Streamlining Battery Pack Testing Labs

Advanced Strategies for Efficiency and Cost Savings

Ante Nikolic

2020 –

Senior Group Product Manager

2019 – 2020

Solution Engineer at AVL List GmbH

2015 – 2019

Development Engineer at AVL List GmbH

2010-2015

System Engineer at Infineon Technologies Graz

Today’s Presenter Dominik Strasser

- **Job Title:**

System Line Manager Cell Test Systems

- **Education / work experience:**

Electrical Engineering and Business (TUGraz)

2017 – 2020	Samsung SDI Battery Systems Testengineer
2021	Magna Steyr Fahrzeugtechnik Abuse Testing
2022	Samsung SDI Battery Systems Testmanager
2023 - present	AVL List GmbH System Line Manager

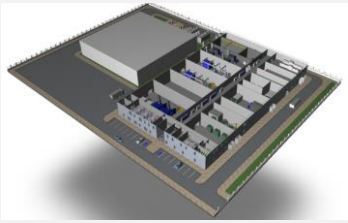
Battery Pack Typical Customers Questions

- "I'm responsible to design a new battery pack testbed and I'm concerned about the safety - Which safety features I need to consider?"
- **"During battery pack testing, I have some high-power tests - How can my testbed cover high power demands?"**

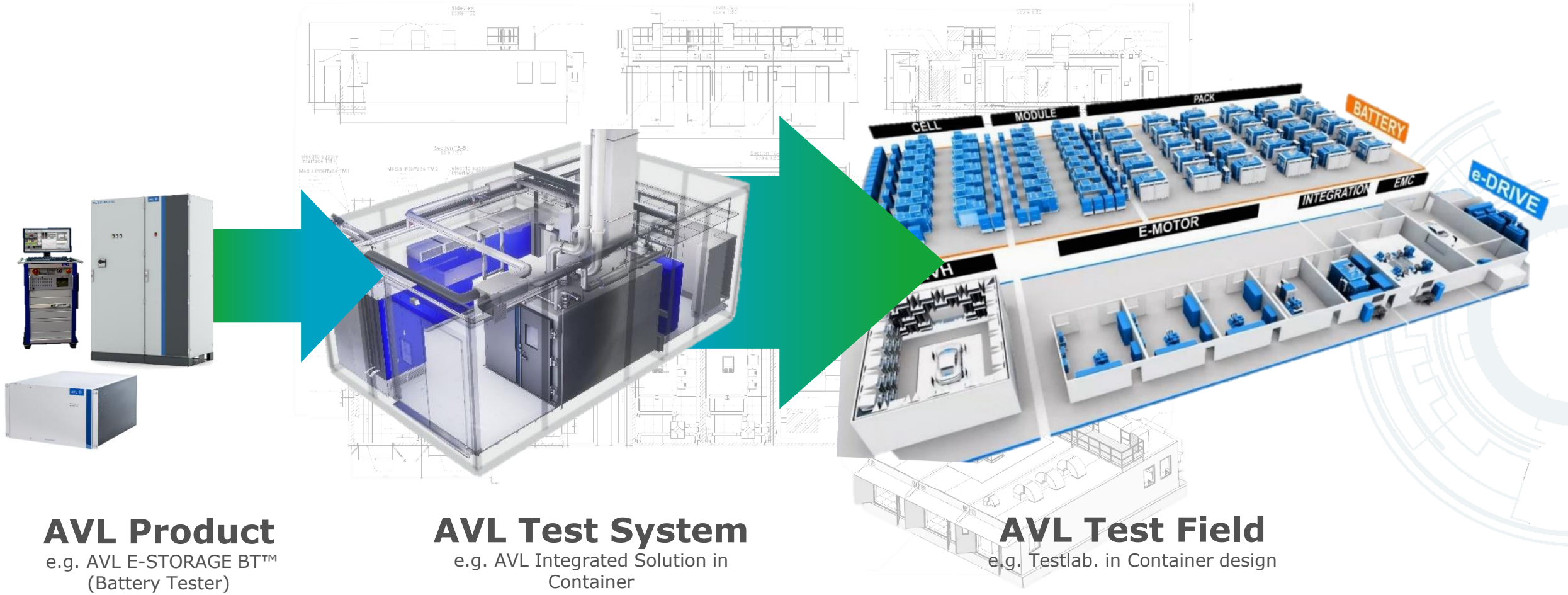
"I need to reuse and existing ICE testbed for my new batter pack testbed and the available footprint is limited – How can I get the most out of my limited space and meet my requirements?"

- "My time for testing is limited due to customer projects and additionally I have cost restrictions – How can I manage these requirements?"
- "I have a concern, that creating test profiles from scratch, keeps my work force busy for years. How can I overcome this?"

