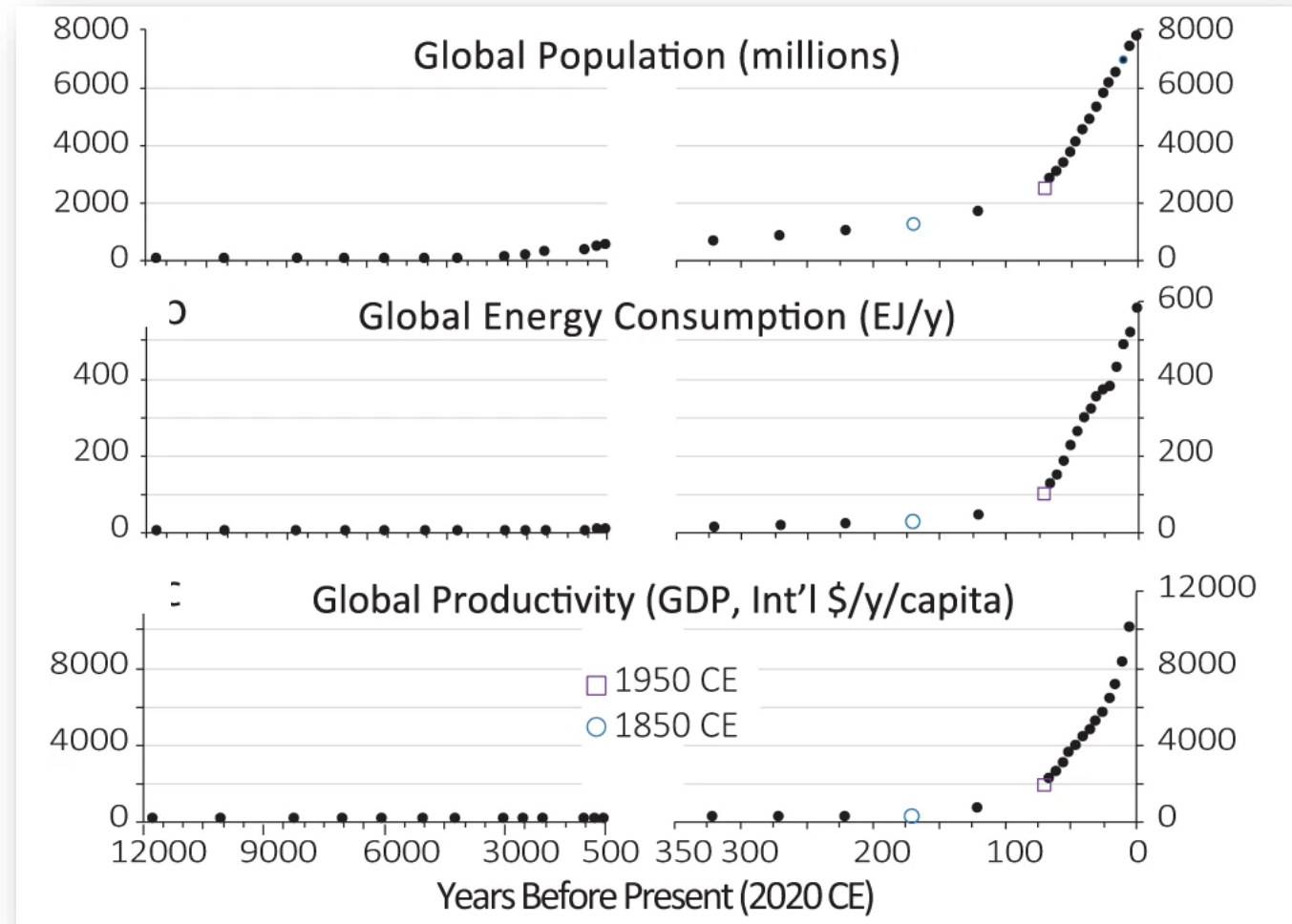


Innovating Energy Management – Tackling Thermal Challenges in Hybrid and Electric Vehicles

