SPOTLIGHT CHARGING SOLUTIONS

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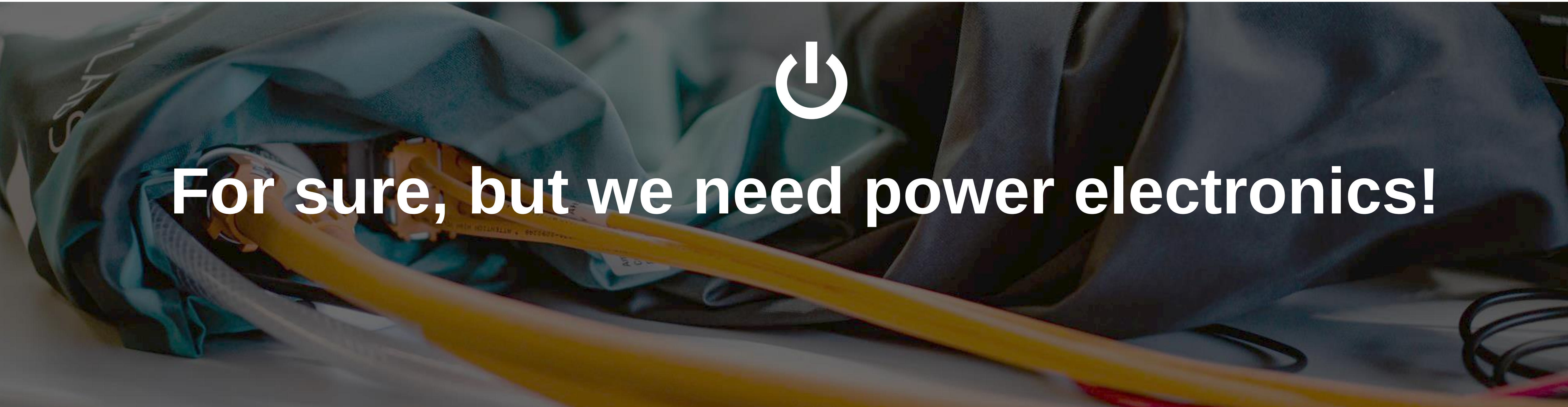
FFG
Das Land Steiermark
SFG
ZUKUNFTSFONDS STEIERMARK
LAND KÄRNTEN
ober österreich
Member of UAR INNOVATION NETWORK

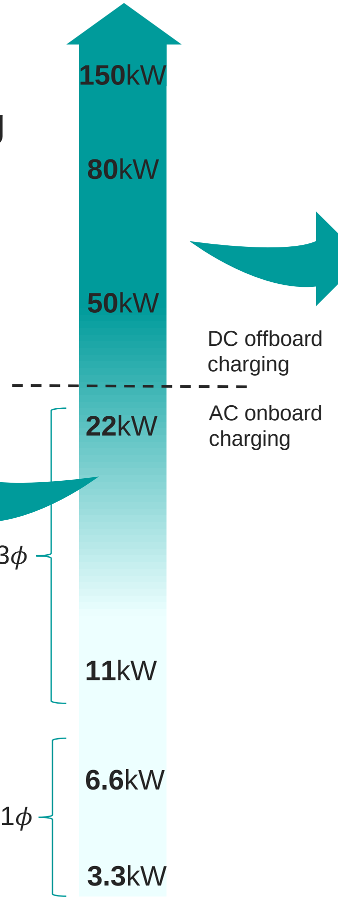
CAN'T WE JUST PLUG THE CABLE TO CHARGE THE BATTERY?



For sure, but we need power electronics!

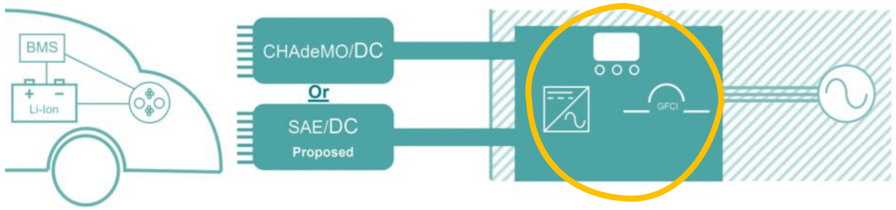
ONBOARD VS OFFBOARD CHARGING

- Slow charging, low charging power
  (typ. 4h for 80% SoC @11kW, 50kWh battery)
- No concern about battery heating during charging
- Operated by pilot signal J1172
- Adds weight to vehicle
- Easy worldwide single phase and three phase operation possible – no grid adoption needed



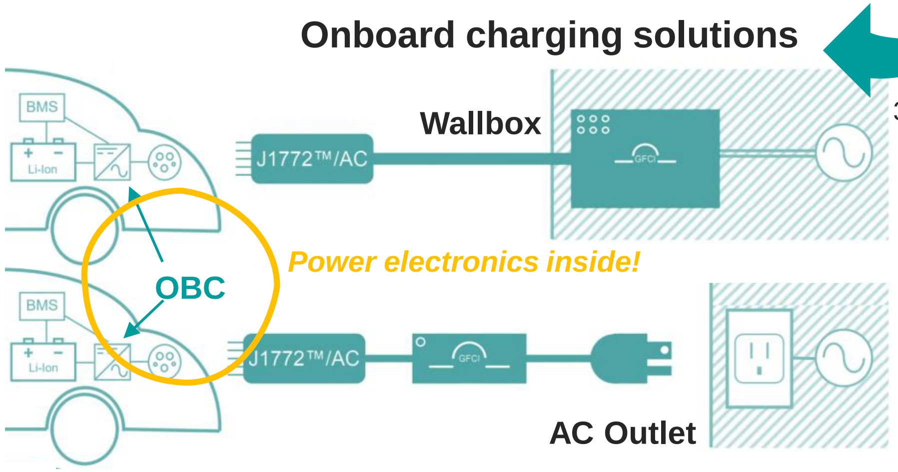
Offboard charging solution

Power electronics inside!



