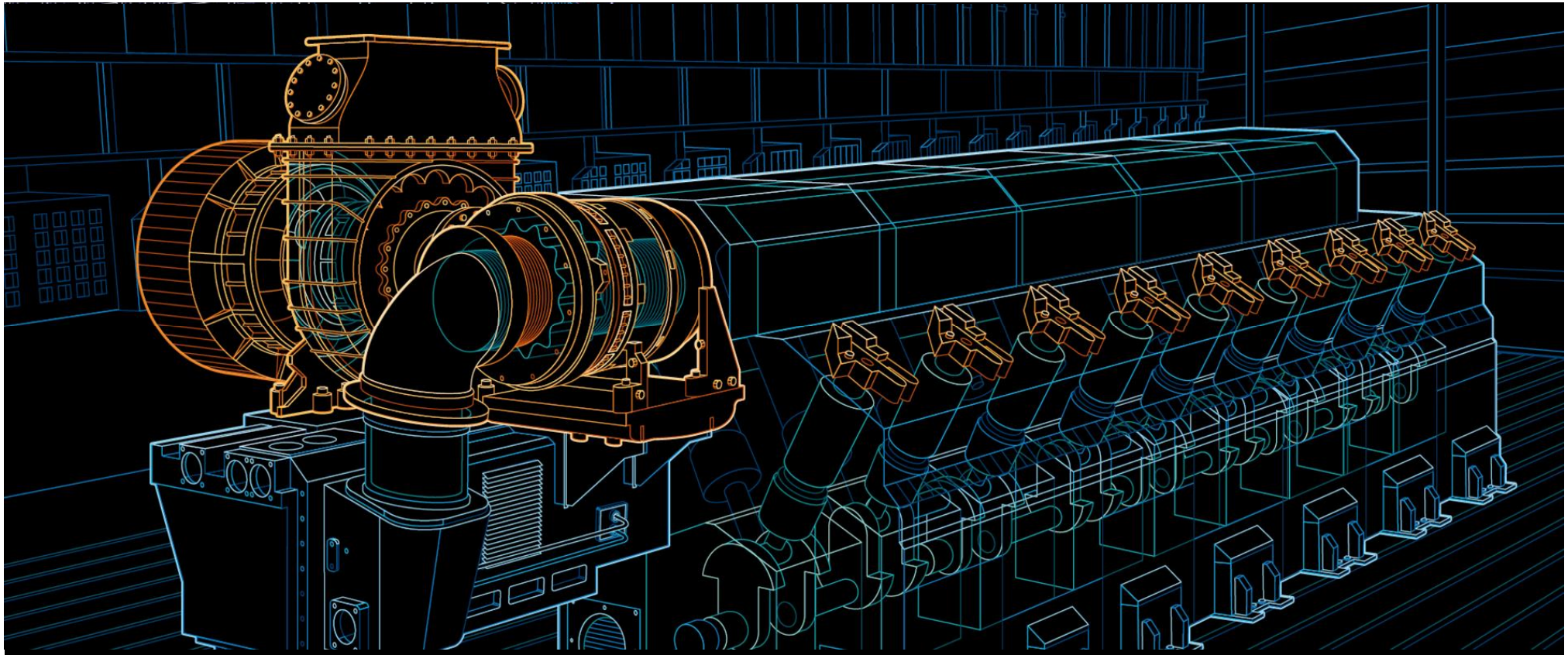

CIMAC Circle @ POWER GEN / Cologne, 2014-06-03

Advanced turbocharging and variable valve timing for improving engine performance

Power and productivity
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CIMAC Circle @ POWER GEN, 2014
Advanced turbocharging and VVT

Topics

- State-of-the-art gas engines
- Advanced turbocharging and VVT
- Engine performance enhancement

