
SCHAEFFLER
Schaeffler Symposium September 6, 2018
Mobility for tomorrow


THERMAL MANAGEMENT SYNERGY THROUGH INTEGRATION
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PETE BRAZAS

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- **Propulsion System Trends**
- Evolution of the TMM
- A Closer Look at Electrification
- System Integration Approach
- Outlook

Powertrain Technology Roadmap

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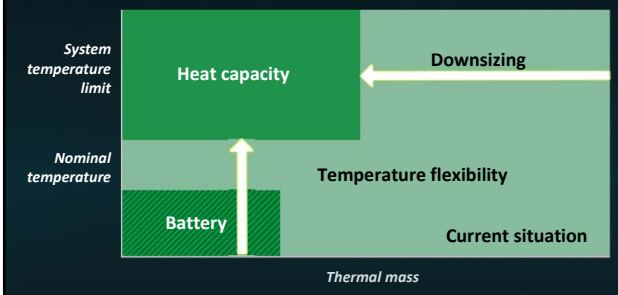
Megatrend: CO_2 **Reduction**

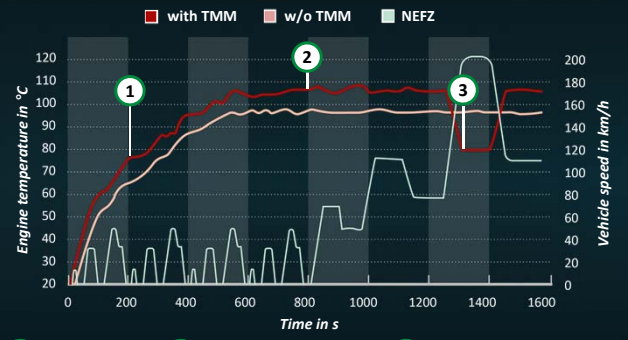
Current situation → Future challenges

Variety of propulsion	→	Modular architecture + advanced system integration
Electrification	→	Responsible charging + waste-energy recovery, use, storage
Stop/Start and Hybrids	→	Increased complexity + multiple cooling circuits
Integrated Turbochargers	→	Increased + accelerated energy transfer to cooling circuit
ICE Downsizing	→	Reduced heat capacity + increased specific load

The Case for Enhanced Control



- Reduced heat capacity with higher nominal operating temperatures (ICE)
- Precisely reach and hold target temperatures
- Temperature as control factor is too slow
- Fast, load-based system control via ECU logic
- Allows for proactive heat rejection
- Larger sandbox for combustion strategy/innovation



1 Faster warm-up 2 Precise temperature level 3 Wide temperature flexibility

Schaeffler TMM enables CO_2 savings up to 3% (NEDC)

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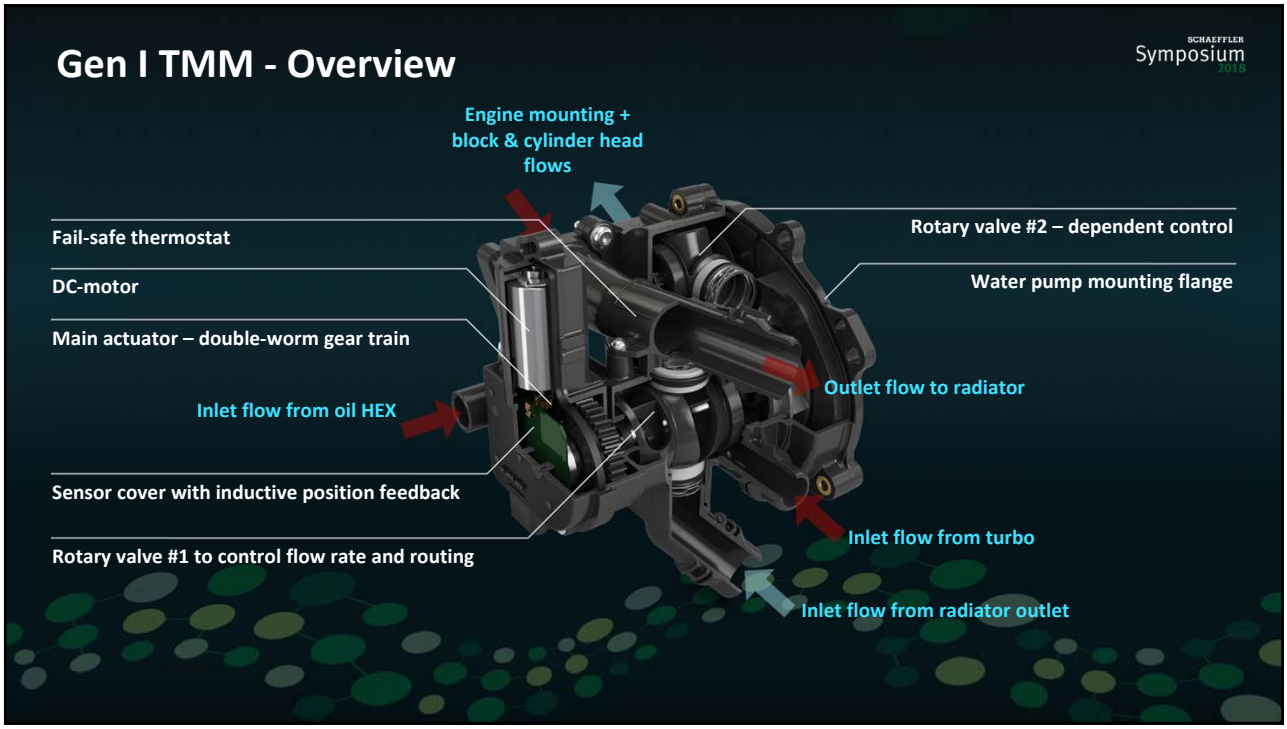
Gen I TMM - Overview
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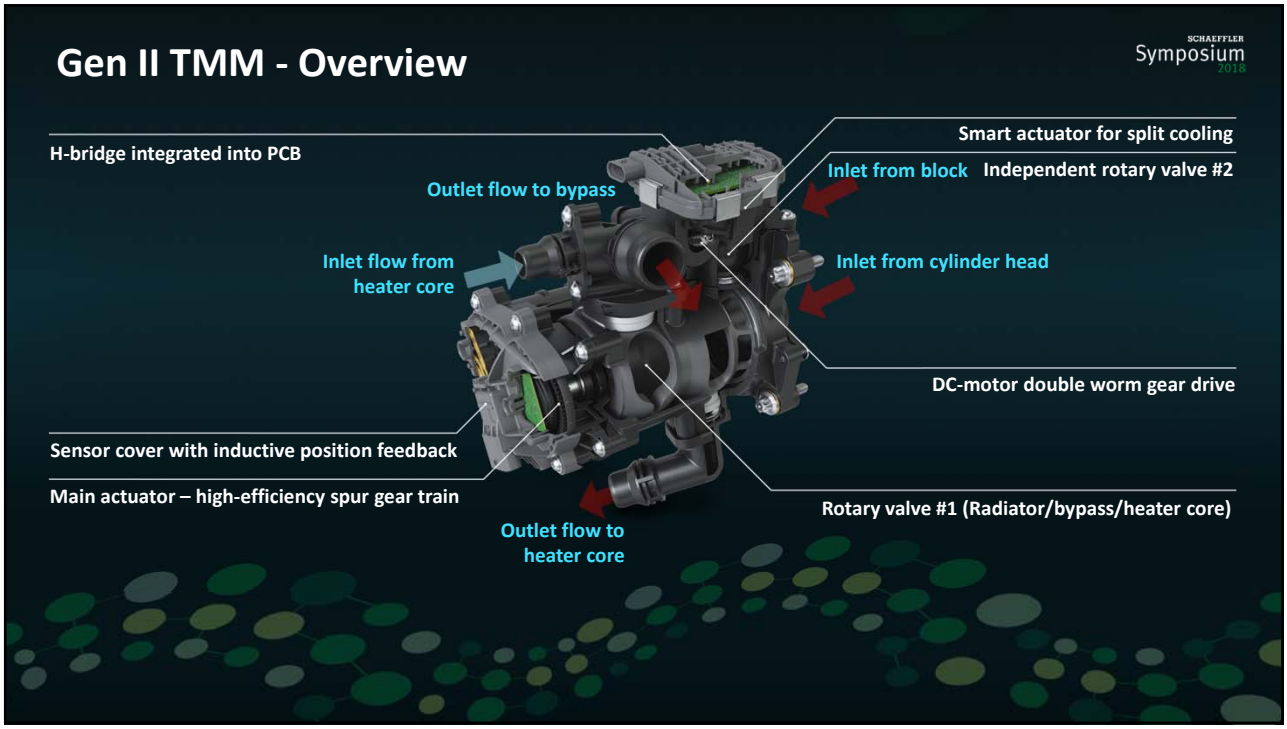
Engine mounting + block & cylinder head flows
Fail-safe thermostat
DC-motor
Main actuator – double-worm gear train
Inlet flow from oil HEX
Sensor cover with inductive position feedback
Rotary valve #1 to control flow rate and routing
Rotary valve #2 – dependent control
Water pump mounting flange
Outlet flow to radiator
Inlet flow from turbo
Inlet flow from radiator outlet