Battery Development
Testing and Validation Solutions

Facility Design	From Products to Test Fields	Operate Testing Laboratories	Data Driven Development	Environmental and Abuse Testing	End of Line Production Testing
					
Engineering support for the design and realisation of complete battery testing laboratories	Complete portfolio of battery testing products	Scalable automation and Lab Management system for efficient operation of testing fields of any dimension	Ready-to-run global standard tests, along with templates for intelligent data analysis and reporting	Design and realisation of turn-key facilities with AVL solutions and the integration of 3rd party equipment	Standardised solutions for end of line tests - from simple test and charge to full load conformity test

From Product to Test Field – From Cell to Pack Test System



AVL Product
e.g. AVL E-STORAGE BT™ (Battery Tester)

AVL Test System
e.g. AVL Integrated Solution in Container

AVL Test Field
e.g. Testlab. in Container design

AVL Electromobiliy Center

Solution

Performance and lifetime testing at pack, module and cell level

Testing capabilities cover battery testing on cell-, module- and pack level

8 test chambers on an area of **700 sqm** for electric and thermal battery testing – up to **1200 V**

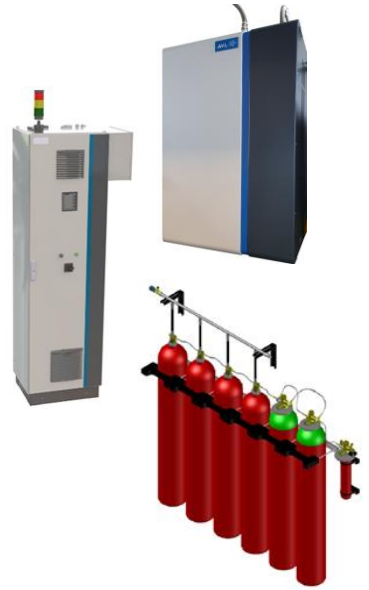
Floodable walk-in chamber for the testing of up to 3 systems in parallel

https://360.avl.com/

AVL Battery Pack Testbed Configuration

AVL Ripple Emulator

T/P/U Measurement



AVL Automation	Battery Pack tester	Climatic Chamber	Battery Conditioning	Safety System
Up to 8 channels	Voltage: 800V up to 1500 V	Gradient ratio 2 or 4.5 K/min	Cooling capacity up to 18.5 kW @20°C	Gas detection
Data exchange rate up to 1kHz	Power: 160kW up to 2 MW	Temperature range -40 to 90 °C	Temperature range –(40) 30 to +90 °C	Pressure relief
Different interfaces	Current: 600A up to 4000 A (up to 4 systems in parallel)	Humidity control up to 98 % rel.H.		Suction (ATEX fan)
Connection to „data management“		Volume 16 or 22 m³		Fire suppression (water mist)
				Flooding

Safety for environmental battery testing

- Batteries can react quite severe → thus, the safety system plays a crucial part in a battery testbed
- Many risks can already be reduced and limited by proper counter measures of the operator itself, such as implemented safety routines to prevent overcharging and over discharging, current limitations, usage of mature BCUs, etc..
- The remaining risks during battery testing are mainly depending on the battery cell itself (SOC, chemistry, age, degree of development, …). A general valid safety concept is therefore not possible and often also not known. A rough clustering can be done according the commonly used **EUCAR Hazard Level** definition

Daniel Steger/OpenPhoto/CC BY 3.0

Source: Weiss Umwelttechnik

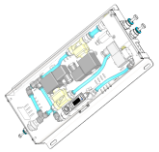
Foto: André März/dpa

Potential Risks in Battery Test Systems

Risk No.1 – Explosion

- Explosion due to slow or fast release of explosive gases


GSU


Inertization


Extraction Fan

Risk No.2 – Volume expansion

- Fast volume increase due to venting gases resulting in mechanical damage of enclosure.


Overpressure Flap

Risk No.3 - Poisoning

- Exposure to harmful substances (solid, liquid, gaseous) → Poisoning of persons.


GSU


Door Lock


Extraction Fan

Risk No.4 - Fire

- Fire due to thermal runaway of a single cell
- Fire due to thermal propagation to other cells


GSU


Fire Surpression

AVL Safety Concept

Base: HZL6-ready

Chamber Safety

- Door monitoring (and lock)
- Overpressure flap
- Chamber is prepared for Level 6/HZL6 equipment
- Customer takes over the complete safety responsibility

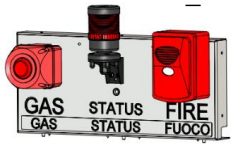
+ HZL 4: Gas, smoke and fire detection

Safety PLC

- Controls all relevant safety products
- Communication to central fire station

AVL Gas Sampling Unit

- Combustible gas sensor 0-100% LEL
- CO2-sensor for 0-5 vol.%
- O2-sensor
- Smoke aspirating sensor



Signal and Alarm Panel

- Visual and acoustic alarm in case of an event

Inertisation Module

- High-flow N2 purging
- Low-flow N2 purging

Extraction Fan

- Extraction fan for purging the chamber with fresh air in terms of detection of venting gases (or smoke)
- Purging before chamber opening

+ HZL 6: Fire suppression

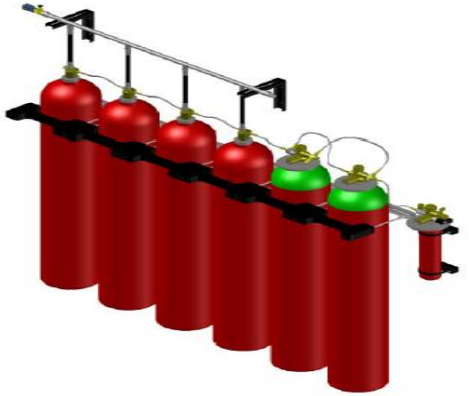
Battery Cooling

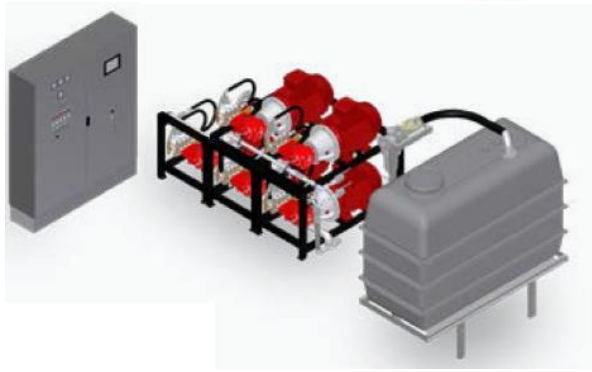
- Portholes are prepared and Safety PLC setup, customer takes over complete piping, area valve and centralised pumping station of the water fog system

