



**EUROPEAN BUS SYSTEM
of the FUTURE 2**

Energy Strategies and Auxiliaries

EBSF_2 Stuttgart Demonstration Event
Stuttgart, October 18, 2017

Juhani Laurikko, VTT (FI)

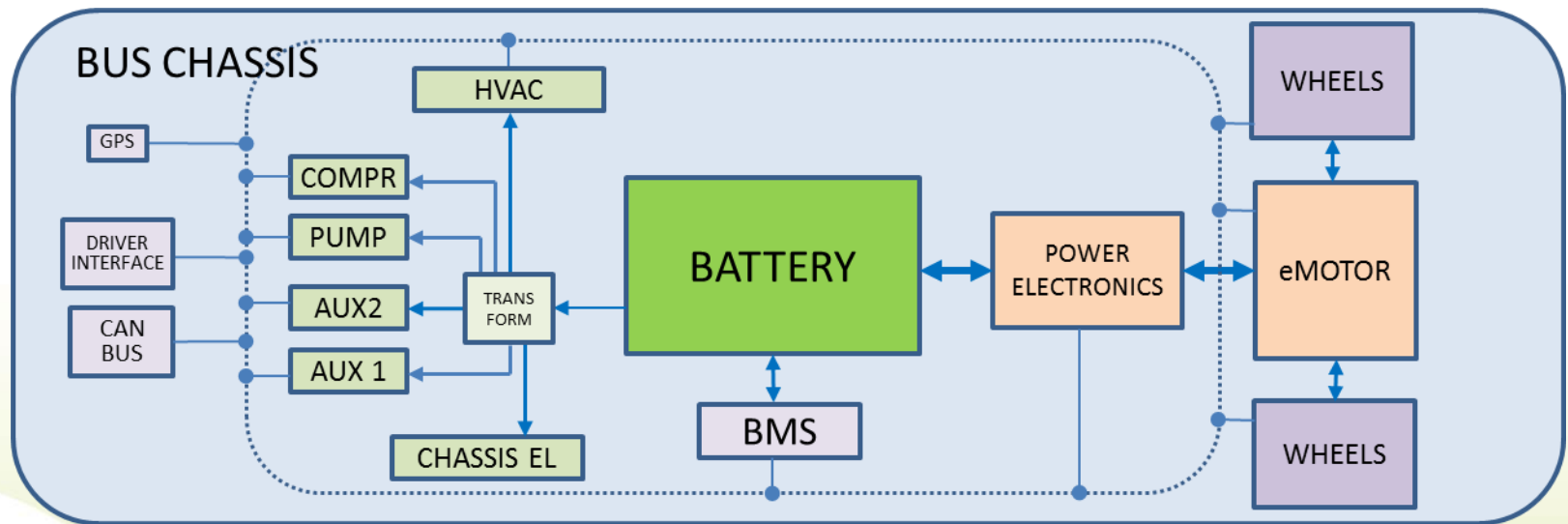
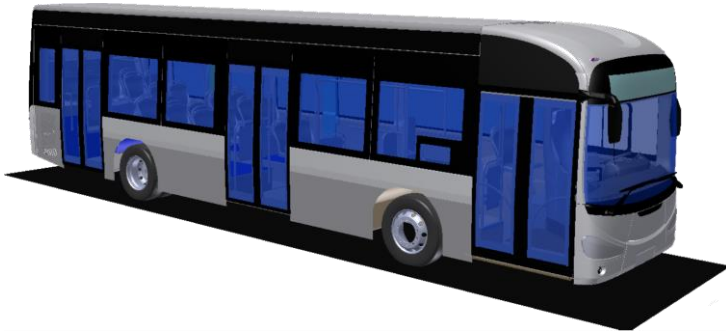
@ebsf_2project

Agenda

- Energy Balance of an e-Bus
- How to Save Energy?
- The Impact of HVAC
- Advanced Auxiliary Management
- Energy Strategies and Auxiliaries in EBSF_2
- Summary



