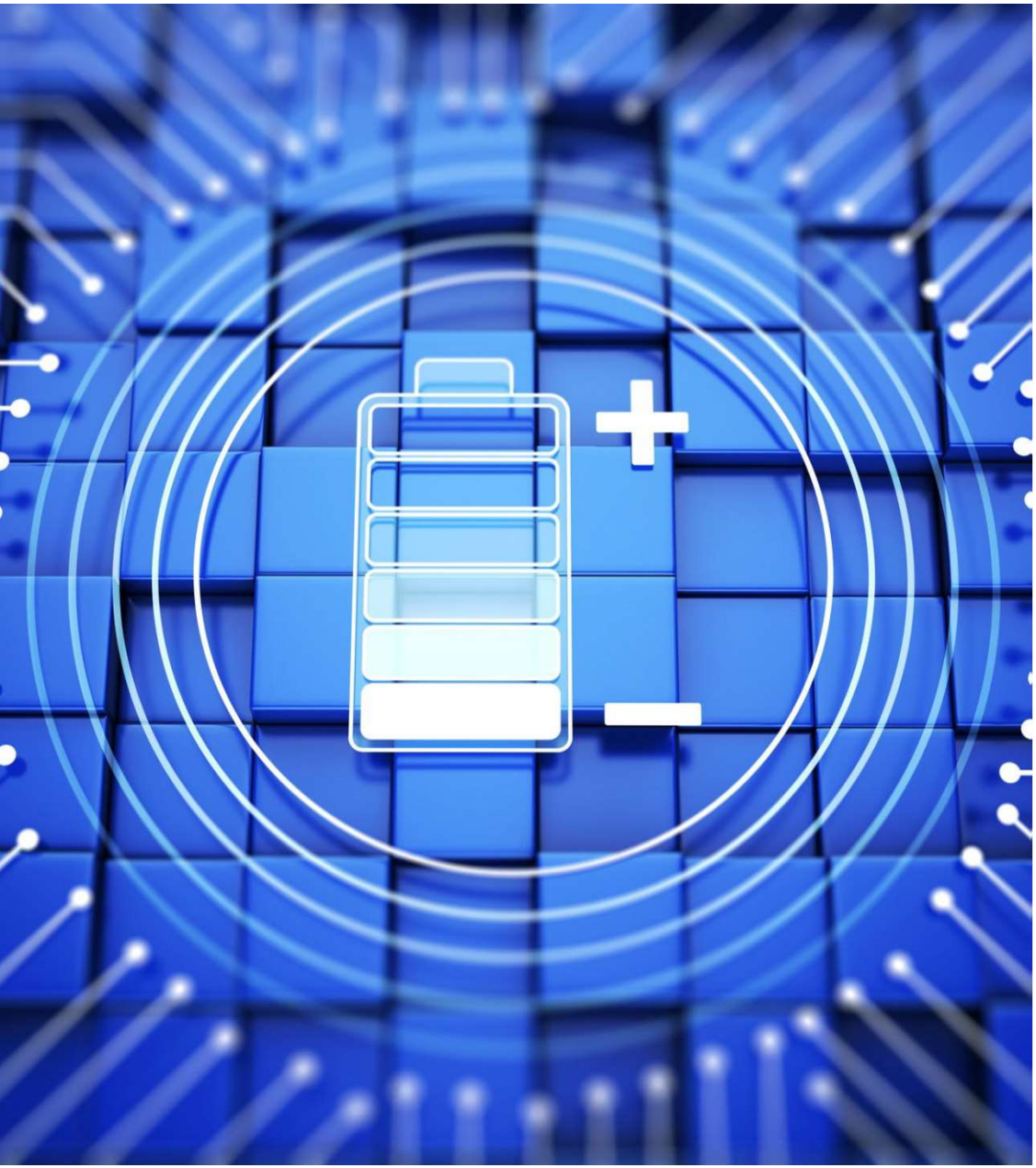


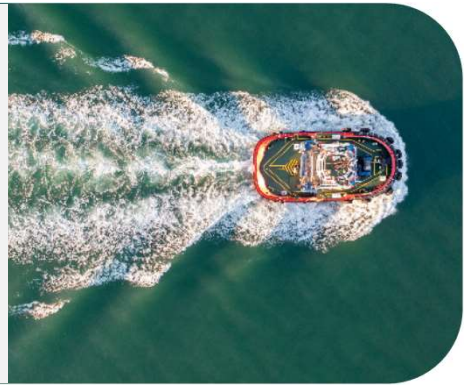
Innovation in Battery Energy Storage Systems

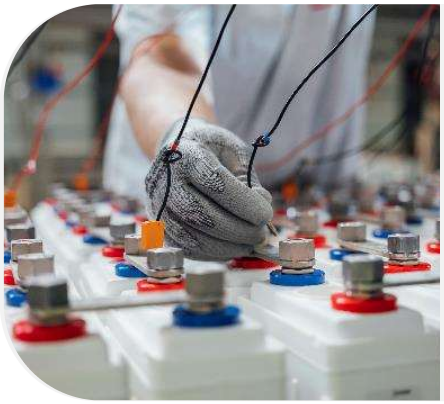
Michael LIPPERT

FIEEC Webinar 30 November 2023

About Saft

Saft specializes in **advanced technology battery solutions for industry**, from the design and development to the production, customization, and service provision.





Our innovative, safe, and reliable technology delivers high performance **on land, at sea, in the air, and in space.**

01 > ESS : what are we talking about ?

02 > Battery technologies: Li-ion today, and what in the future ?

03 > Whatelse do we need ? Some aspects of system development

04 > AC Batteries

01.

ESS – what are we talking about ?


Power Management System (PMS)
Grid Connection
Energy Storage Unit
Power Conversion System (PCS) and MV Transformer
saft

What matters

Energy and **Power**
in given **Space**

125MW x 4h = 500MWh
15 000m²
incl roads and safety distances

Life Time

15 – 20 years
+/- 1 full cycle per day

Environment

-35°C to +45°C

Efficiency

85% round-trip efficiency

IHE-LFP is SAFT 5th generation of ESS battery containers

Generation 1 - NCA

2012

620 kWh – 1MW

Generation 2 - NCA

2014

1 MWh – 500 kW
900 kWh – 2.1 MW

Generation 3 – NMC/NCA

2017

1.2 MWh – 2.5 MW

Gen 4 IHE NMC pouch → LFP prism

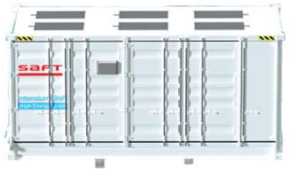
2019

2.5 MWh – 2.0 MW

2021

2.3 MWh – 2.2 MW

Gen 5 Intensium Shift LFP prism



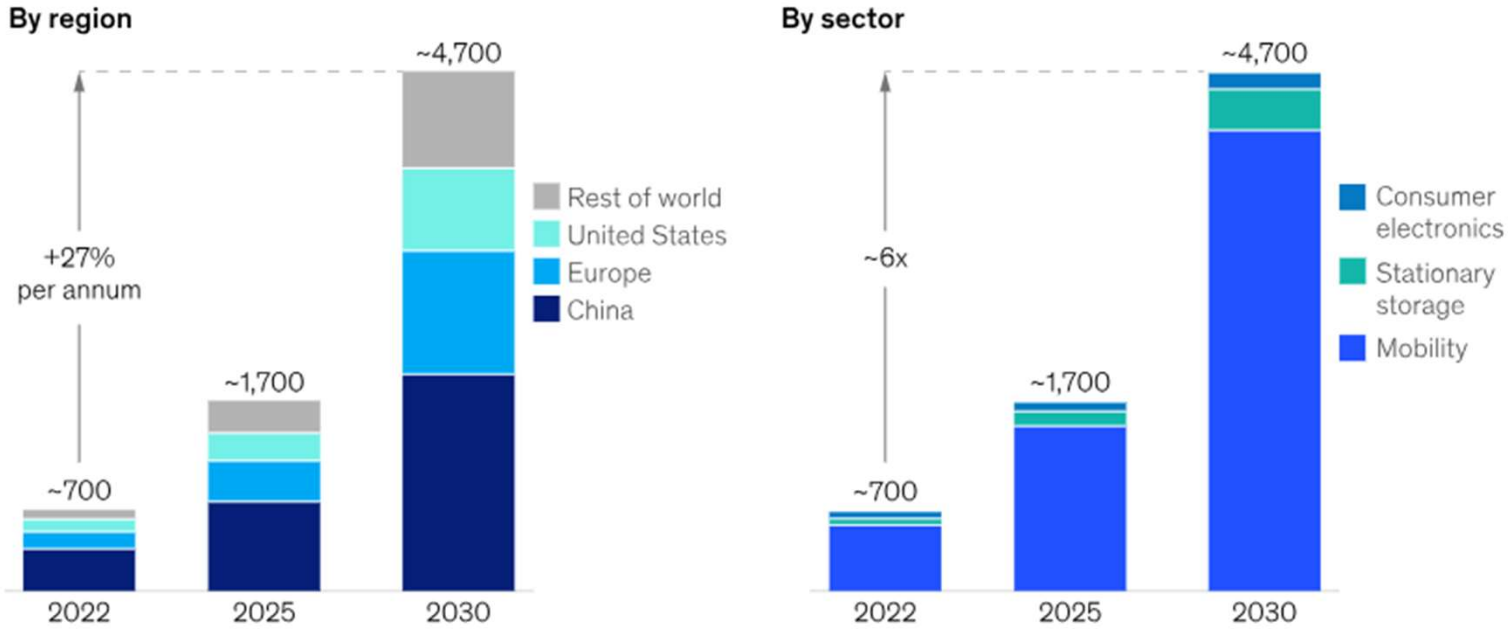
2023

3 MWh – 1,5 MW

- **Continuous choice for 20” container**
- **Plug and play solution, fully populated and tested on plant before delivery.**

