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Past, Present and Future of the Vanadium-Redox -Flow-Battery (VRFB) system at Fraunhofer ICT embedded into EU-Horizon project SMHYLES

Yannick Seiler

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Introduction

Institute and team

Located in Pfinztal, near **Karlsruhe**, Germany one of 75 Fraunhofer Institutes

530 employees (250 scientists, 200 technicians and assistants, 80 administration)

Team RFB

- Jens Noack (Group leader)
- Michael Schäffer (System)
- Yannick Seiler (System)
- Nataliya Roznyatovskaya (Electrolytes & basic electrochemistry)
- David Bähr (Technician)
- Tobias Gerber (Defense)
- Matthias Fühl (Analytics)
- Akhil Challuri (Iron)
- Daniel Gerlach (Techno-Economics)
- Manaswitha Todupunuri (High-Throughput Electrochemistry)
- Sancia Morris (High-Throughput Electrochemistry)
- Anand Dhayalan (Student assistant)
- Shashank Ravichandar (Student assistant)

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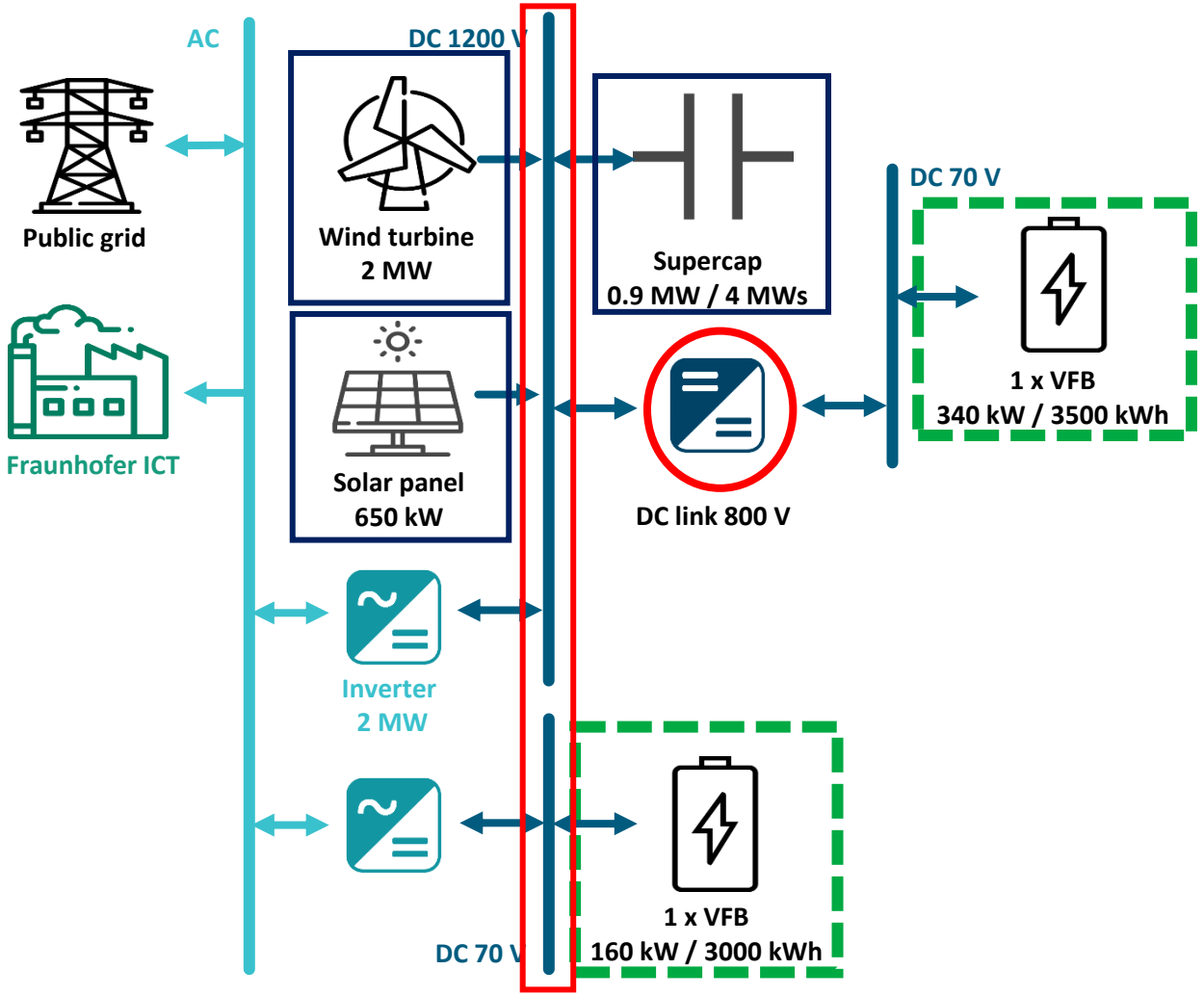
Past