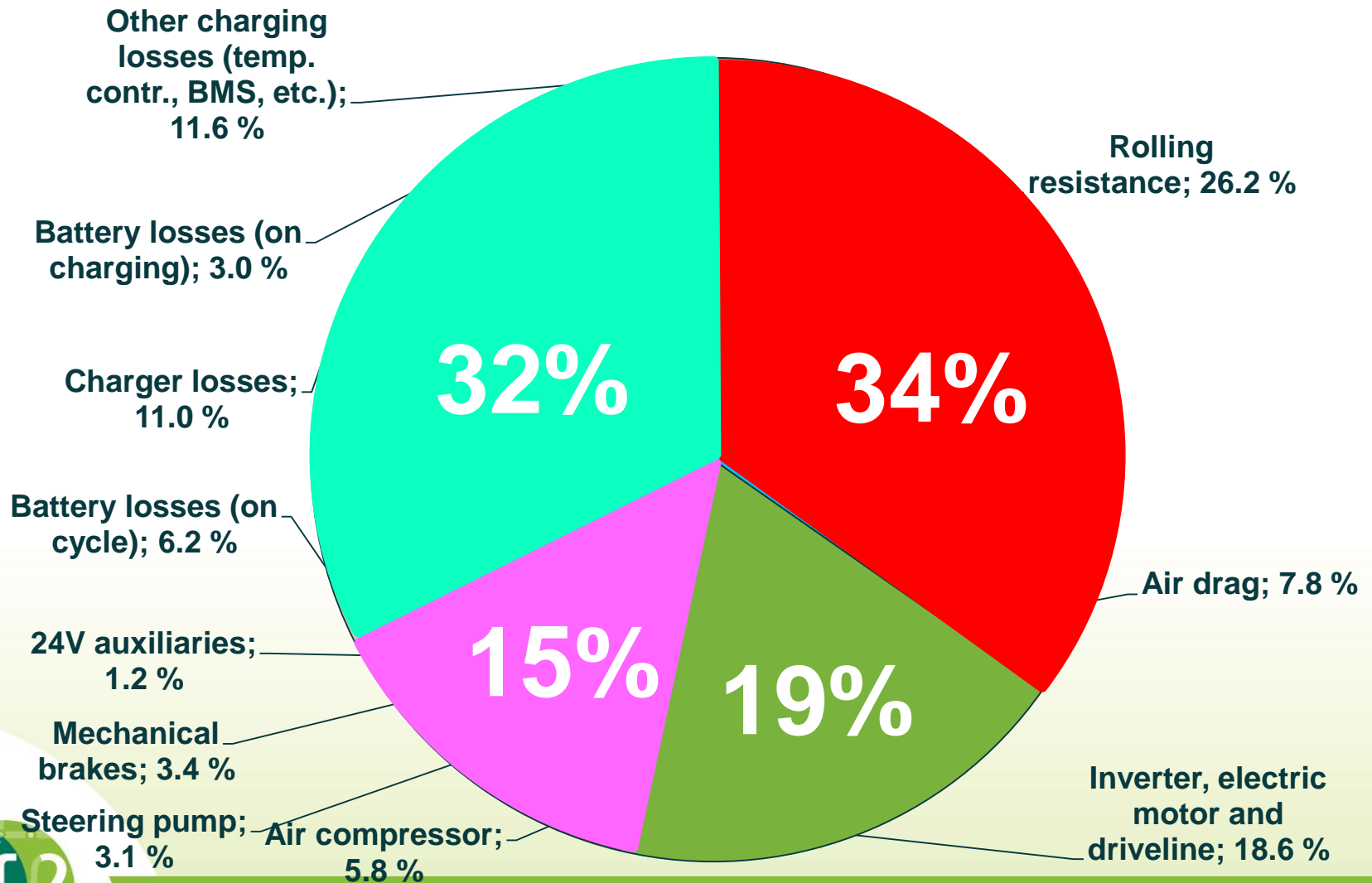
Topology of an eBus (Basic)