Fire Suppression for Battery Testbeds

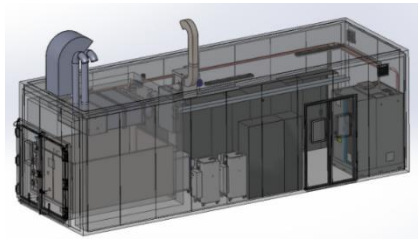
Standard Systems for AVL test beds

- Water spray ("Sprinkler") ~300 l/min
- Low/Mid-pressure water mist (>8bar) ~100 l/min
  - From available building water supply
  - Central Pumping Station
- High-pressure water mist (HPWM) ~75 l/min
  - Central Pumping Station
  - Bottle Solution





AVL Climatic Products & Solution

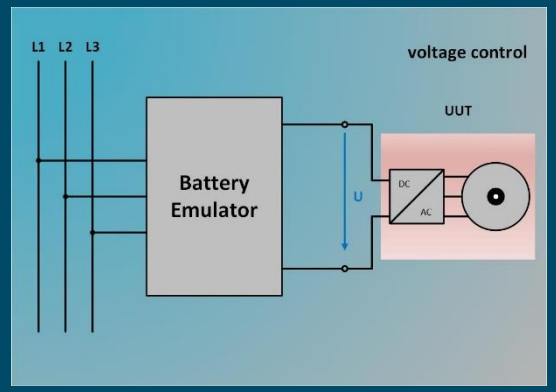
Climatic-Chamber Battery Pack for Outdoor Installation	Climatic Chamber: Battery Pack	Climatic Chamber: Battery Cell and Modules	Container for Storage: Battery Pack
			
Size: from 12 to 30m³ Temp. range -40 to +90°C Temp. gradient 1/2 K/min Humidity control HZL up to level 6 Flooding option Testing equipment integrated Technical room integrated	Size: from 12 to 30m³ Temp. range -40 to +130°C Temp. gradient 2/4,5 K/min Humidity control HZL up to level 6 Flooding option Testing equipment integrated	Size: from 0,72 to 1,4m³ Temperature range -40 to +90°C Humidity control HZL up to level 6	Size: from 12 to 30m³ Temperature range 25°C up to HZL 6 AVL iBLM State Of Charge (SOC)

DC Portfolio Overview for Battery Testing

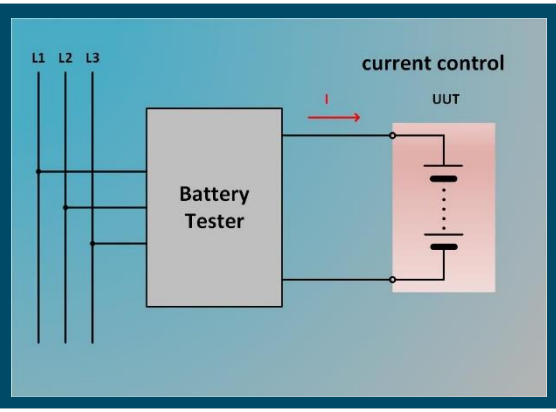
CELL	MODULE	PACK
		
BATTERY CELL TESTER Voltage up to 5 V Current low range 2 – 5 A Current mid range 10 – 50 A Current high range 250 – 2400 A Accuracy: up to 0.01% of actual value	**E-STORAGE LV /MV** 60V / 130V / 160V / 240V / 320V (500V / 1000V / 1500V) 9kW-162kW Matrix combination (serial /parallel)	**HIGH VOLTAGE BATTERY PACK TESTER** **SPECTRA DCS** 1200V 500kW increments 1000A per Channel **E-STORAGE SiC** 1200V 275kW - 1.1MW Up to 4 Ch. And 4000A **E-STORAGE BTE** 800V / 1200V / 1500V 160kW – 2MW Up to 1600A per Channel

What is E-STORAGE & SPECTRA DCS?

