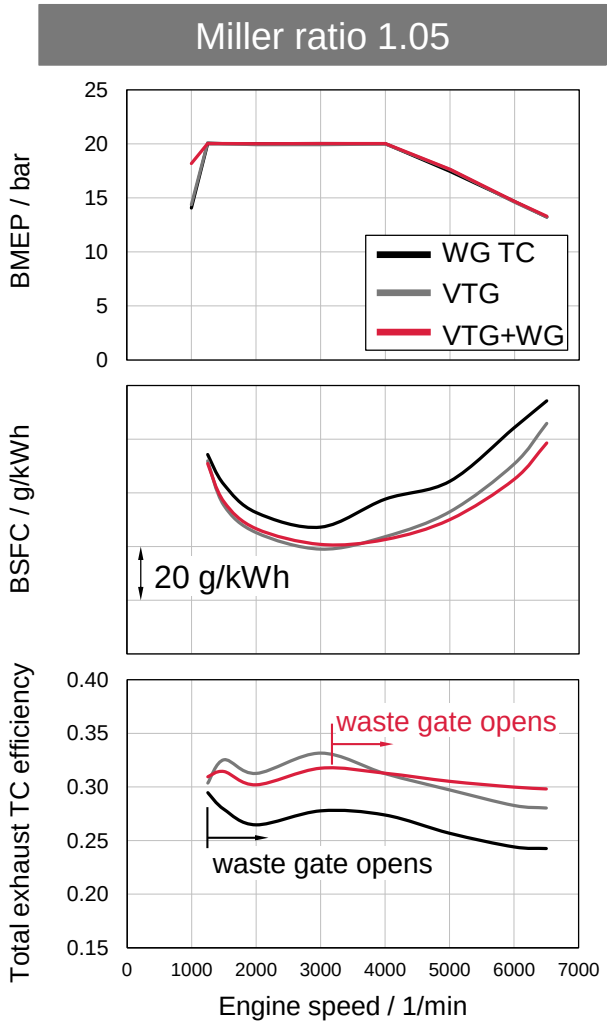

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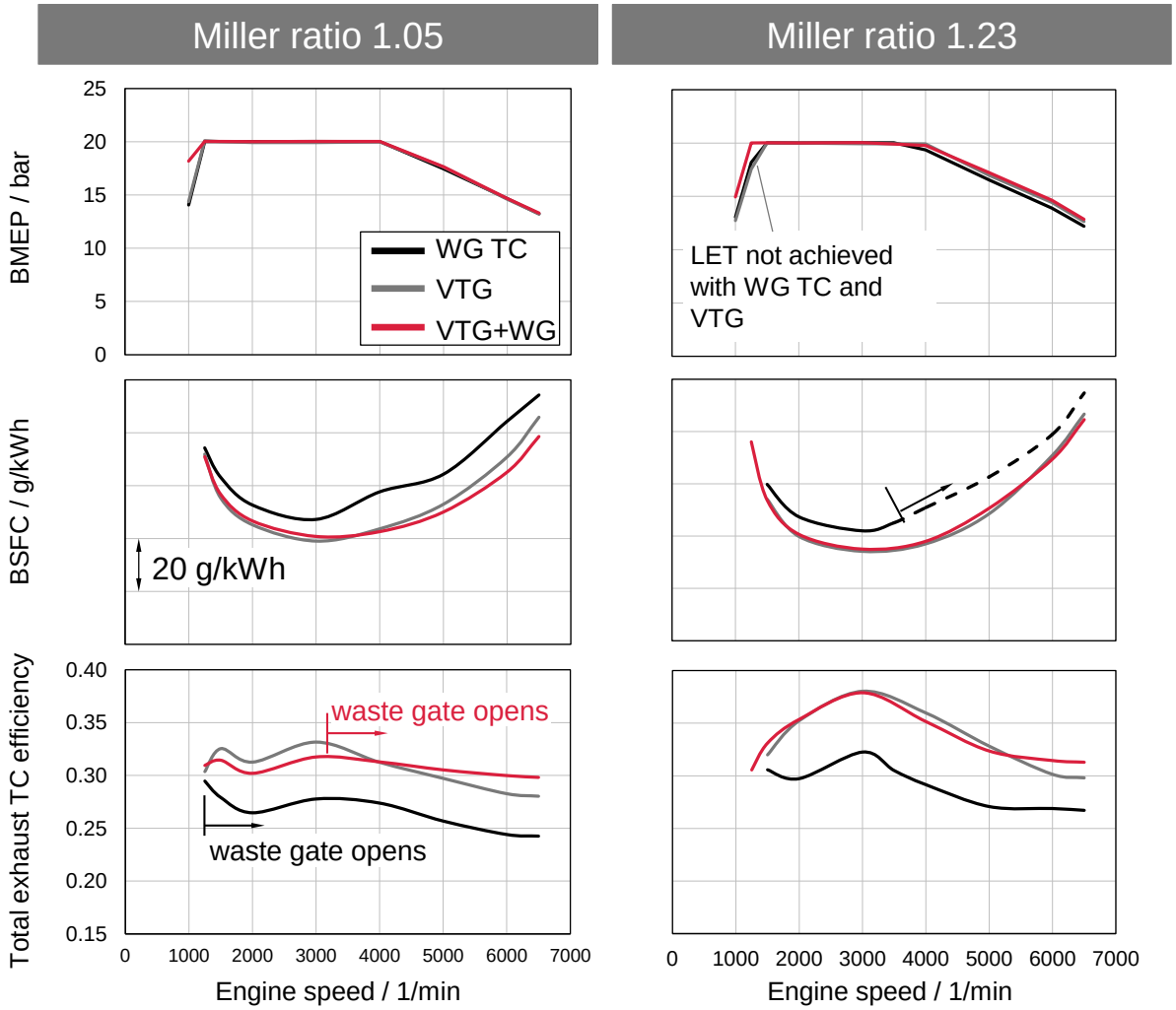

