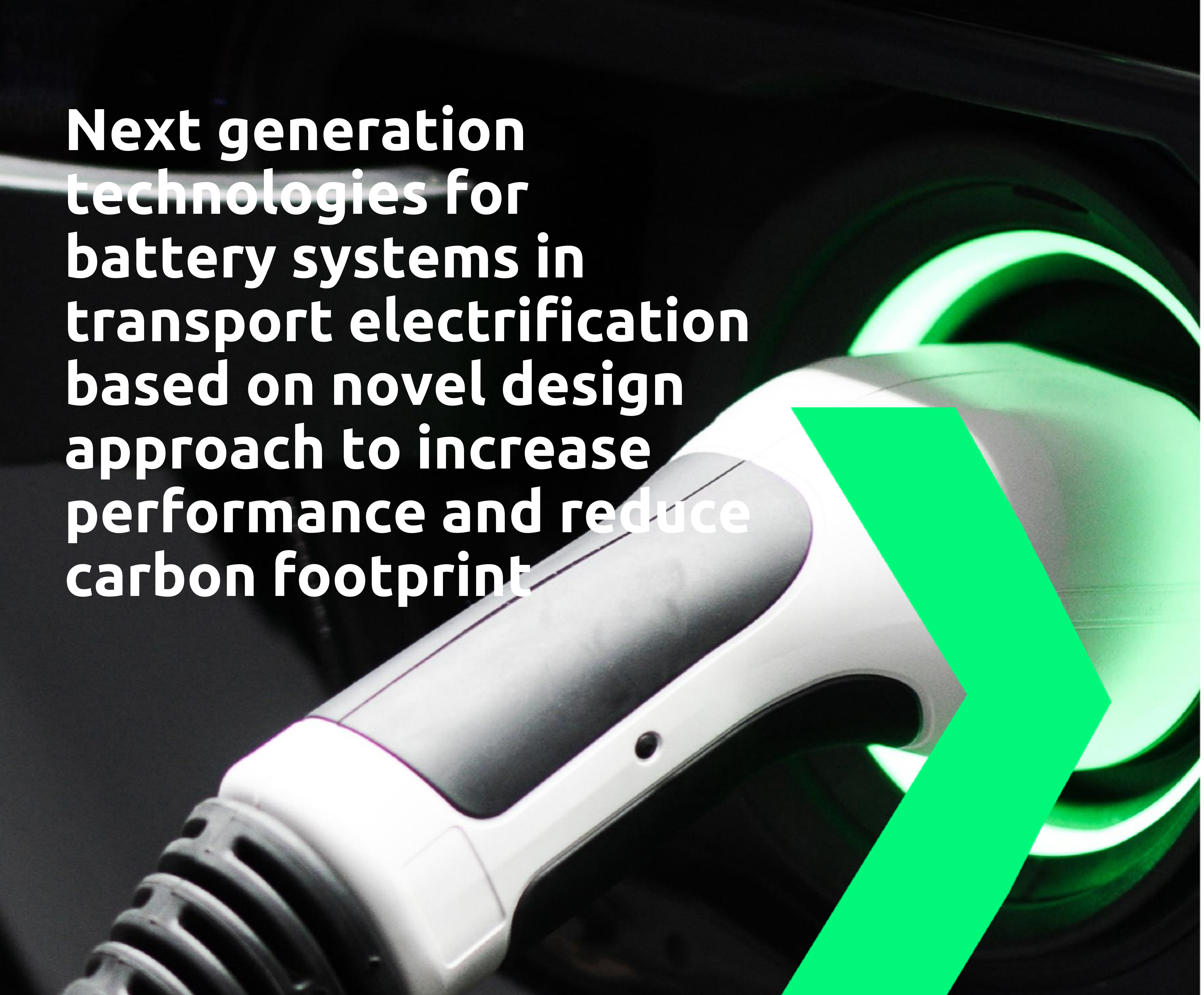
Next generation technologies for battery systems in transport electrification based on novel design approach to increase performance and reduce carbon footprint



Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or [name of the granting authority]. Neither the European Union nor the granting authority can be held responsible for them. Project Number 101103983