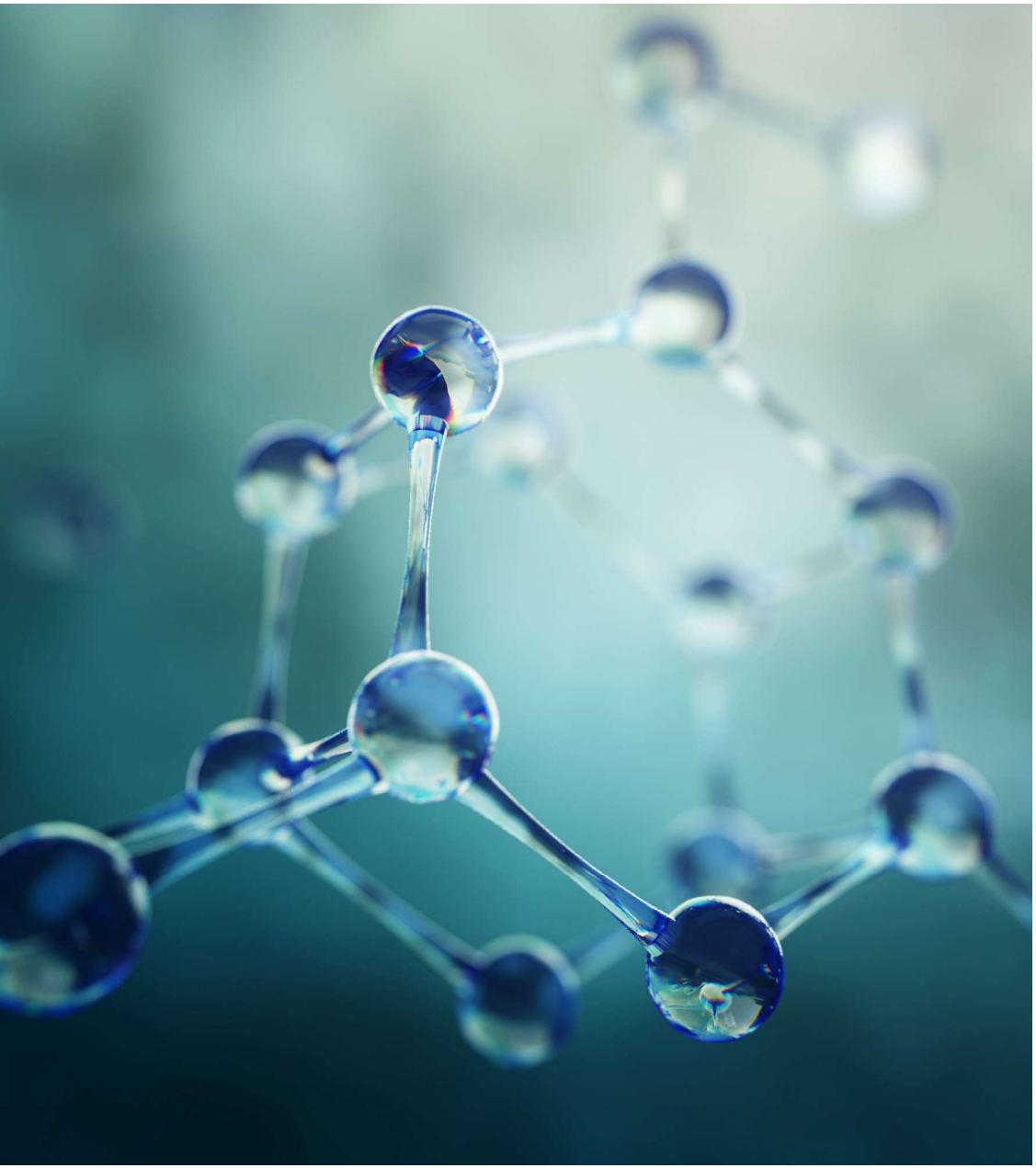
Global Li-ion battery market

Global Li-ion battery cell demand, GWh, Base case



[1]Including passenger cars, commercial vehicles, two-to-three wheelers, off-highway vehicles, and aviation.
Source: McKinsey Battery Insights Demand Model