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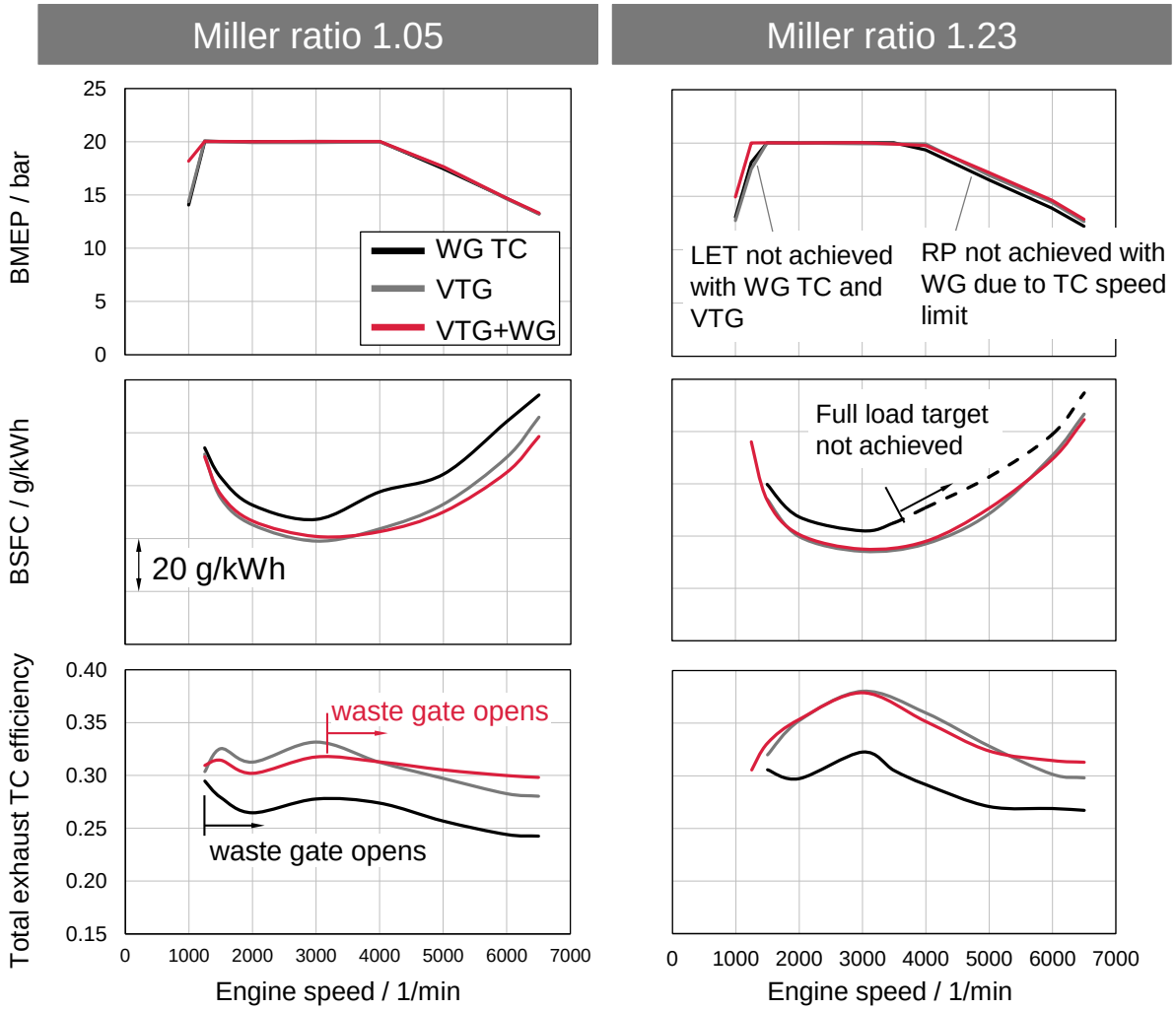
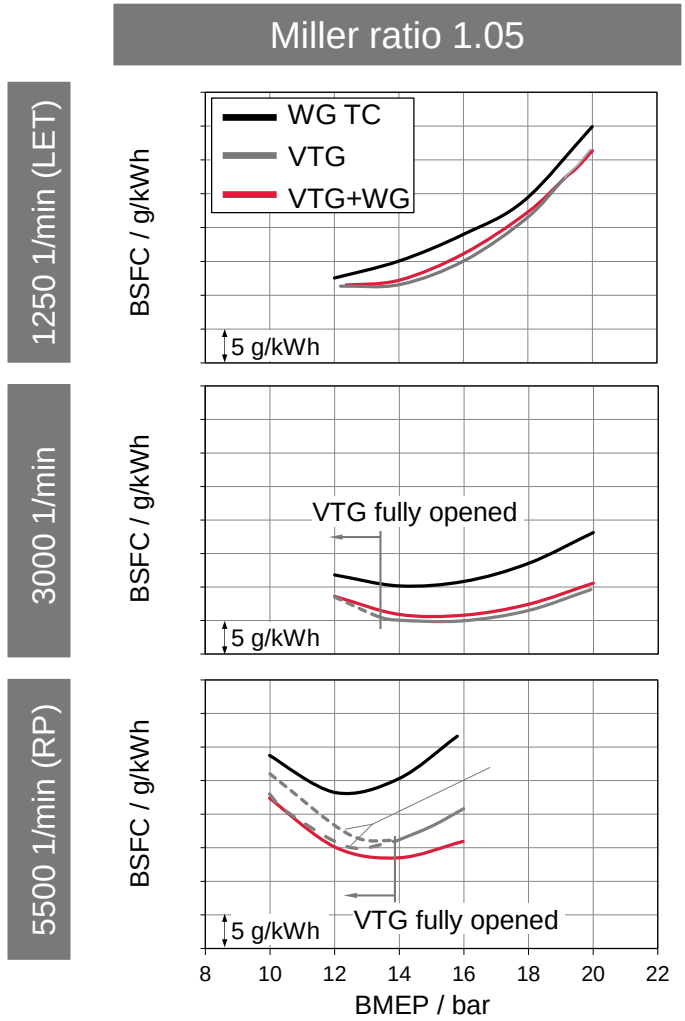