The **AVL E-STORAGE and AVL SPECTRA DCS** are **high-dynamic DC power supplies** that are optimised for characterization and verification of electric driveline components for automotive, off-highway, marine and aviation applications



Emulator Operation



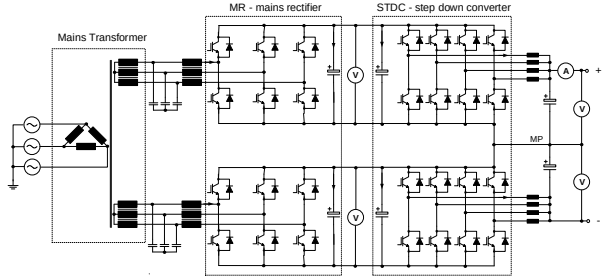
Tester Operation

AVL E-STORAGE BTE™

When dynamic meets accuracy

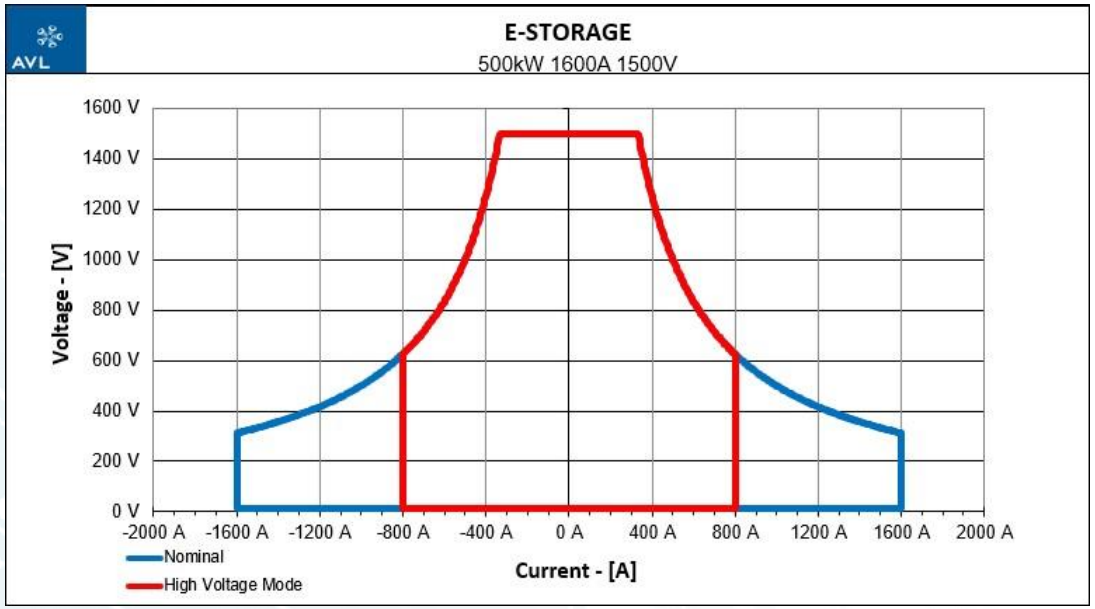
- Combination of high measurement accuracy and high dynamic control
- High voltage output stability also with high dynamic UUT load changes
- Unique minimal footprint (-25% required floor space)
- High utilisation by automated and safe sharing between several testbeds

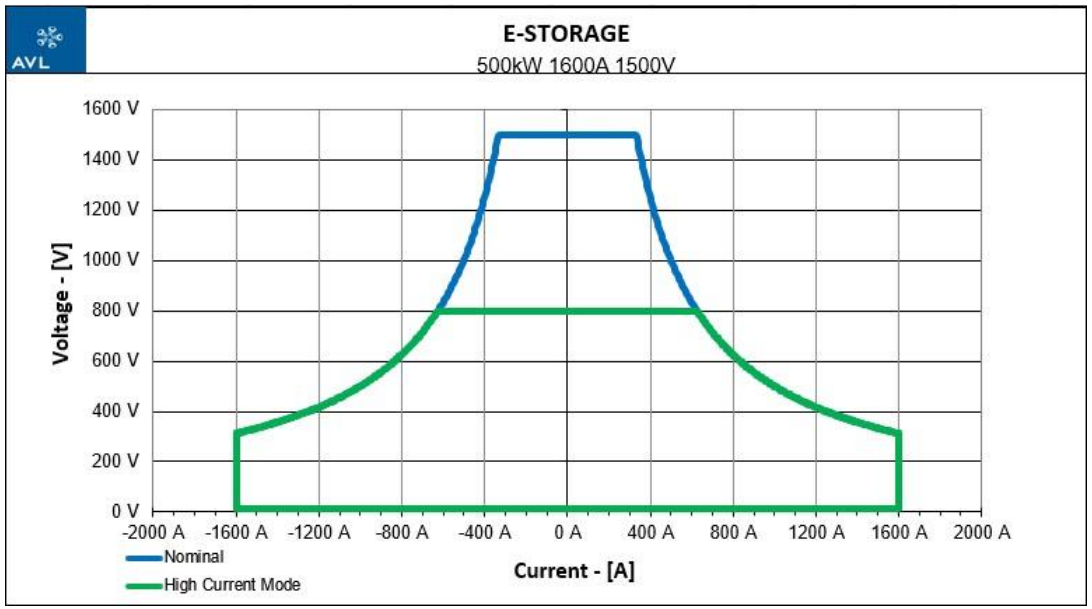
500kW/1500V/800A Dual Mode (1600A)



Change output configuration of the STDC between

- 1500V/800A (High Voltage Mode) – typical 800V UUTs
- or 800V/1600A (High Current Mode) – typical 400V UUTs





AVL E-STORAGE SiC™

Minimal footprint – unique power density

Unleashed SiC power in a new dimension

- Latest Silicon-Carbide technology with 1000A per output Chanel
- Power Blocks with 275kW nominal and 330kW overload capability
- Smallest footprint - 50% space*
- 100ppm voltage and current accuracy (measurement and control)