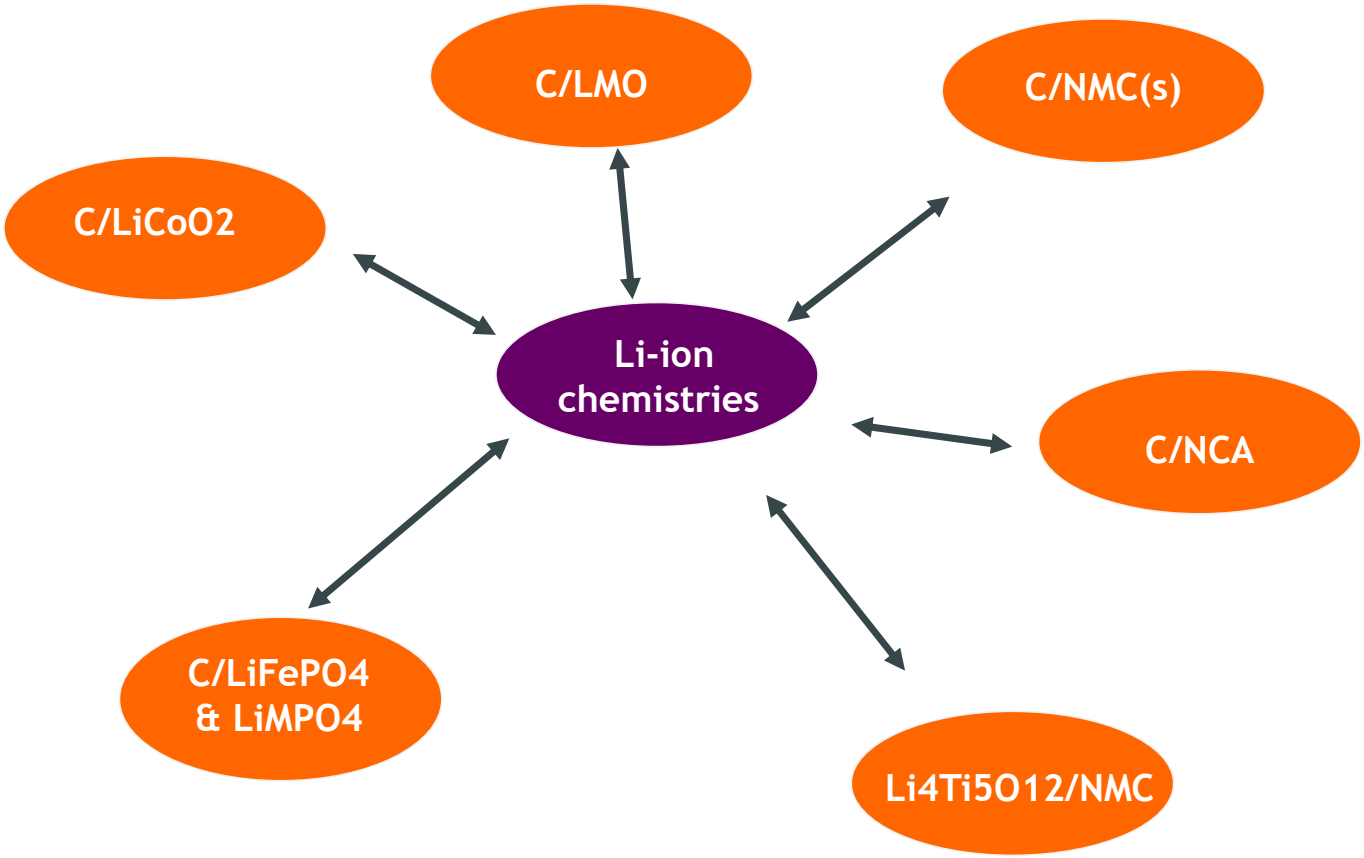
McKinsey & Company



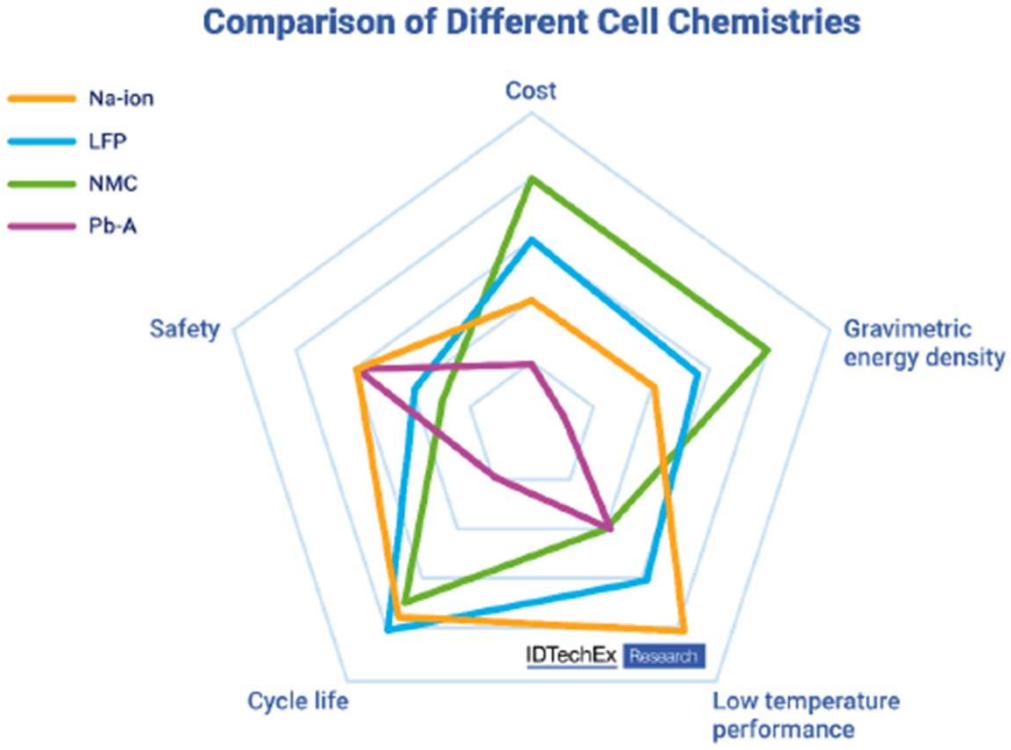
02.

Battery technologies

Current Li-ion chemistries



No « best in class »

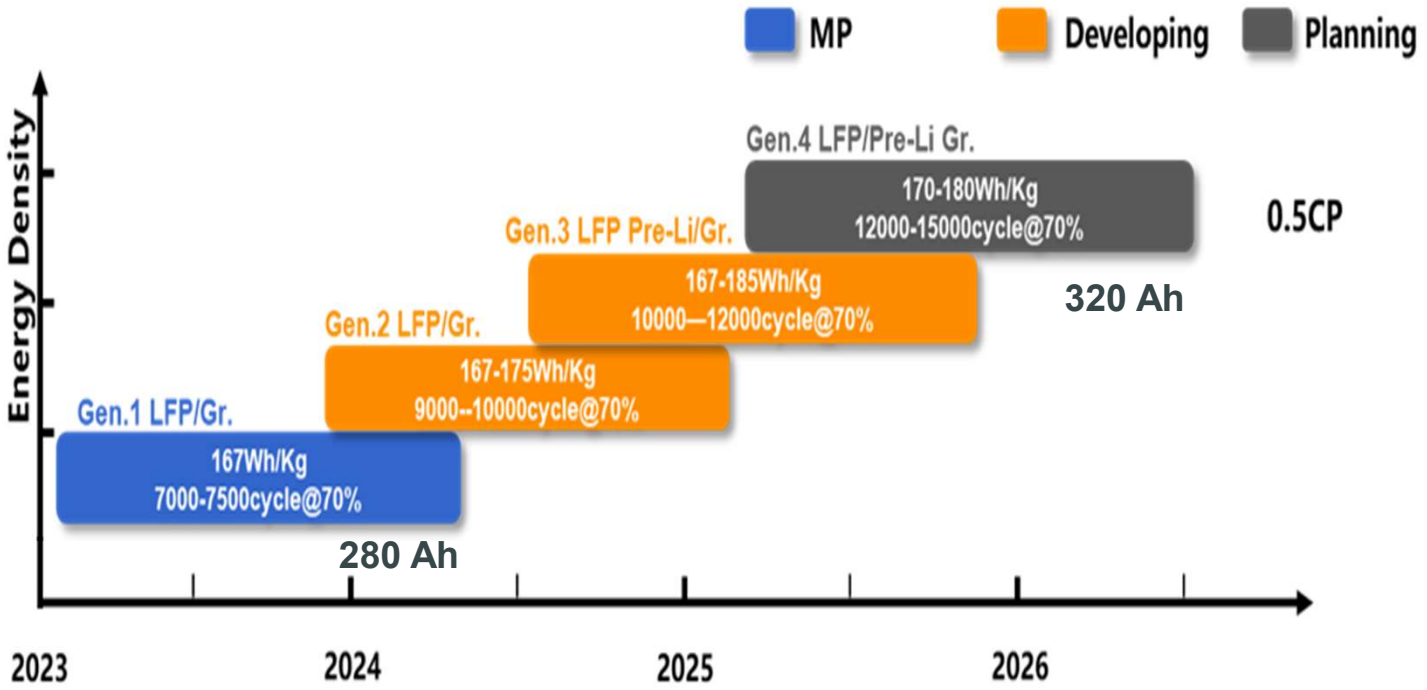


Specific Energy	Energy Density	Cost	Power	Safety
274 Wh/kg	700 Wh/L	<100 $/kWh	3000 W/kg	thermal stability
NMC	NCA	LFP	NMC/ LTO	LFP

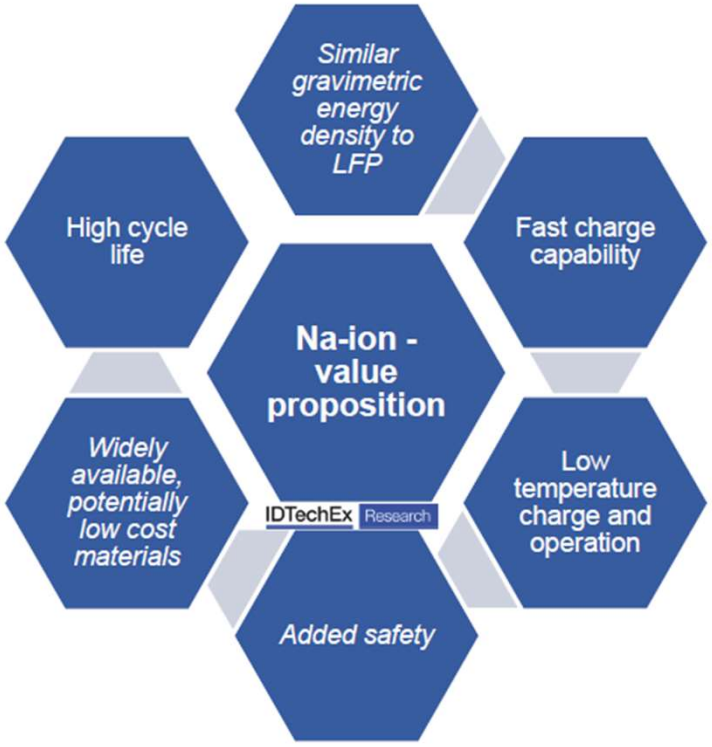
- Availability of raw materials
- Manufacturability
- Sustainability of materials and processes
- Recyclability

Stationary storage: LFP versus Na-ion ?

Prismatic LFP cell
71 x 173 x H 207mm



The Value Proposition of Na-ion



Fast charge/high power - demonstrated

- >4C charge rates demonstrated

Low temperature charge - demonstrated

- Low impedance/fast transport electrode materials

High cycle life - demonstrated

- High cycle lives >1000 cycles often demonstrated with very high cycle lives also possible in certain designs

Added safety – partially demonstrated

- Can be transported in a zero SoC state
- Though thermal runaway is less likely, Na-ion currently still uses flammable organic electrolytes

Widely available/low cost materials – partially demonstrated

- Dependent on specific cathode material choices but can avoid Co and Ni (and Li) use
- Manufacturing scale needs to be reached for cost benefits to be realised but Li-ion infrastructure can be utilised

Similar specific energy to LFP - demonstrated

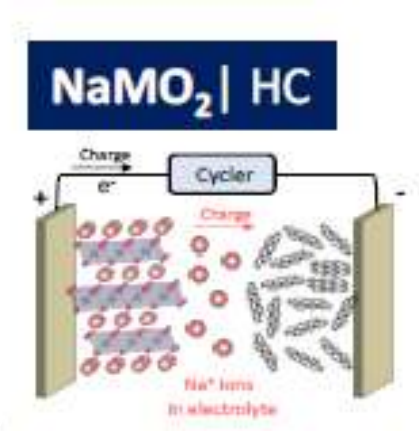
- Allows it to be competitive with LFP, though volumetric energy density is likely to be lower and NMC type Li-ion will have a considerable advantage

Na-ion choices to make

TotalEnergies

3 FAMILIES OF CHEMISTRY ⇔ 3 Cathode Active Materials (CAM)

$NaMO_2$ | HC

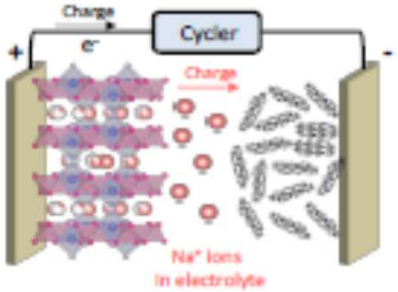


CAM1 : Layered Oxides

Most mature (CN)
R&D scale in Europe (Umicore, Topsoe)

✚ Higher energy
— Sensitive to moisture => PROCESS

$Na_3V_2(PO_4)_2F_3$ | HC

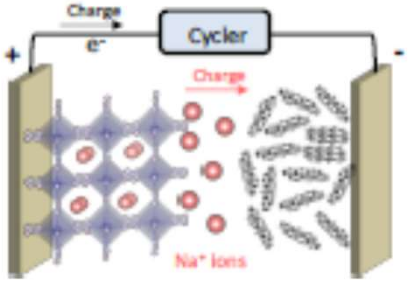


CAM2 : polyanion

Except NVPF (poor life), still in dvlpt (CN)
Stability to moisture: aqueous process ?