Dr Mikko Pihlatie, VTT

Project Coordinator

Project general data

Call: **HORIZON-CL5-2022-D2-01**

Topic: **HORIZON-CL5-2022-D2-01-05**

Type of action: **HORIZON Research and Innovation Actions**

Coordinator: **VTT Technical Research Centre of Finland**

Granting authority: **European Climate, Infrastructure and Environment Executive Agency**

Project starting date: fixed date: **1 June 2023**

Project end date: **30 November 2026**

Project duration: **42 months**

Grant Amount: 4 966 935.0 €

NEXTBAT project - summary

The transport sector represents around 25% of all EU CO2 emissions. NEXBAT will significantly contribute to **decrease the carbon footprint** of the innovative battery system by decreasing production costs thanks to the high recyclability capacity of both hardware and cells components introduced along the production chain.

The NEXTBAT consortium will contribute to this through:

- Providing a **new framework for standardization and safety of next generation battery system designs**
- Enhancing battery system **performance**, specifically increases in energy and power density
- **Decreasing battery system weight** by 25% using a newly developed lightweight material
- Incorporated at the cell and system unit allowing to
- **Increase battery lifetime** by 20% at a SoH of 80% at cell level with innovative electronic sensing/actuating systems.

VTT | NEXTBAT

The approach of the NEXTBAT project

Decreasing the carbon footprint of the innovative battery system

Decreasing production cost due to the high recyclability capacity

Enhancing performances with battery management systems

Increasing the lifetime of the battery by 20%

NEXTBAT will provide **the safest, interoperable, and sustainable battery system** based on multiphysical safety design, and develop **a new framework for the standardization** of next generation battery system production chain in the European Union.

Casting and joining the battery modules with **innovative materials**

Improving **supplementary safety features and recyclability**

Reducing **production time and costs**

Establishing **new standards**

Objetives 1/2

1

To establish **standardized Safety Assessment Methodology** for battery systems, and database development. (WP1)

2

To define **framework requirements and technical specification** of next generation technologies in battery systems. (WP1)

3

To design **innovative battery prototypes and configuration architectures**, and to improve the manufacturability of the battery system. (WP2)

4

To develop **the NEXTBAT software** and to evaluate **a digital twin strategy**. (WP3)

Objectives 2/2

5

To develop **the hardware elements** for intelligent battery management concepts and to battery pack designs. (WP4)

6

To manufacture **battery packs** for prototype configurations and to reuse of the battery and packs for the second life cycle. (WP5)

7

To **demonstrate and validate** the performance of the prototypes, and to establish a **roadmap toward certification of next-gen battery systems**. (WP6)

8

To **promote the market uptake** of the technologies, processes and tools and to communicate project results maximizing the impacts. (WP7)

Overall concept of NEXTBAT project

PILLAR 1: REQUIREMENTS FOR HIGH-PERFORMANCE, SAFE AND INNOVATIVE BATTERY SYSTEMS USING NEXT GENERATION TECHNOLOGIES

- **Next gen. chemistries (gen 3-4)** to increase energy and power performances up to 30%
- **Increase performances and safety** through novel battery designs and concepts
- **Avoiding thermal runaway** with new electrical & thermal management systems
- **Innovative materials** to mitigate mechanical electrical and thermal risks (EURCAR 2-4)

VTT, RISE, Fraunhofer IVI, csem, cea, Applus

PILLAR 2: DIGITALISATION AND MODELLING FOR BATTERY SYSTEM DESIGN, MANUFACTURING AND RECYCLABILITY

- **Multiscale electrical hardware** for Battery Management System
- **Improved manufacturability** with digital twin algorithms along the production chain
- **Decrease production time and costs** with high recyclability of BMS
- **Improve battery lifetime** with power electronics and reconditioning

idneo, Fraunhofer ILT, BSC, cea, Fraunhofer IVI, VTT, csem

PILLAR 4: CREATING IMPACT IN EUROPEAN ELECTRIFICATION OF TRANSPORT AND MOBILE APPLICATIONS WITH ACTIVITIES TO MAXIMIZE REPLICATION

- Establishment of **networks for battery manufacture** at EU level
- **Governing bodies** meetings & interaction with the advisory board
- Dissemination, communication and **IP management**
- Creating of new business models and individual **exploitation plans**