275kW/ 1200V / 1000A

*compared to existing BTE 250kW water cooled System

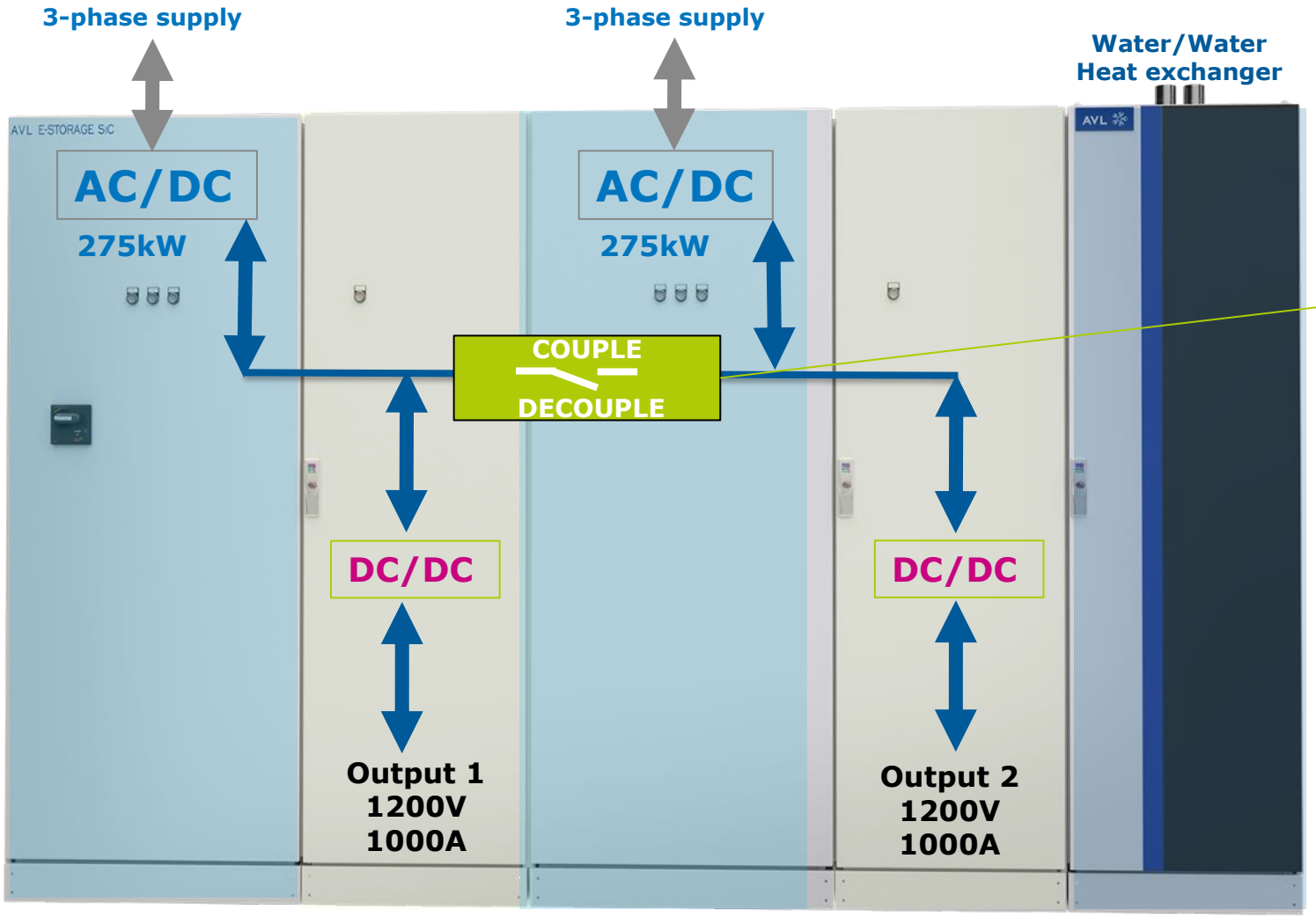
E-STORAGE SiC – **1200V / 1000A per Channel**