Jeff Hemphill
CTO Schaeffler Americas
April 2025

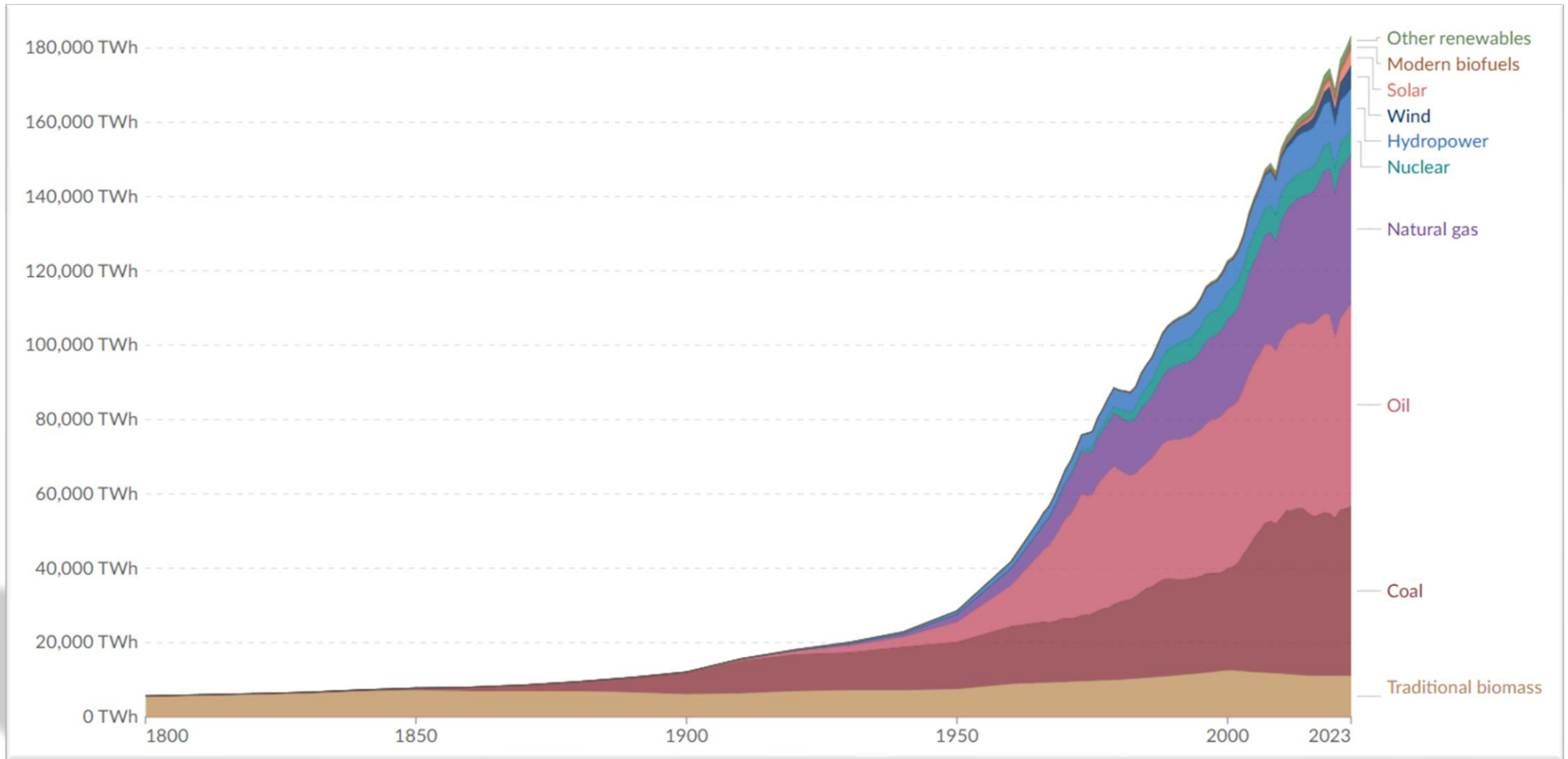
We pioneer motion

Human Population, Energy Consumption, and Productivity throughout History



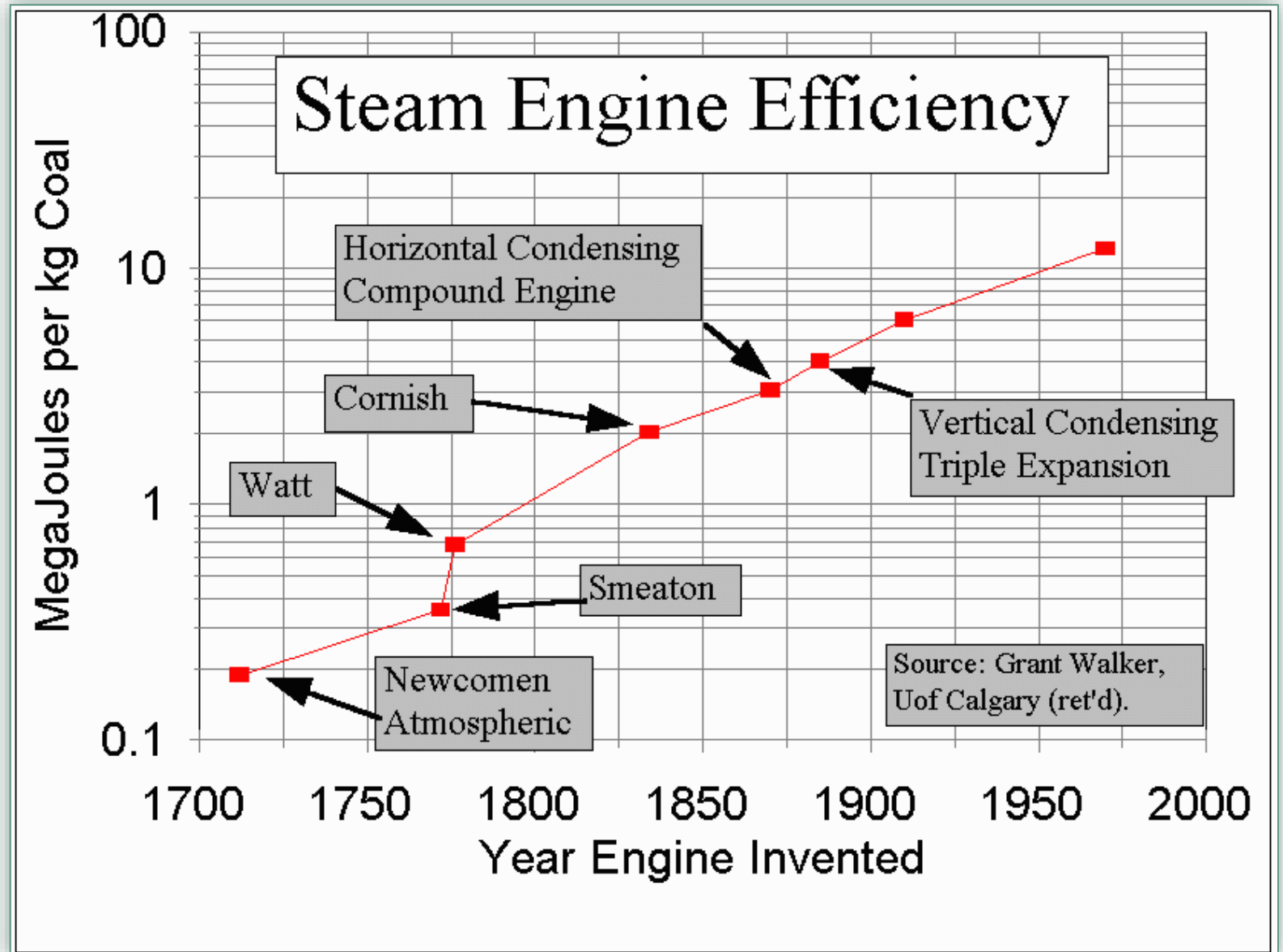
Syvitski, J., Waters, C. N., Day, J., Milliman, J. D., Summerhayes, C., Steffen, W., Zalasiewicz, J., Cearreta, A., Gałuszka, A., Hajdas, I., Head, M. J., Leinfelder, R., McNeill, J. R., Poirier, C., Rose, N. L., Shotyk, W., Wagreich, M., & Williams, M. (2020). Extraordinary human energy consumption and resultant geological impacts beginning around 1950 CE initiated the proposed Anthropocene Epoch. *Communications Earth & Environment*, 1(1), 1–13. <https://doi.org/10.1038/s43247-020-00029-y>

Global Primary Energy Consumption by Source



Global primary energy consumption by source. (n.d.). Our World in Data. <https://ourworldindata.org/grapher/global-energy-substitution>

Thomas Newcomen	0.5%
John Smeaton	1%
Watt	2.5%
ICE Car	16-35%
Combined Cycle Gas Turbine	63%
BEV (plus, can regen 22%)	65-69%



We Are Getting Better at Energy Efficiency!

Light is **500,000x cheaper** now than in hunter-gatherer societies.

Chopping wood for **60hrs** would give **1000 lumen hours of poor-quality light**, about **54 minutes of an LED bulb**.