* All chassis auxiliaries are run by 24V electricity



Distribution of Total Grid Energy (12.5 kWh) Braunschweig cycle, 12 400 kg



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Data from a non-commercial, light-weight prototype bus

Improving Energy Efficiency (1)

Increase system & component efficiency of:

- * Mechanical driveline
- * Power electronics
- * Charger(s)
- * BMS



Improving Energy Efficiency (2)



Decrease driving energy needs:

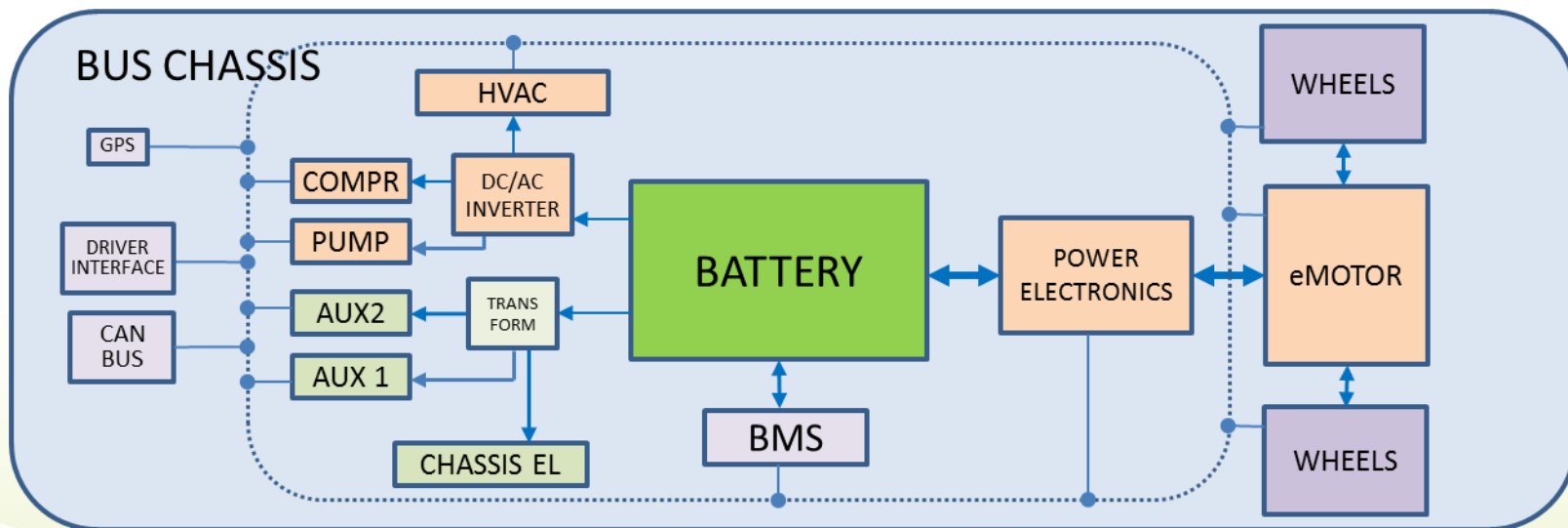
- * Decrease vehicle mass (lightweight chassis)
- * Decrease rolling resistance (tyres & bearings)

Decrease on-board auxiliary energy needs

- * Decrease need to use mechanical brakes by maximising regenerative braking >> Driver training also required!
- * Decrease chassis auxiliary energy need & use, with intelligent management systems



Topology of an eBus (Advanced)



- * Auxiliaries are run by 24V electricity or with high voltage
- * All auxiliaries are run individually, according to the current need