Engine fuel consumption in part load operation



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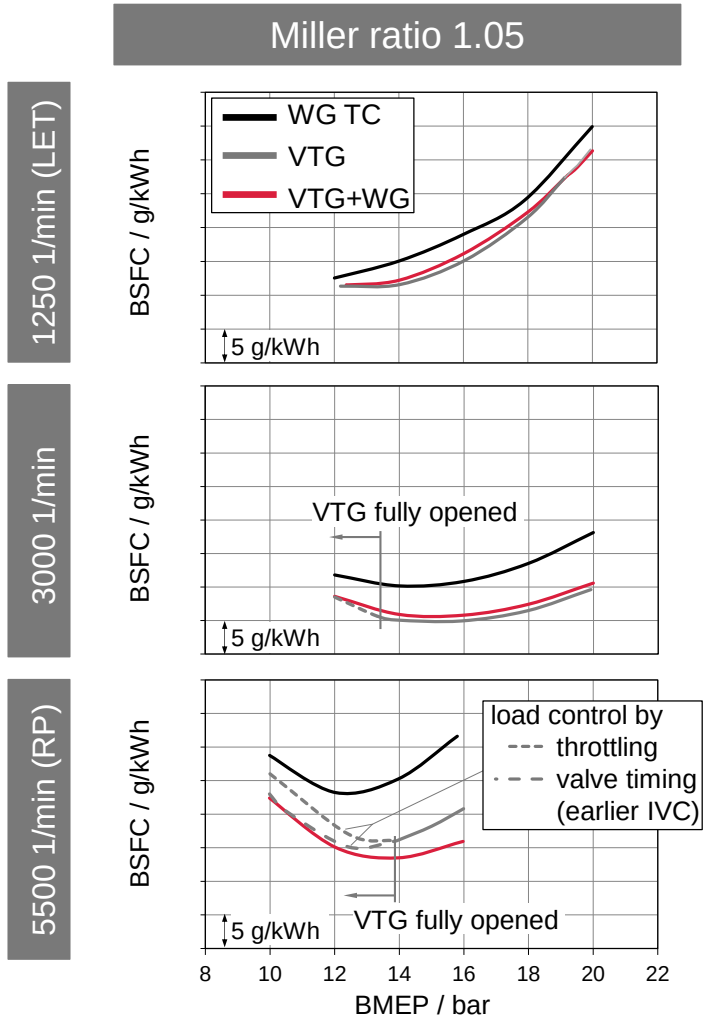