Gen II TMM - Overview
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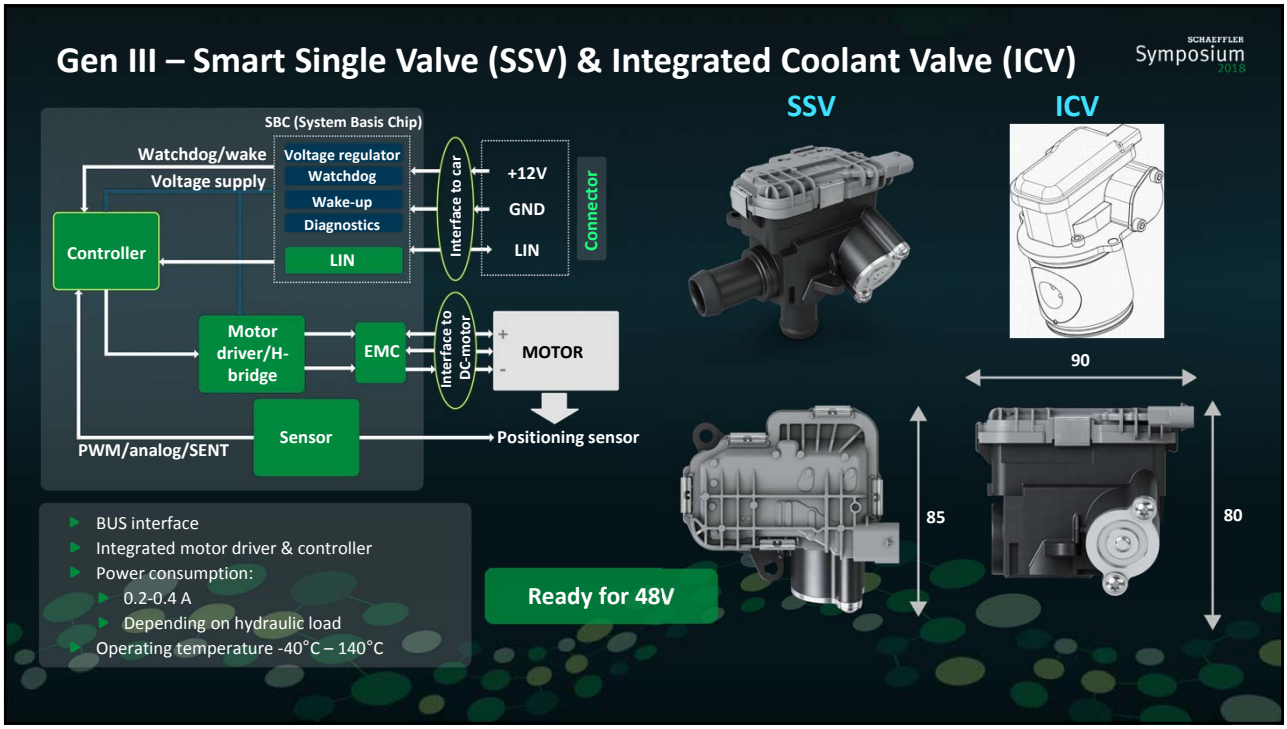
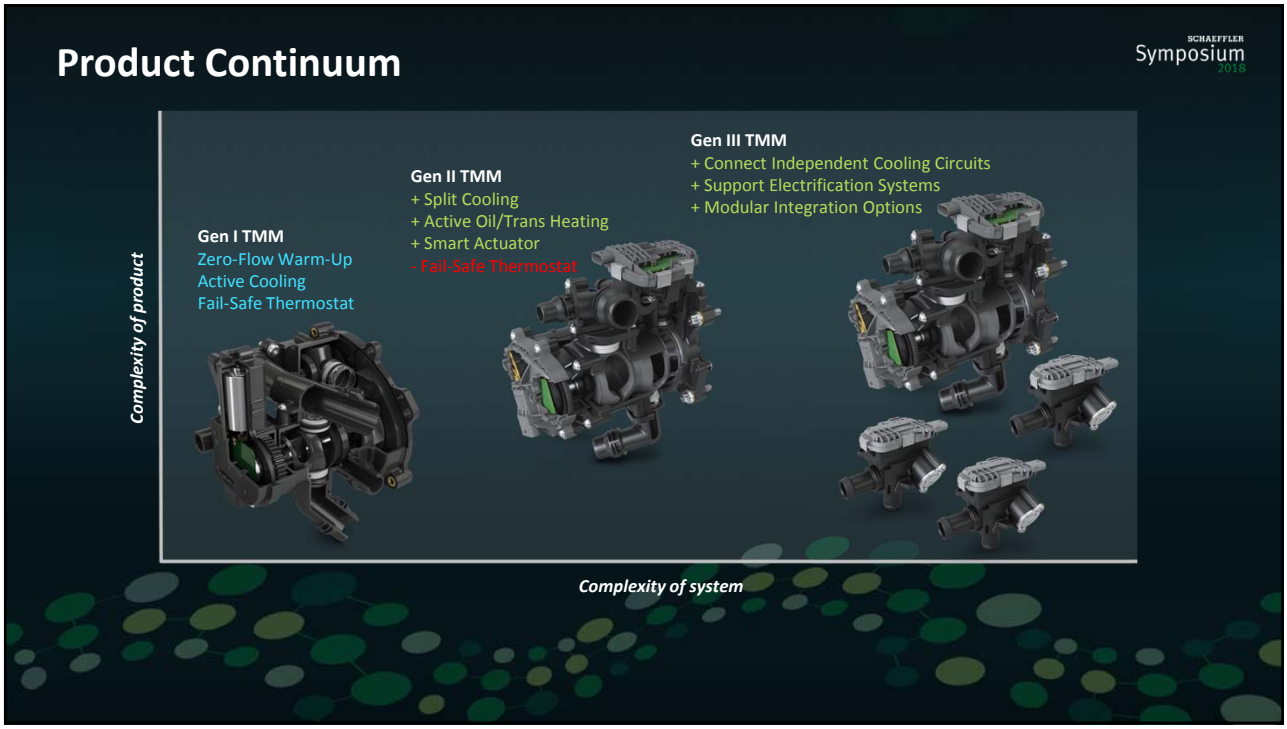
H-bridge integrated into PCB
Outlet flow to bypass
Inlet flow from heater core
Sensor cover with inductive position feedback
Main actuator – high-efficiency spur gear train
Outlet flow to heater core
Smart actuator for split cooling
Inlet from block
Independent rotary valve #2
Inlet from cylinder head
DC-motor double worm gear drive
Rotary valve #1 (Radiator/bypass/heater core)