State-of-the-art Gas Engines
Main characteristics

Turbocharging

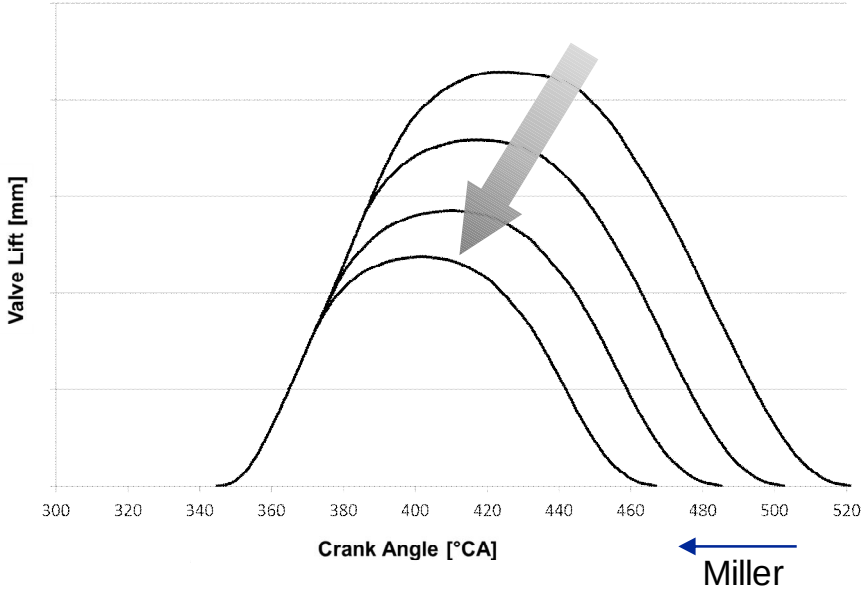
- Mainly 1-stage (first applications 2-stage)
- Pressure ratios up to ~5.5 (~6.5)
- Turbocharger efficiencies 65 – 68% (73%)