Challenging Weather Conditions



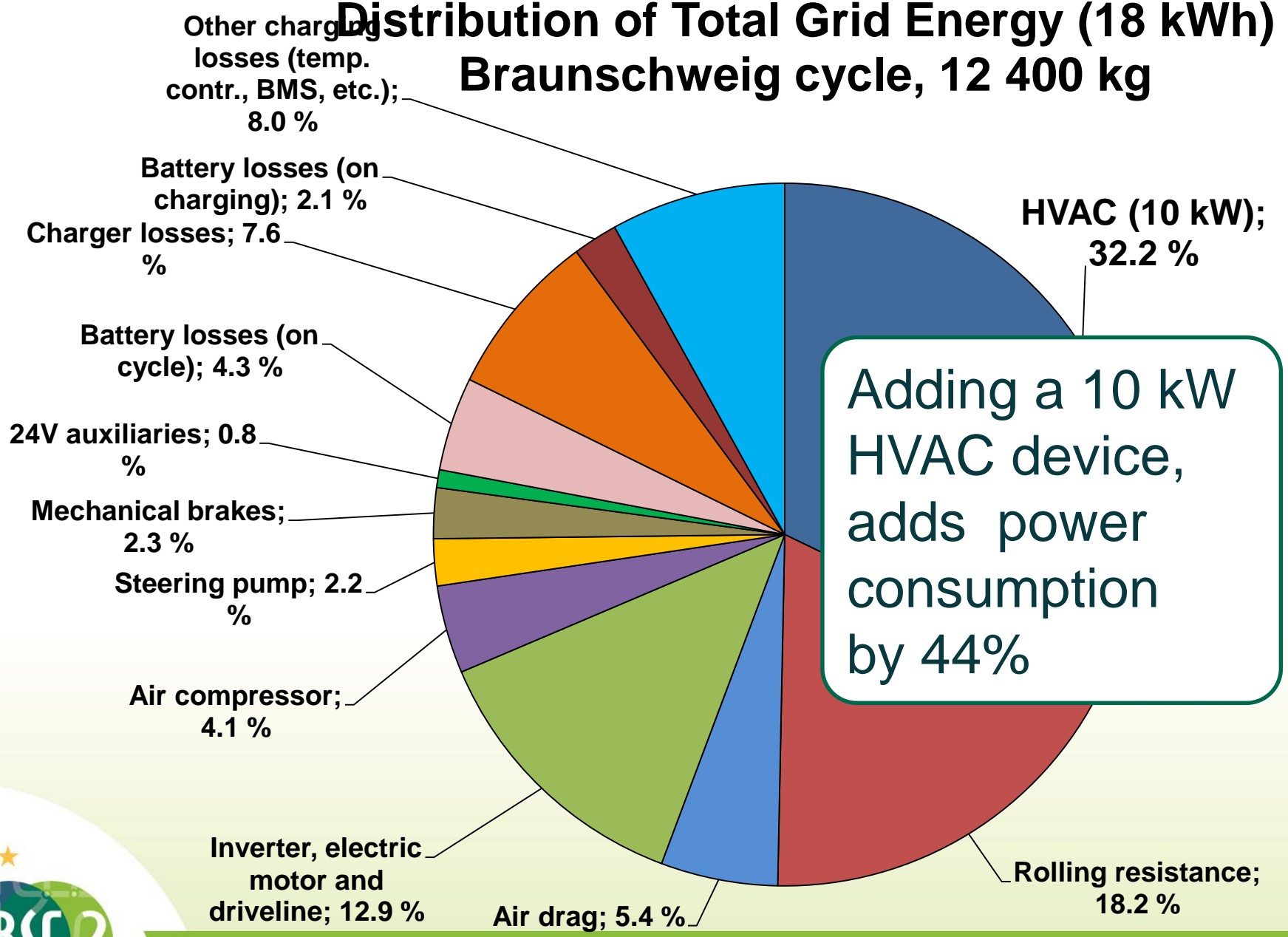
Challenging Weather Conditions



We Need Lots of HVAC!