✚ Low cost, longer life
— Low energy, low maturity

$Na_xM_1M_2(CN)_6.yH_2O$ | HC



CAM3 : PW / PBA

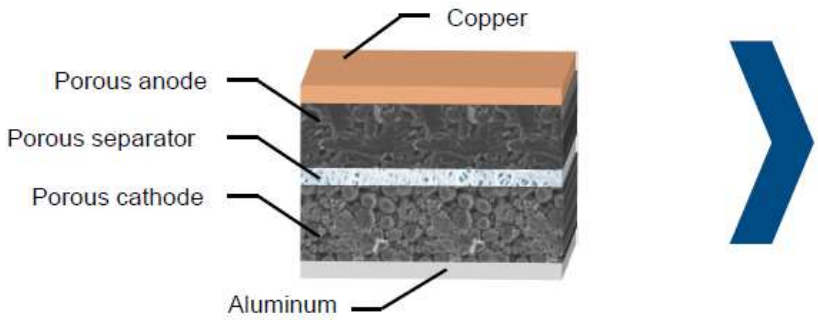
Stopped for SAFETY issues (CN)
HCN release during CAM processing (CN)

✚ Lowest cost, process possible in ambiant air
— Short cycle life

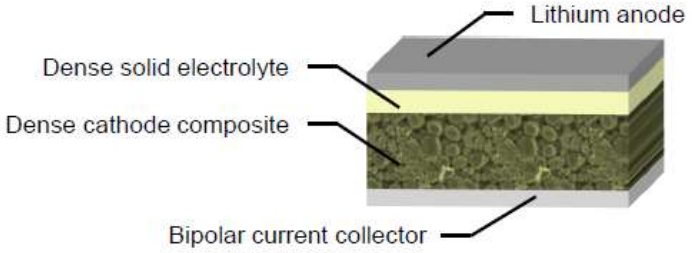
saft

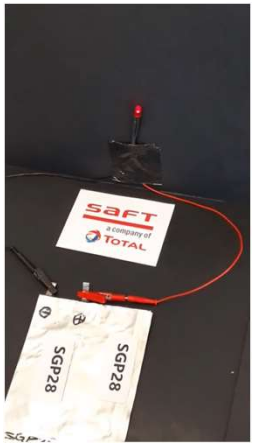
Solid State Batteries
Principle, benefits

Conventional lithium-ion (Gen3)



Solid State (Gen4)





J. Schnell et al. Journal of Power Sources 382 (2018) 160–175

Principle

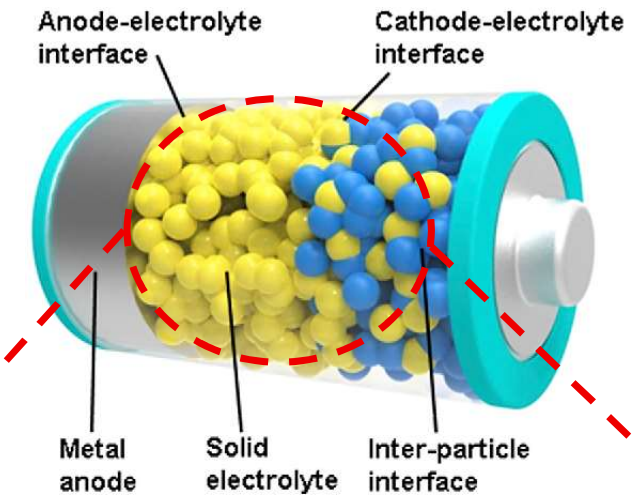
- Replace **liquid** electrolyte by **solid** electrolyte
- Replace standard graphite electrode by **lithium or silicon**

Benefits

- **Improved safety**
  - Hazard level / EUCAR **<4 (no flame)**
- **+50% higher energy density**
  - gravimetric (290 -> **430 Wh/kg**)
  - volumetric (750 -> **1100 Wh/l**)

Solid State Batteries
SS electrolytes & key challenges

Solid - state



Main solid electrolyte technologies

Polymer | Sulfide | Oxide

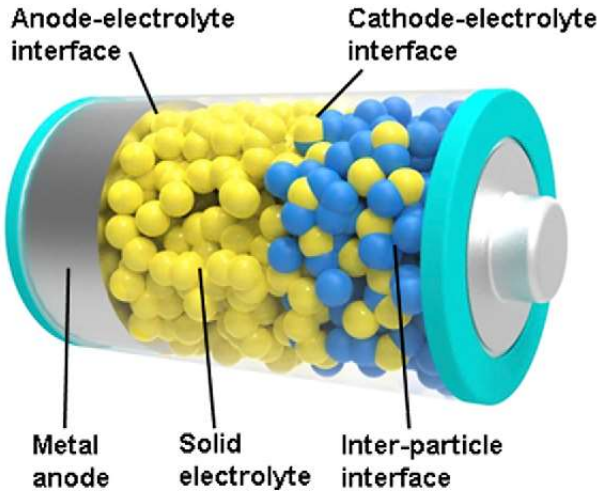
Key challenges

- Develop room temperature solid electrolyte
- Stable interfaces between materials
- New processes (dry process, densification)
- Industrial scale-up of new materials and new processes

Solid State future will be likely hybrid

POLYMER

- **Advantages**:
  - Easy to process
  - Multitude of solutions (SPE, GPE,CPE…)
  - Good compatibility with liquid additives or plasticizers
- **Challenges:**
  - Low σ_{ionic} at RT
  - Mechanical stability of SEL at low thickness (Li dendrites)
  - Electrochemical stability of used polymers



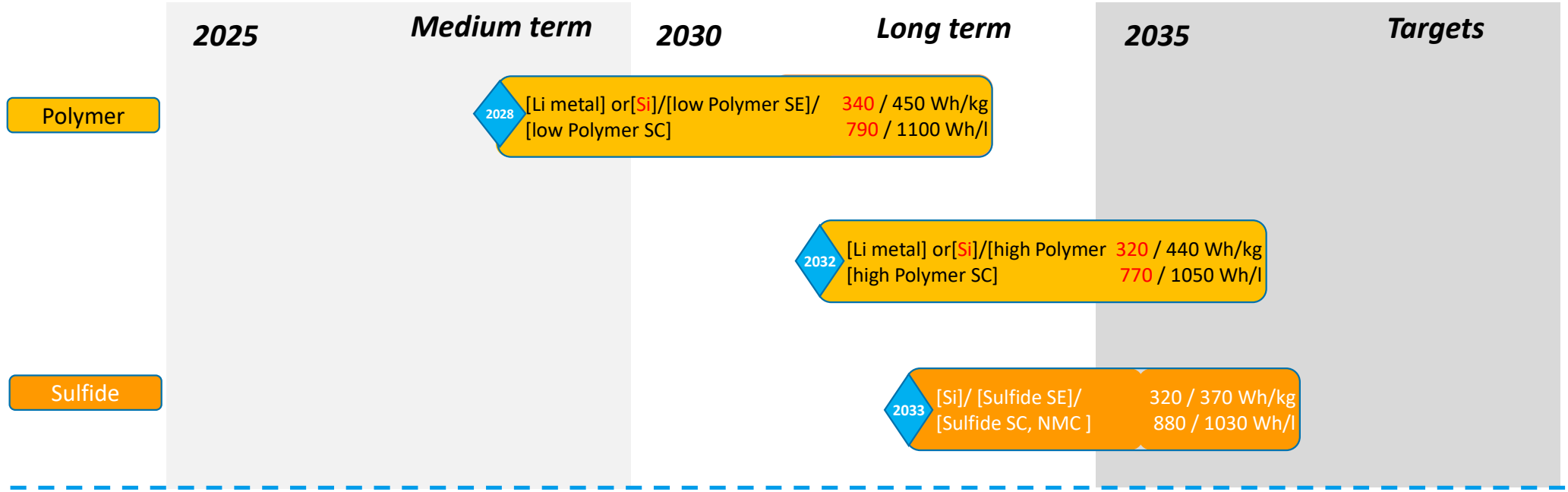
OXIDE

- **Advantages:**
  - Intermediate σ_{ionic}
  - Mechanically stronger
- **Challenges:**
  - Processing thin layer and sintering & associated cost
  - Density
  - Limited stability with Li-M anode