- Removes weight from vehicle
- Fast charging (typ. 20min for 80% SoC)
- Generally higher charging power (typ. 50kW+)
- Include more sophisticated BMS systems
  - It is required to managing battery heating during charging
- Communications to building/home/grid energy management systems
  - Demanding high power charges
  - The higher the energy transfer rate, the higher the required battery conductivity

Onboard charging solutions

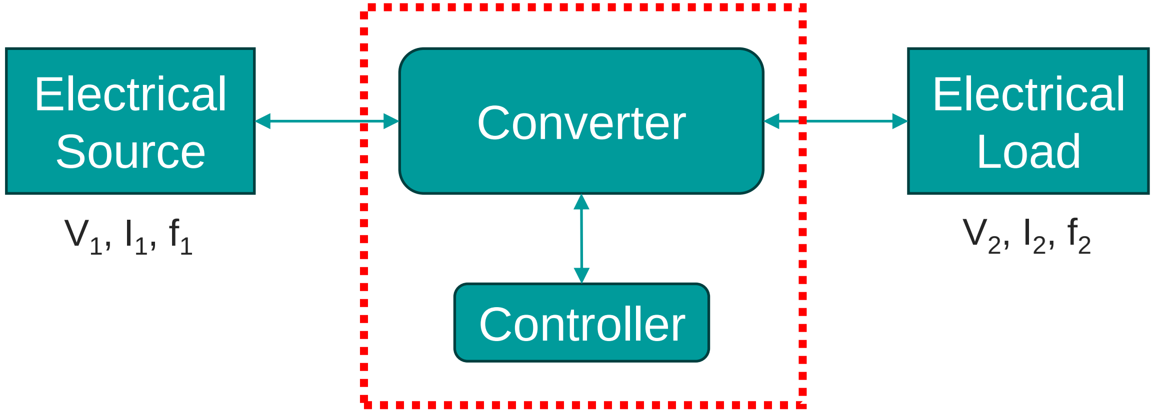


GFCI…Ground fault circuit interrupter
BMS …Battery Management System
OBC …Onboard Charger

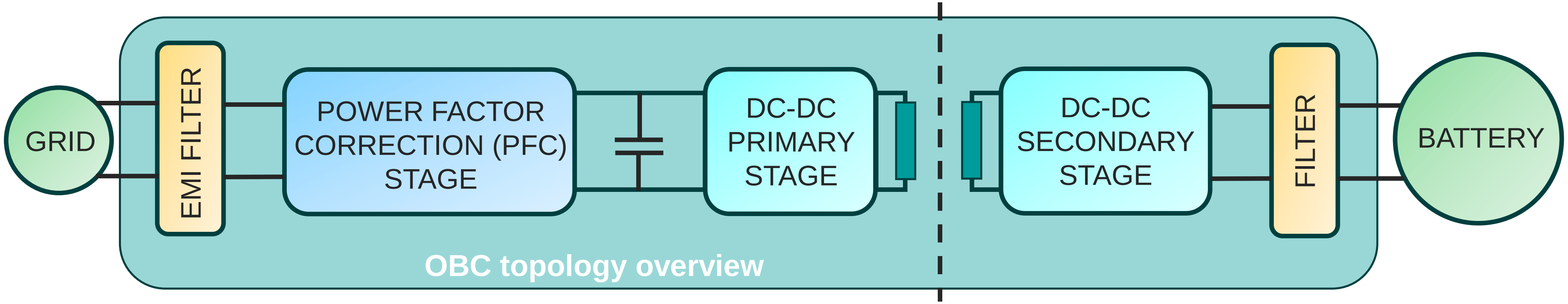
WHAT IS POWER ELECTRONICS?

- **Power Electronics** deals with the control and low loss conversion of electric power by using power semiconductor switches.

- **Classification of power electronics systems**
  - AC to DC converter (rectifier)
  - DC to DC converter
  - AC to AC converter (cycloconverter)
  - DC to AC converter (inverter)