VTT, RISE, Applus, cea, Fraunhofer ILT, Fraunhofer IVI, csem, BSC, idneo, VALMET AUTOMOTIVE, zabala INNOVATION, SUNLIGHT POWER IS KNOWLEDGE, Heart Aerospace

PILLAR 3: DEMONSTRATION AND VALIDATION OF PROTOTYPED INNOVATIONS FOR TRANSPORT AND MOBILE APPLICATIONS USES CASES

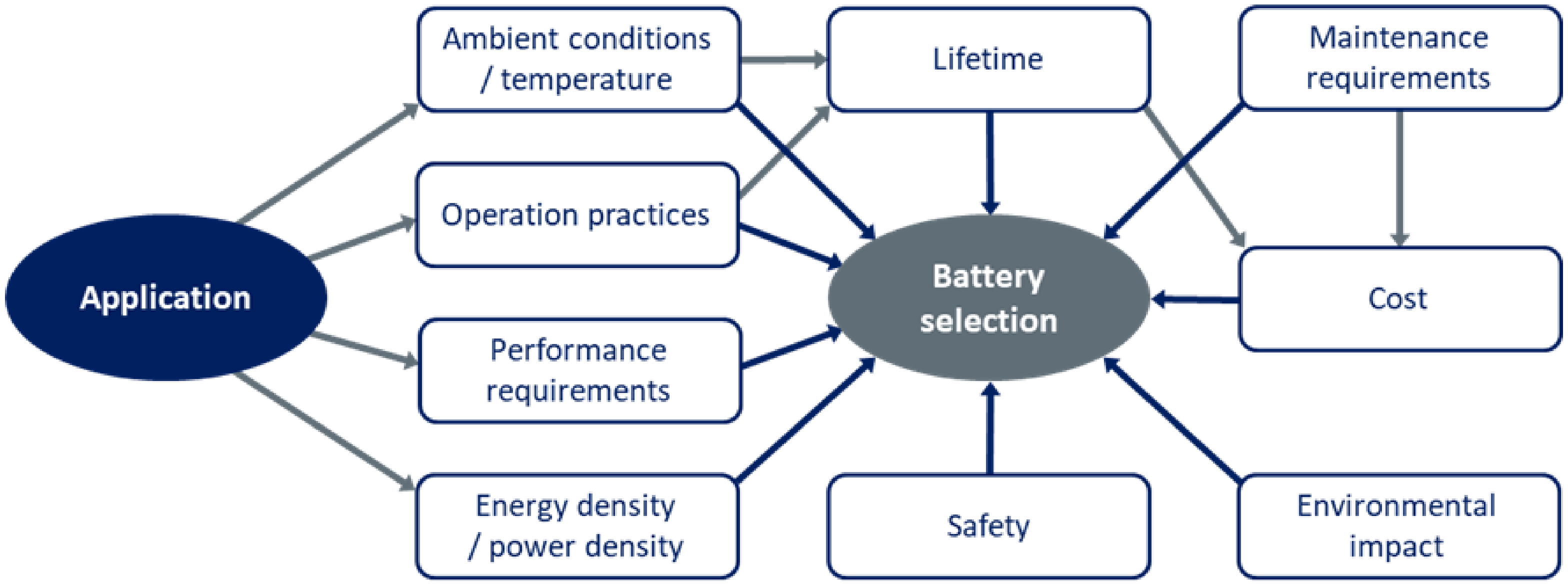
- Guidelines on **safety requirements** and safety analysis reports
- **Increased versatility** and assessing 2nd life capability
- Improved **dismantling and recycling** decreasing carbon footprint by <= 30%

Applus, Fraunhofer ILT, Heart Aerospace, VALMET AUTOMOTIVE, SUNLIGHT POWER IS KNOWLEDGE

VTT | NEXTBAT

Use cases and the main requirements for battery technology selection

Application	Use case
Road	Passenger car
	Bus
	Long-haul truck
Non-road mobile machinery	Forklift
	Construction machine
	Forestry machine
Waterborne	Trolling batteries
	Start batteries
Airborne	Regional aircraft
Rail	Passenger train