SULFIDE

- **Advantages:**
  - Best σ_{ionic}
  - Softer than oxides
- **Challenges:**
  - Limited stability with high potential CAM
  - Limited stability with Li-M anode
  - H_2S risk management at cell & pack levels
  - High pressure to apply

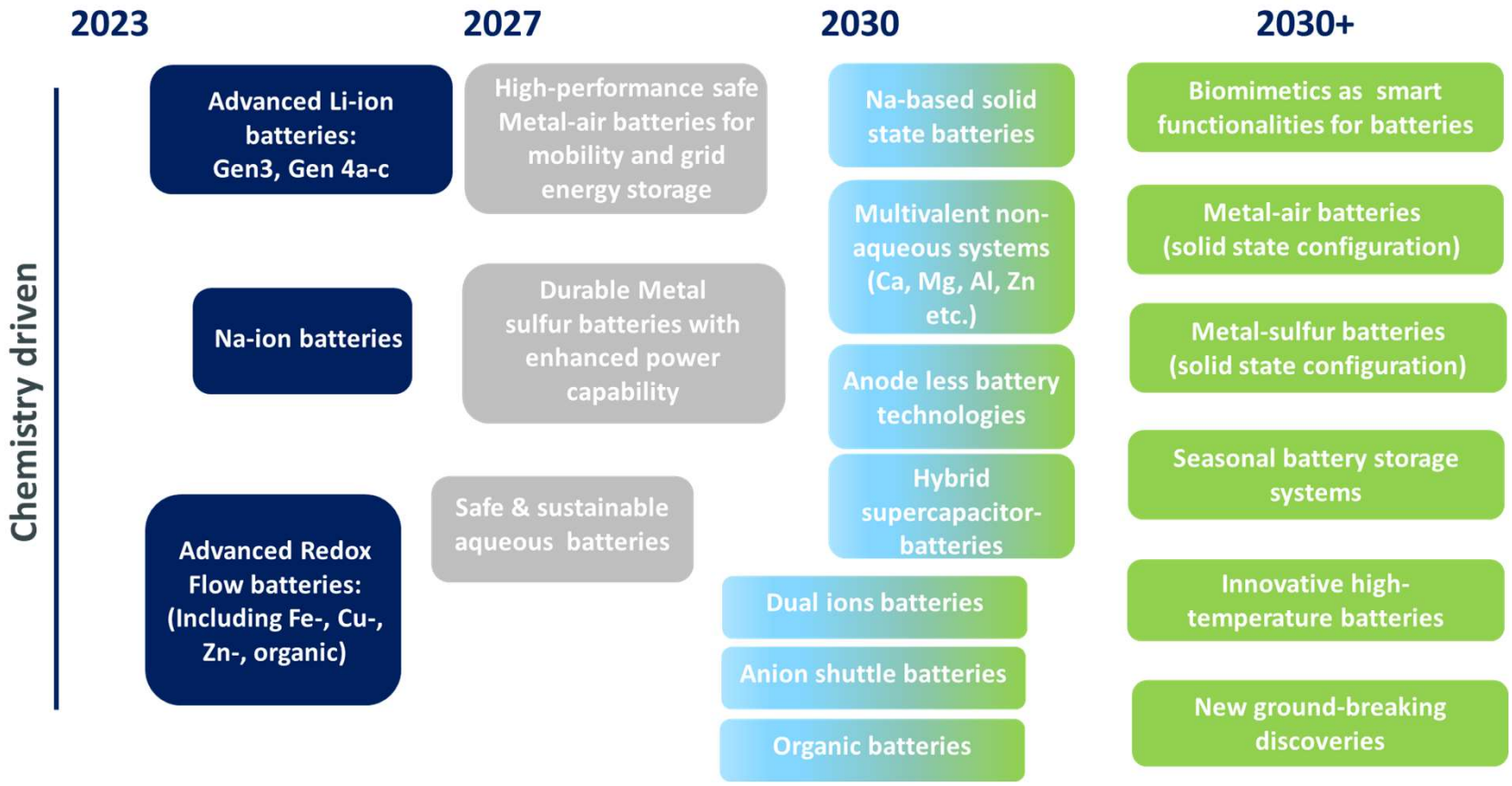
Solid State TRL9 technical direction



Oxide — Hold on pathway: process and density issues

Beyond Lithium …

Expected availability of functional prototype cells



Source:
Batteries 2030+ /
Batteries Europe

03.

Whatelse ?
System design

Battery building blocks

Holistic System Design

- **Battery cell and module technology**
- **Thermal management**
- **Safety management**
- **Controls**
- **Supervision**
- **Service**

Intensium® Shift
- 2 - 8 hours applications
- 3 MWh – 1.5 MW_{max}
- 8 strings x 17 modules = 136 modules
- 280 Ah LFP cells 1P24S