Overview energy campus ICT

- Grid-forming inverter
  - Transforms DC-Power to AC for ICT grid
  - 2 MW Capacity

  → Storing energy of 2.6 MW generator power essential
- DC Bus 1200 V
  - Wind Turbine
  - PV
  - SC
  - Trumpf DC TruConvert 1008
- DC-link 800 V
  - Consists of DC TruConvert 1008
  - RFB



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Past

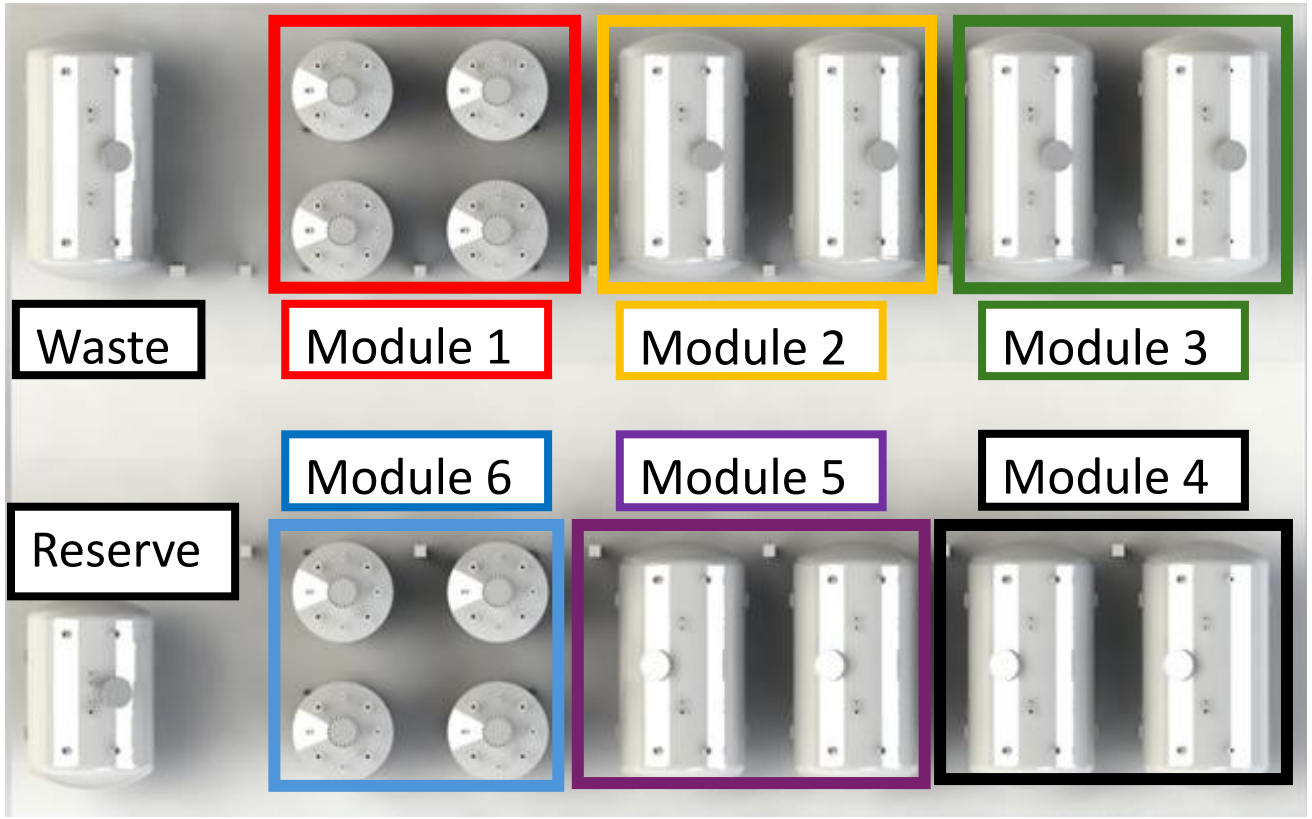
VRFB Infrastructure

Generators

- 2 MW wind turbine
- 650 kW PV-Installation

VRFB System 6 Modules

- Stack level
  - 126 stacks installed
  - 500 kW power
- Basement (Tank Level)
  - 18 Tanks
    - Standing (1,6)
    - Lying (2,3,4,5)
    - 480 m³ for 6 modules