Power Electronic System



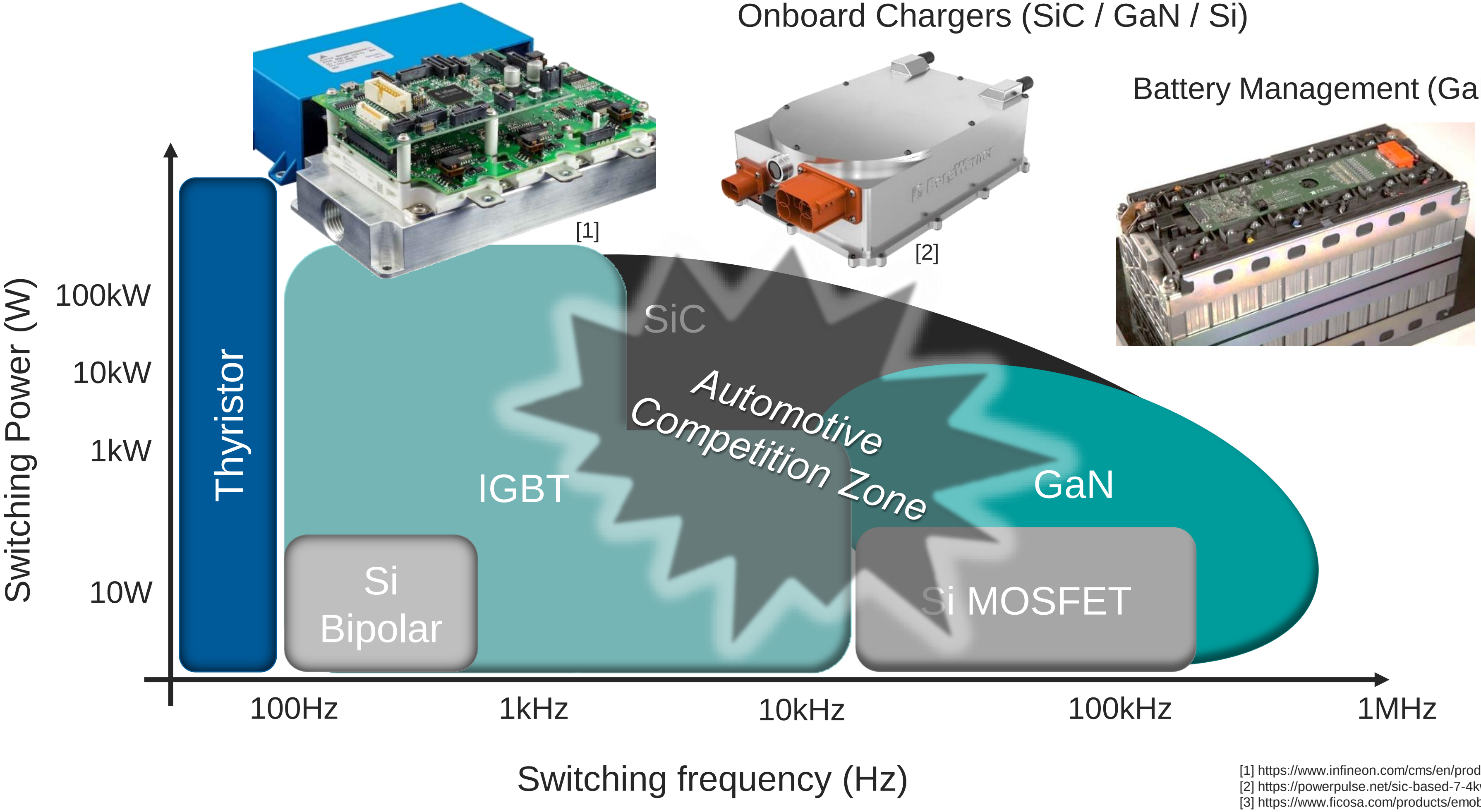
OBC topology overview

AUTOMOTIVE POWER ELECTRONICS

Traction Inverter (IGBT / SiC)

Onboard Chargers (SiC / GaN / Si)

Battery Management (GaN / Si)



Power Electronics for Automotive Infotainment (GaN / Si)

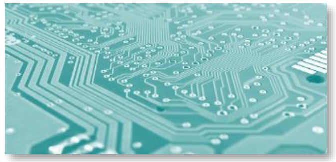
[4]

[1] https://www.infineon.com/cms/en/product/evaluation-boards/hybrid-kit-drive/
[2] https://powerpulse.net/sic-based-7-4kw-11kw-22kw-onboard-battery-charger-for-evs-and-hevs/
[3] https://www.ficosa.com/products/emobility/battery-management-system/
[4] https://www.linkedin.com/company/avl-software-and-functions-gmbh/

AUTOMOTIVE ONBOARD CHARGER
DESIGN CONSIDERATIONS

TINY POWER BOX | SAL SILICON AUSTRIA LABS

Higher Power Density



Functionality
- Driving range
- Fast charging
- Regeneration
- Driveability

Component Interaction
- Thermal crosstalk
- Electromagnetic compatibility
- Vibration and noise

Wide-Bandgap Semiconductors
- High voltage
- High operating temperature
- High switching power (SiC)
- Fast switching (GaN & SiC)

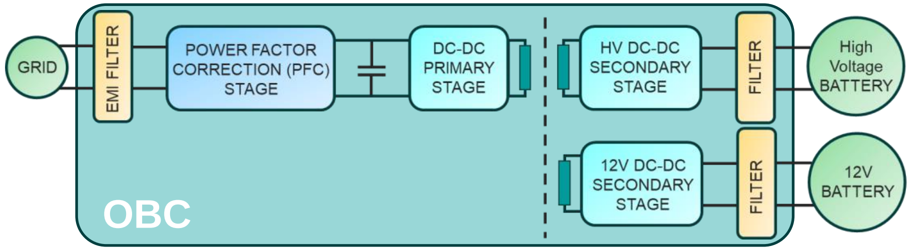
Integration and Packaging
- More compact concepts
- Integration of sensors, gate drivers, safety devices
- Integration of charger, converter, heater, cooler, etc.