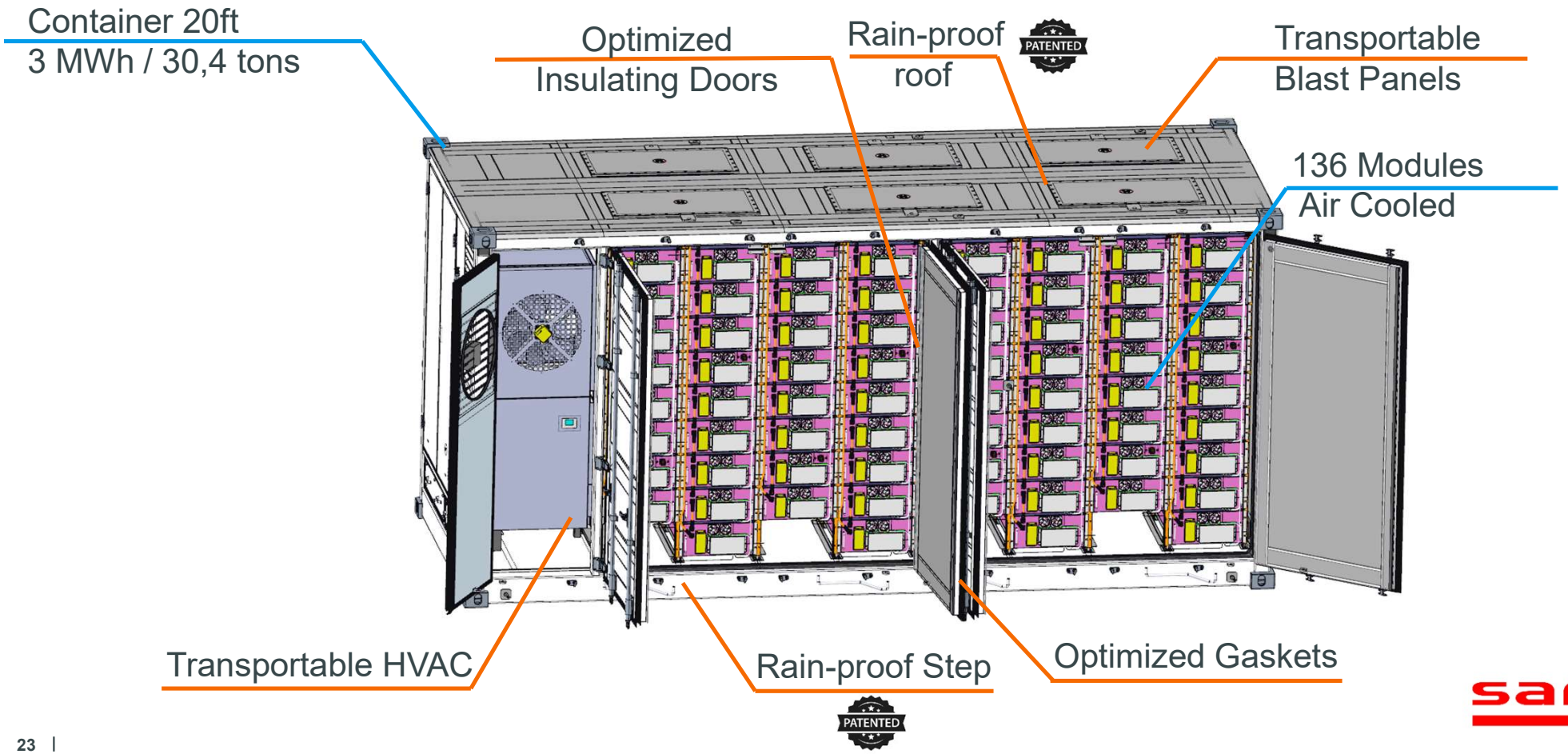
TotalEnergies

Outstanding system performance thanks to Saft's holistic design approach

- Safety
- Long life
- Energy efficiency
- High performance and availability

SAFT

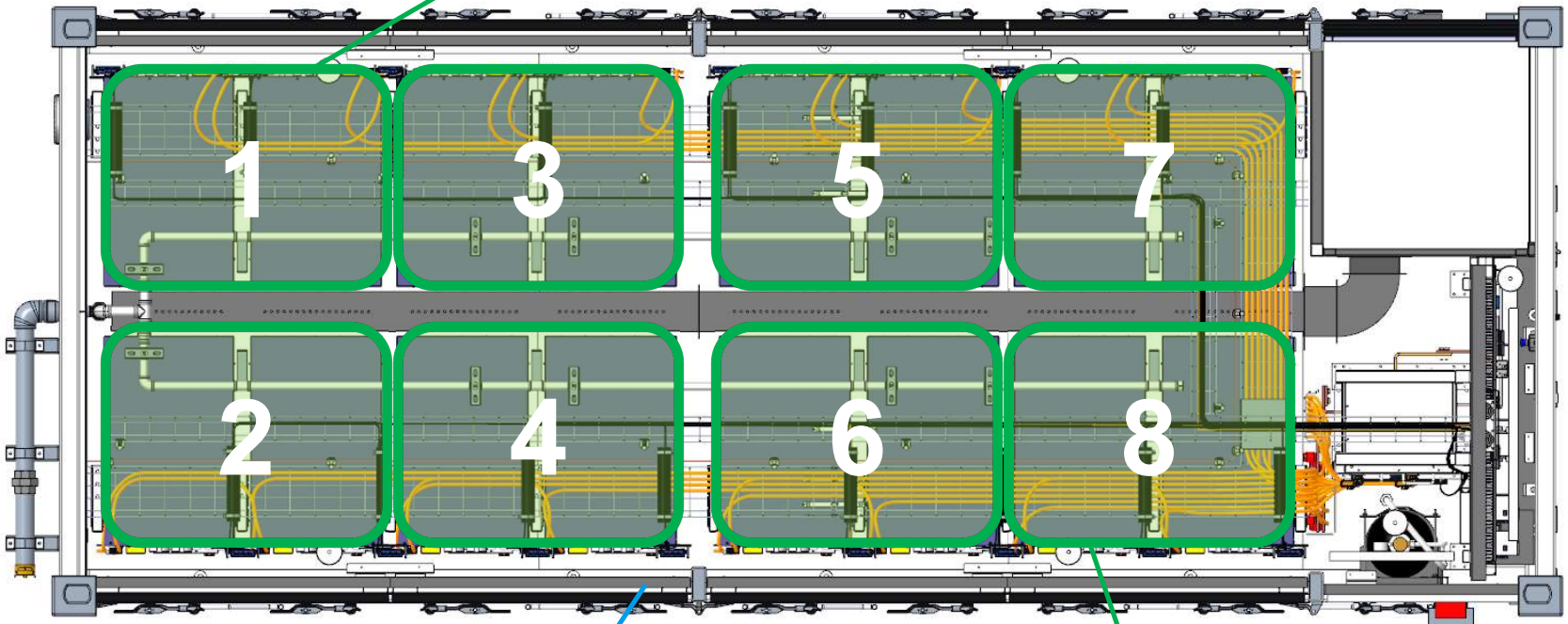
Patented solutions based a decade of field experience for ease of installation and trouble-free operation

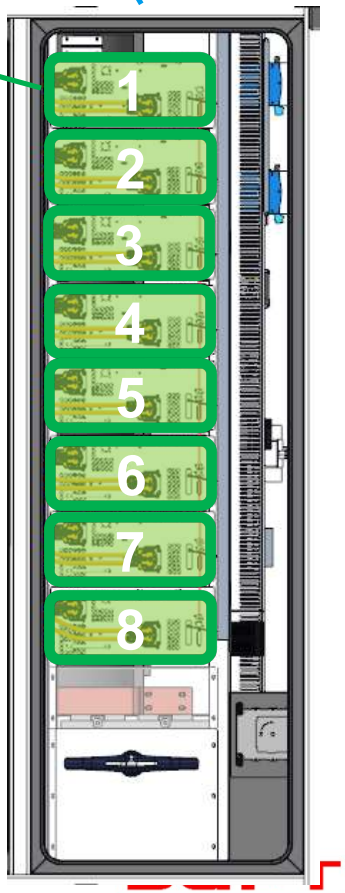


Intensium Shift – String (ESSU) distribution

1 string = 17 Modules + 1BMM

8 BMM
Battery Management Modules

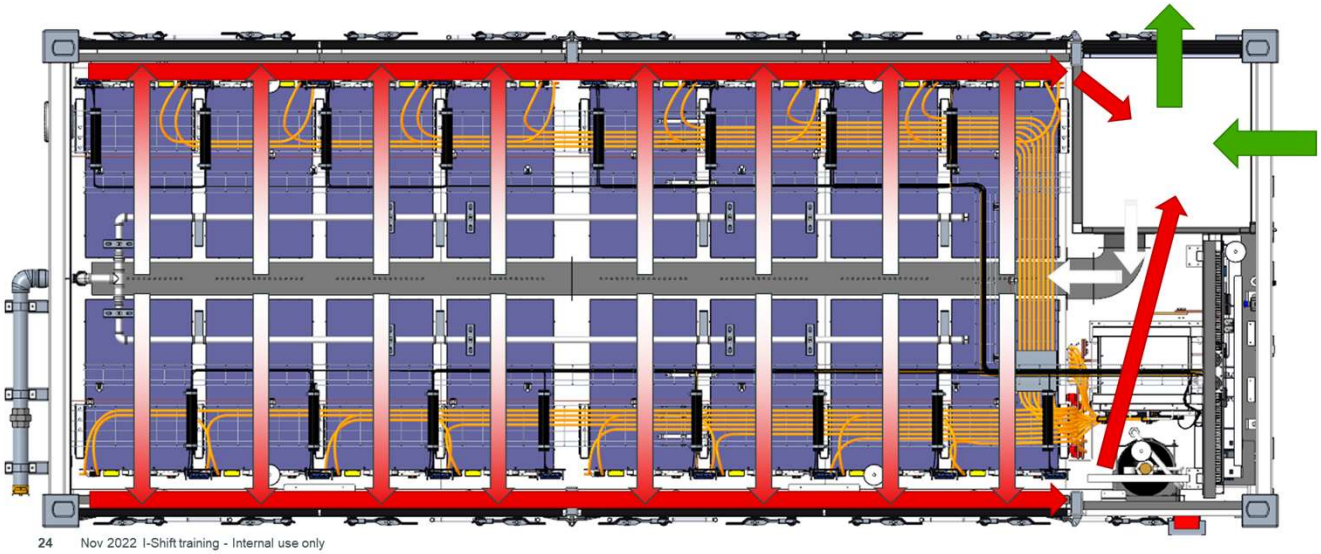


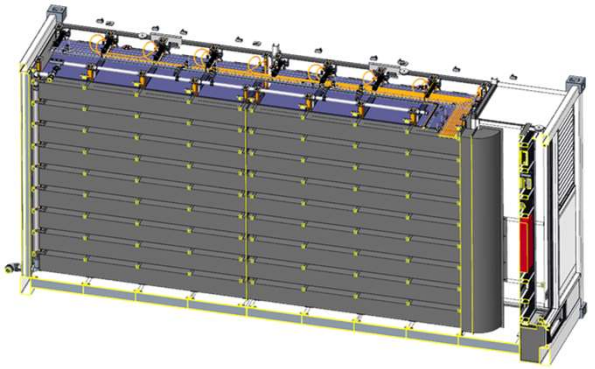


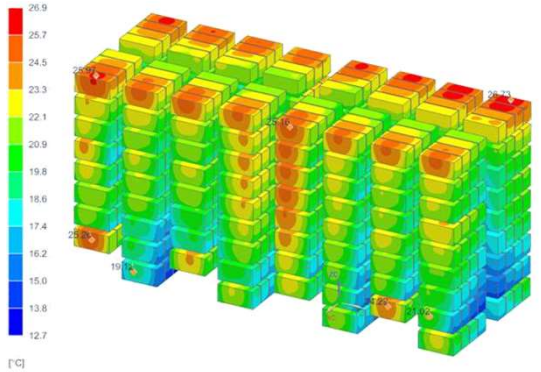
8 strings distribution
8*17= 136 Modules

2 racks = 17 Modules

Intensium Shift – Thermal description



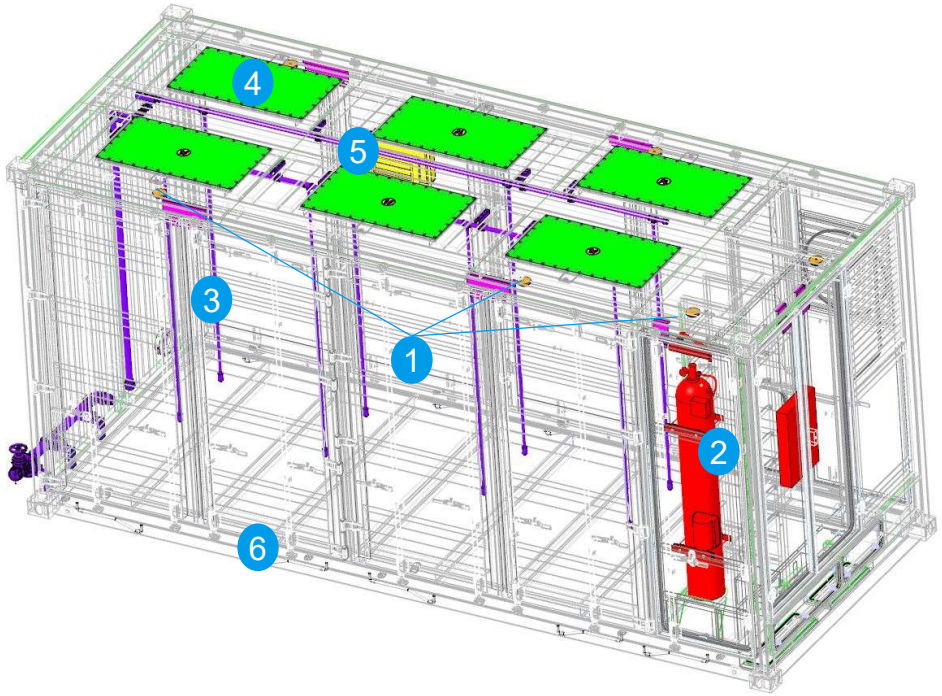




A unique combination of safety features

Preventive and functional safety layers

- **BMS**
  - Overheat
  - Overcharge
  - Overload and short circuit
- **String**
  - Short circuit protection
  - Arc Flash protection
- **HVAC**
  - Temperature control
  - Humidity control
- **Disribu-tion**
  - Contactors and Short Circuit protection
  - B-Stop
- **Enclo-sure**
  - Water and dust intrusion
  - Mechanical abuse