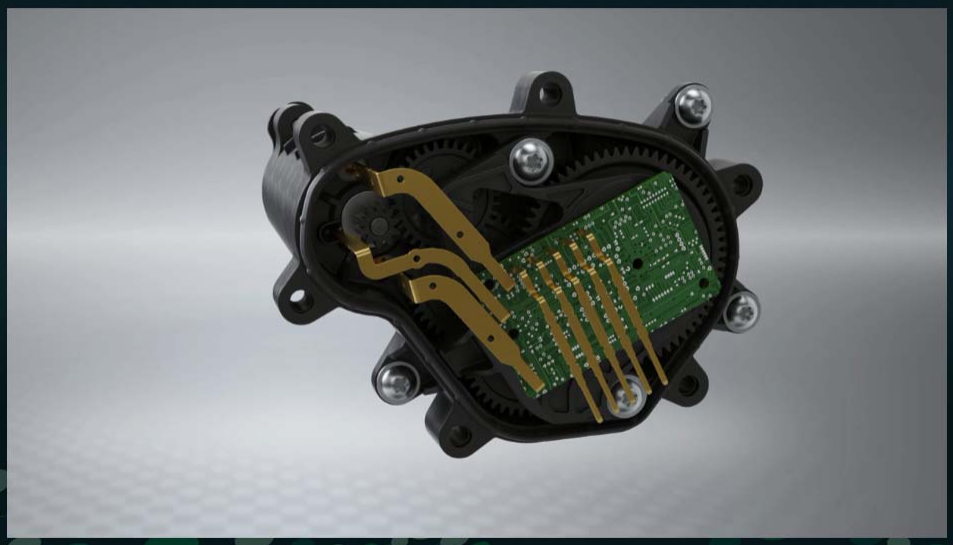
Pete Brazas – Thermal Management Synergy Through Integration





Gen II – Exploded View

Gen II – Main Rotary Valve (MRV) Actuator



Gen II – SMART Block Rotary Valve (BRV) Actuator

Gen II – Rotary Valve and Sealing Elements

Gen II – Cutaway View

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Hydraulic Simulation Support – TMM Level

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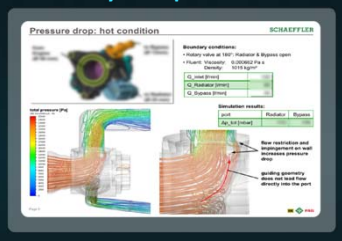
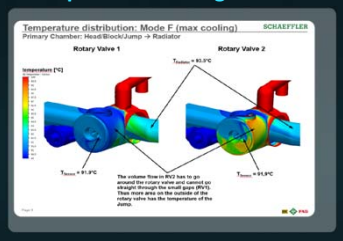
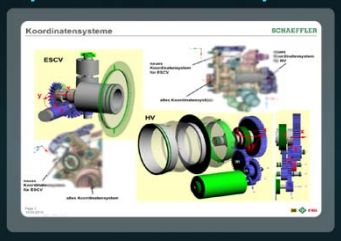
CFD analysis of pressure losses



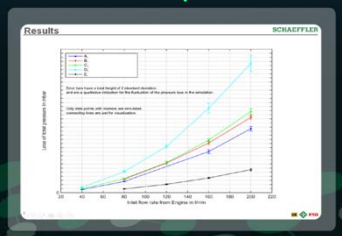
Temperature mixing behavior



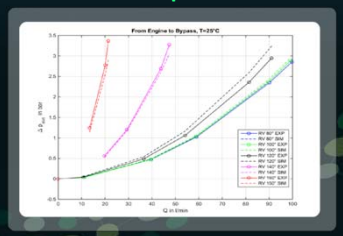
Hydraulic forces on rotary valve



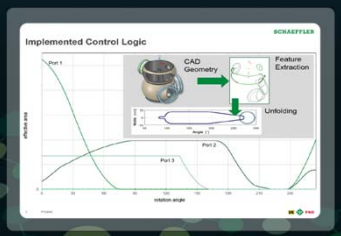
Measurement of pressure losses



Validation with experimental results



Automated calculation of effective flow area



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Hybrid Case – Production Vehicle Drive Cycle