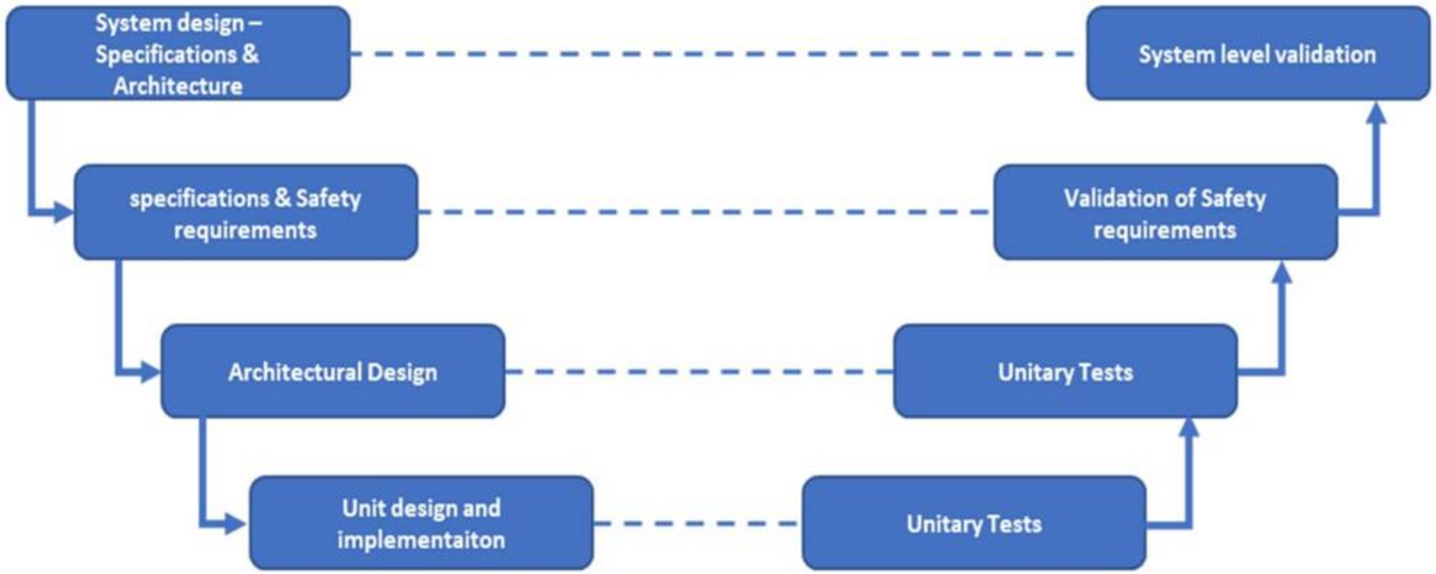
Prototyping tracks for NEXTBAT

Prototype 1 (48 V module)

- Cells: generation 3b/4a (Semi-solid state battery), large format pouch
- Thermal management: liquid cooling
- BMS: module-level PCB
- Electrical configuration: 13-15s1p
- Design basis: maximum energy
- Target use cases: HDV on-road, NRMM

Prototype 2 (48 V module)

- Cells: generation 3 a/b, large format pouch
- Thermal management: immersion cooling pressurised
- BMS: cell-level management with PCB for each cell
- Electrical configuration: 15s1p
- Design basis: maximum power
- Target use cases: automotive, NRMM, aviation



Innovations proposed in NEXTBAT

NEW LIQUID COOLING SYSTEM BY IMMERSION TO CONTROL HEAT DISSIPATION AND THERMAL RUNAWAY (SAFETY)