Valve timing

- Fixed valve timing or simple «2-step»
- Miller timing

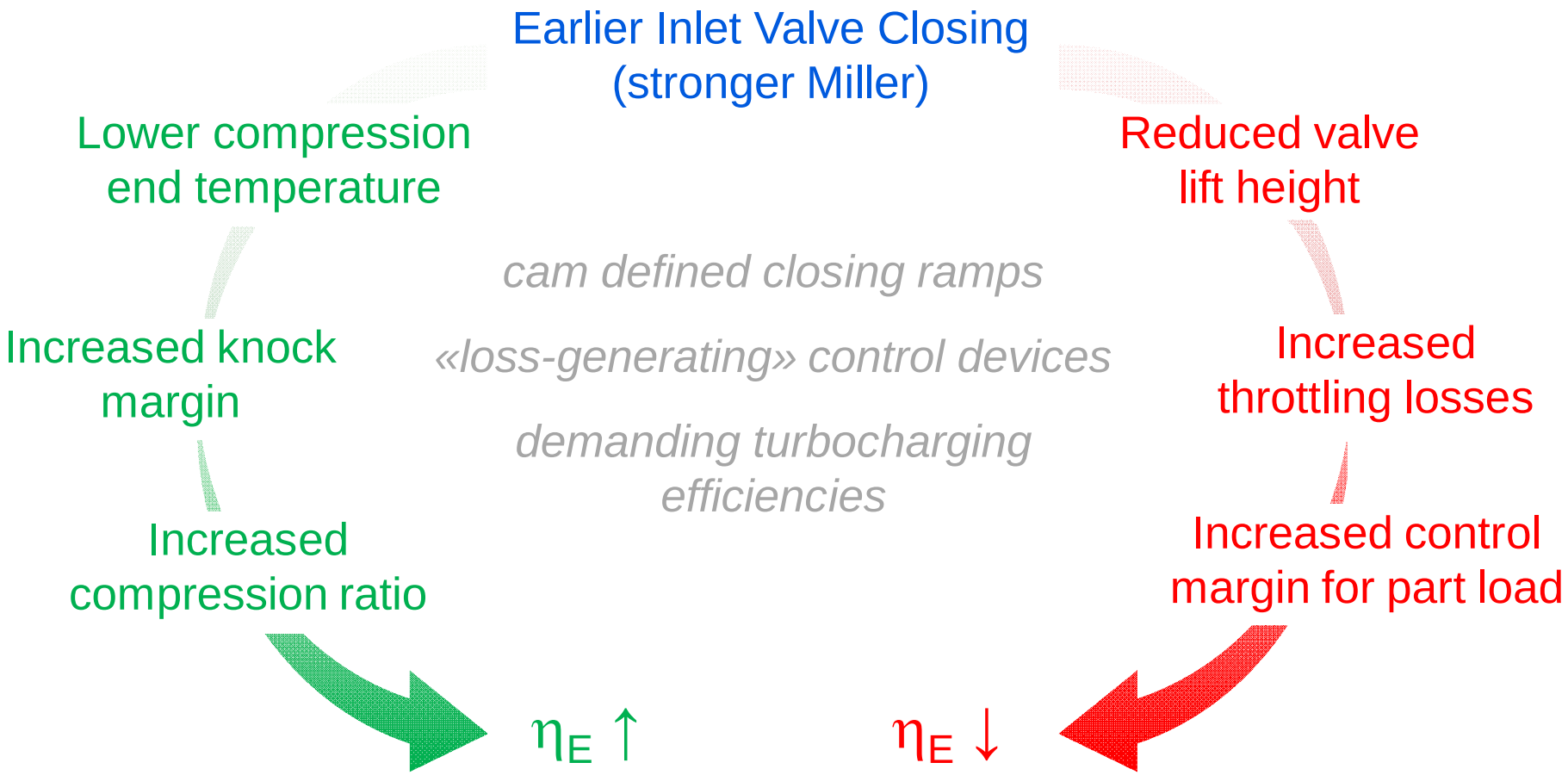
Others

- Throttle valve, waste gate and/or compressor bypass for λ_V control
- Compression ratios of 12 to 13