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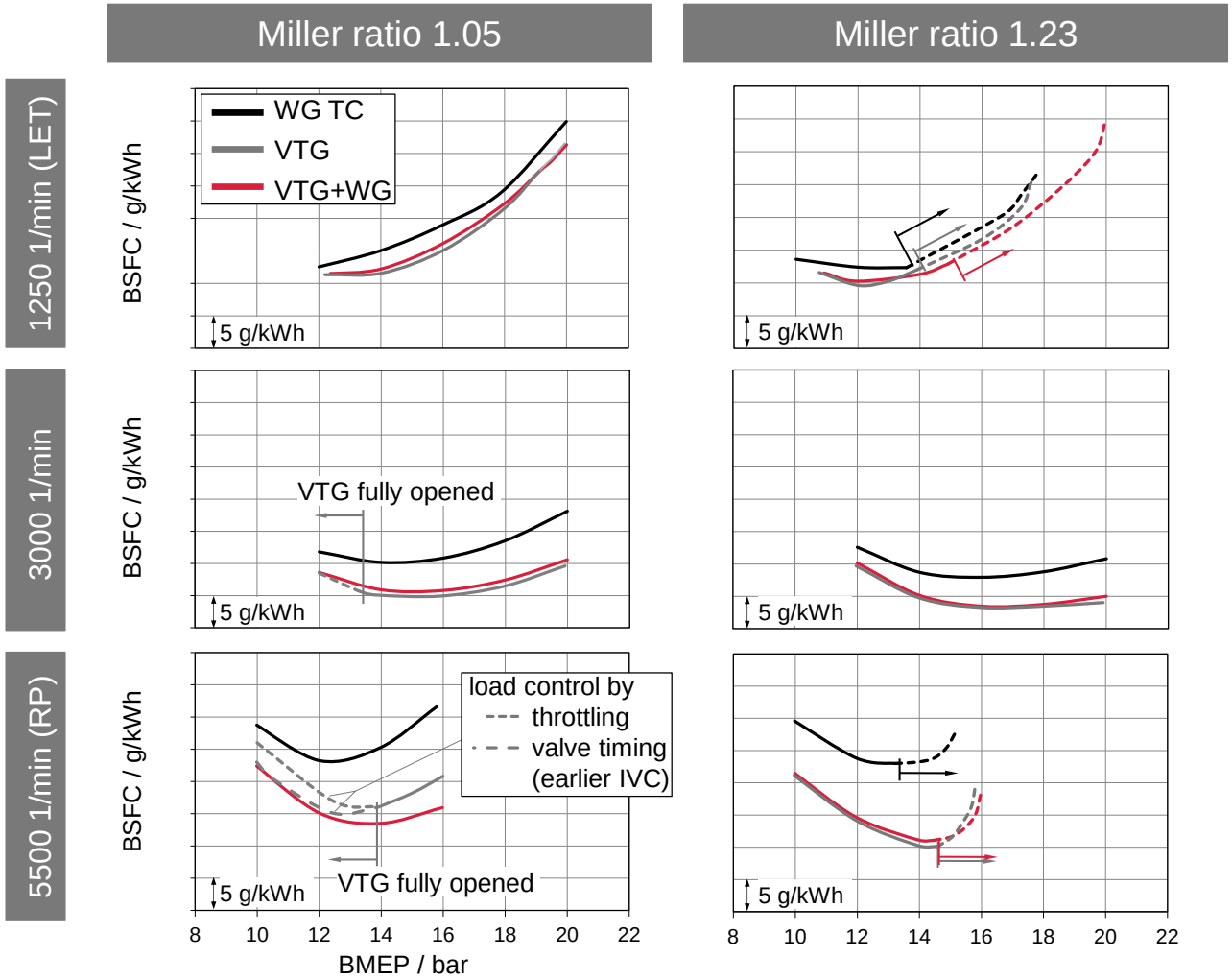