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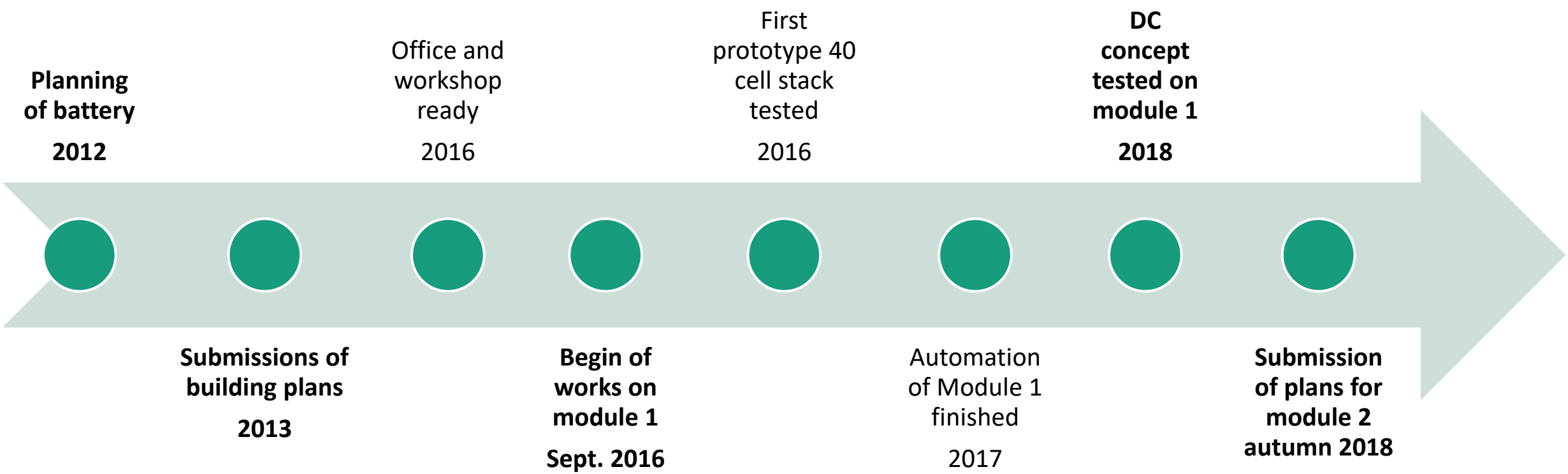
Past

VRFB History



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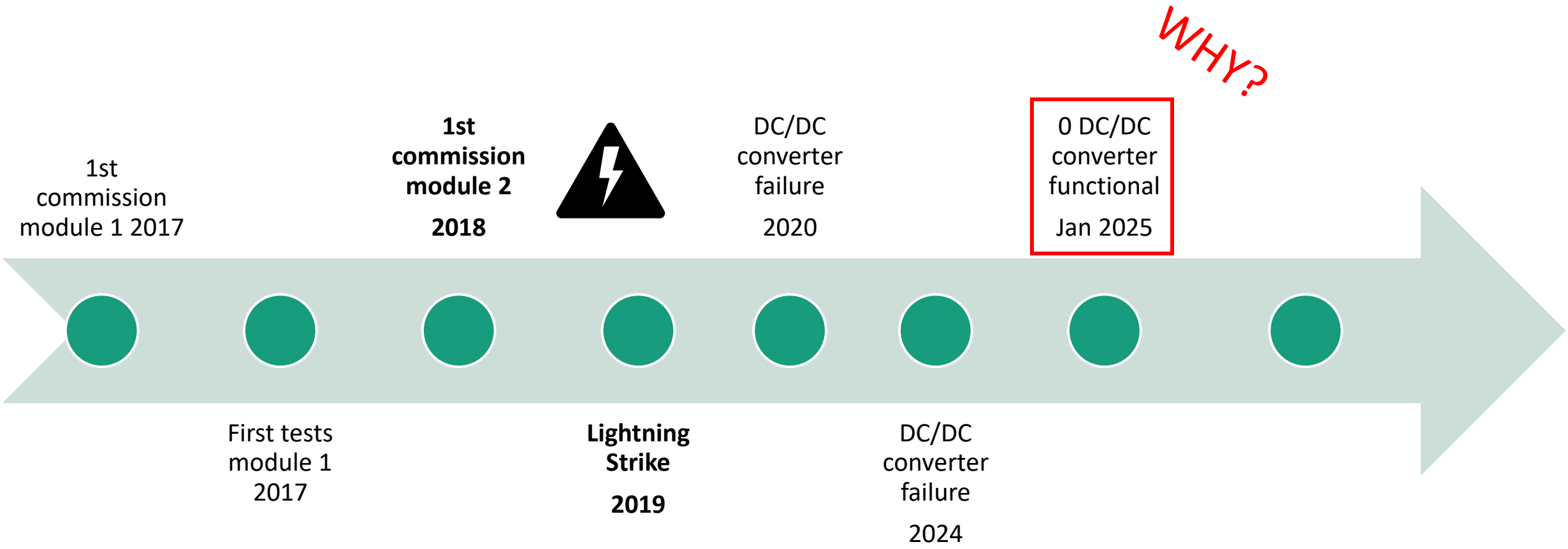
Link between past and present