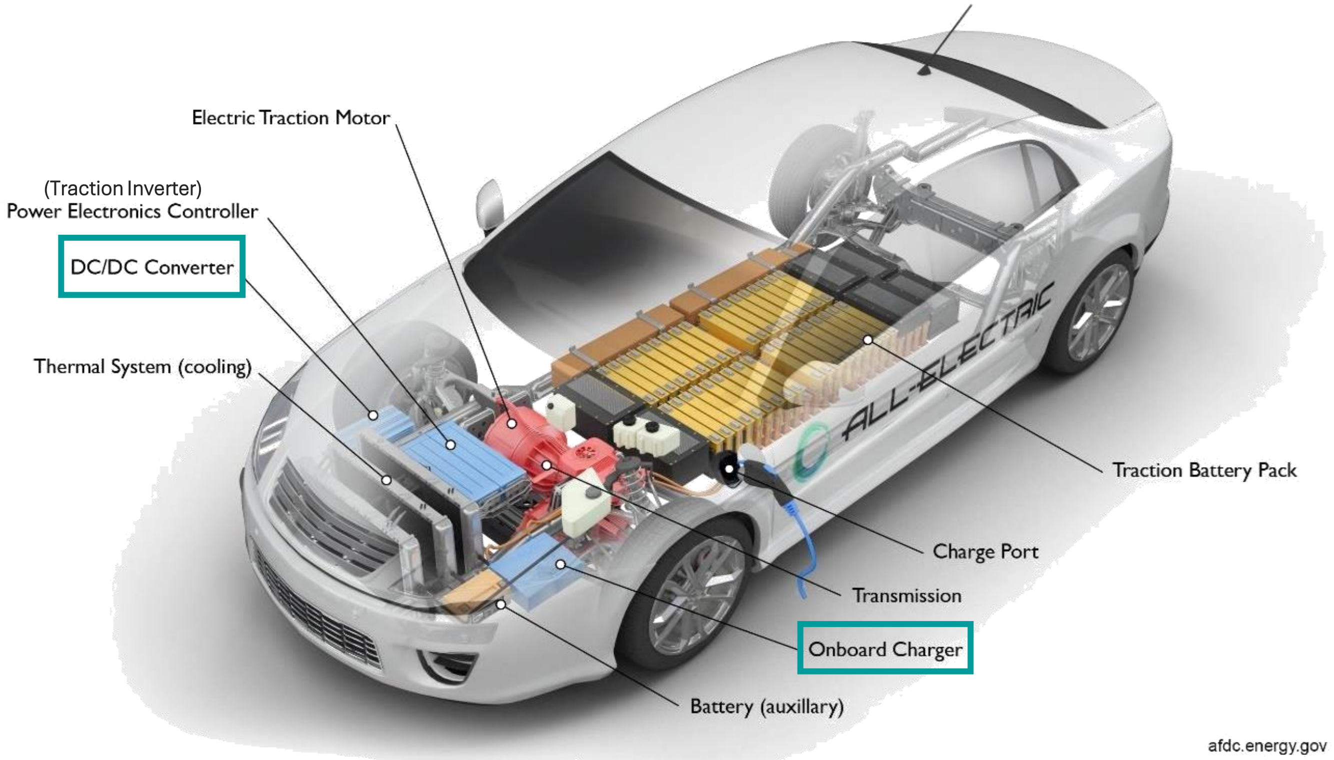
Reliability
- Failure prevention
- Health monitoring
- Durability

Economy
- Cost reduction: development & production
- Time to market
- Modularity

AUTOMOTIVE ONBOARD CHARGER

- The power grid offers alternating current (AC) electricity and is available almost everywhere
- Onboard chargers are necessary to perform the AC to the required-DC conversion for charging of the electric vehicle batteries.
- **OBC integrated addon functions**
  - Integrated 12V DCDC converter(s) for e.g. operating headlights, air conditioning and infotainment.
  - Bi-directional charging feature for Vehicle-to-home operation mode.





Internal view of an all-electric vehicle [1].

[1] Diaz, M.N. *Electric Vehicles: A Primer on Technology and Selected Policy Issues*; R46231; Congressional Research Service: Washington, DC, USA, 2020.

ONBOARD CHARGER ASSEMBLY

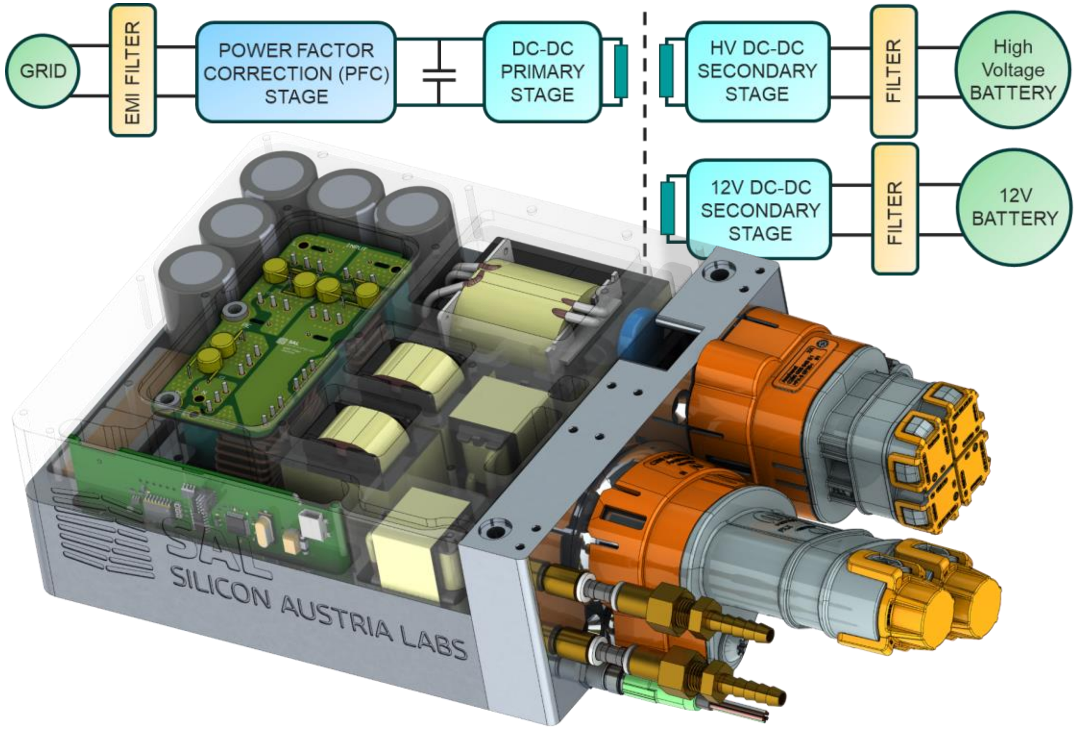


Figure 2 Overall assembly concept with integrated liquid cooling for an automotive OBC application. The sytem setup includes **a)** top side cooling system, **b)** aluminum housing which is filled with potting material, **c)** passive components PCB, **d)** power stage PCB, **e)** bottom side cooling system thermal interface material, **g)** auxiliary supply board, **h)** control board, **f)** EMI filter board. The potting material (not shown) help to increase the heat transfer towards the liquid cooling system and improve cooling of the components. Thermal interface materials are used to thermally attach the coldplates to the semiconductors the aluminum housing.