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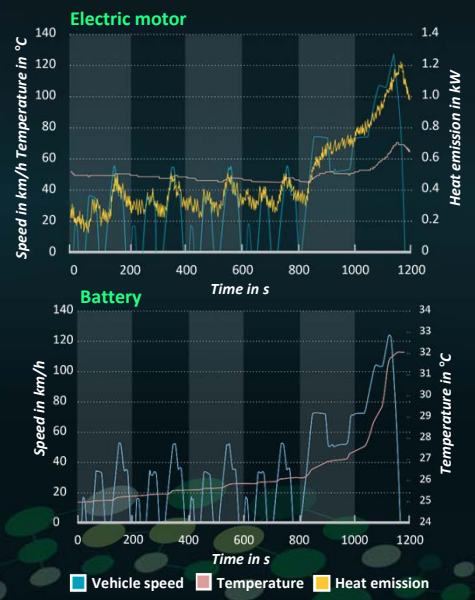
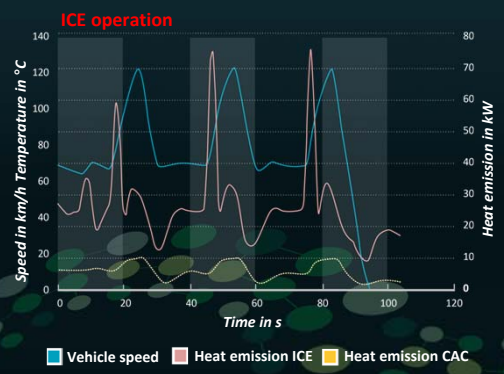
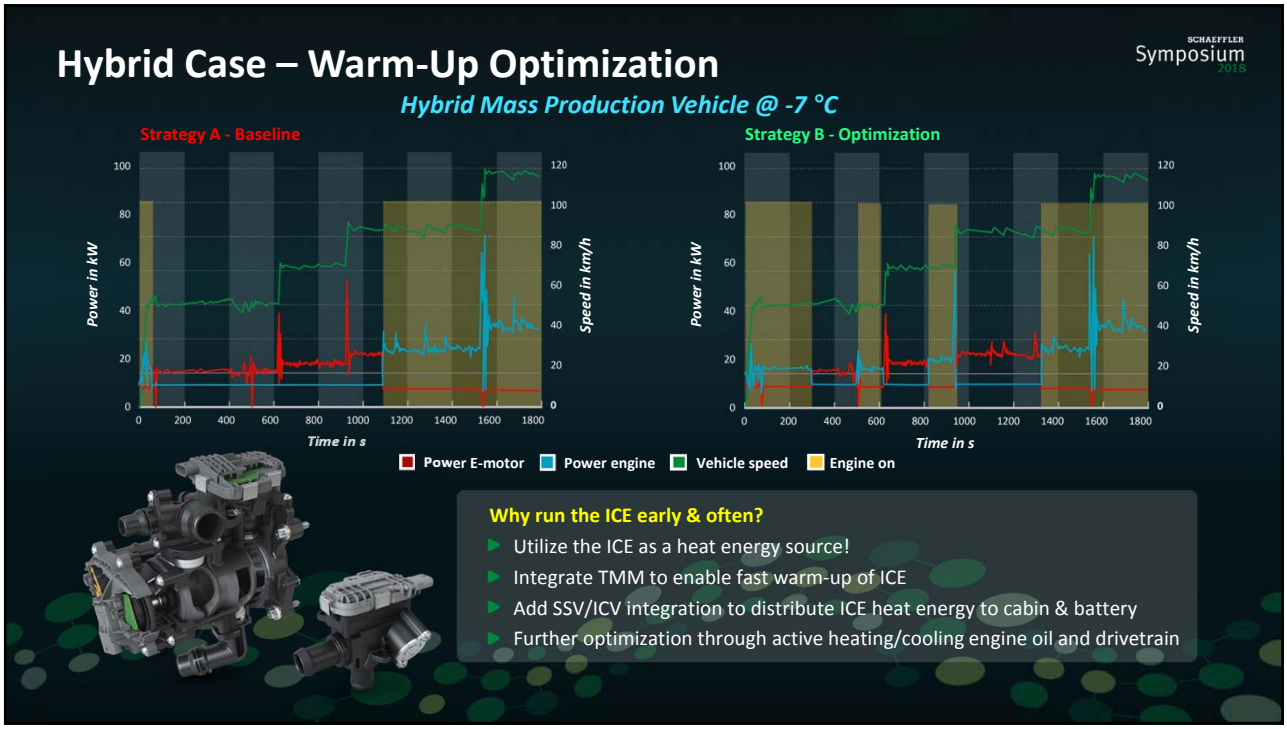


- Hybrid system generates much less waste heat energy than ICE
- Must condition battery & cabin during transient ambient conditions
- Energy emission from ICE is 30 kW + CAC 5-10 kW
- How to optimize the system to maximize electric range & reliability?
- Is plug-in conditioning responsible & what if no plug available?




Hybrid Case – Warm-Up Optimization
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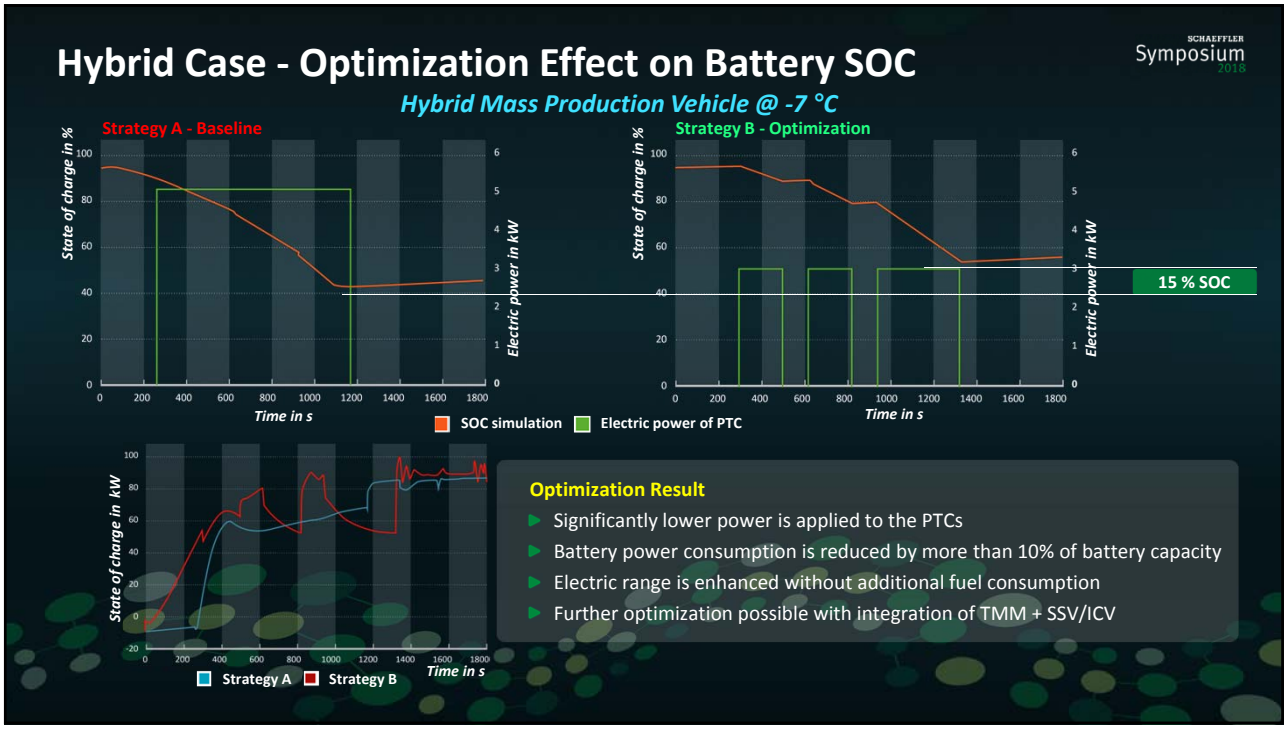
Hybrid Mass Production Vehicle @ -7 °C
Strategy A - Baseline
Strategy B - Optimization
Power in kW
Speed in km/h
Time in s
Power E-motor
Power engine
Vehicle speed
Engine on
Why run the ICE early & often?
Utilize the ICE as a heat energy source!
Integrate TMM to enable fast warm-up of ICE
Add SSV/ICV integration to distribute ICE heat energy to cabin & battery
Further optimization through active heating/cooling engine oil and drivetrain