State-of-the-art Gas Engines
Limitations, challenges

Low engine compression ratio due to knocking

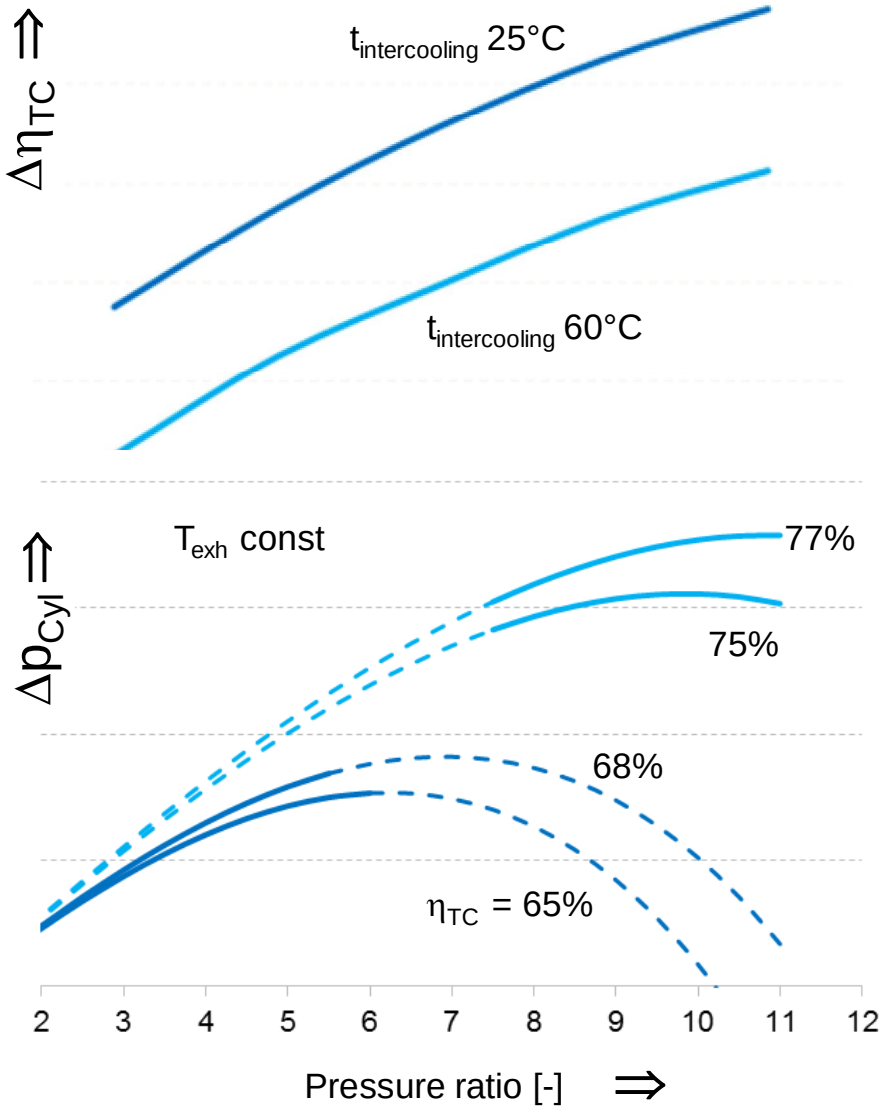


Advanced Turbocharging
Two-stage turbocharging

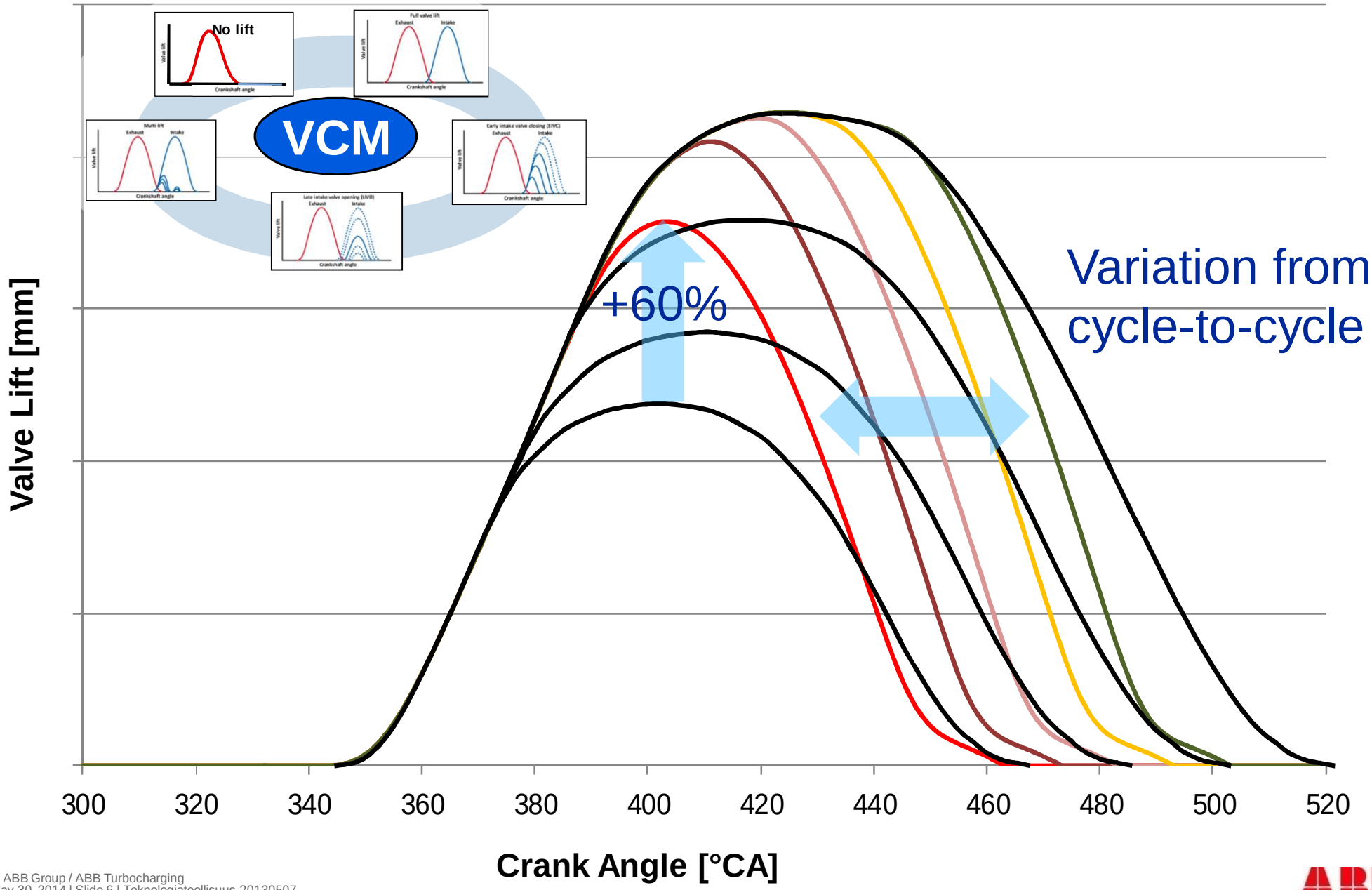
Basic potential

- Pressure ratios of up to 12
- Turbocharging efficiencies above 75%

- With higher pressure ratio …
  - ⇒ … increase in η_{TC}
  - ⇒ … increase in Δp_{Cyl}
  - ⇒ … more compact 2-stage system



Advanced Variable Valve Timing
Valve Control Management (VCM)