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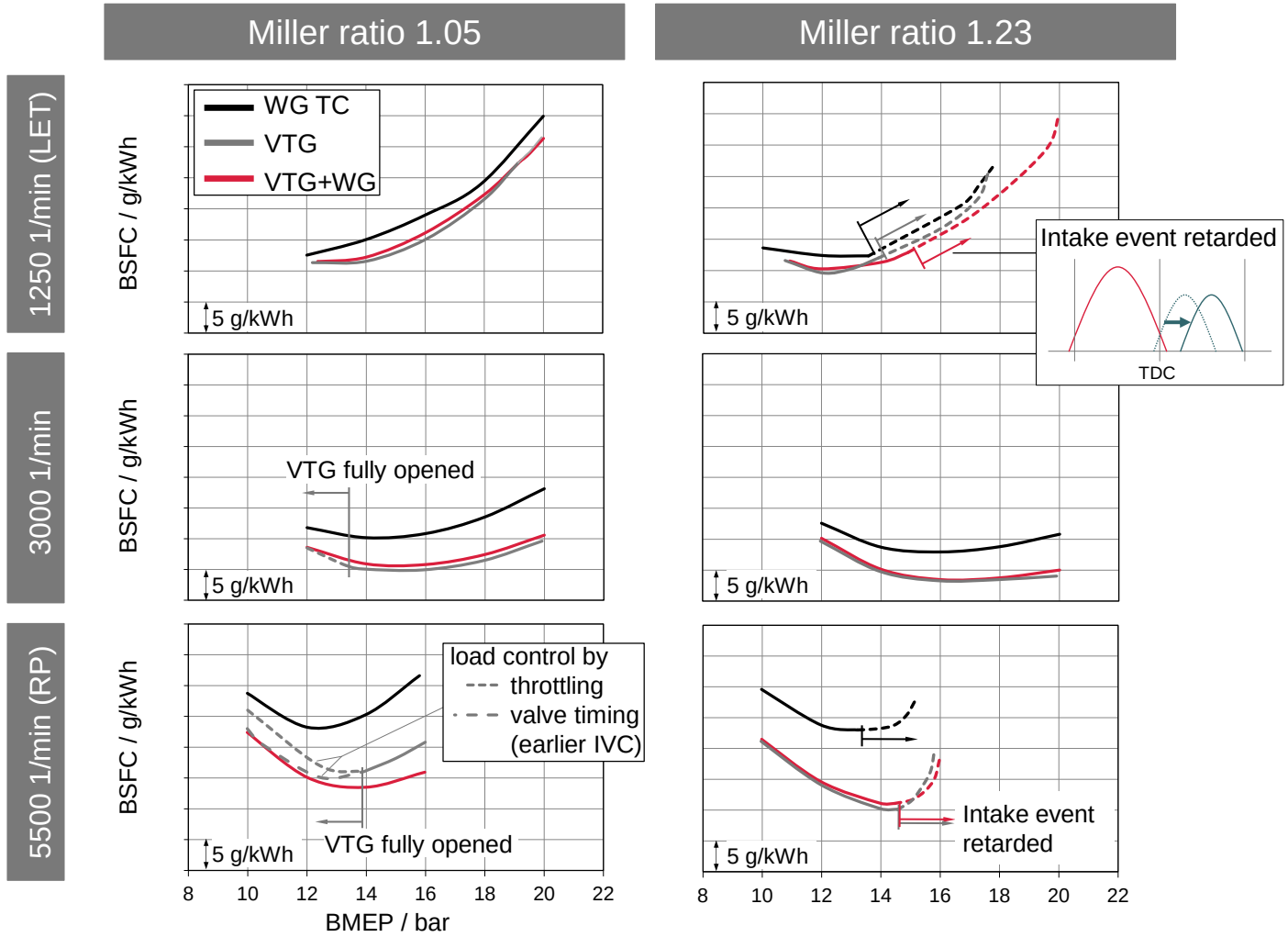
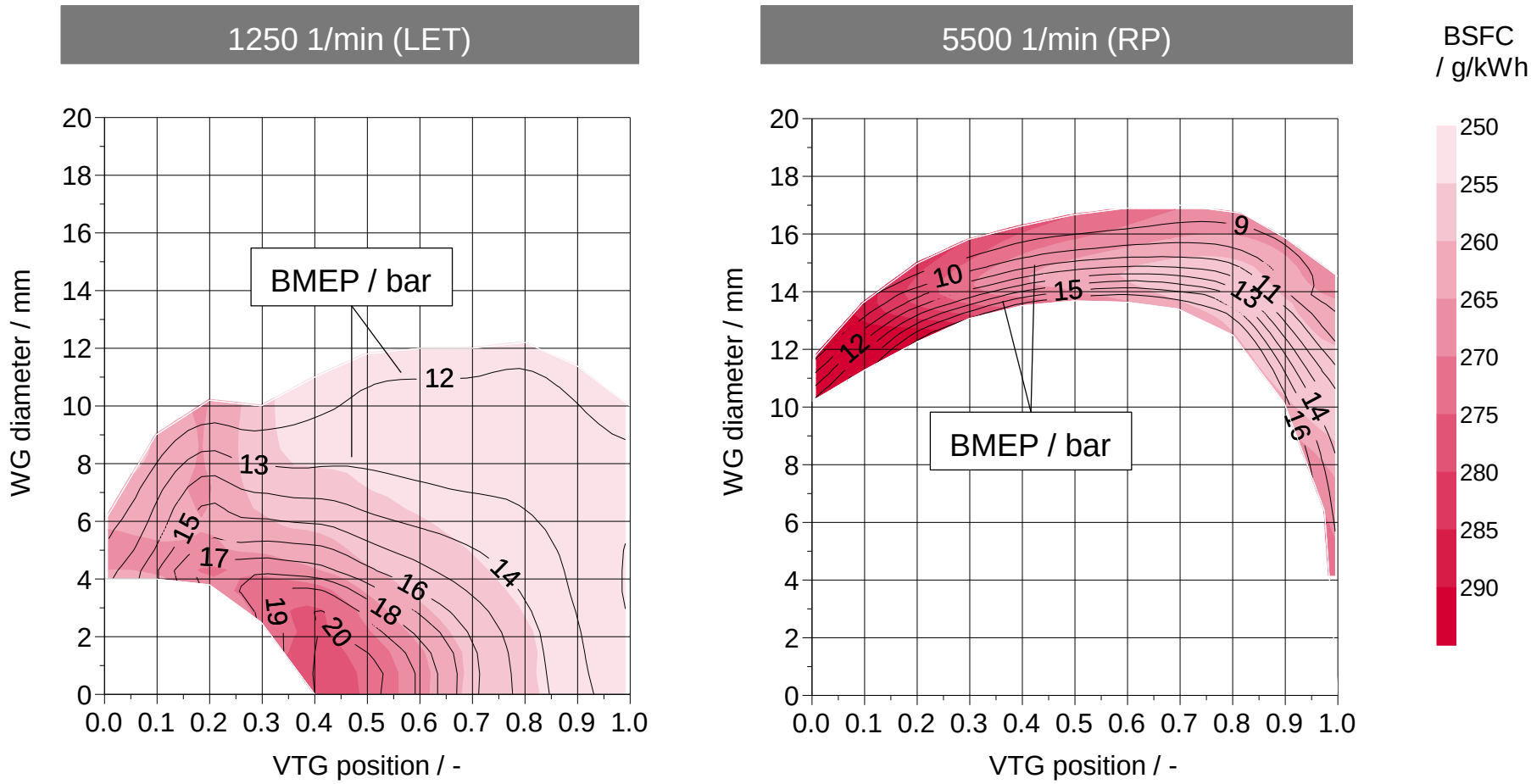