BATTERY SYSTEM SAFETY ASSESSMENT METHODOLOGY

DIGITALISATION & OPTIMISATION: AI & VIRTUAL DESIGN

NEW SYSTEM DESIGNS: MATERIALS, CHEMISTRY, MECHANICAL, ELECTRICAL ARCHITECTURE, ELECTRICAL & THERMAL MANAGEMENT

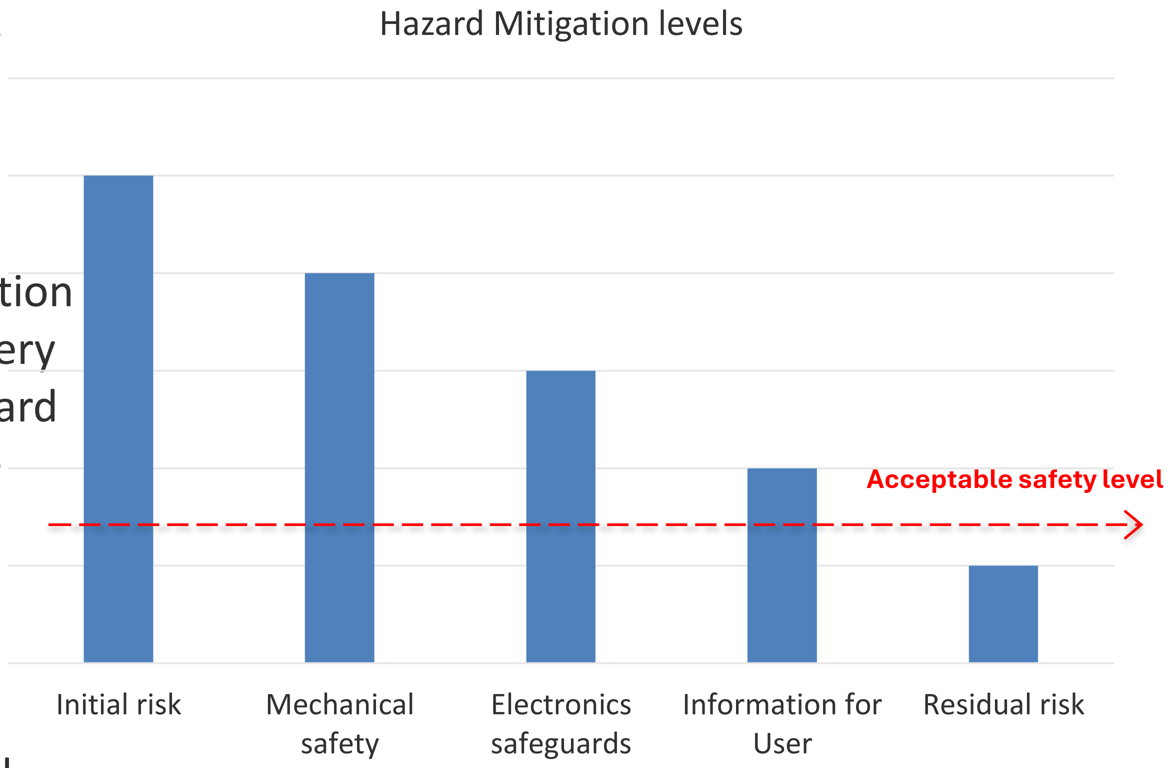
PACKING OF NEXT GENERATION BATTERY CELLS

MANUFACTURING & RECYCLING

NEXT-GENERATION BATTERY SYSTEM

Safety Design of NEXTBAT Prototype 1: risk mitigation

- SAFETY design principle is based on Hazard Mitigation levels
- Initial risk is mitigated by using Semi-solid –type of cell.
- In Semi-solid the amount of flammable electrolyte is minimized thus reducing the fire hazard.
- Mechanical safety is based on robust vibration/shock mitigation at application level combined with flame suffocation at battery pack level; emitted gas/particle emissions in case of fire hazard are managed to avoid thermal propagation and high voltage ARCing.
- Electronics safeguarding is handled at battery pack level by cybersecure BMS, which controls voltage, current and temperature at corresponding ASIL levels
- Information for user refers to user instruction/safety-manual, which would be provided to end user/OEM in case development continues beyond concepting
- Residual risk is assumed low enough to provide safe battery pack
- Refer to standards: ISO 26262, IEC 61508/ISO 13849, IEC 62061



Module safety main problematics :

- Cell thermal runaway (TR) propagation
- Module casing integrity in TR

Oil vaporization & combustion / inerting function

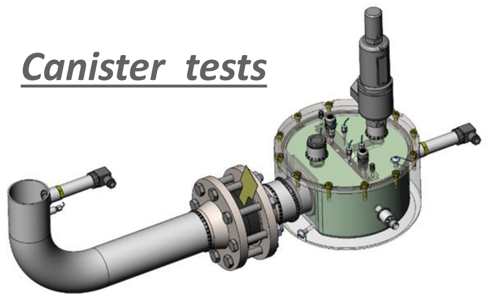
Pic of pressure in the module ? (absence of free space)