Advanced Variable Valve Timing
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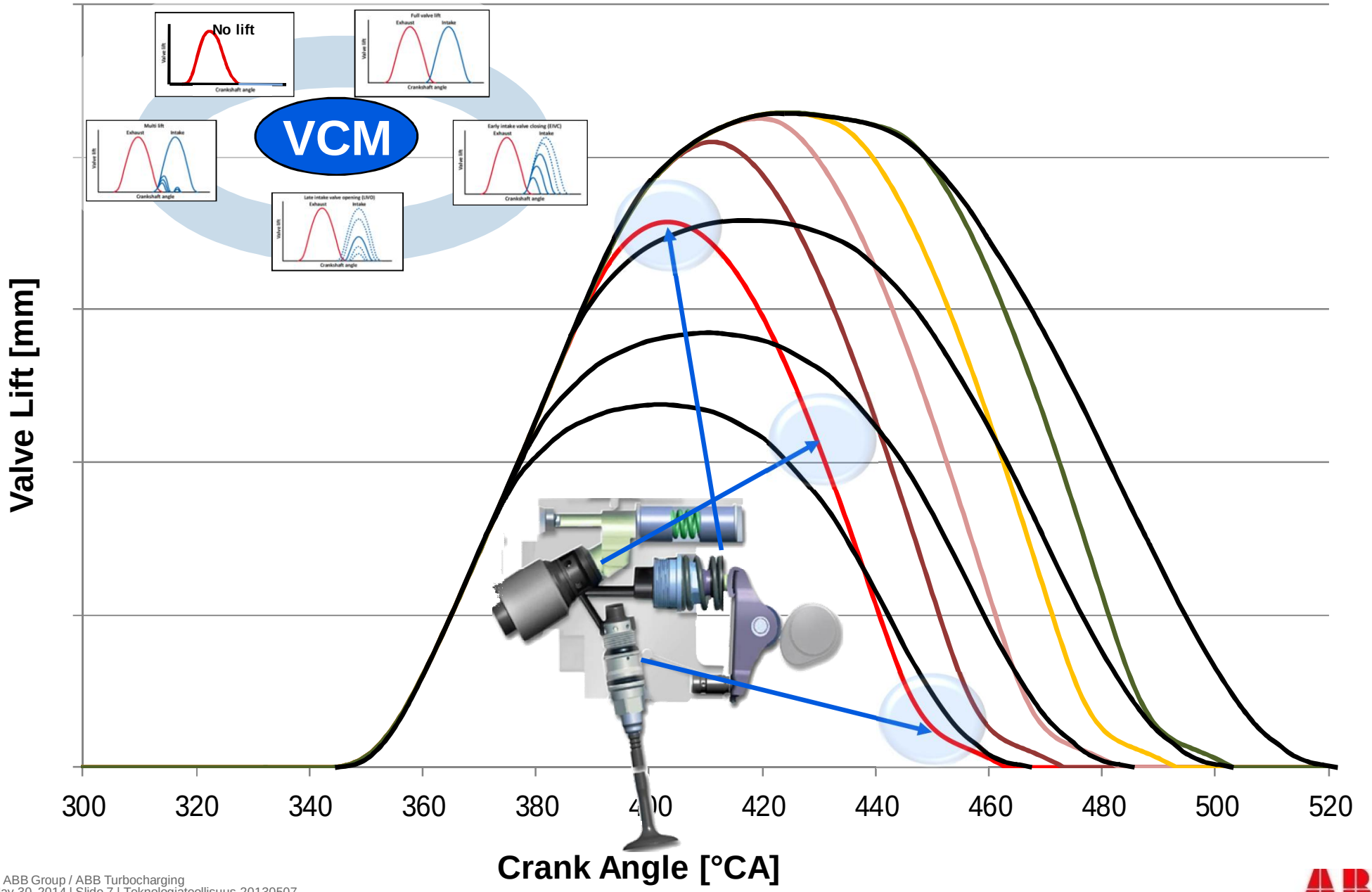
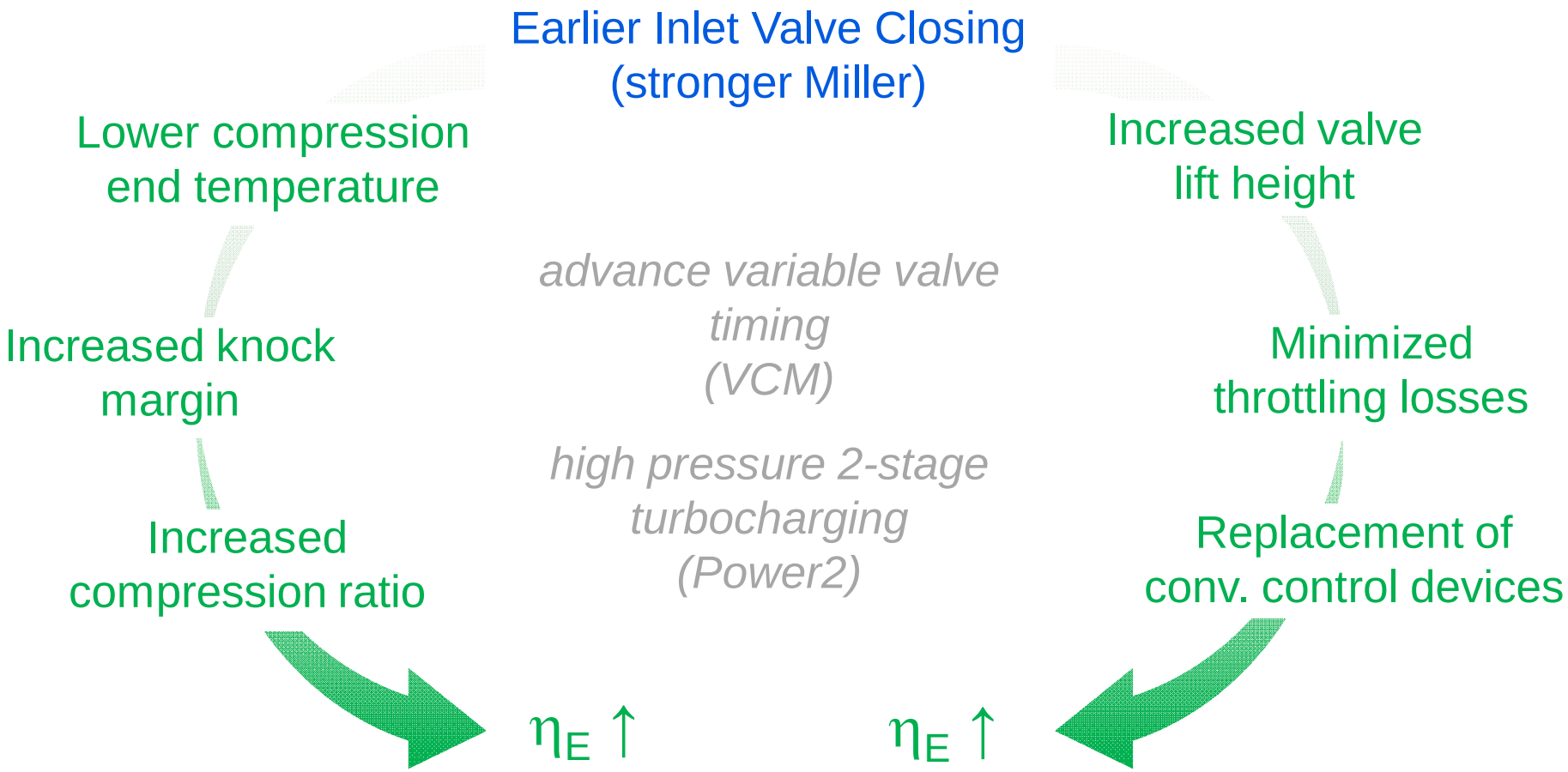
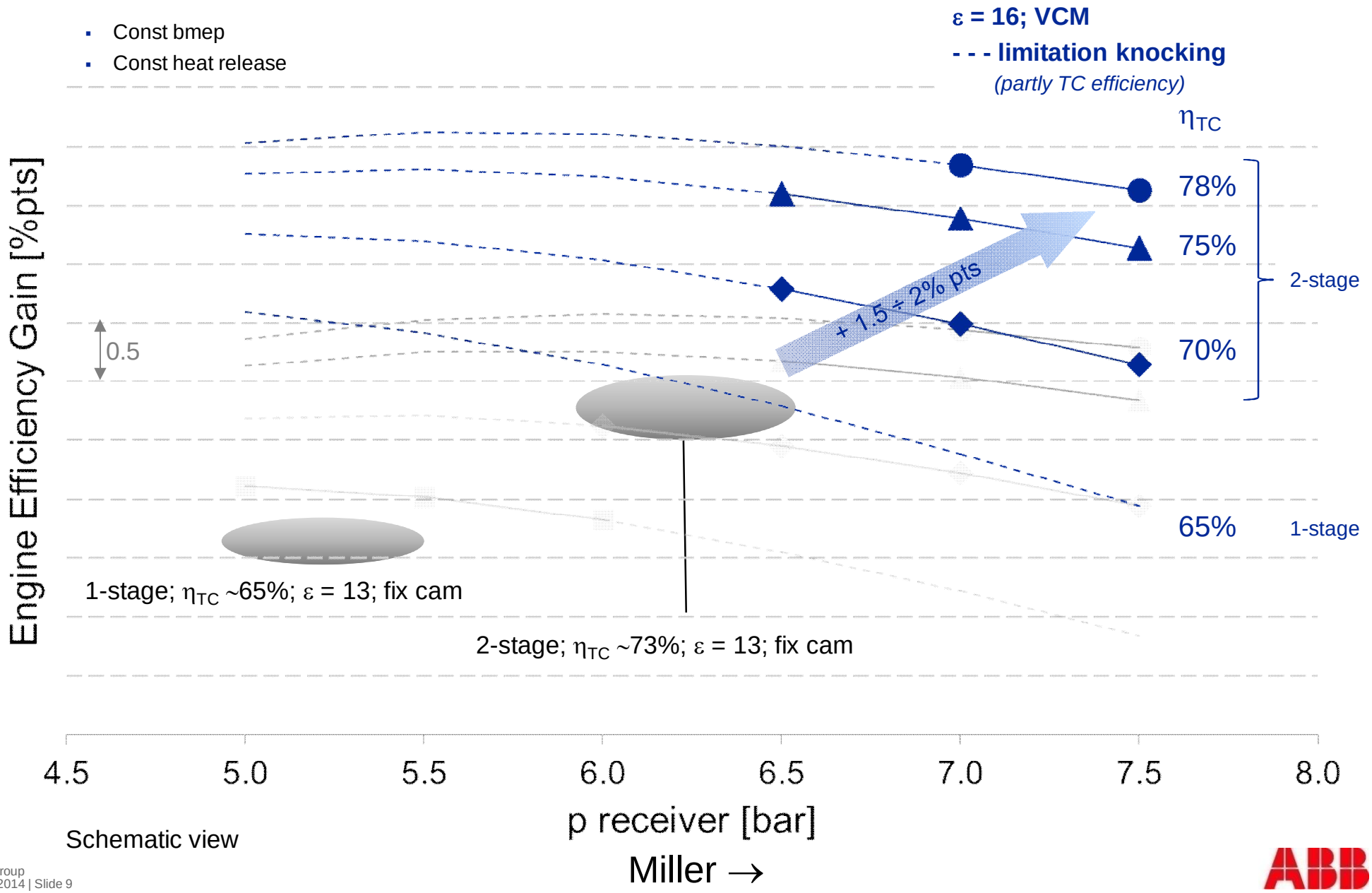