Load control strategy for a VTG turbine with additional WG



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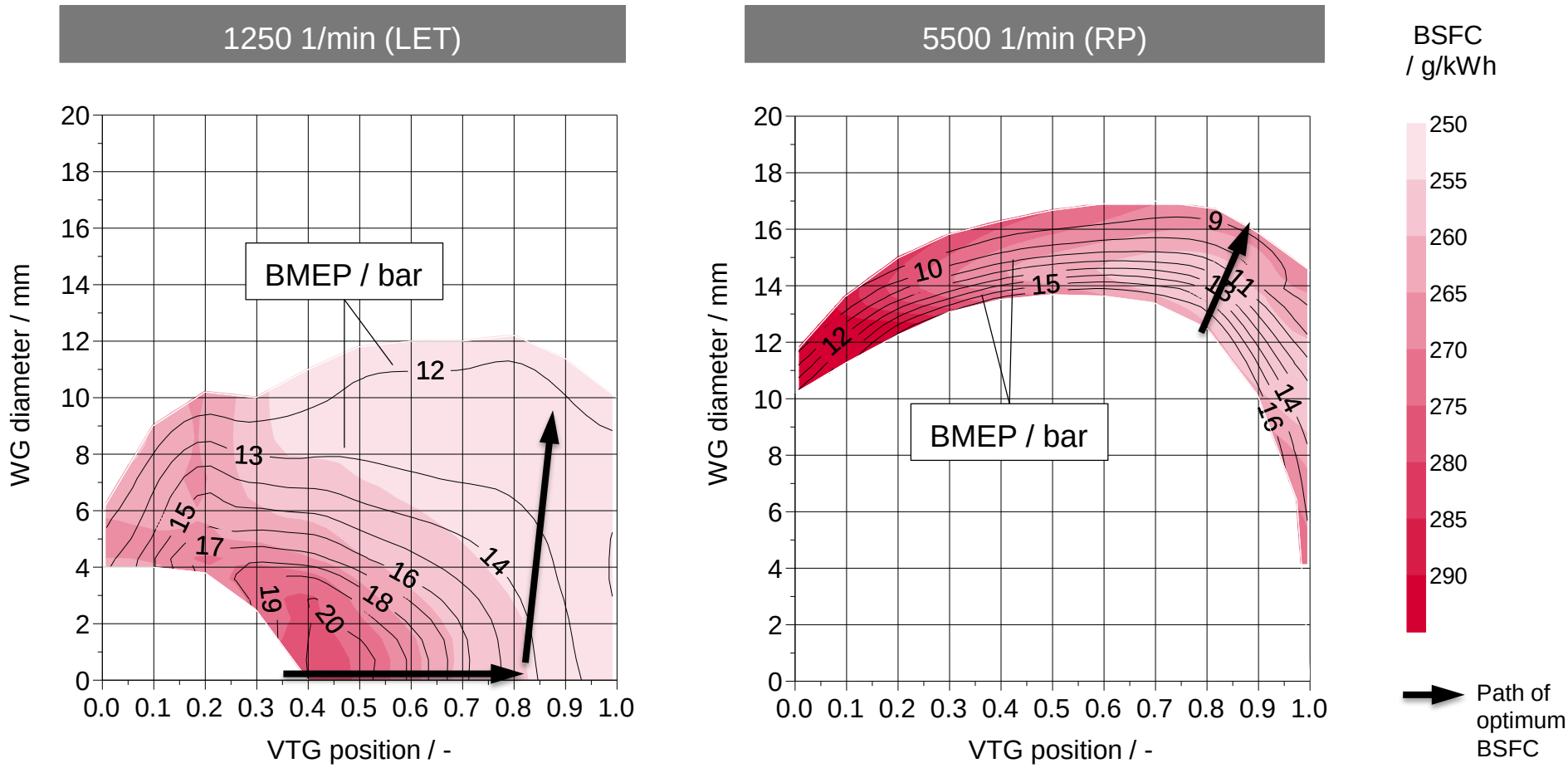
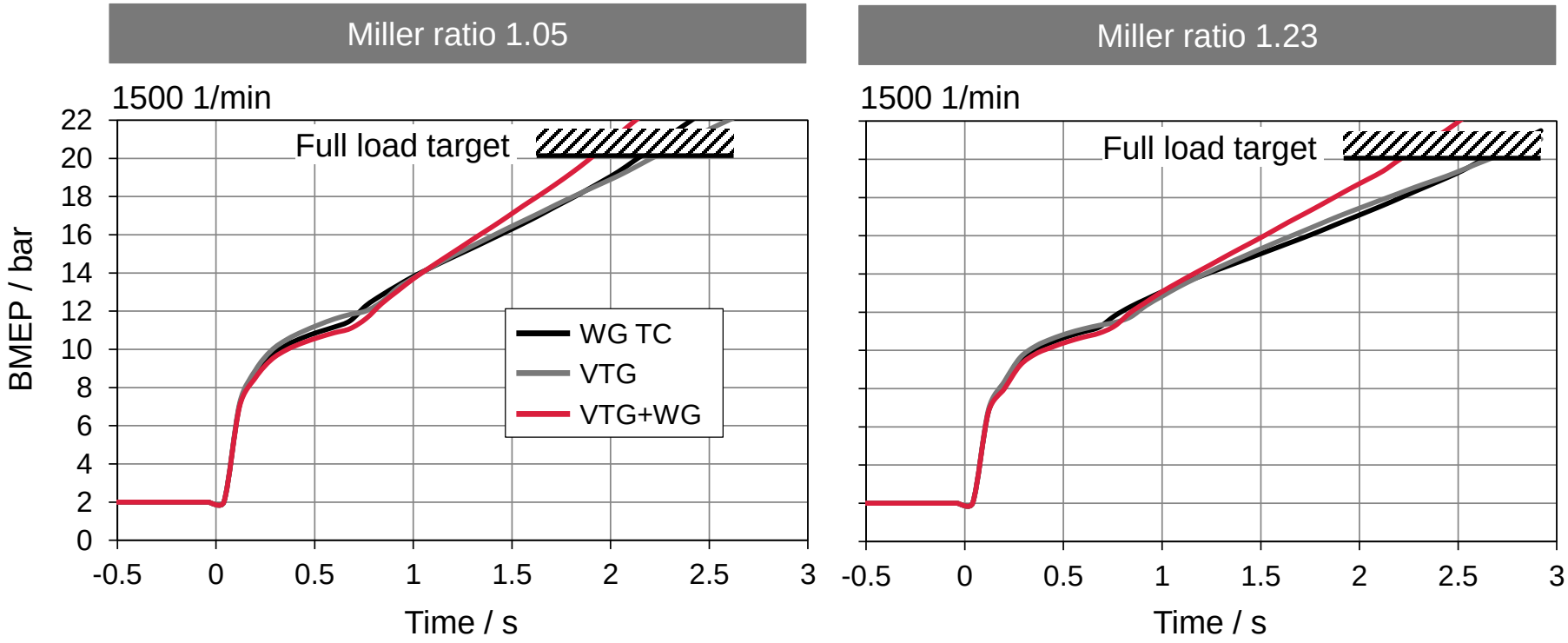