MIVOLT® IMMERSION COOLING LIQUIDS

Selecting MIVOLT oil with high fire point

Canister study ⇒ improving models accuracy (peak of pressure)

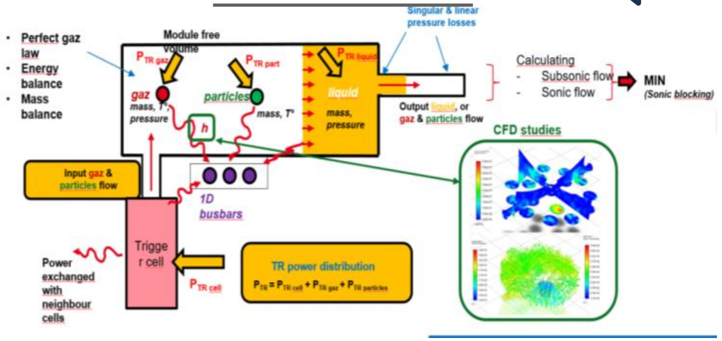
Canister tests



2 tests made at CEA energy source, gaz & particle mass

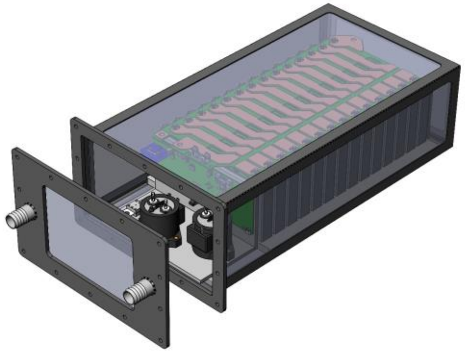
20 tests planned at APPLUS
Interaction with oil
Varying exhaust port surface
Varying Oil volume
…