Hybrid Case - Optimization Effect on Battery SOC
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Hybrid Mass Production Vehicle @ -7 °C
Strategy A - Baseline
Strategy B - Optimization
State of charge in %
Electric power in kW
Time in s
15 % SOC
SOC simulation
Electric power of PTC
State of charge in kW
Strategy A
Strategy B
Optimization Result
Significantly lower power is applied to the PTCs
Battery power consumption is reduced by more than 10% of battery capacity
Electric range is enhanced without additional fuel consumption
Further optimization possible with integration of TMM + SSV/ICV

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Optimize Your Energy Source (ICE)

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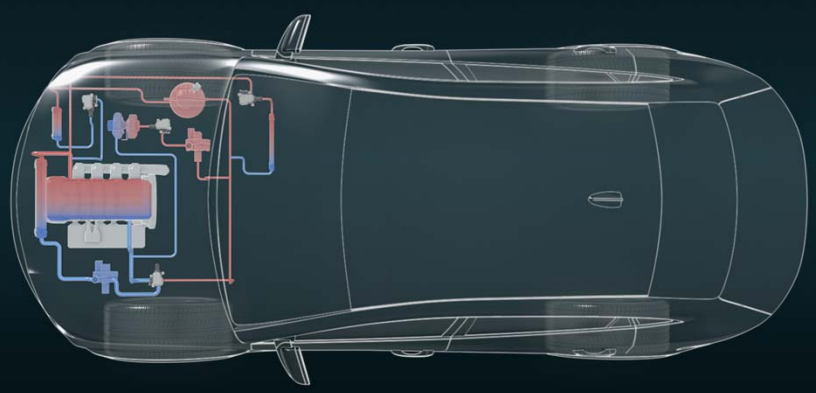