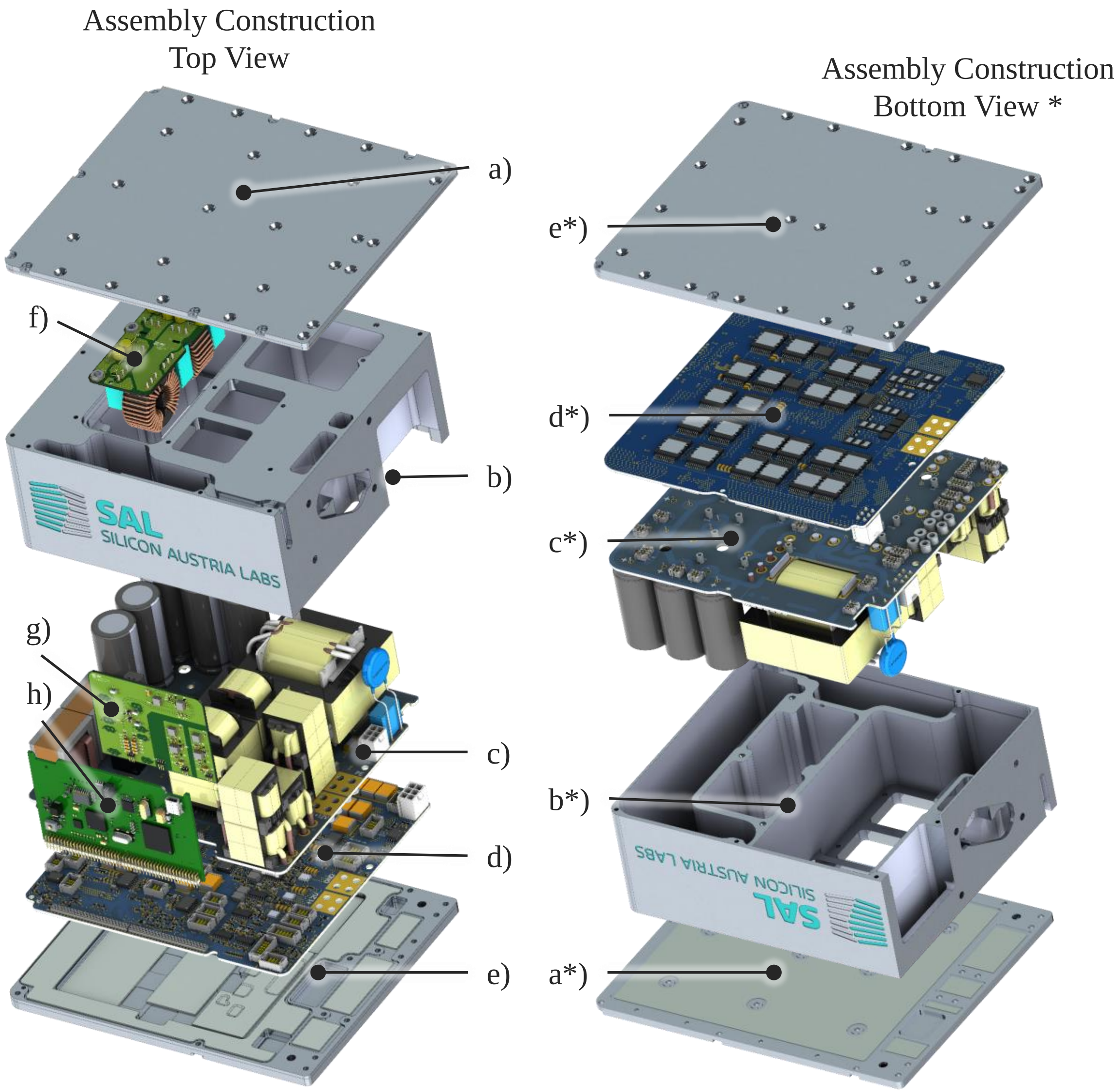


Figure 2 – Overall assembly concept

TINY POWER BOX

ROLE MODEL FOR SAL CO-OP PROJECTS

Beyond state-of-the-art power density

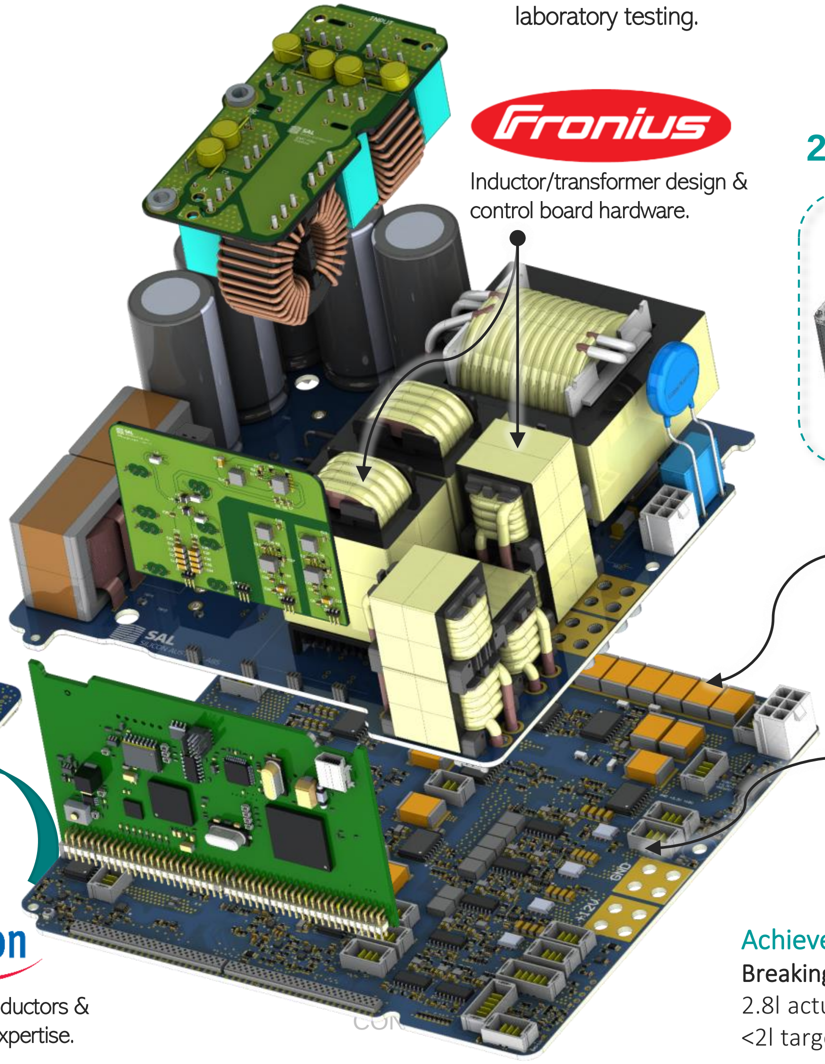
Bi-directional Onboard Charger for…

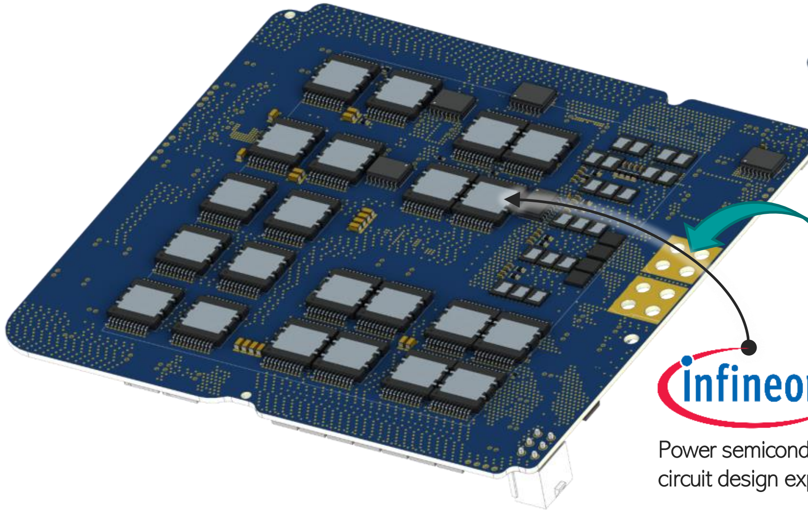
Variant A: **Automotive** (7kW) - 1Φ

With integrated LVDC output

SAL SILICON AUSTRIA LABS
Topology optimization, system design, EMC design, control development, simulation & laboratory testing.

Fronius