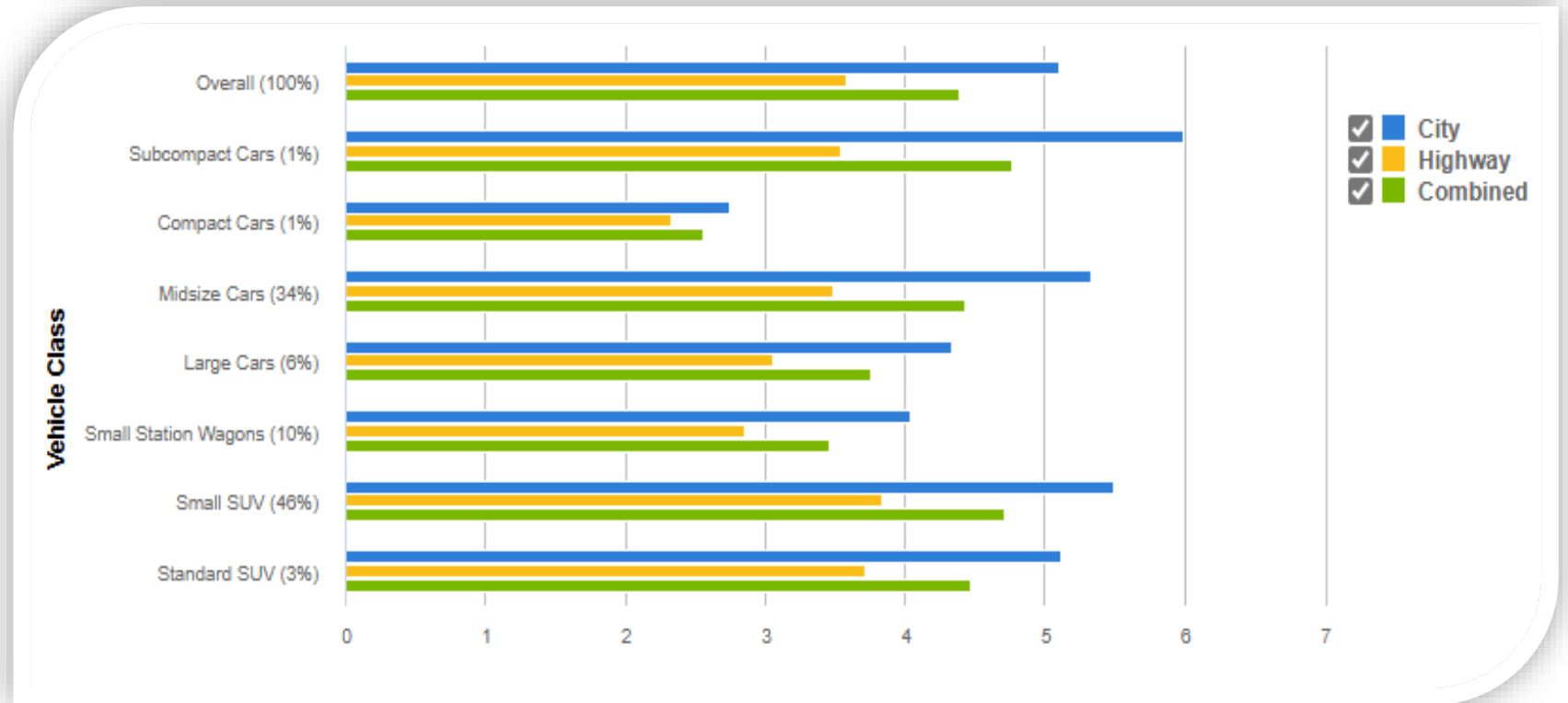
Now **60 hours** of labor buys **52 years** of continuous, high-quality light.



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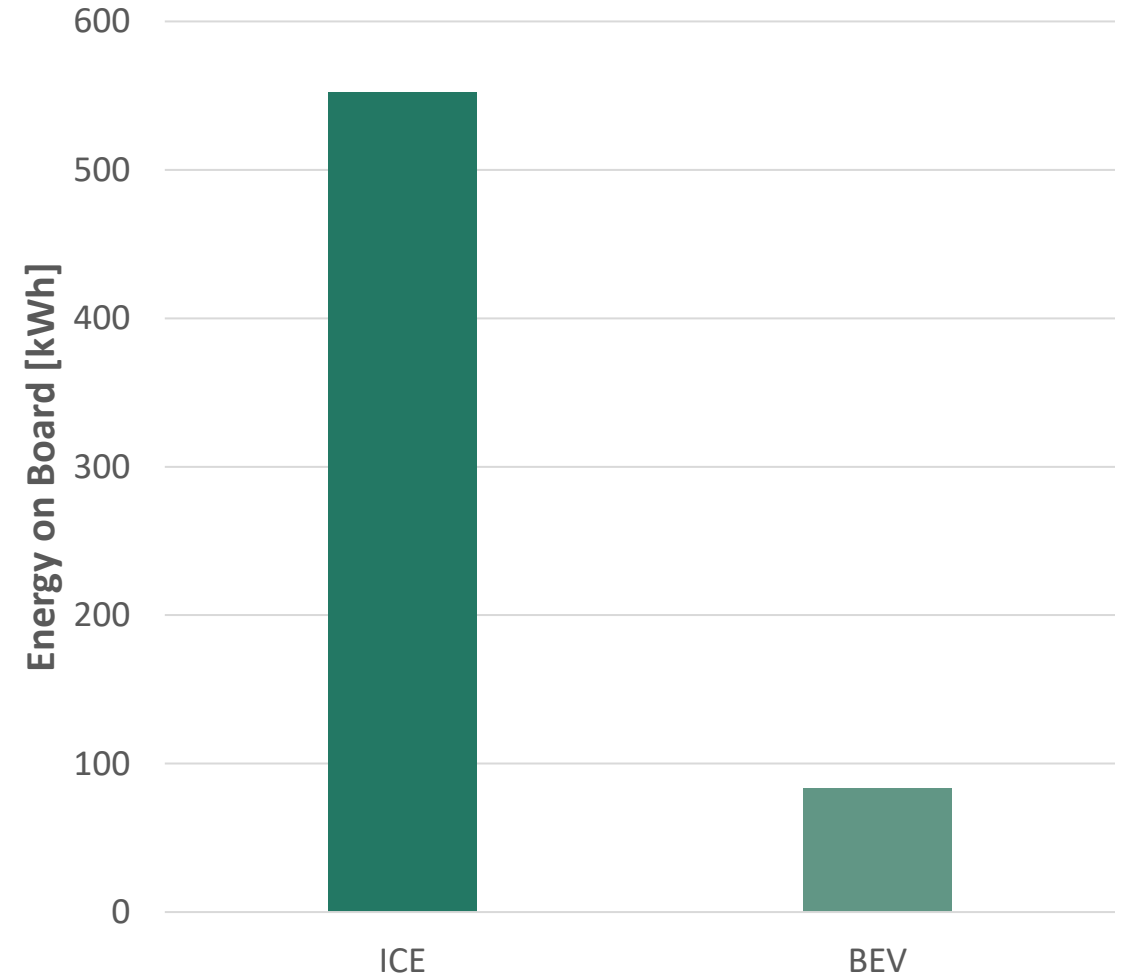
Efficiency Ratios for Light-Duty All-Electric Vehicles in the United States

- **EVER:** BEV vs. gasoline ICE efficiency.
- **Similar Vehicles:** Compares classes with BEV options.
- **Exclusions:** No light-duty trucks or vans.
- **Overall Efficiency:** BEVs are 4.4 times more efficient.
- **City Driving:** 5.1 times more efficient.
- **Influential Classes:** Midsize cars and small SUVs.