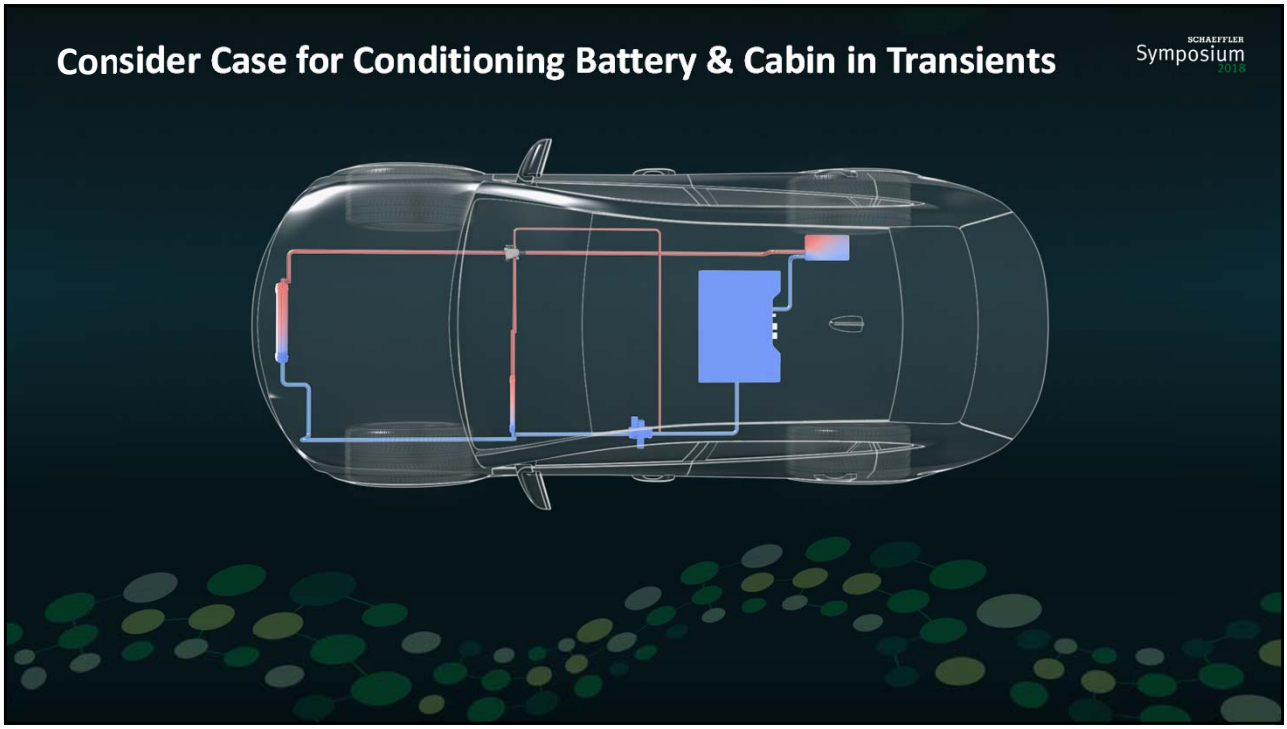
Consider Case for Conditioning Battery & Cabin in Transients
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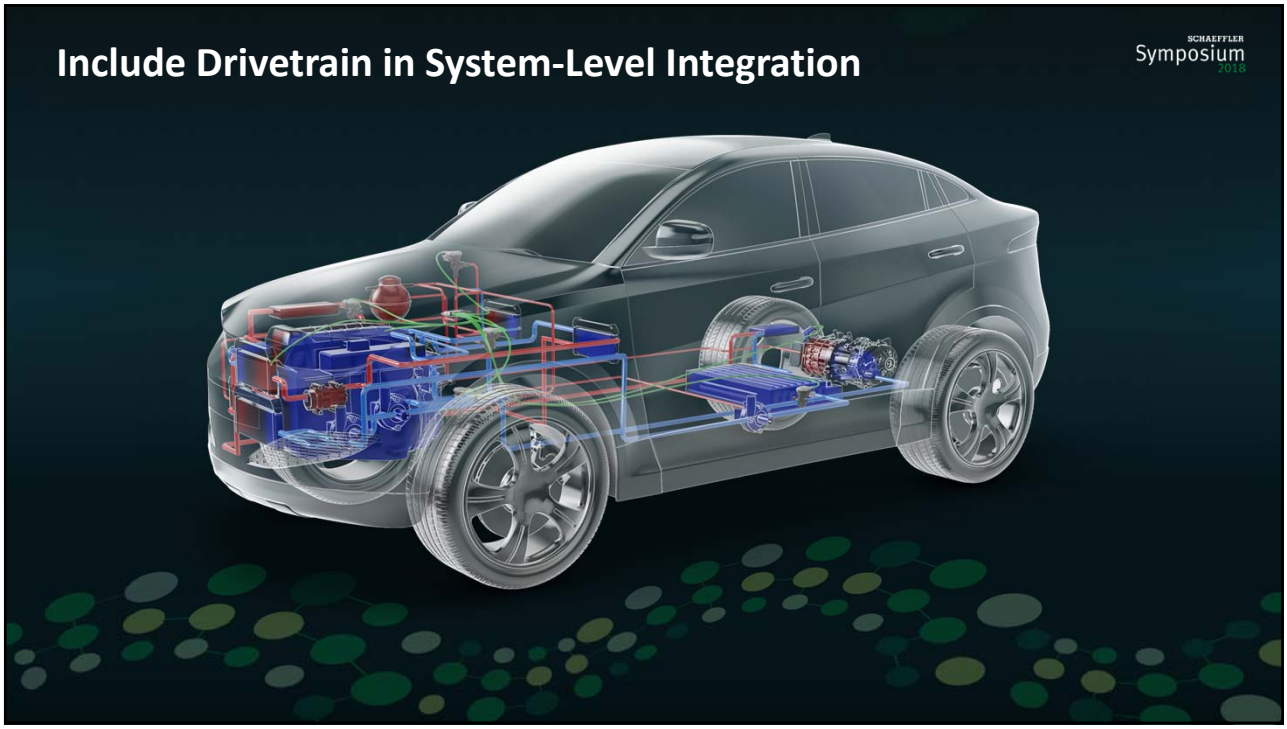
Include Drivetrain in System-Level Integration
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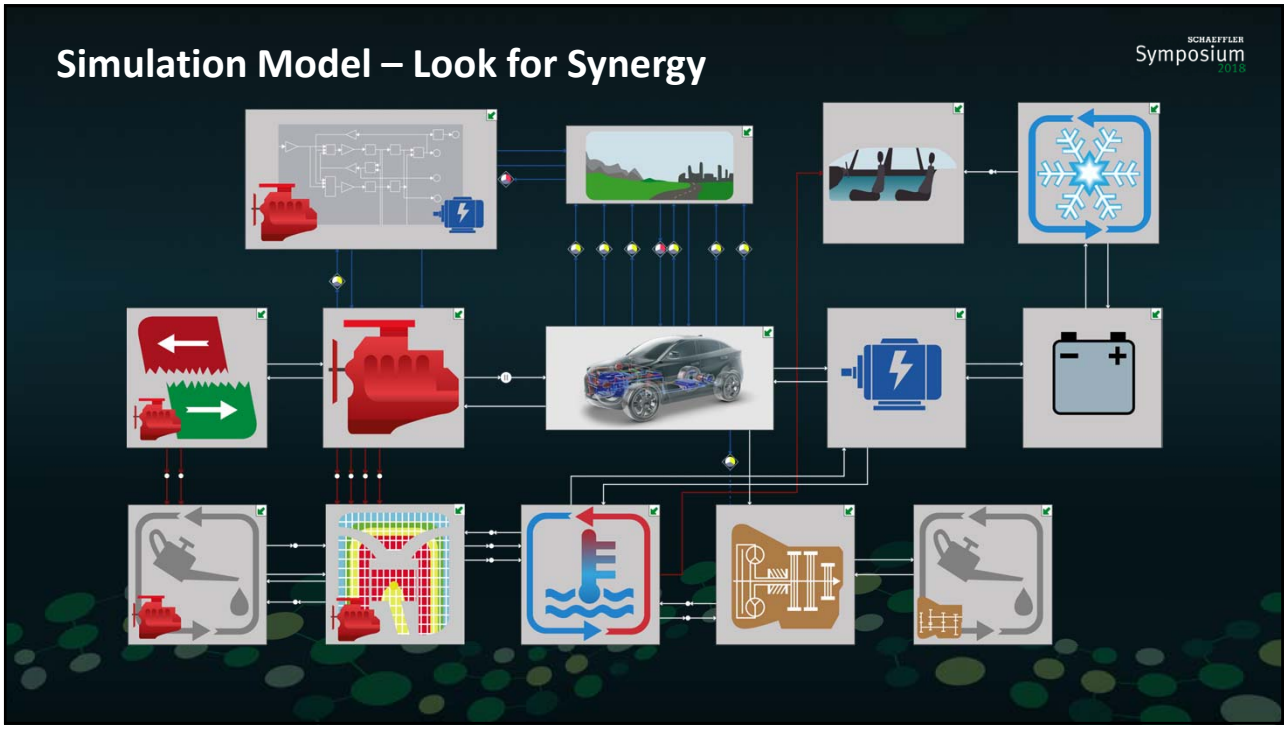
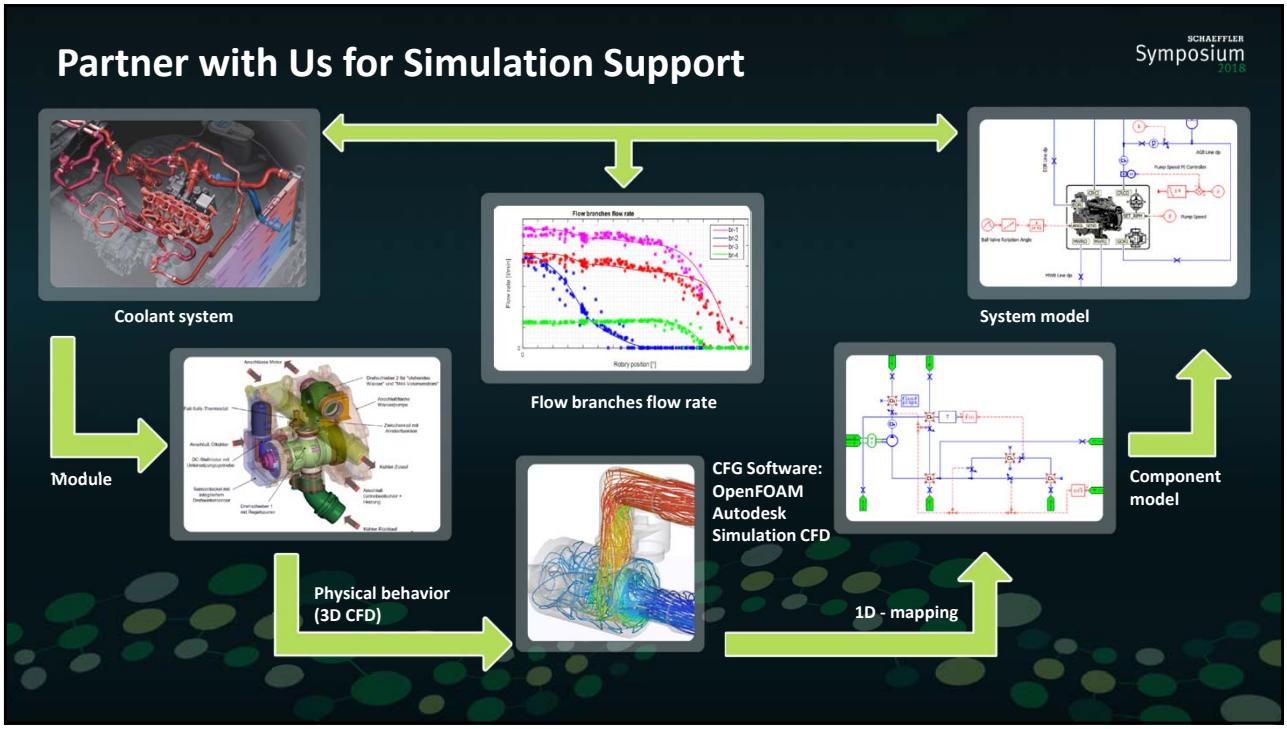
Pete Brazas – Thermal Management Synergy Through Integration