275kW 1CH

275kW 2CH

550kW 2CH

E-STORAGE SiC 550kW, 1200V, 2x 1000A

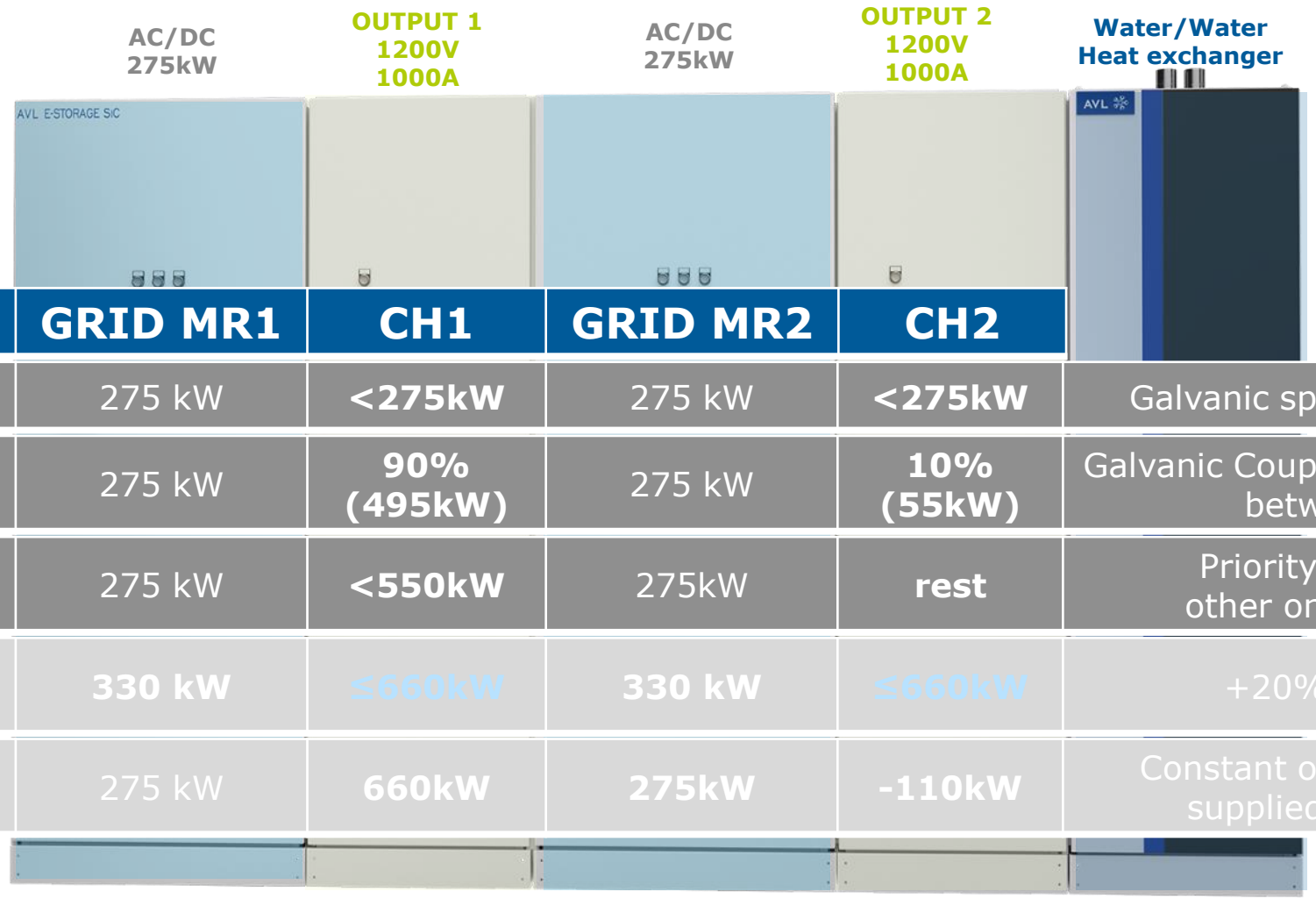


With coupling and decoupling functionality, it's possible to split the 550kW in two completely decoupled 275kW units

Modes:

- **Isolated**
- **Coupled, for power sharing**

E-STORAGE SiC 550kW 1200V 2 x 1000A



POWER SHARE	GRID MR1	CH1	GRID MR2	CH2	
FIX – Isolated Mode	275 kW	**<275kW**	275 kW	**<275kW**	Galvanic split between Channels
FIX – Coupled Mode	275 kW	**90% (495kW)**	275 kW	**10% (55kW)**	Galvanic Coupled Variable power Split between Channels
PRIORITY - Mode	275 kW	**<550kW**	275kW	**rest**	Priority on one channel, other one gets what's left
Nominal SYSTEM OVERLOAD (30s)	**330 kW**	**≤660kW**	**330 kW**	**≤660kW**	+20% power for 30s
CHANNEL PEAK POWER INCREASE	275 kW	**660kW**	**275kW**	**-110kW**	Constant overload on CH1 with supplied power from CH2