Inductor/transformer design & control board hardware.





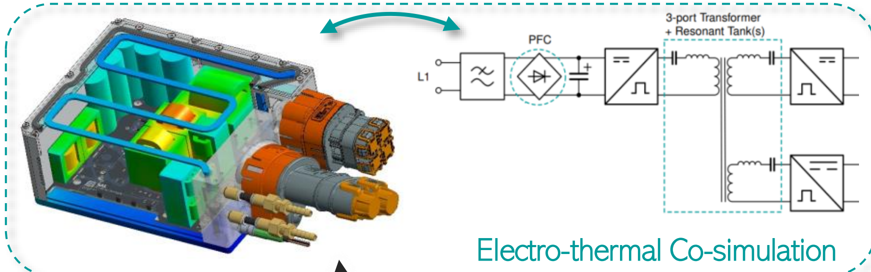
infineon
Power semiconductors & circuit design expertise.

TDK
Ceralink™ modelling, capacitor expertise & potting assembly.

AT&S
Embedded MOSFET benchmarking & simulation.

Duration		SAL Tiny Power Box Team		
3 Years		10+ scientists and engineers		
2019	2022	6 Post-Doc	2 PhDs	2 Engineers

2) Holistic simulation workflow



Electro-thermal Co-simulation

+ develop path for:

System Lifetime

AVL
Thermal, system & reliability simulation expertise.