Advanced Variable Valve Timing
Opportunities

Low engine compression ratio due to knocking

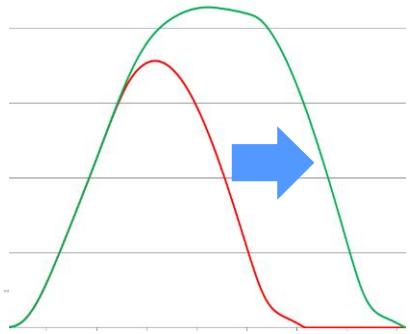


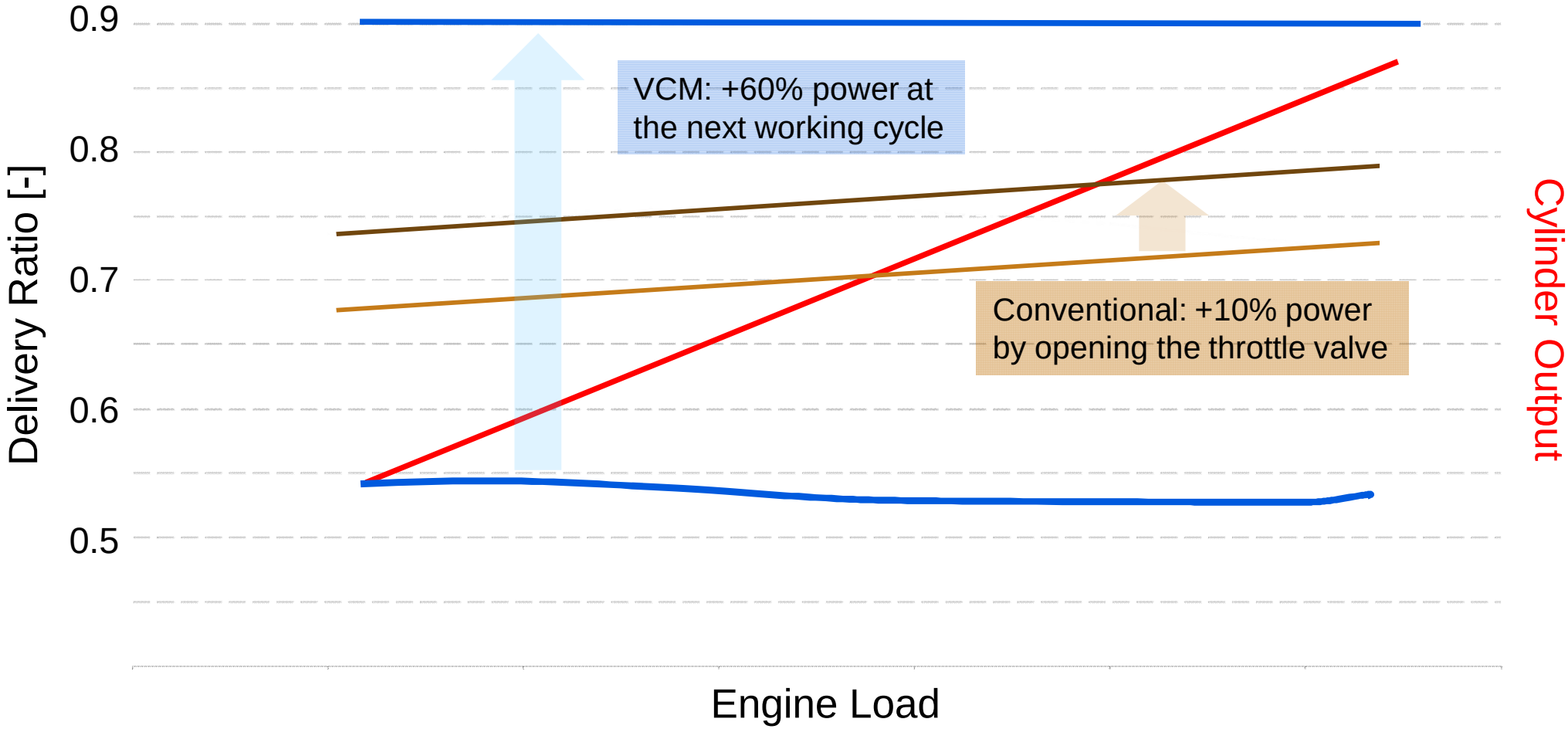
Engine Performance Enhancement
Efficiency – Miller / TC efficiency variation