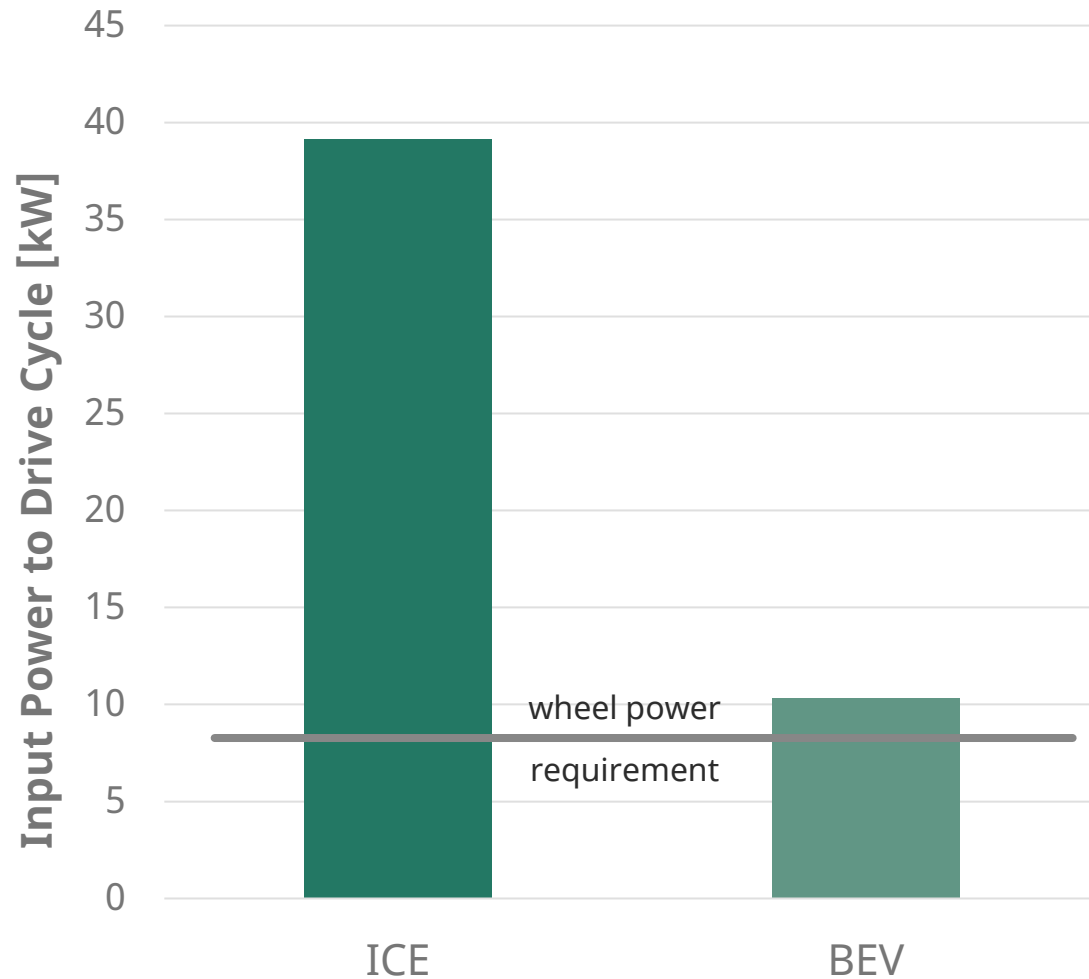


Energy on Board

- **150lbs** of gas carries **10x the** energy of 2000lb of batteries!
- Wise use of energy is of **utmost importance** to an electrified vehicle!

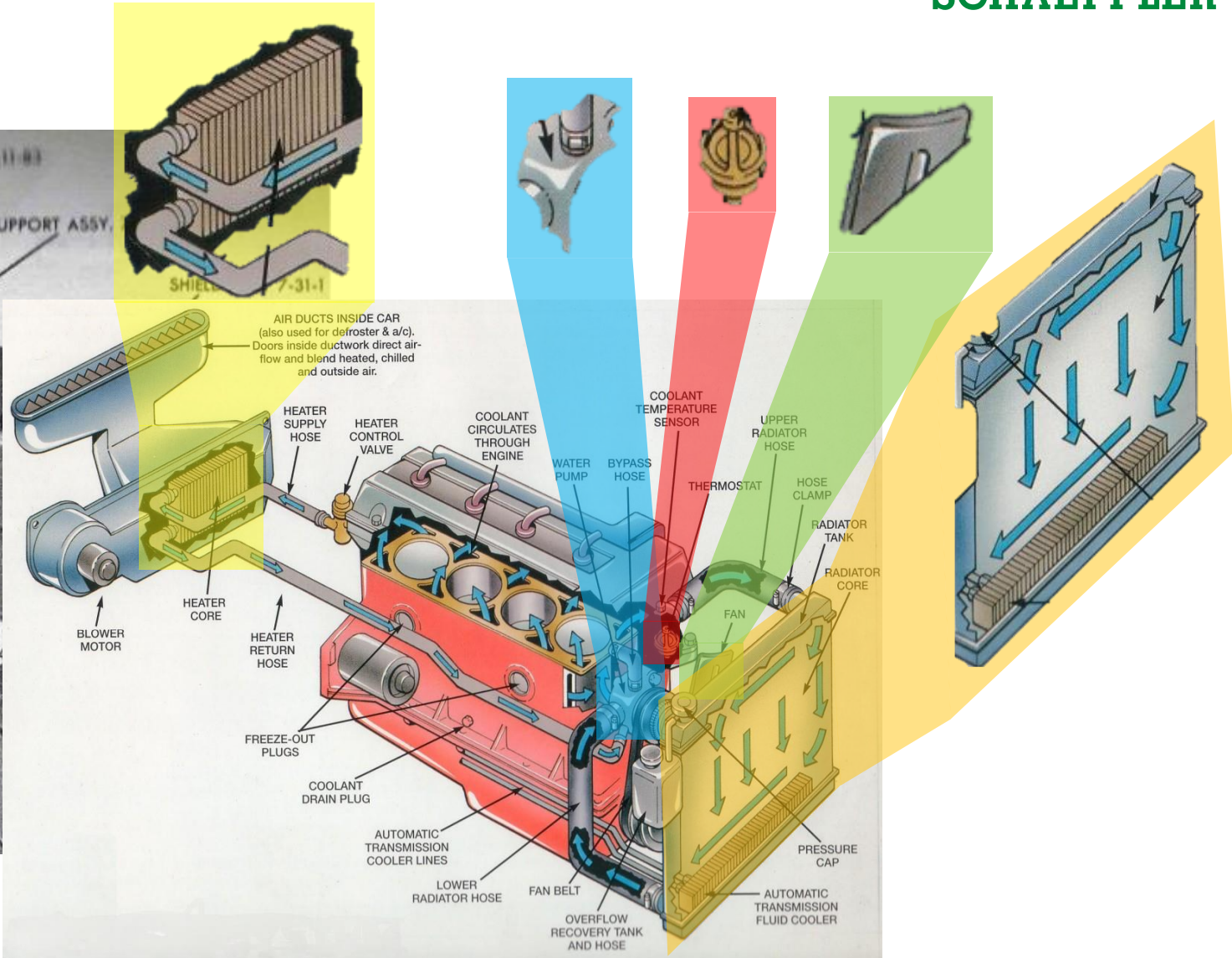
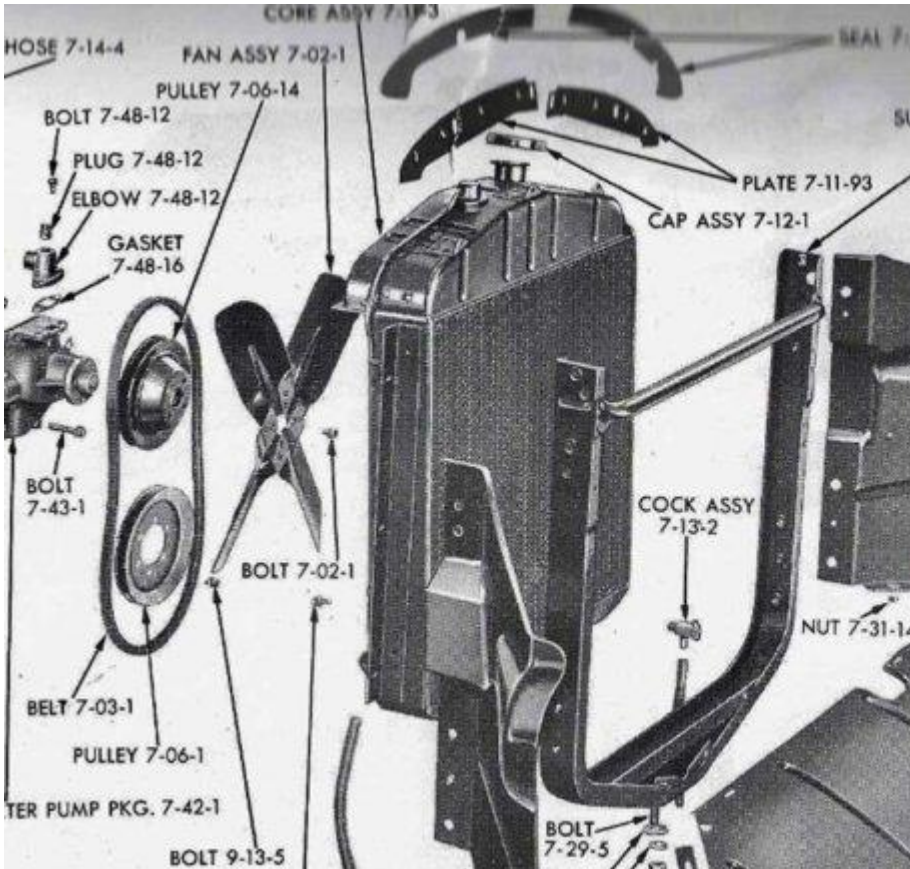