History of module 1 and 2



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Present

Failure analysis

All DC TruConvert prototypes (G0) were tested (build in 2018)

- A significant amount of DC TruConvert failed
- Capacitor group is responsible for system failures
- Trumpf laboratory investigations shows that capacitors are already too damaged or will fail sporadically over time

→ Trumpf recommendation: don’t use old devices

Possible causes

1. **Pre-damage of components due to lightning**
   likely but no clear evidence due to 6-year gap
2. **Improper storage/installation conditions**
   unlikely but no clear evidence due to 6-year gap
3. **Component quality**
   cracking in capacitors was observable, cause cannot be identified due to 6-year gap
   possible causes: overvoltage, storage conditions, bad batch from supplier

→ **Component is no longer in use since 2020**

→ **G2 TruConvert 1008 devices are safe to use and won’t experience the same problems**

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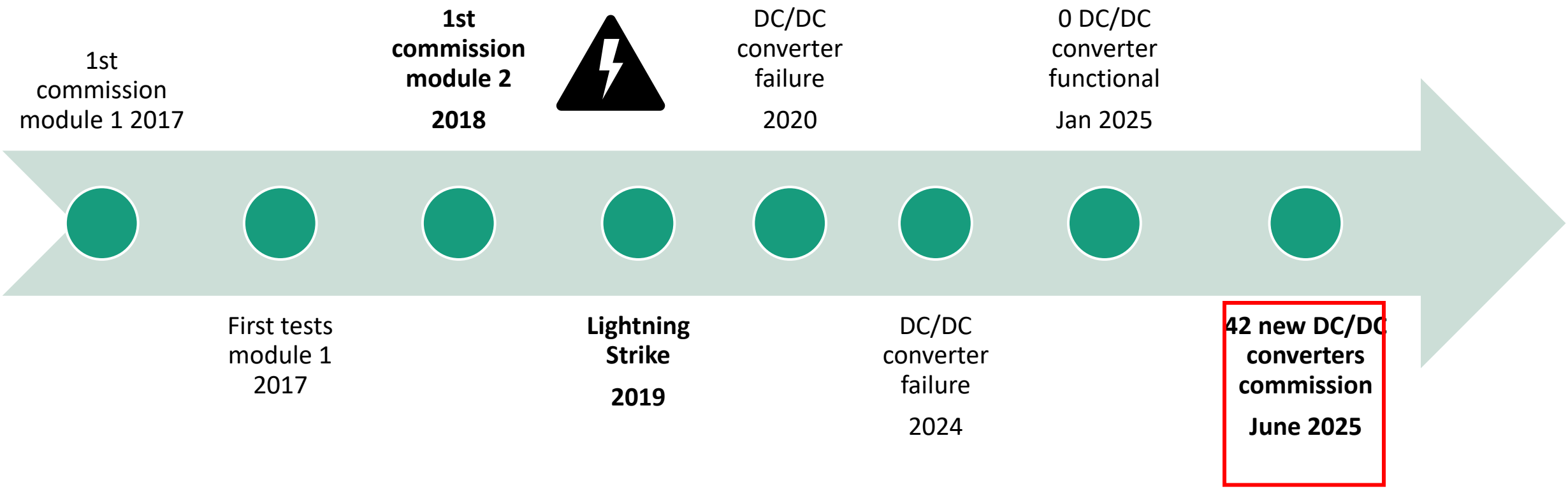