PhD & Master Students

TU Graz

KÄRNTEN University of Applied Sciences

Achievements

Breaking state-of-the-art OBC power density

2.8l actual total volume with case

<2l target volume for re-design step

Breaking state-of-the-art OBC efficiency

>98% in PFC stage

>98% in DCDC stage

THE TINY POWER BOX TEAM

TINY POWER BOX | SAL SILICON AUSTRIA LABS


Franz Vollmaier


Rudolf Krall


Christian Mentin


Ismail Recepi


Alexander Connaughton


Philip Matzick


Thomas Langbauer

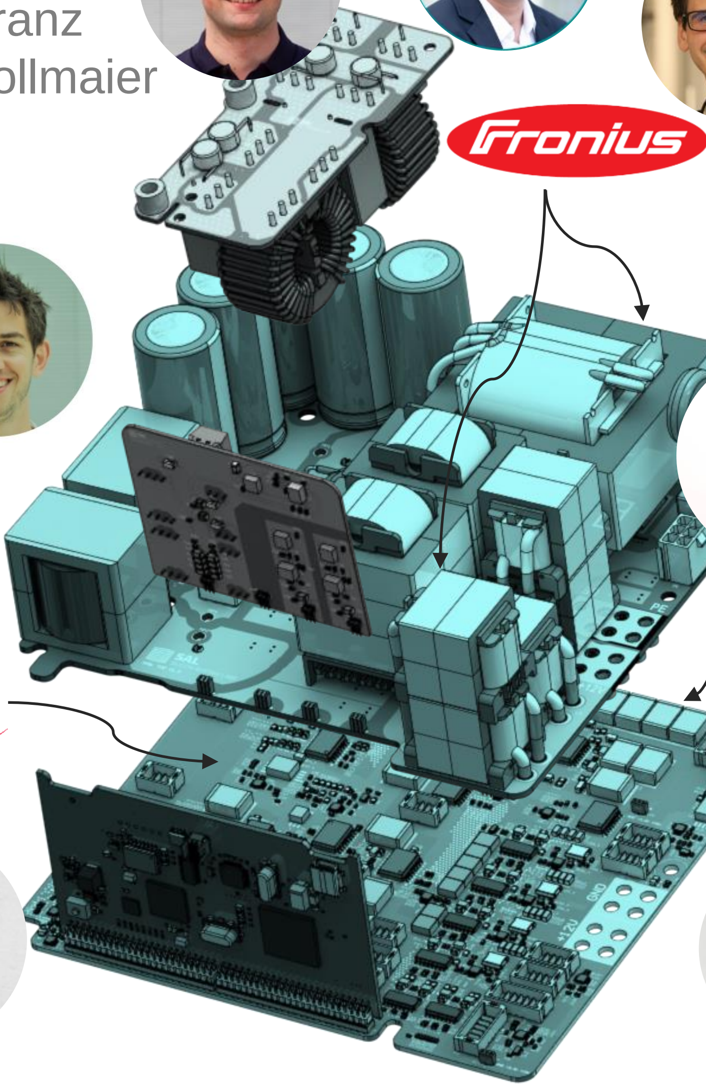

Milan Pajnic


Werner Konrad


Sajid Aqeel

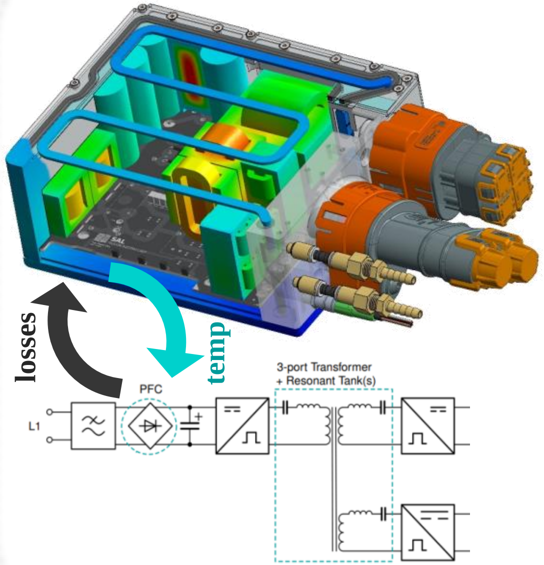

Michael Rindler


Nazmul Hasan



Fronius · TDK · infineon · AT&S · AVL

System simulation



Towards electro-thermal Co-simulation

+ develop path for: System Lifetime

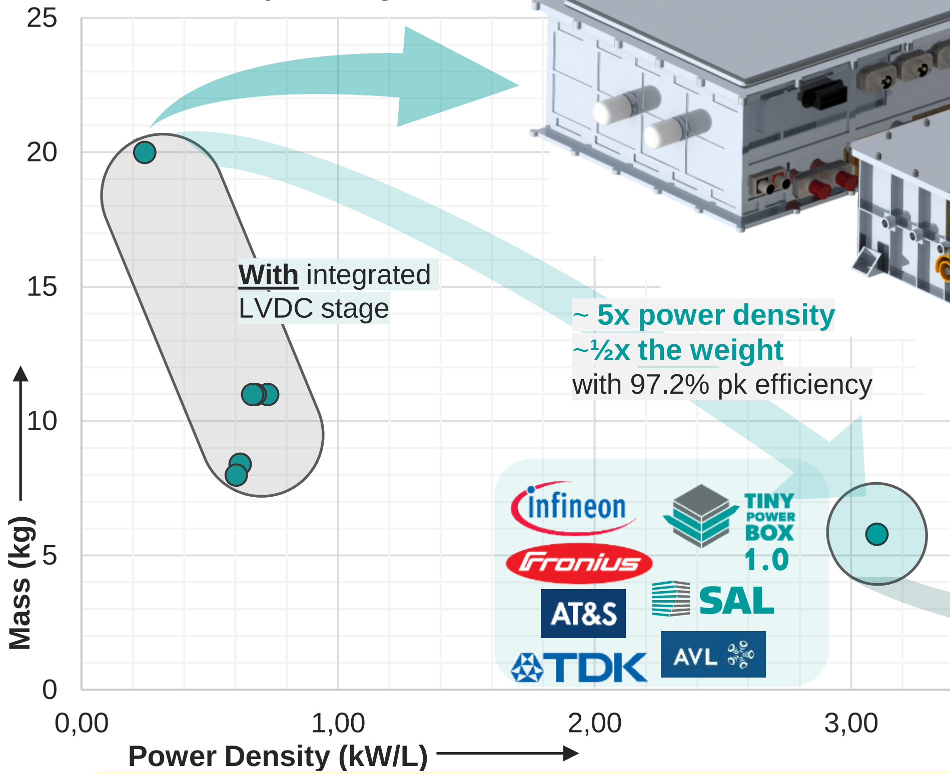
THE TINY POWER BOX vs MARKET

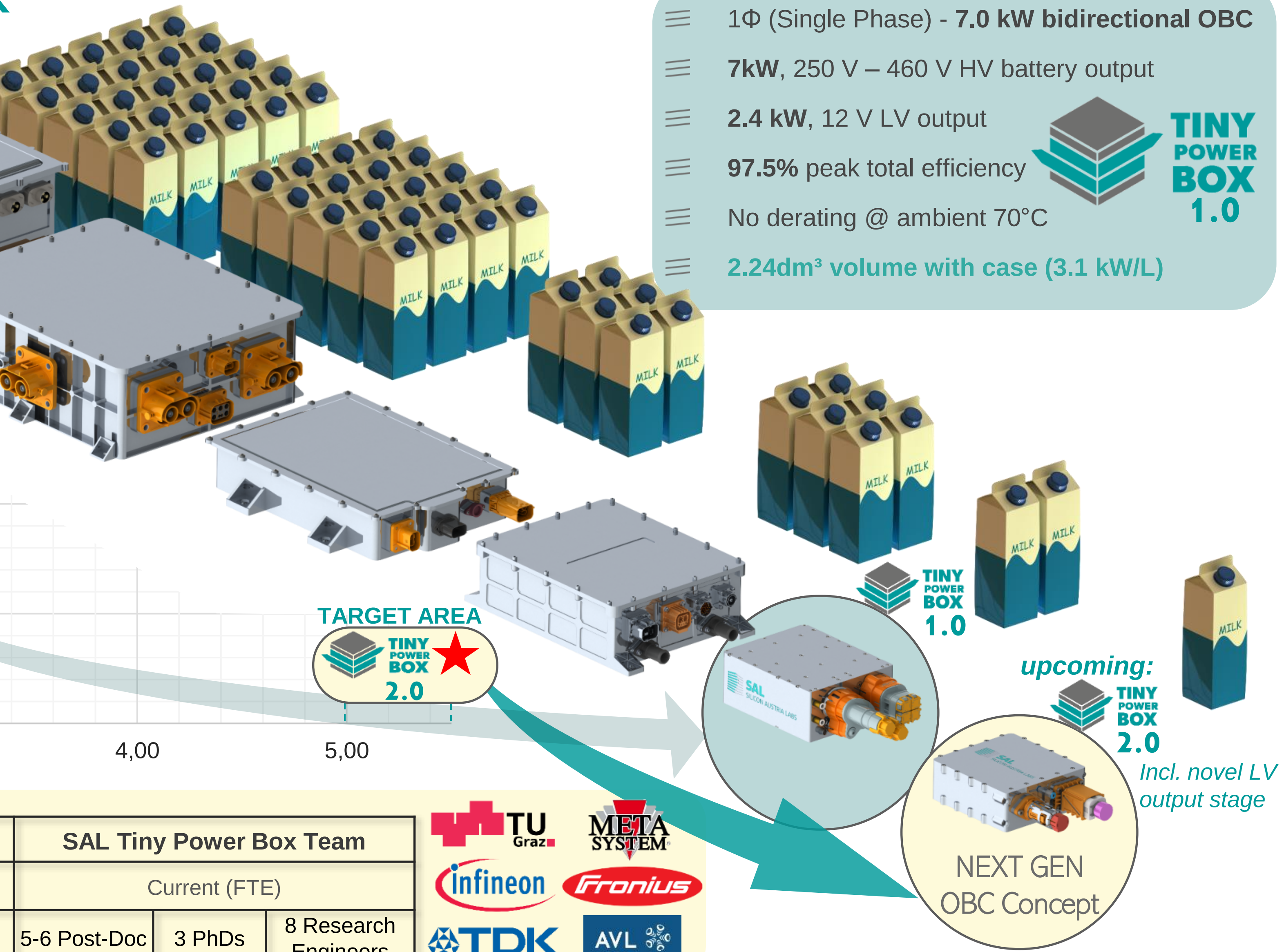
+UPCOMING PROJECT OUTLOOK

TINY POWER BOX | SAL SILICON AUSTRIA LABS

- 1Φ (Single Phase) - **7.0 kW bidirectional OBC**
- **7kW**, 250 V – 460 V HV battery output
- **2.4 kW**, 12 V LV output
- **97.5%** peak total efficiency
- No derating @ ambient 70°C
- **2.24dm³ volume with case (3.1 kW/L)**

Comparison of 7kW OBC
with integrated LV stage
Power Density vs Weight





Bi-directional OBC Concept for Automotive Applications
11kW (3.5kW) / 3 (1) phase;
>5kW/L power density;
Optimized water cooling;
3phase / 1phase operation.

TINY POWER BOX 2.0

Duration		SAL Tiny Power Box Team		
3.5 Years starting 01/2023		Current (FTE)		
2023	2026	5-6 Post-Doc	3 PhDs	8 Research Engineers

TU Graz, META SYSTEM, Infineon, Fronius, TDK, AVL

Lightweight and beyond 5kW/L power density

UNFOLD THE FUTURE

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