A Bigger Role for Smaller Losses

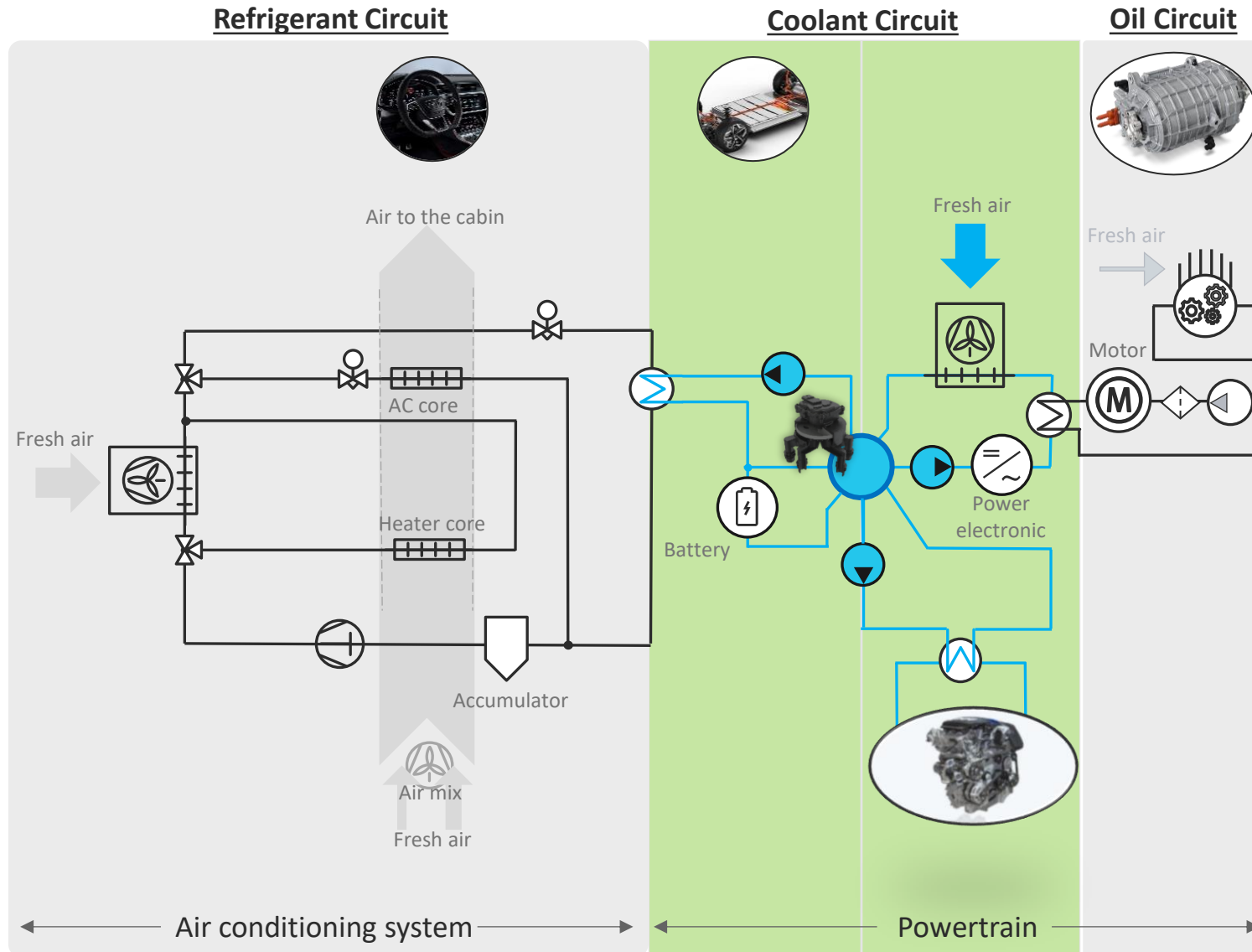


- **Small SUV** on the combined cycle needs around **9kW average power** at the wheel.
- The **fuel power** needed for the **ICE vehicle** is almost **40kW** due to the poor efficiency.
- A **500W** efficiency improvement is **1%** for the ICE and **5%** for the BEV.
- Every Joule of energy is **5x more** important to a BEV!