Fire and explosion mitigation safety layers

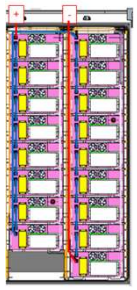
1. Detection of gas and smoke
2. Gas Fire Suppression System
3. Water sprinkling system (cooling in case of thermal runaway)
4. Explosion mitigation blast panels
5. Overpressure vent
6. Rockwool thermal insulatinon

Fully tested and certified

Battery System Control

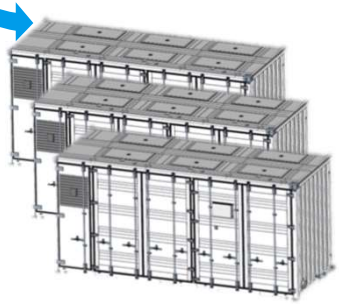
Cell/module level

- Temperature and voltage measurement
- Cell SOC balancing



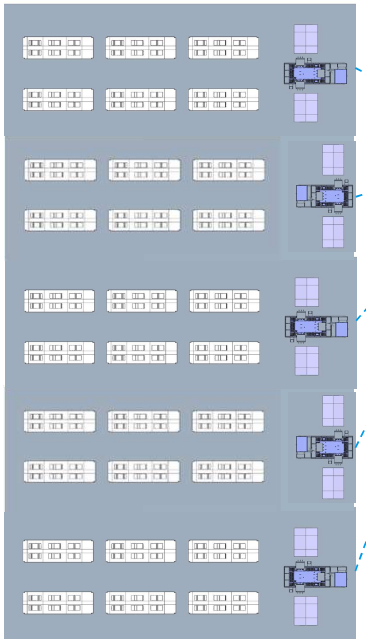
String level

- BMM
- SC protection
- String breaker



Container level (CUBE)

- String parallelling
- Paralelling of multiple containers
- PCS connection



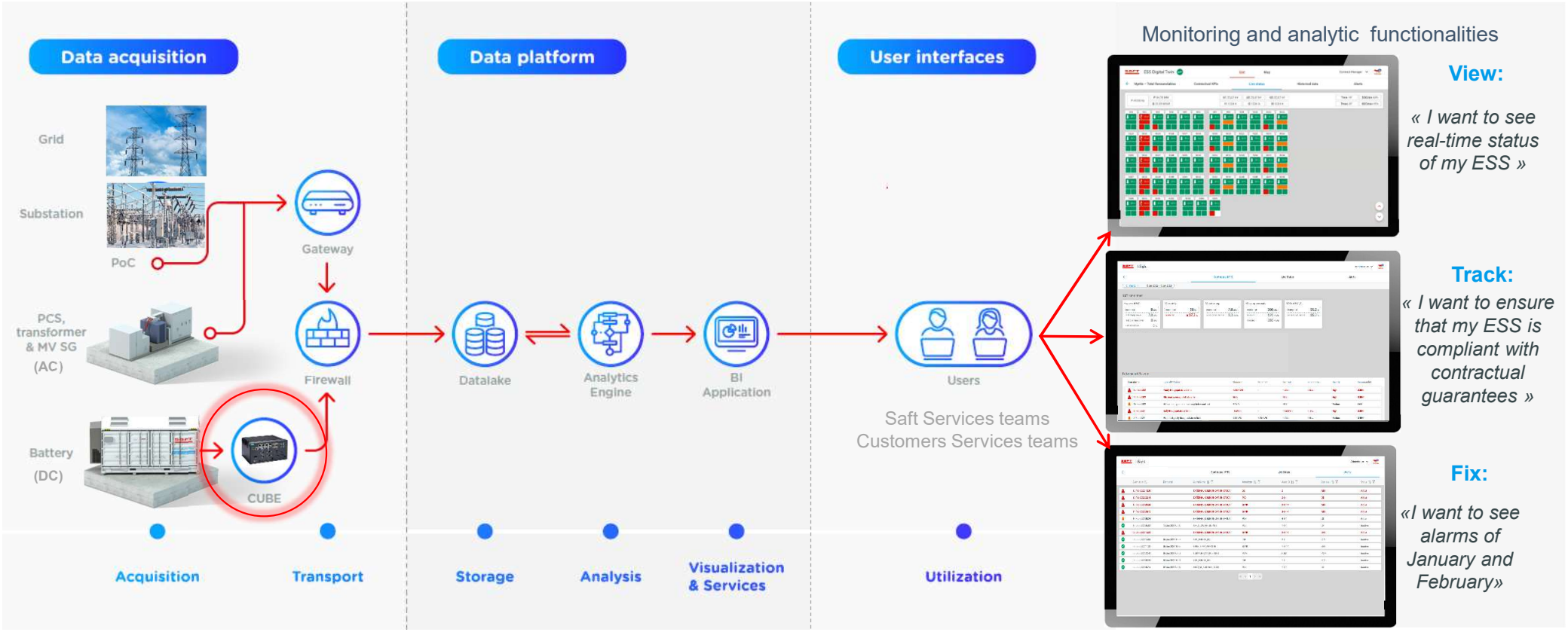
EMS

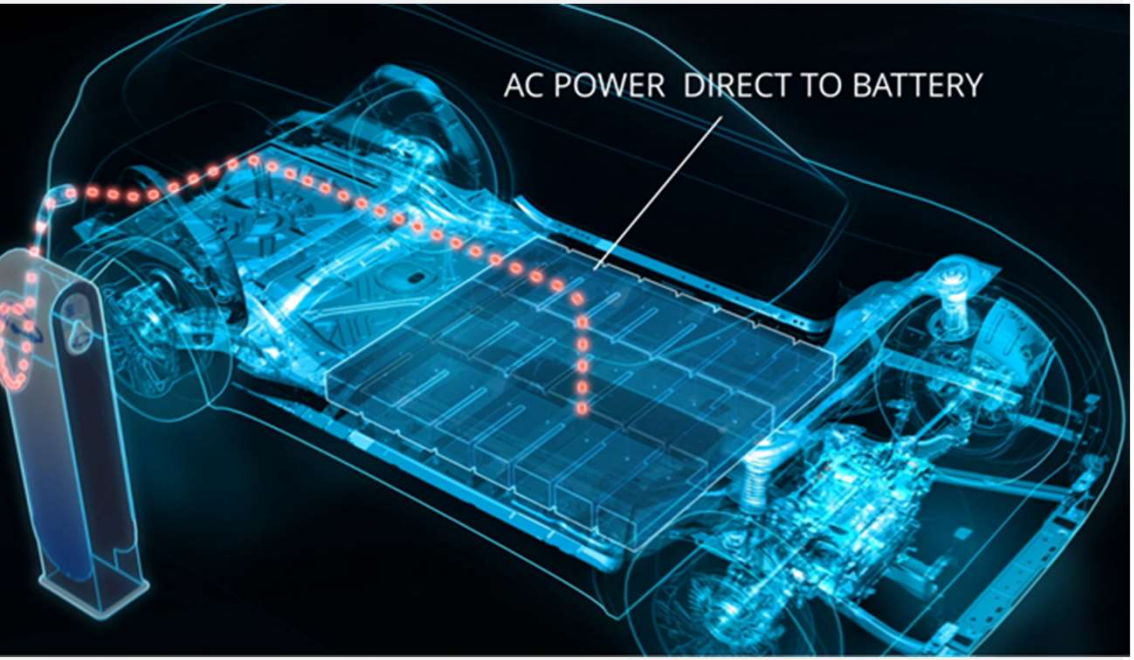
PMS

System level

- Line-Up control
- Power dispatch

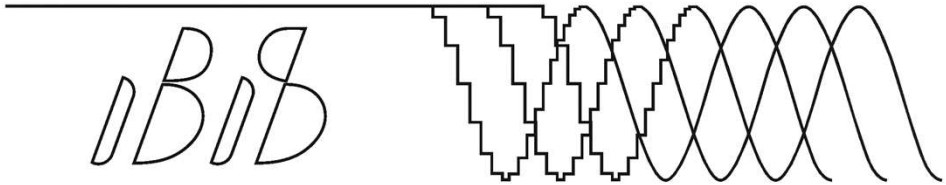
I-Sight Remote Supervision and Monitoring