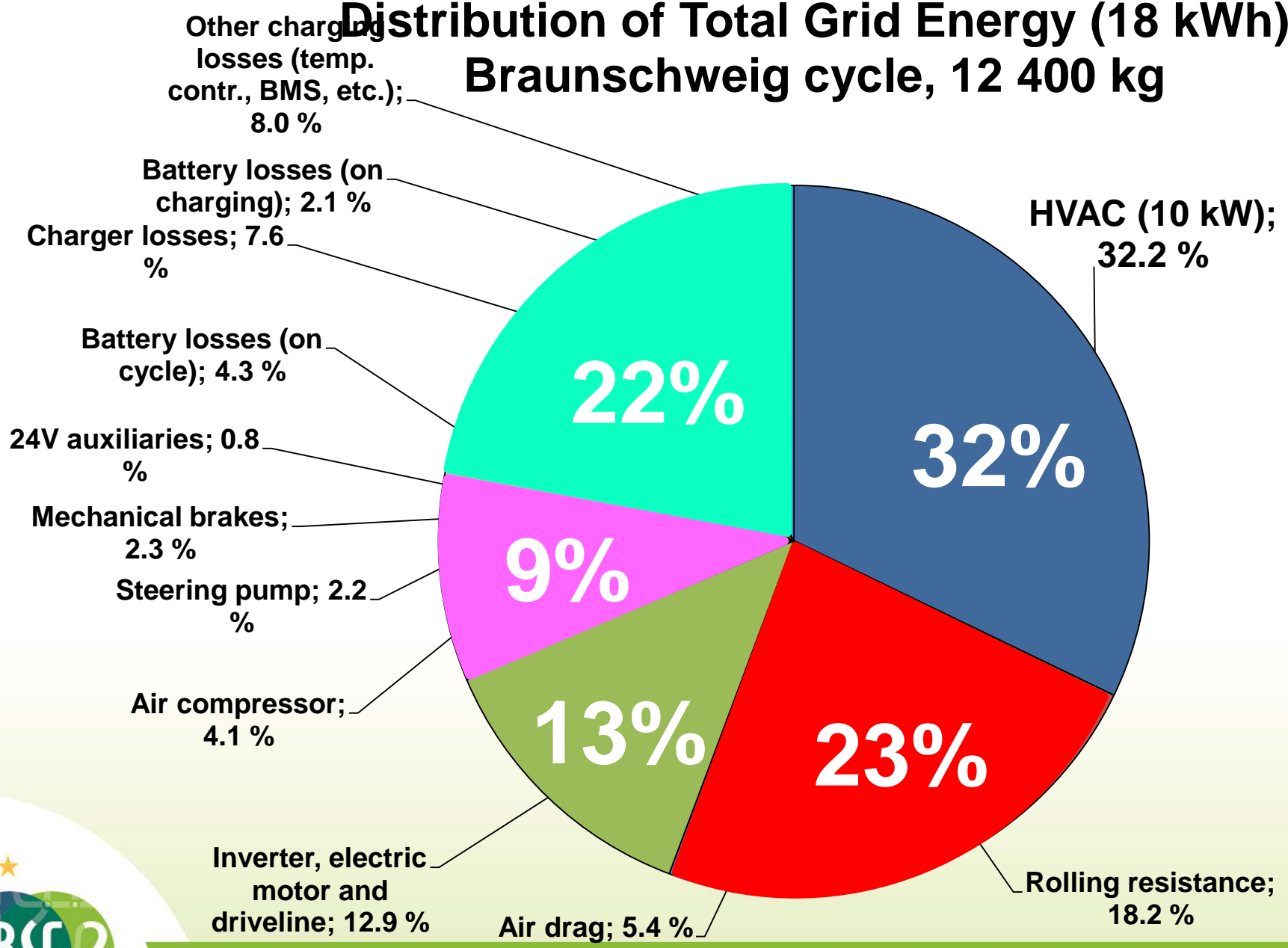
Distribution of Total Grid Energy (18 kWh) Braunschweig cycle, 12 400 kg