The Good Olde Days?



Thermal Management System Architecture for HEV's



Integrated Coolant System



Integrated Thermal Management System (ITMS) for REEV

Thermal Management System



Features

- High integration of coolant and refrigerant components
- Integrated valve housing with manifold design
- Improved insulation to reduce heat loss
- Multi-way valves provide complex coolant distribution modes
- Refrigerant circuit: Integrated heat exchangers, expansion valves, receiver dryer and sensors

Technical Data ICS

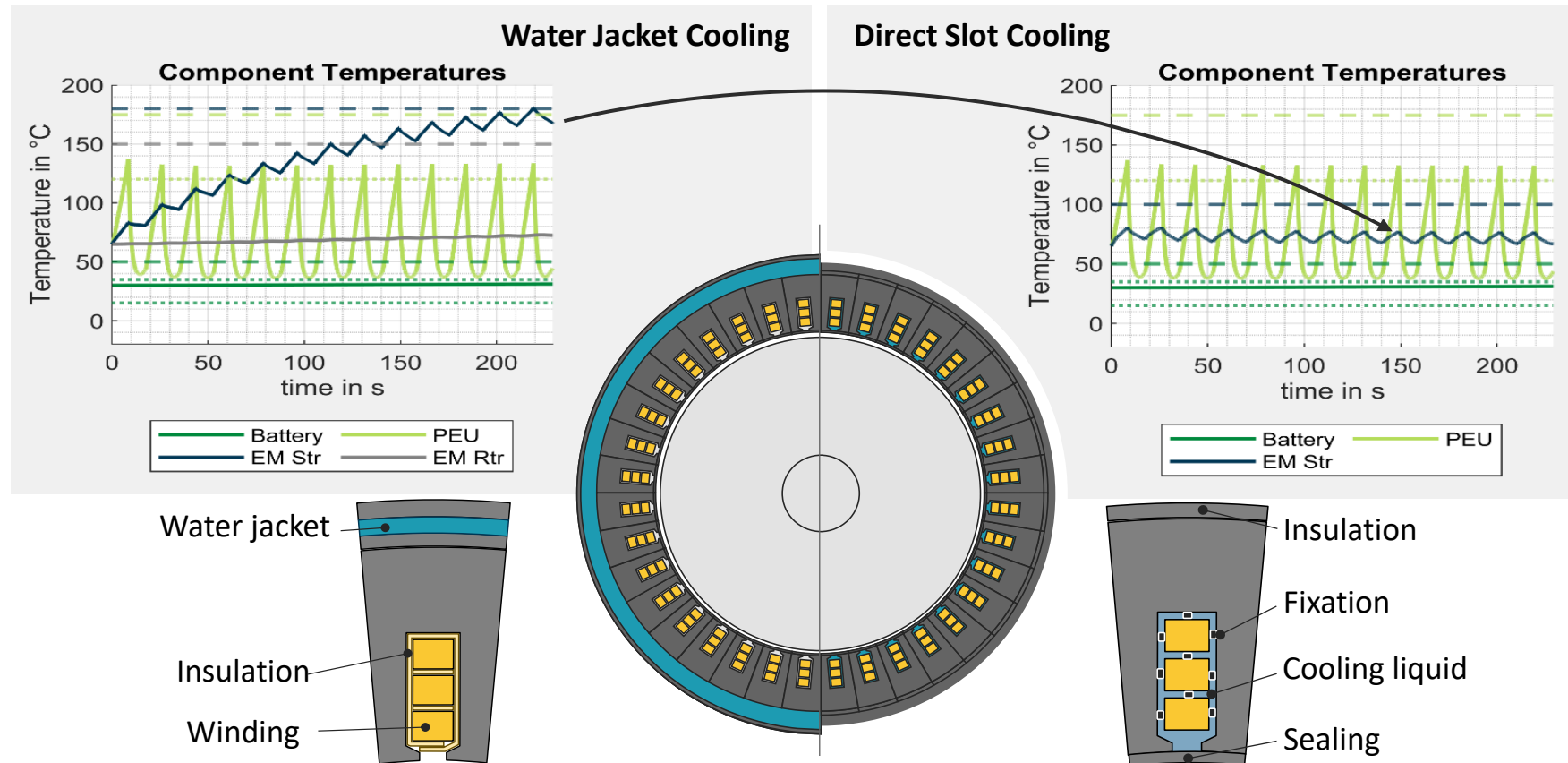
Integrated Thermal Management System

E-Water pumps	Multi-way valve
Heat Exchanger	Expansion Valves
Receiver dryer	Reservoir and level sensing

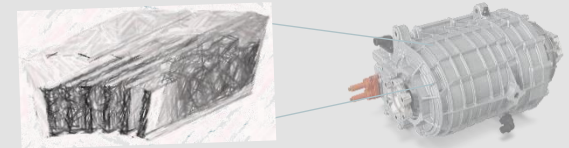
Benefits

- Multi-way valve internal leakage $\leq 15\text{ml/min}$ @ 1bar
- Coolant circuit heat loss $\leq 200\text{W}$
- Cost and space savings of approx. 20% in comparison to non-integrated system
- Simplified assembly in vehicle
- Lower system pressure losses
- Large number of operating modes