04

AC batteries



TotalEnergies

Intelligent Battery Integrated System

GeePS

SATIE

LePMI

cnrs

INSTITUTLAFAYETTE

STELLANTIS

SHERPA engineering

saft

E²CAD Smart and Efficient Solutions

Financé par

RÉPUBLIQUE FRANÇAISE
Liberté
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ADEME
AGENCE DE LA TRANSITION ÉCOLOGIQUE

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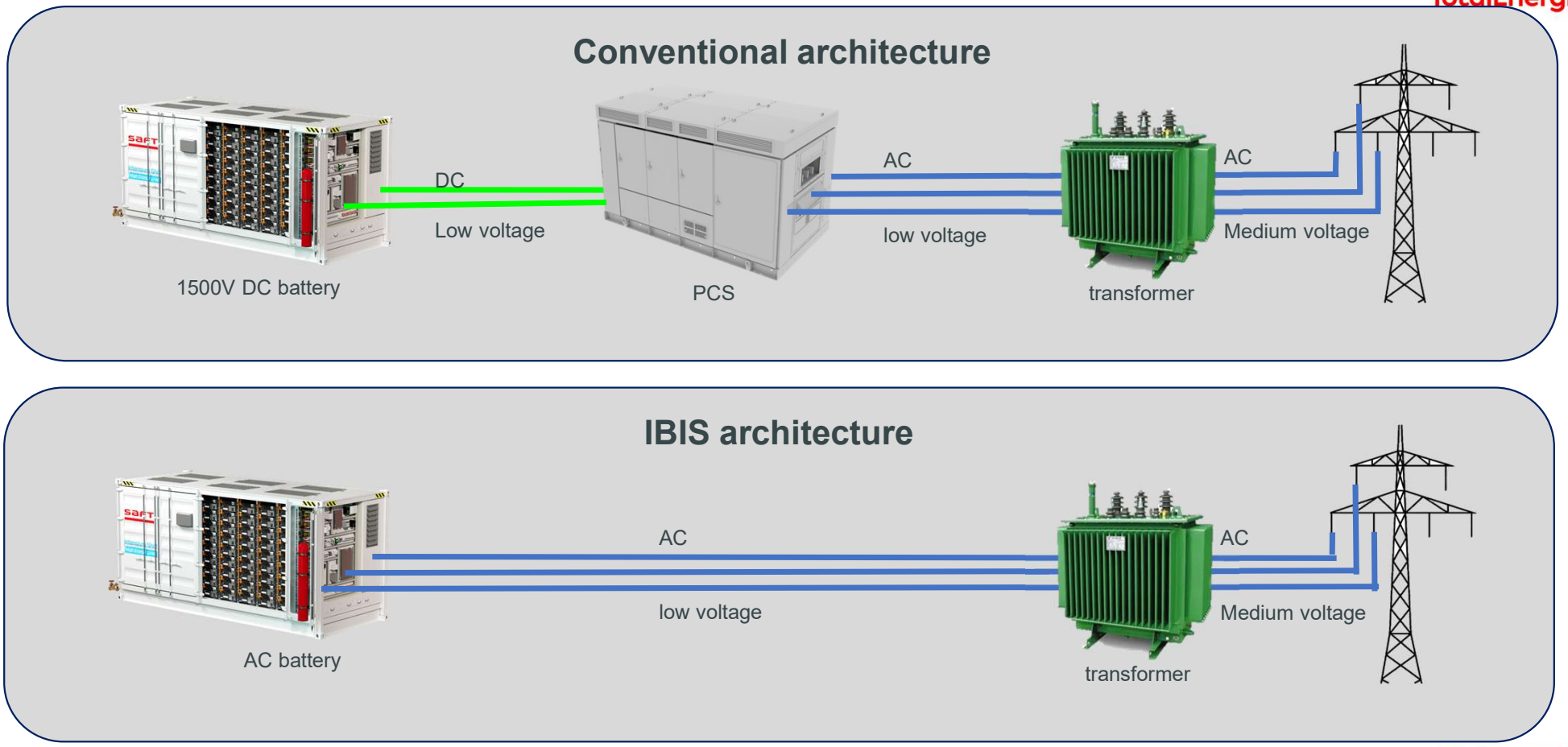
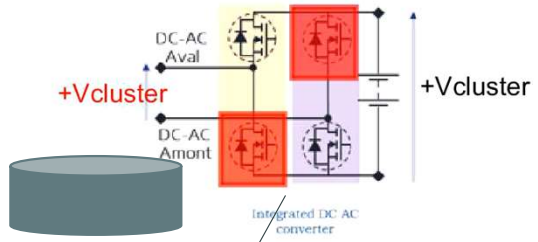
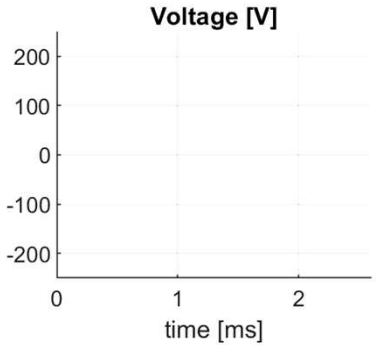
Future stationary systems

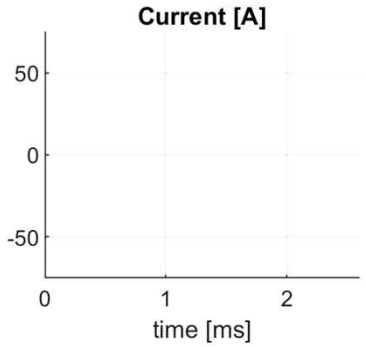


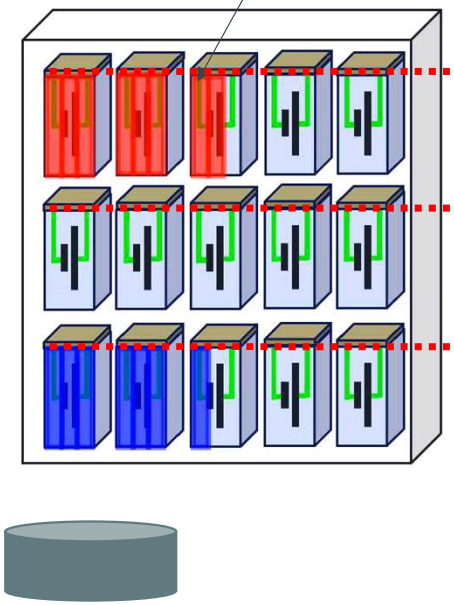
Operating principle – IBIS battery



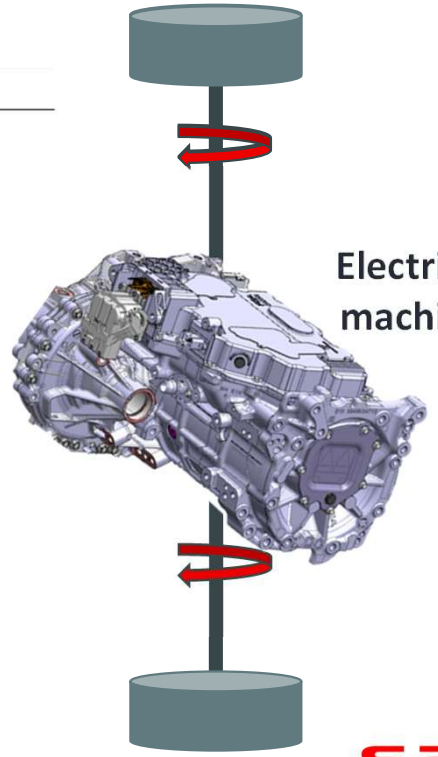
+Vcluster







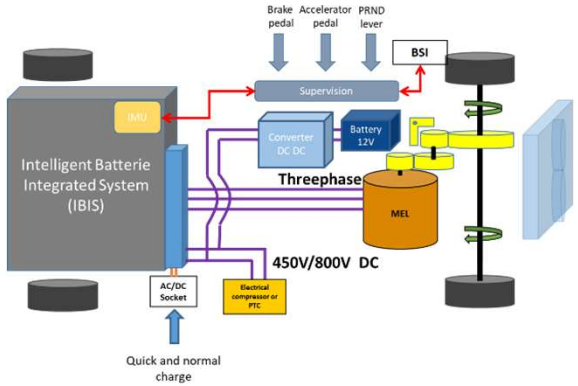
Three phase current



Electrical machine

Benefits

- Reduces BESS **footprint**
- Improved **round-trip efficiency**
- Higher **availability**
- **Self-healing** architecture
- Optimize **battery sizing** and **usable energy**
- Improved quality of AC signal
- Simplifies energy **augmentation and module replacement** (Allows mix of clusters of different ageing)



- **Performance** (efficiency, lifetime, better battery capacity use, less weight, No electric noise, …)
- Production **cost**
- **Reliability** (safety, maintenance, …)
- **Vehicle design** (less volumes = more freedom in architecture design and style)

Merci

michael.lippert@saft.com