UUT..**U**nit **U**nder **T**est
TB… Testbed
TAS…Test Automation System

Ultimate flexibility 2 x 550kW with 1000A each

Mode change and power sharing in TAS via CAN messages

FIX – Mode Coupled

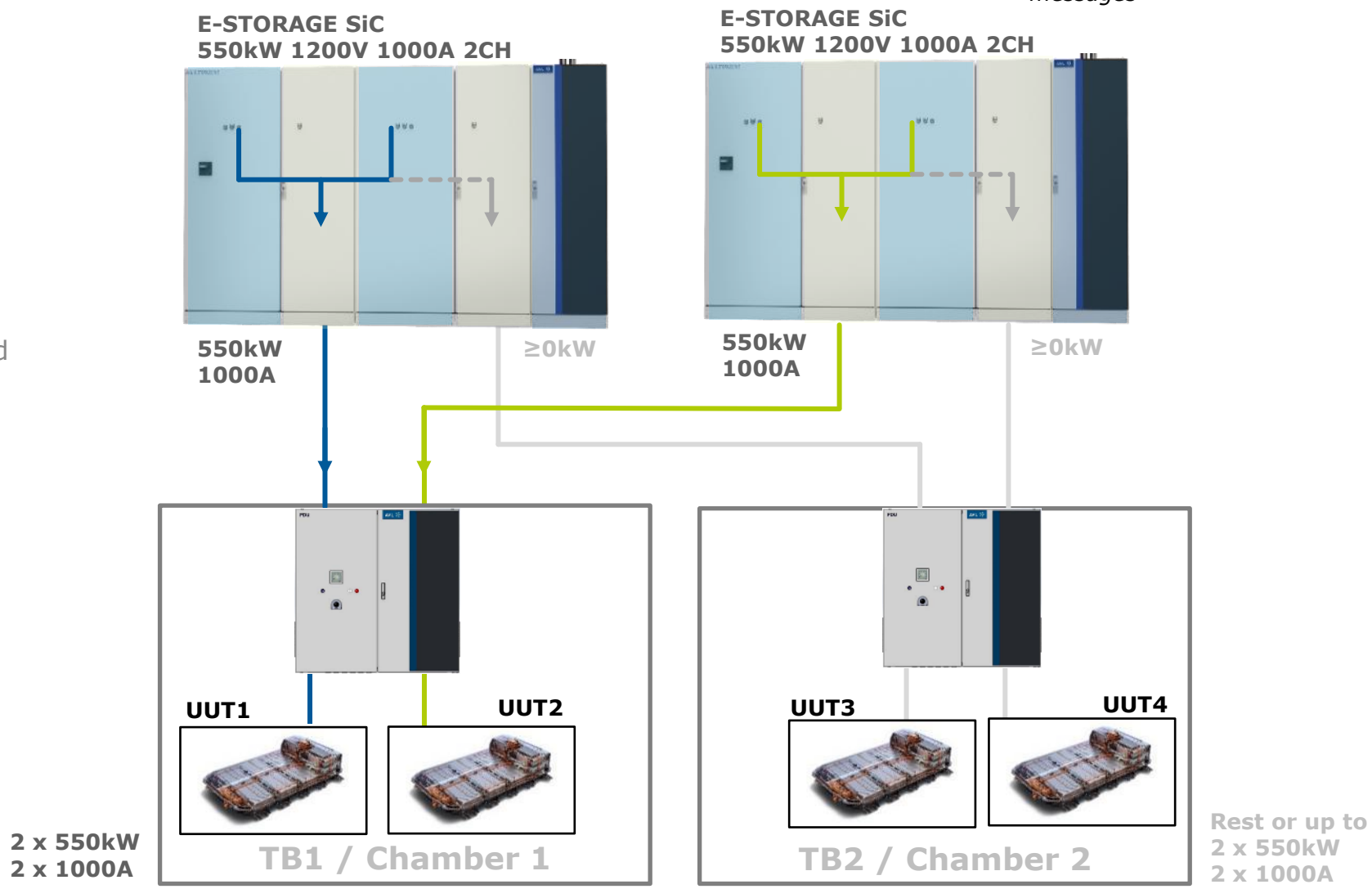
Priority Mode

Coupled systems, up to 550W 1200V 1000A Fixed or in priority mode on two outputs with overload up to 660kW for 30s

USE CASES:

- Commissioning and Preparation Chamber 2 and Full Power Testing in Chamber 1
- Conditioning UUT3 and UUT4 for the next Test (SOC, temperature) and running the test cycle on UUT1 and UUT2

The modes are not limited to specific outputs, functionality is available on all outputs



Application Packages and Startup Services

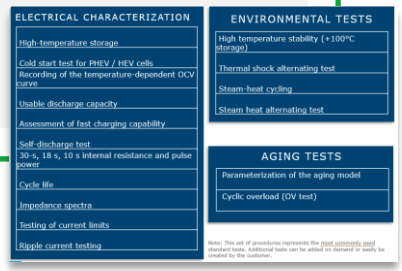
E-Library addresses those fundamental questions…
… What to do, How to do , Are we doing it right ?

E-Library Solution

PACKAGED TEST METHODOLOGY

1

- Electrical characterisation
- Lifetime tests
- Environmental tests
- Etc.

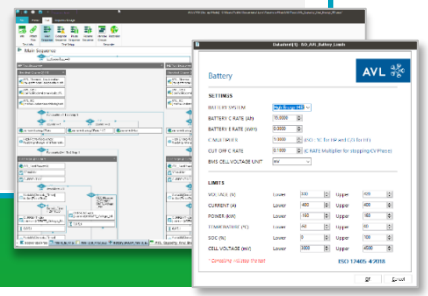


READY TO RUN TESTS

2

- Finished test scripts
- Tested .Validated. Verified
- Building blocks for easy custom test scripting

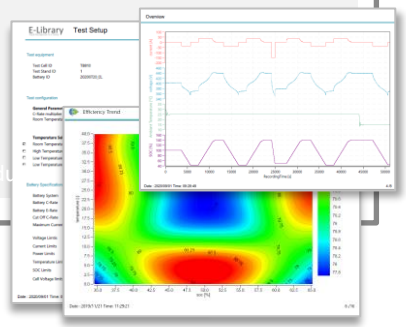
Full Customization Possibilities



INSTANT EVALUATION

3

- Instant data Analysis
- Customisable reports
- Auto email reports



Reference Solutions

AVL Battery Test Center – Testing Institute

Solution

- Performance and lifetime tests on battery pack and battery module level

Highlights

- **78** bidirectional battery testbed up to 500 kW / 1200 V / 800 A per channel (1000 kW / 1200 V / 1600 A possible by parallelisation)
- **32** climatic chambers (safety technology up to Hazard level 6) up to 30 m³ volume
- Room temperature adjustable between **-40** and **+90 °C**, temperature gradient up to 6 K/min
- Humidity up to **98% rel. humidity at 70 °C**
- Conditioned coolant supply **(-30 to +80 °C**) up to 65 L/min