Schematic view

Engine Performance Enhancement
Transient

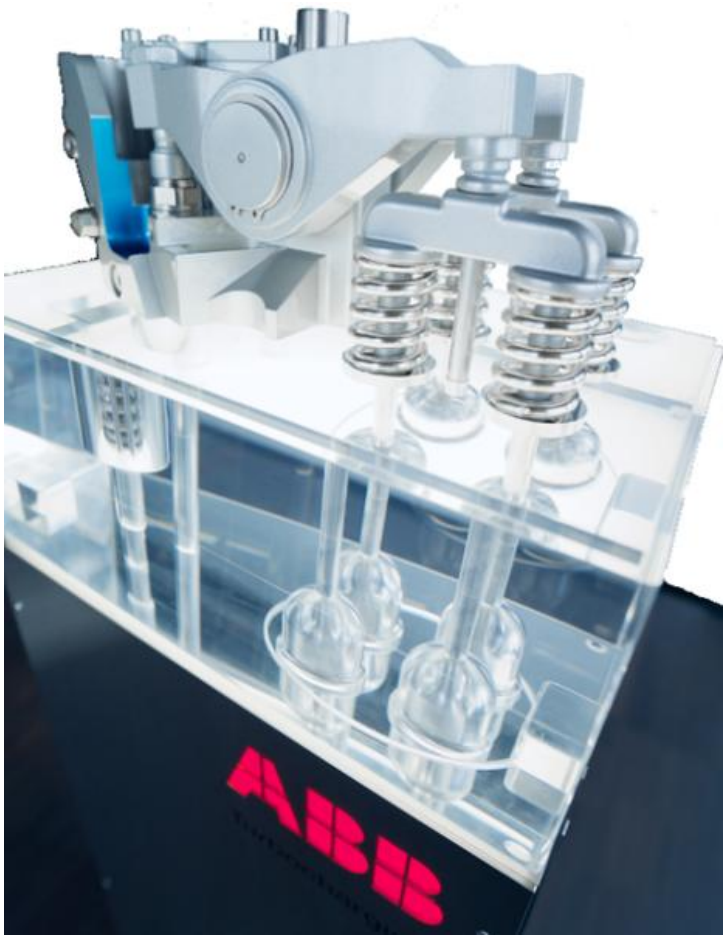




Schematic view

Advanced Turbocharging and VVT
Summary potentials

- Engine efficiency improvements by:
  - replacing conventional control elements
  - enabling high compression ratios
  - full utilization of 2-stage turbocharging
- Superior transient capabilities
- Better p_{Zmax} utilization by cylinder balancing and increased knock margin
- Acceptance of lower Methane numbers (→ less de-rating, standardization)



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