Adding a 10 kW HVAC device, adds power consumption by 44%



Distribution of Total Grid Energy (18 kWh) Braunschweig cycle, 12 400 kg



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Decrease HVAC Energy Needs



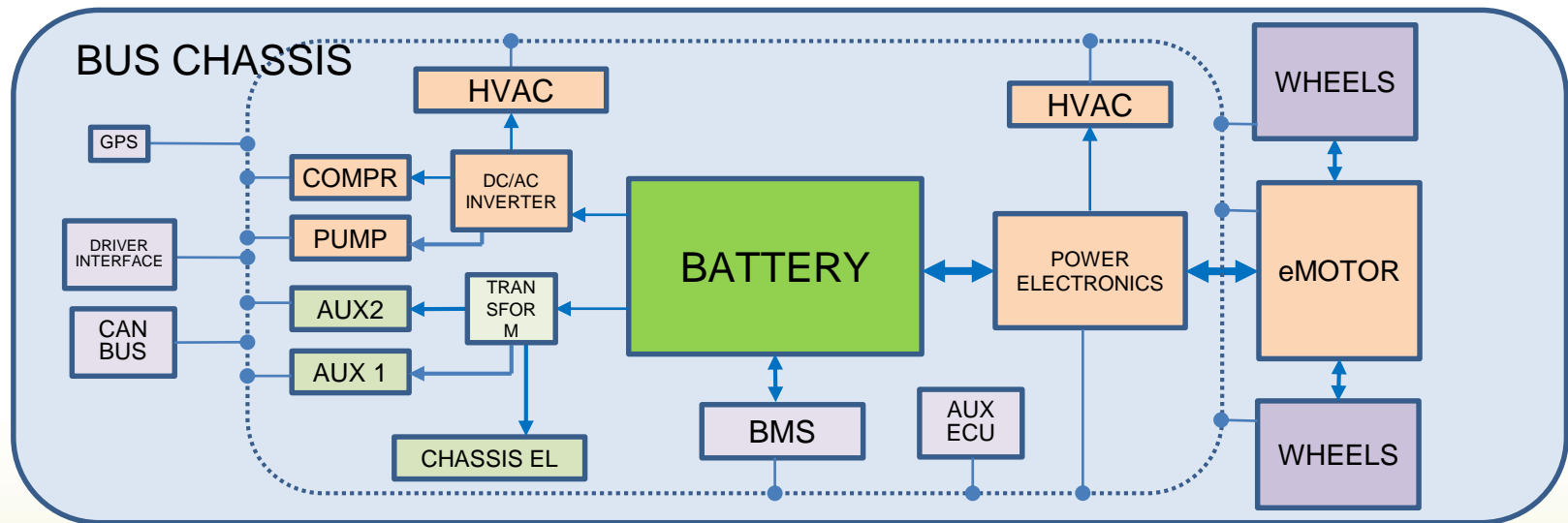
Decrease HVAC needs by:

- * Using heat pump technology to enhance HVAC
- * Improving system efficiency of HVAC
- * Decreasing radiation influx by shades/tinting
- * Increasing air circulation in cabin
- * Decreasing air exchange while boarding/alighting ("air scarf" or cabin-type of bus stops with HVAC)



Advanced AUX Management

Auxiliaries are controlled with a dedicated AUX ECU
AUX ECU can have a "forward looking" type of logic



Second HVAC unit run directly from the regenerative power to avoid battery in/out -losses