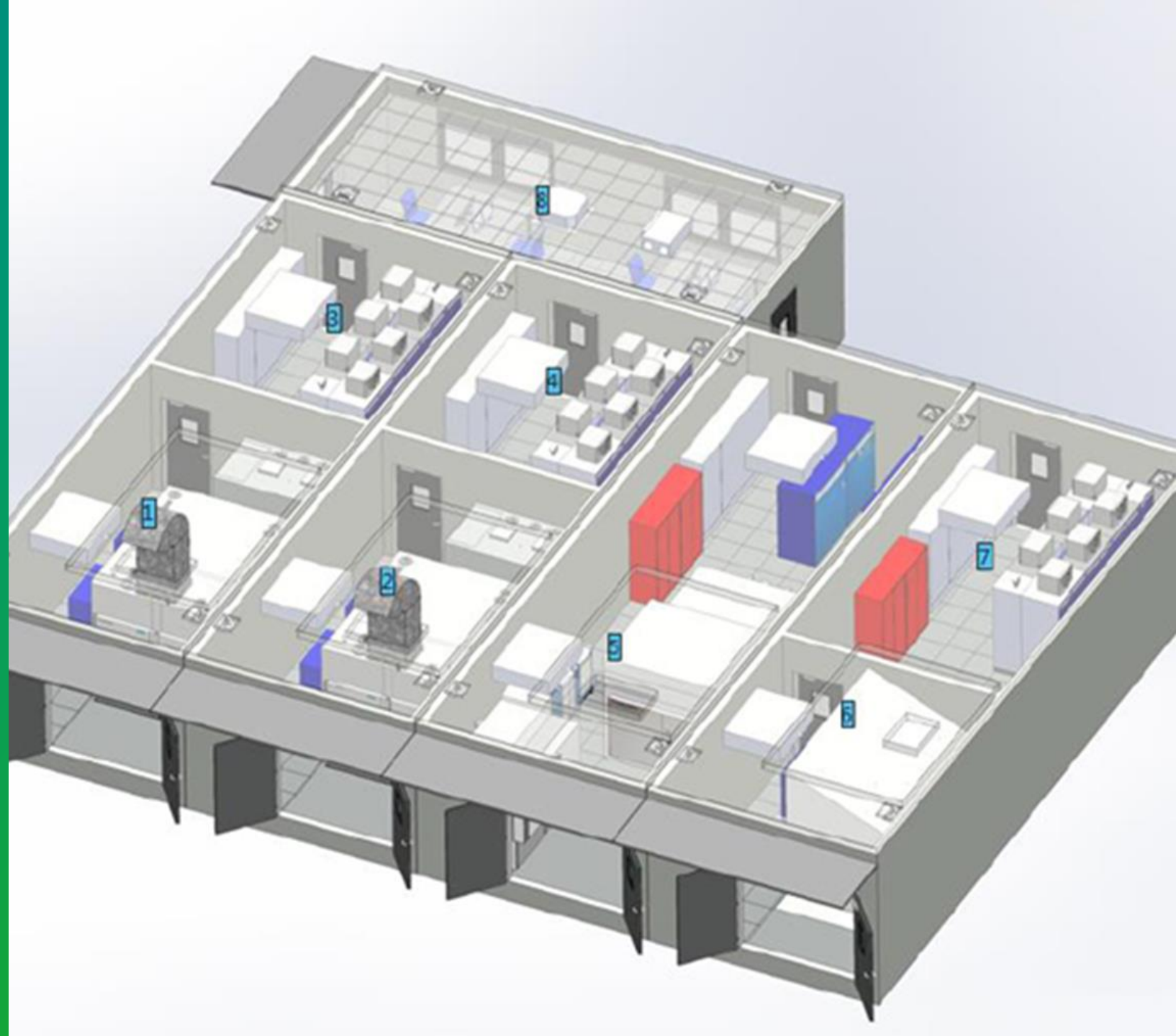
AVL Battery Test Center
Tier 1

Solution

- Performance and lifetime testing at battery pack and battery module level
- Salt spray chamber
- Container solution

Highlights

- **1&2:** Testroom: 16m³ AVL climate chamber, battery conditioning, AVL automation
- **3&4:** Technicalroom: 2x AVL E-Storage BTE 400kW/1200V/880A. Parallelizable to 1600kW
- **5:** Test room: 6m³ climatic chamber, 2,7m³ climatic chamber, 2x AVL E-Storage BTE 160kW/250V/800A, 4x AVL E-Storage MV 32kW/130V/300A, battery conditioning, AVL automation
- **6:** Test room : 16m³ salt spray chamber, battery conditioning, AVL automation
- **7** Technical room : AVL E-Storage BTE 400kW/1200V/800A
- **8** Control room



Battery Testing at VOLVO Group

Public source: Testing batteries to the extreme - YouTube

Battery Pack Typical Customers Questions

- "I'm responsible to design a new battery pack testbed and I'm concerned about the safety - Which safety features I need to consider?"
- **"During battery pack testing, I have some high-power tests - How can my testbed cover high power demands?"**

"I need to reuse and existing ICE testbed for my new batter pack testbed and the available footprint is limited – How can I get the most out of my limited space and meet my requirements?"

- "My time for testing is limited due to customer projects and additionally I have cost restrictions – How can I manage these requirements?"
- "I have a concern, that creating test profiles from scratch, keeps my work force busy for years. How can I overcome this?"

Thank you

www.avl.com