Integrate Modular Solutions

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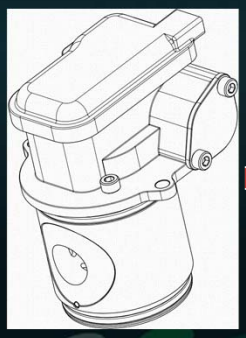
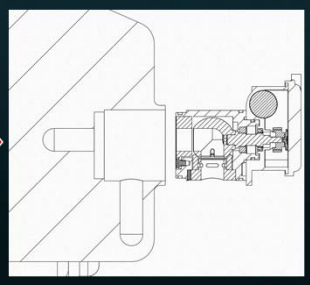
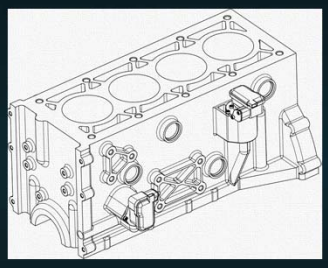
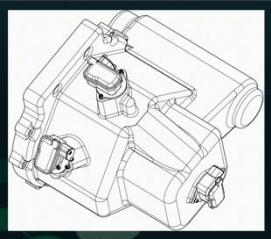
Why ICV?

- System control at point-of-use
- No hoses = packaging benefit and mass reduction
- Fast system response due to less thermal mass
- Mounting concept eliminates external housing
- Centralized ECU control or independent SMART control









- **Engine optimization – split cooling, flow control**
- **Drivetrain elements – transmission, differential, transaxle**
- **Electrification – battery conditioning, hybrid synergy, energy recovery/storage**

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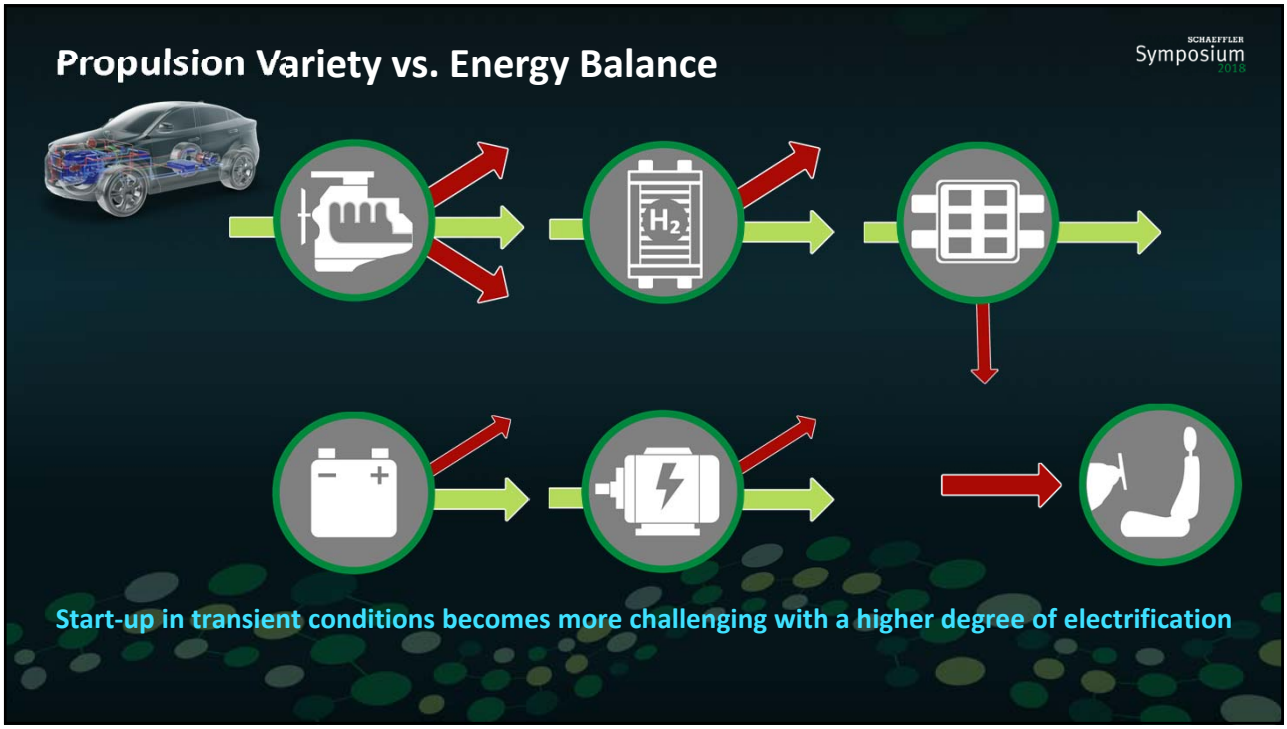
Propulsion Variety vs. Energy Balance
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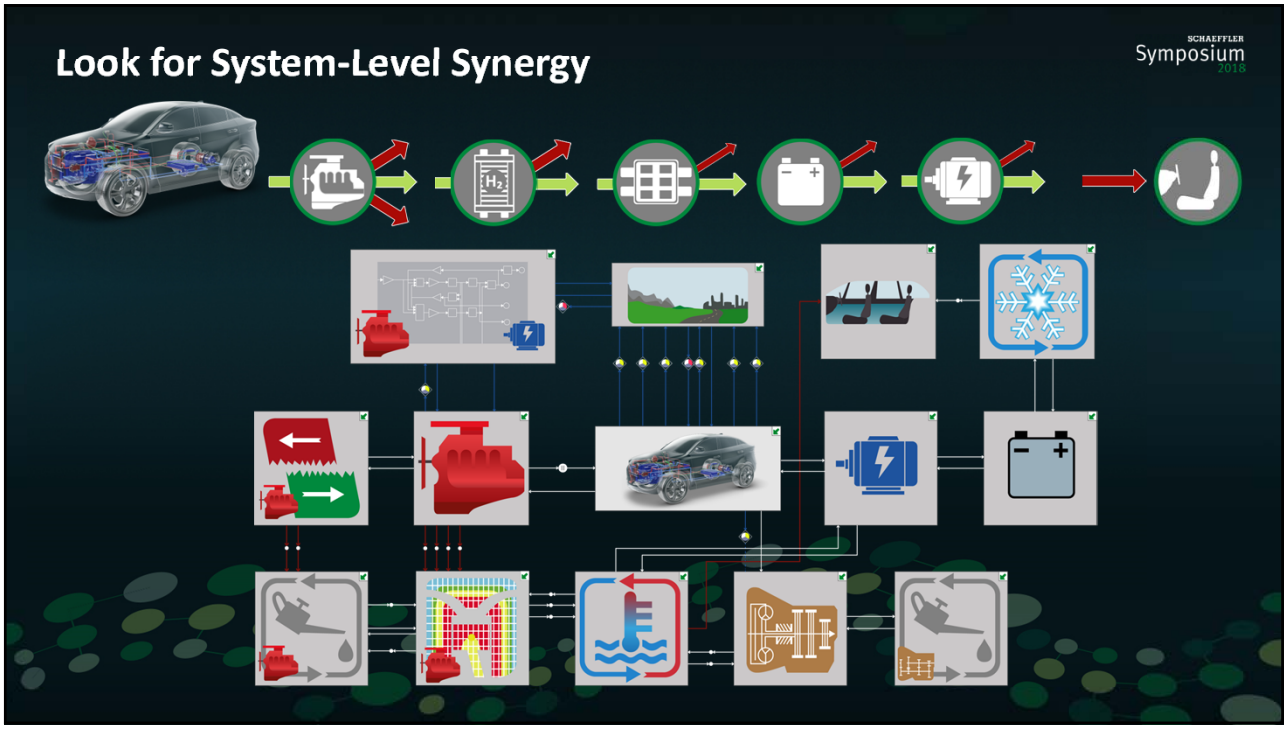
Start-up in transient conditions becomes more challenging with a higher degree of electrification