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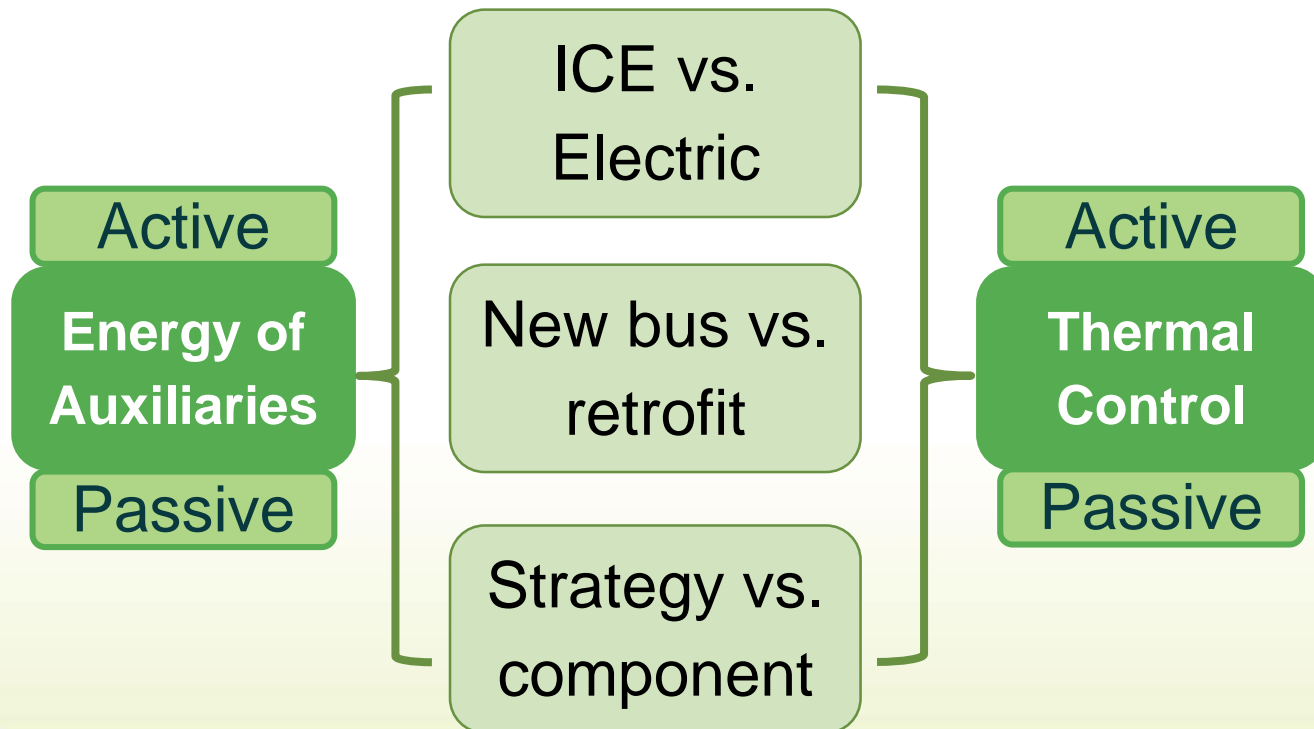
Energy Strategies and Auxiliaries in EBSF_2