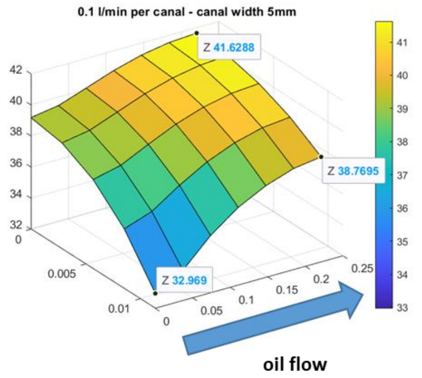
modelisation

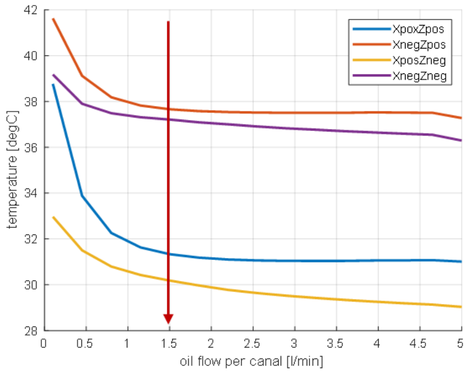


P2 Module design

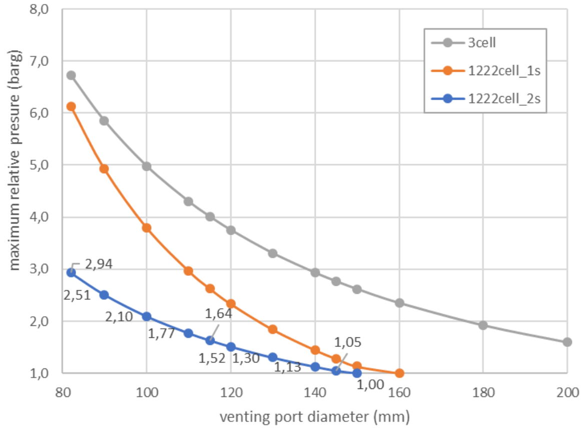
Supported by modelisation



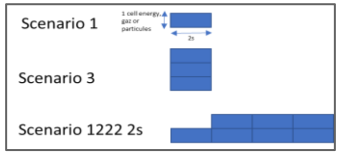




Peak of pressure vs venting port surface

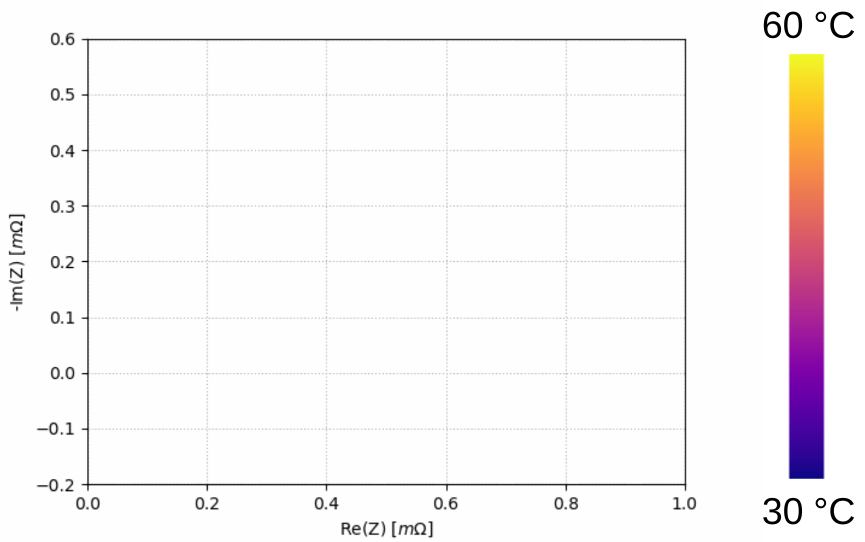


Cell TR sequence scenarii



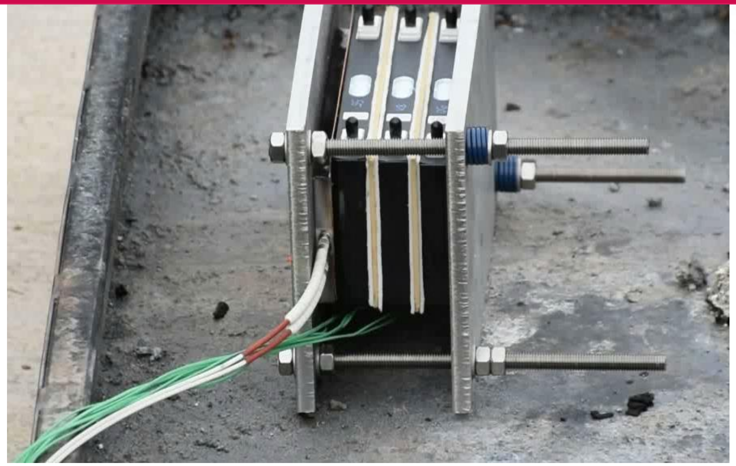
Safety Improvements Via Online EIS

Concept: exploit in-situ and in-operando **EIS measurements** to predict potential safety relevant hazards.



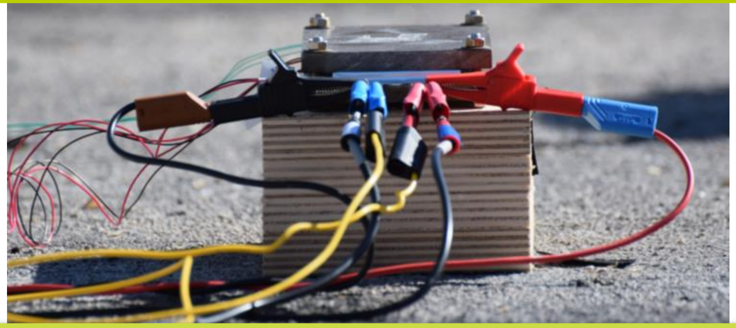
standard cell

TR due to overheating or overcharge



cell with EIS sensing

TR avoidance based on EIS data



Status: cell-level **EIS prototype** was implemented; **core temperature estimation** has been validated for standard operating conditions (-10 to 60°C).

Ongoing activities: data generation above standard operating conditions together with modelling and algorithm development for definition of SoS indicator.

Contact us

Project coordinator

Mikko Pihlatie

mikko.pihlatie@vtt.fi

Follow us

Project website: https://nextbat.eu/

LinkedIn: NEXTBAT project

X: @NextbatEU

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or [name of the granting authority]. Neither the European Union nor the granting authority can be held responsible for them. Project Number 101103983

Logo