Look for System-Level Synergy
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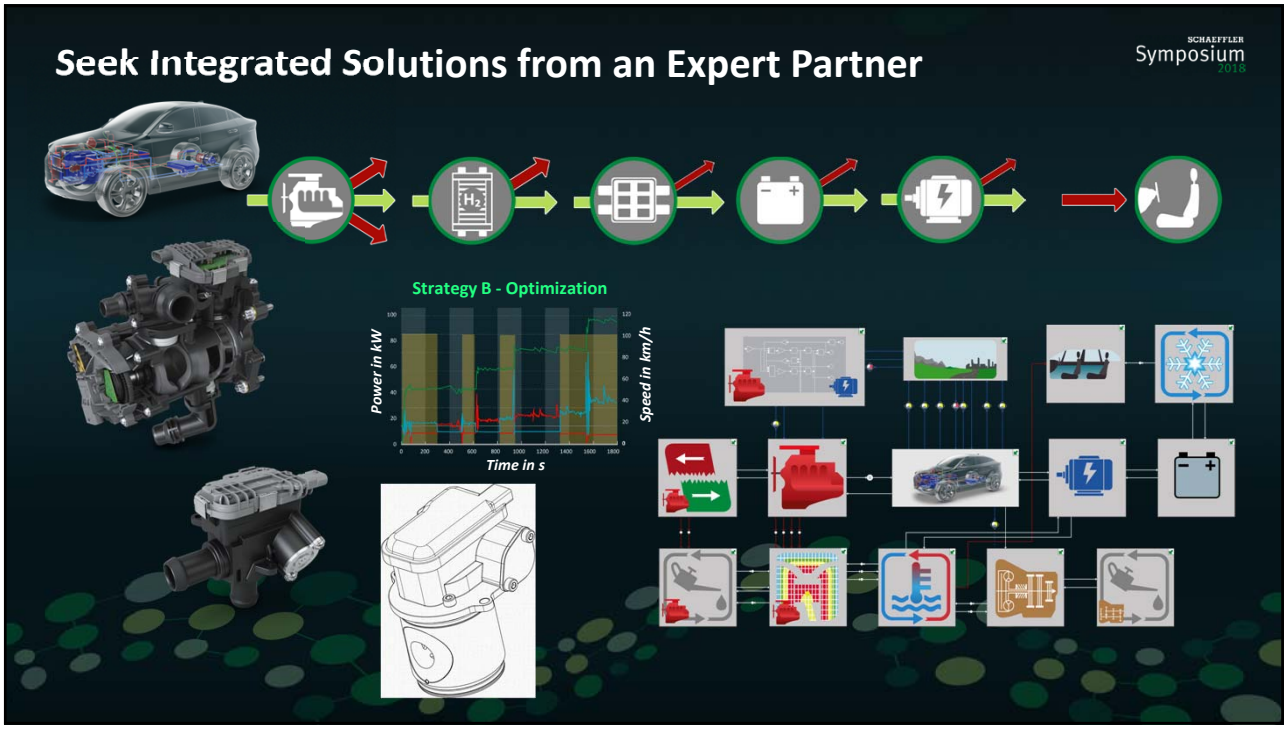
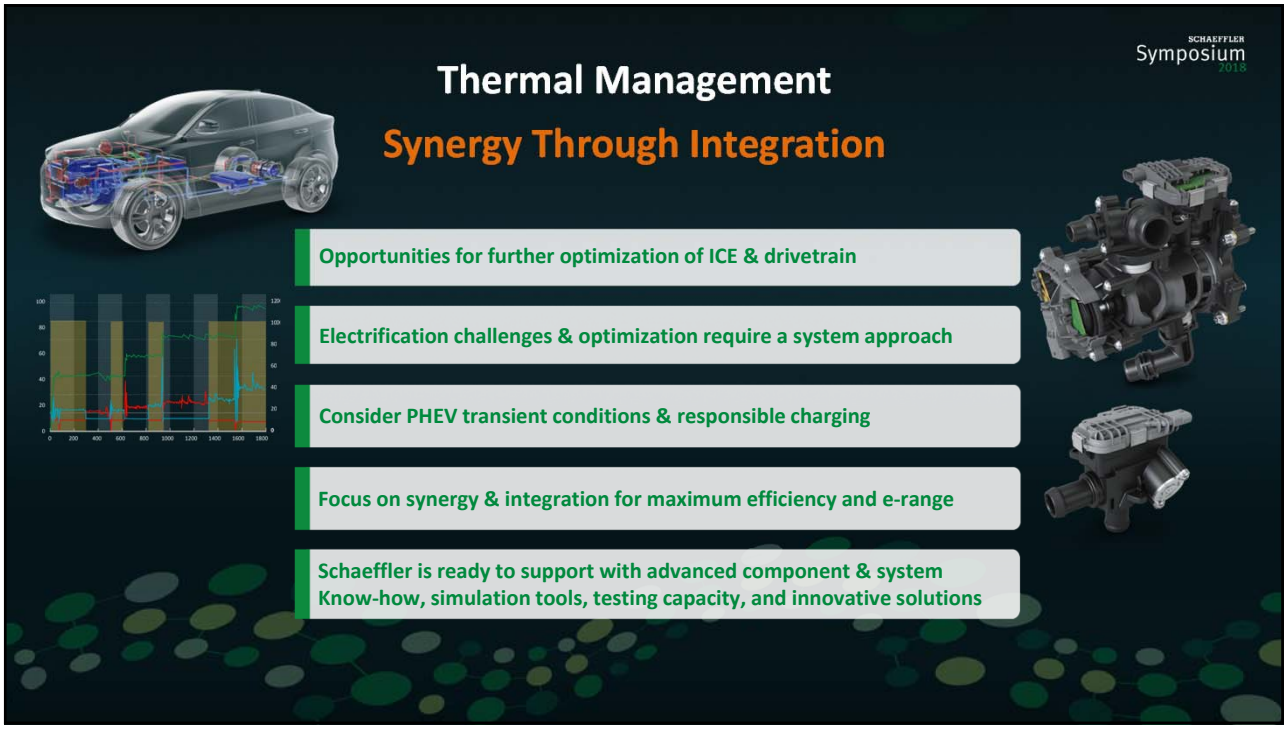
Pete Brazas – Thermal Management Synergy Through Integration



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