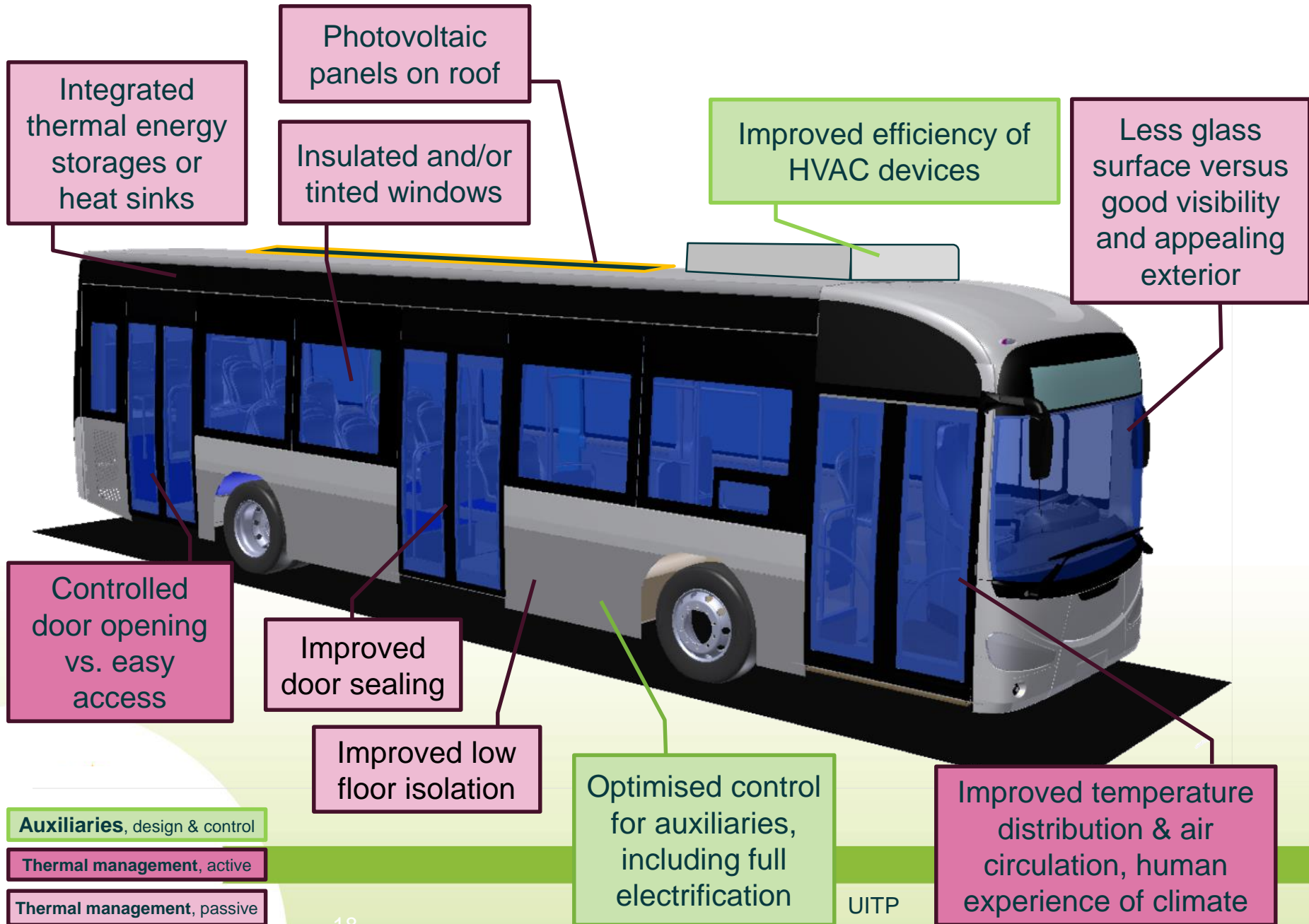
OBJECTIVES AND RESULTS

- **Strategies and solutions for energy management to:**
 - improve energy and thermal management of buses, by improving the efficiency of the auxiliaries and sub-systems on-board
 - lower the energy needed for passenger cabin heating, ventilation and cooling (HVAC)
- **Guidelines for including energy efficiency in procurement material**, in order to help procurement on:
 - how to address energy efficiency when tendering new vehicles or services,
 - how to assess and improve energy efficiency of the existing fleet or operations.



Energy and Thermal control solutions tested in the EBSF_2 Demonstrations - THE DOMAINS





INNOVATIONS per Demo Site

DEMO SITE	DESCRIPTION
Barcelona	Intelligent Energy Management
	Thermal management (improved HVAC device)
Gothenburg	New solutions for heating
Helsinki	Intelligent Energy Management for Auxiliaries
Lyon	ZEV mode extension on hybrid bus
	Improvement of auxiliaries management
Stuttgart	Innovative HVAC for battery-only buses



SMART ENERGY MANAGEMENT IS ESSENTIAL FOR e-BUSSES!

- Limited battery capacity (or high price & weight) is a great challenge to e-bus autonomy & energy balance
- Addressing all energy consuming systems is necessary
- Improvements can come either by using more efficient systems, or by ...
- Decrease the need to use energy, and especially by...
- Employing an intelligent energy management system





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Thank you!

Juhani.laurikko@vtt.fi