New Electric Drive with Efficient Cooling

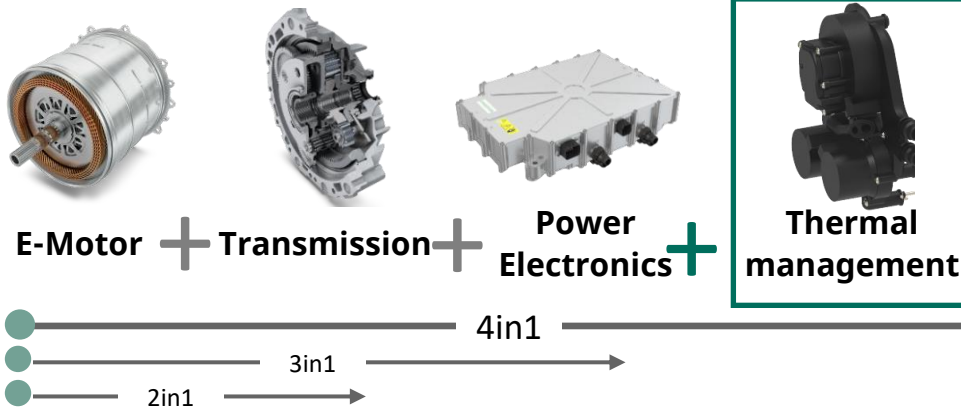
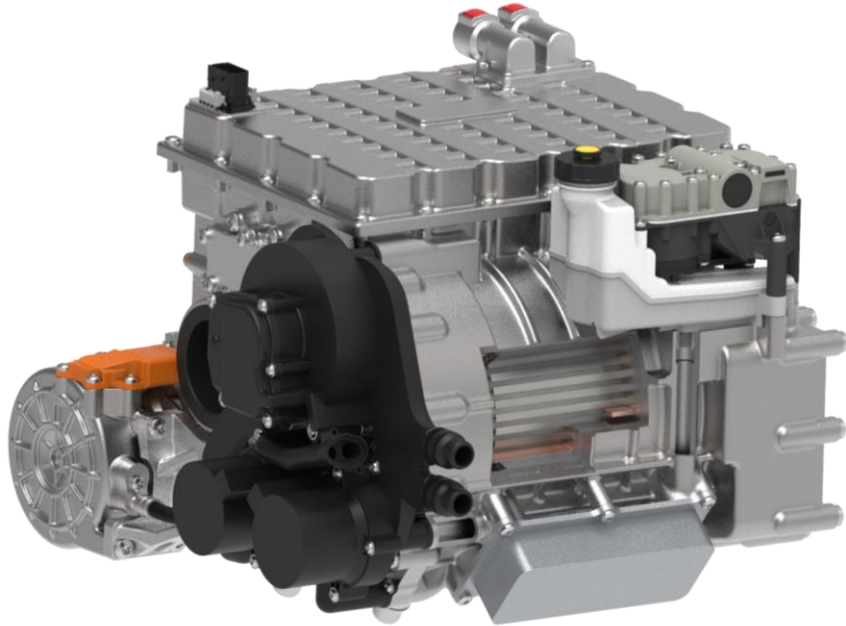


Harvest



- High cooling performance by direct heat extraction at heat-source
- **Allows dynamic waste heat harvesting**
- Reduces temperature levels significantly
- Enables 100% continuous-to-peak power ratio

4 in 1 System Benefits



10% lower costs*

(reduced parts, weight & assembling steps)



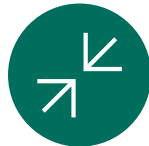
14% lower energy consumption*

(waste heat recovery and CO₂ HP)



Higher cont. performance

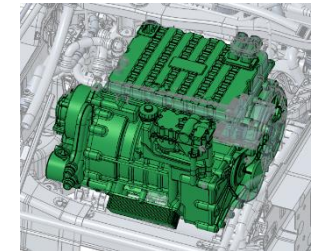
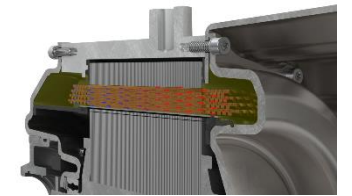
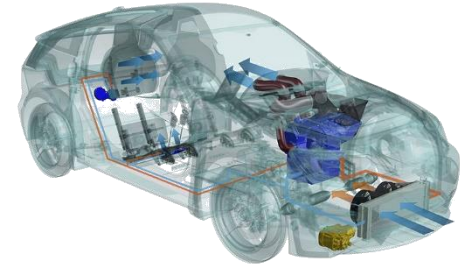
(with slot (oil) cooled e-motor)



Fits in 3in1 package

(including thermal management)

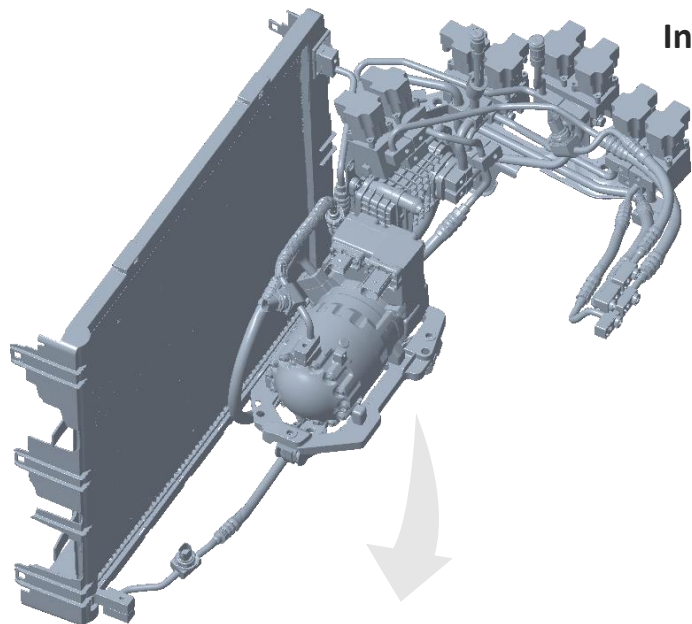
SCHAEFFLER






*Reference: C-segment vehicle 160 kW / R1234yf heat pump system

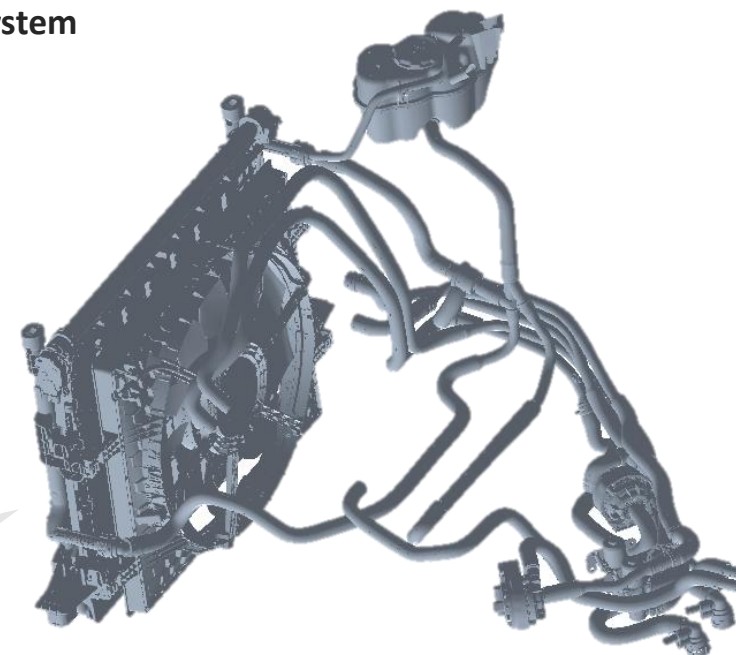
TMS Packaging



Integrated Refrigerant System



-  Volume reduced by up to 30%
-  Reduced interfaces pipes (6 vs. 13 single pipes)
-  Less assembly steps