Engine transient response behavior at engine speed 1500 1/min



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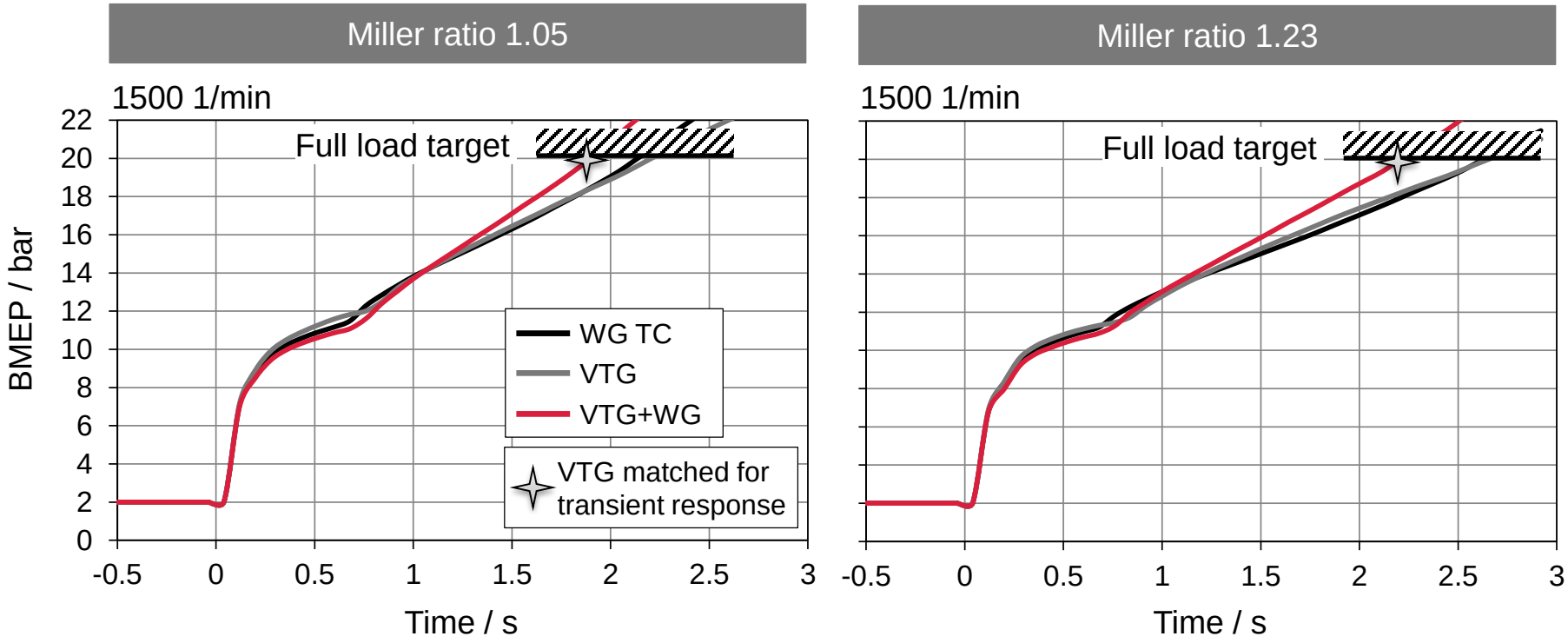