Integrated Coolant System



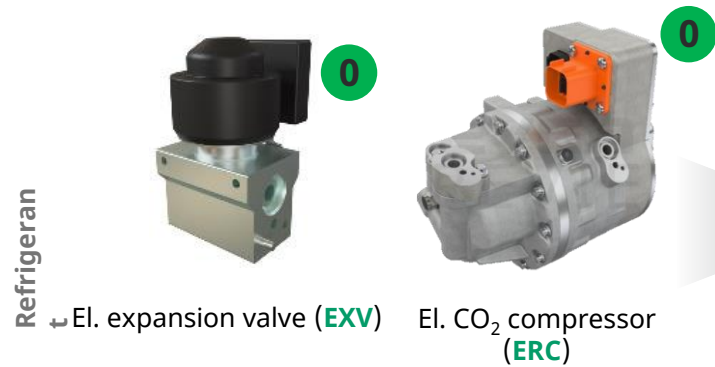
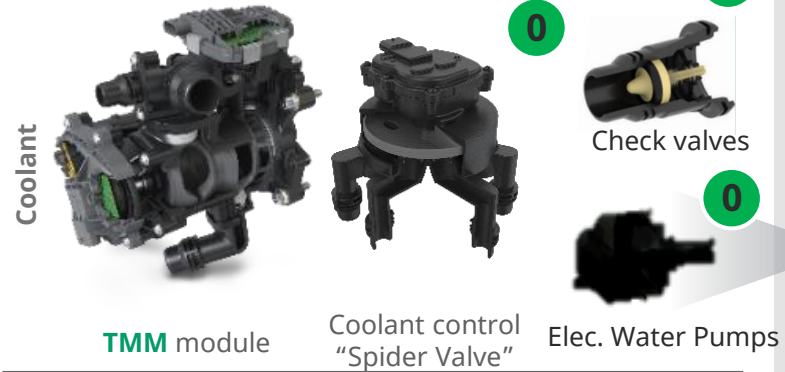
-  Volume reduced by up to 30%
-  6 interface tubes (vs. 30 tubes)

Estimations based on 3D scanned models

The Vertical Integration Route

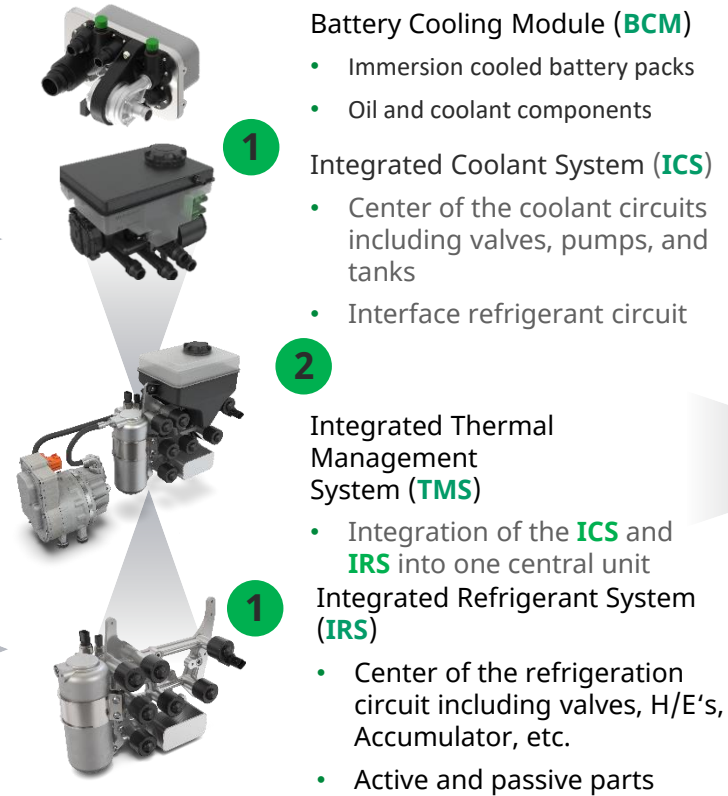
USP

Components



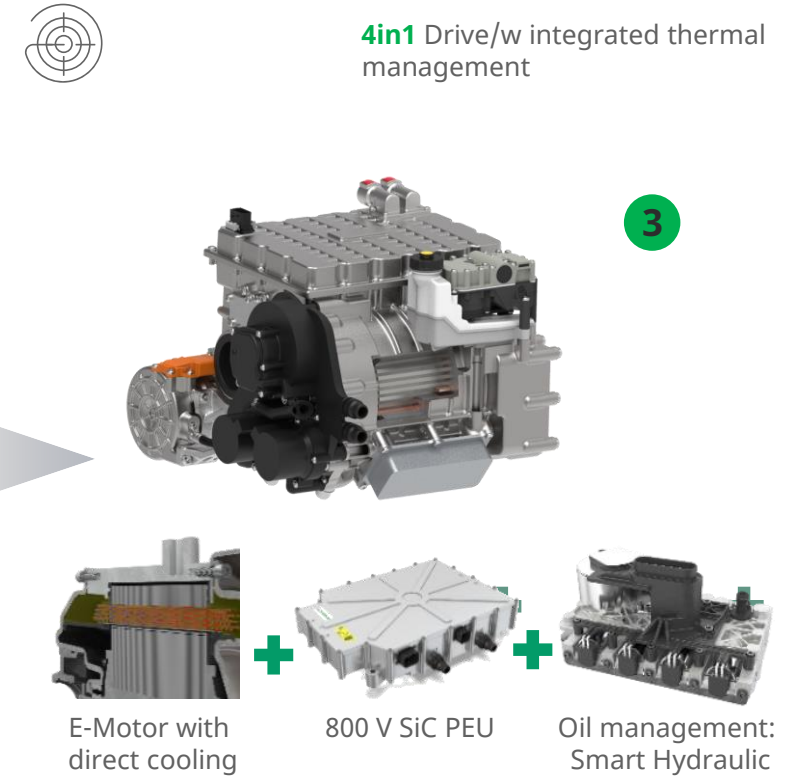
USP+

Sub-Systems



USP++

Vehicle Systems

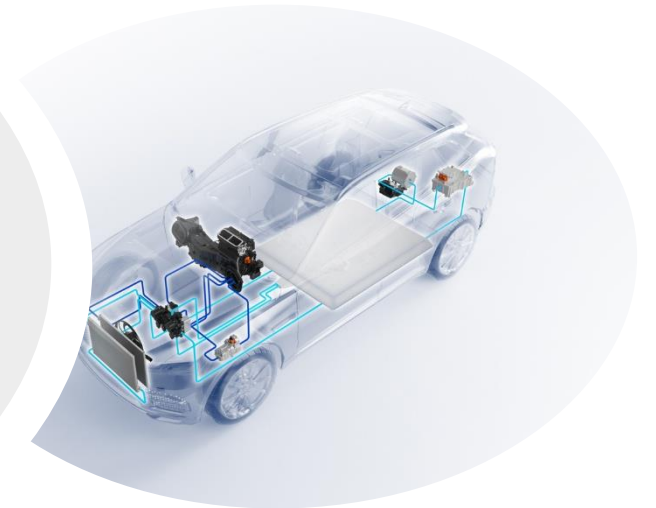


Conclusion

Utilizing external energy is the key to our success and we are getting better at it!

The more efficient we get, the larger the role played by small losses.

There is much more room for innovation in thermal management!



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