Combining Miller cycle and VTG – A promising concept for future gasoline engines?

SUMMARY AND CONCLUSION

- Combination of Miller cycle and VTG
  - significant improvement of the fuel consumption throughout the whole boosted operation range (up to 15 g/kWh)
  - Improved full load performance for the Miller cycle engine
  - Improved transient response behavior

- Upgrading the VTG with an additional waste gate
  - allows for a wider flow control range
  - Improves fuel consumption at higher engine speed and load

- Yes, the combination of VTG and Miller cycle is a promising concept that achieves
  - ⊕ very good fuel consumption with at the same time
  - ⊕ good full load performance and
  - ⊕ good engine responsiveness

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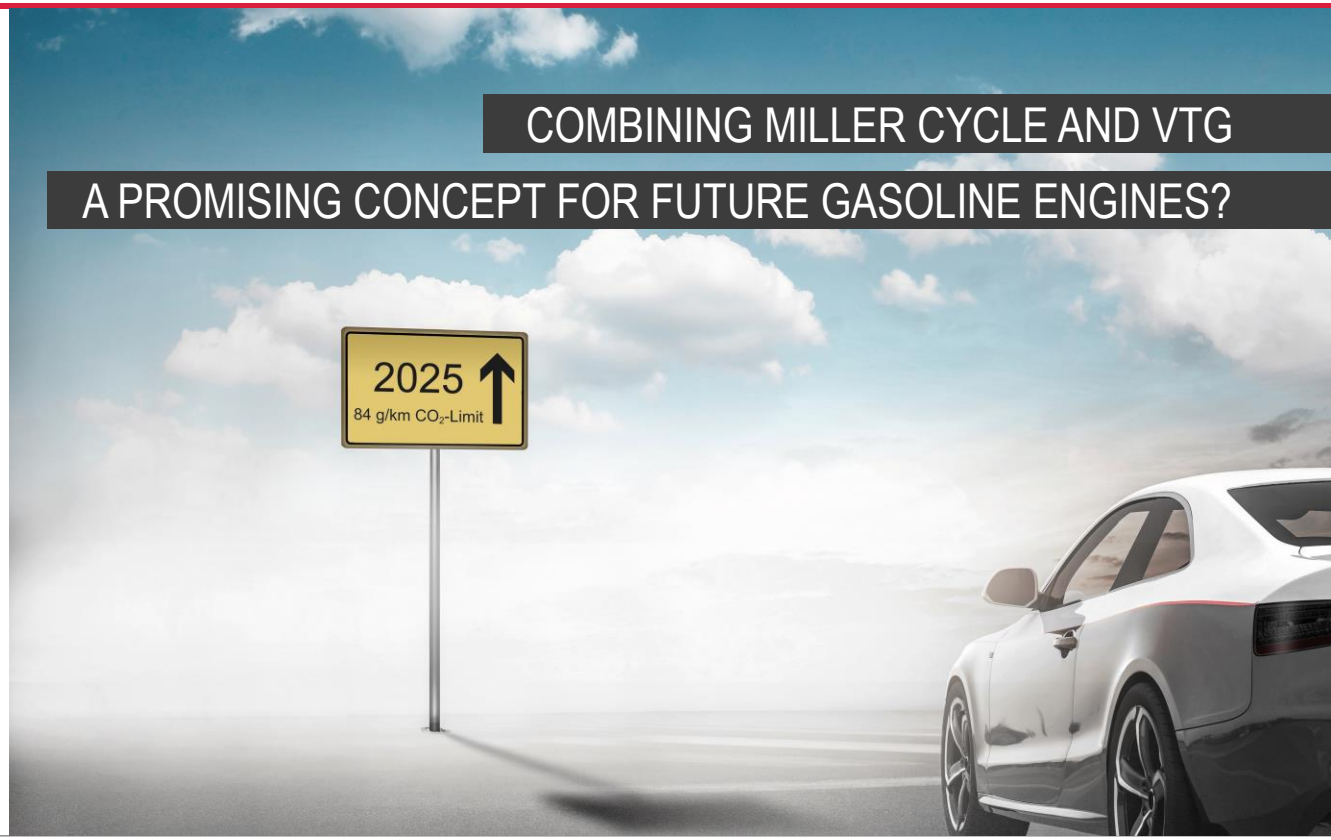

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