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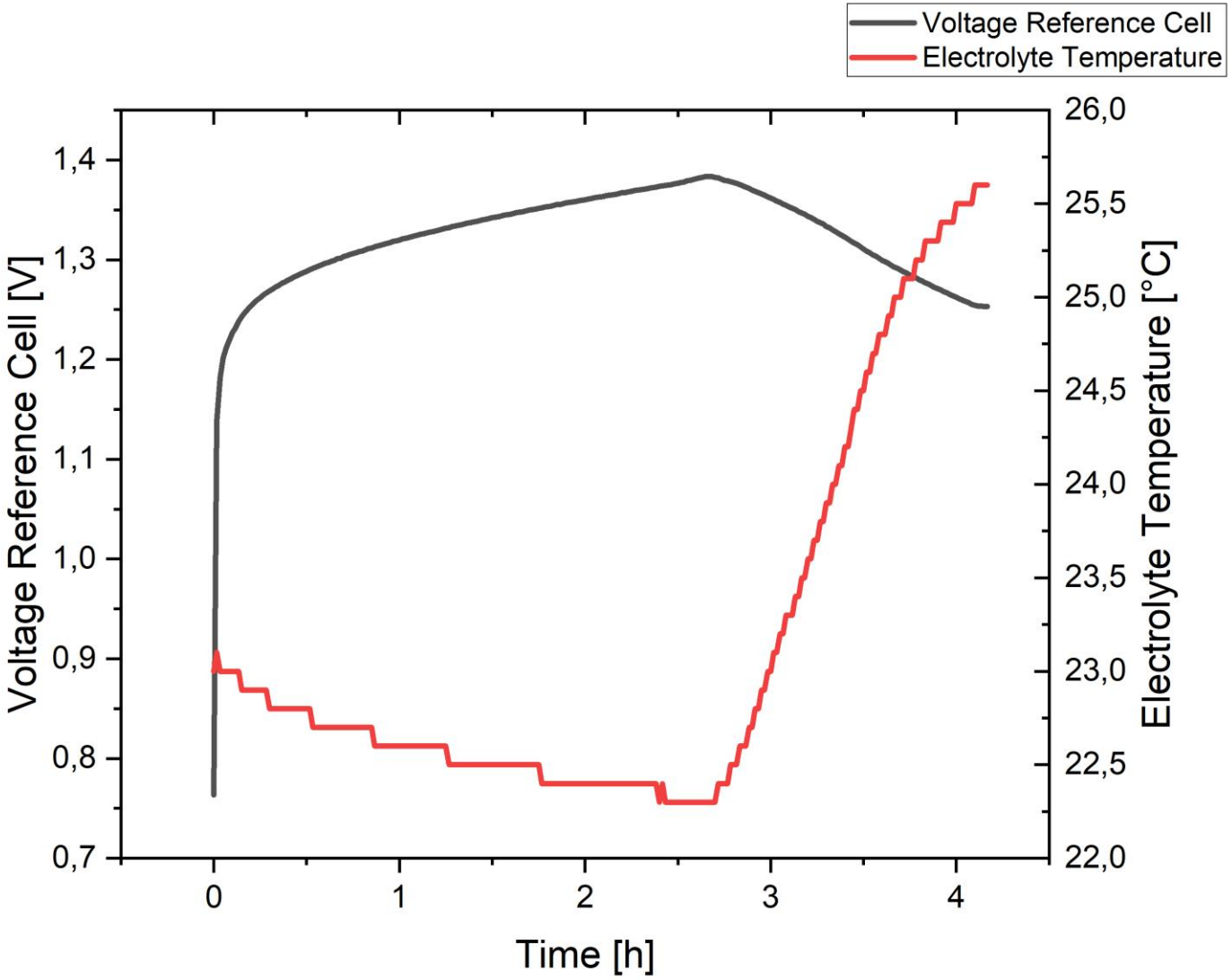
Present

First Cycle



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Future

SMHYLES

SMHYLES - **S**afe, sustainable and **M**odular **H**ybrid systems for **L**ong-duration **E**nergy storage and grid **S**ervices

16* partners, 5 EU countries (Italy, Portugal, Germany, Spain and Czech Republic), Switzerland and Tunisia

Novel sustainable **Hybrid Energy Storage Systems (HESSs)**, combination of **2 low-CRM** storage technologies (1x **high-power density**, 1x **long-duration**) ultra **fast ancillary** services, managed in a combined control by **smart EMSs**

ICT one of **3** demonstrator sites

Maia

Graciolica

ICT

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Future

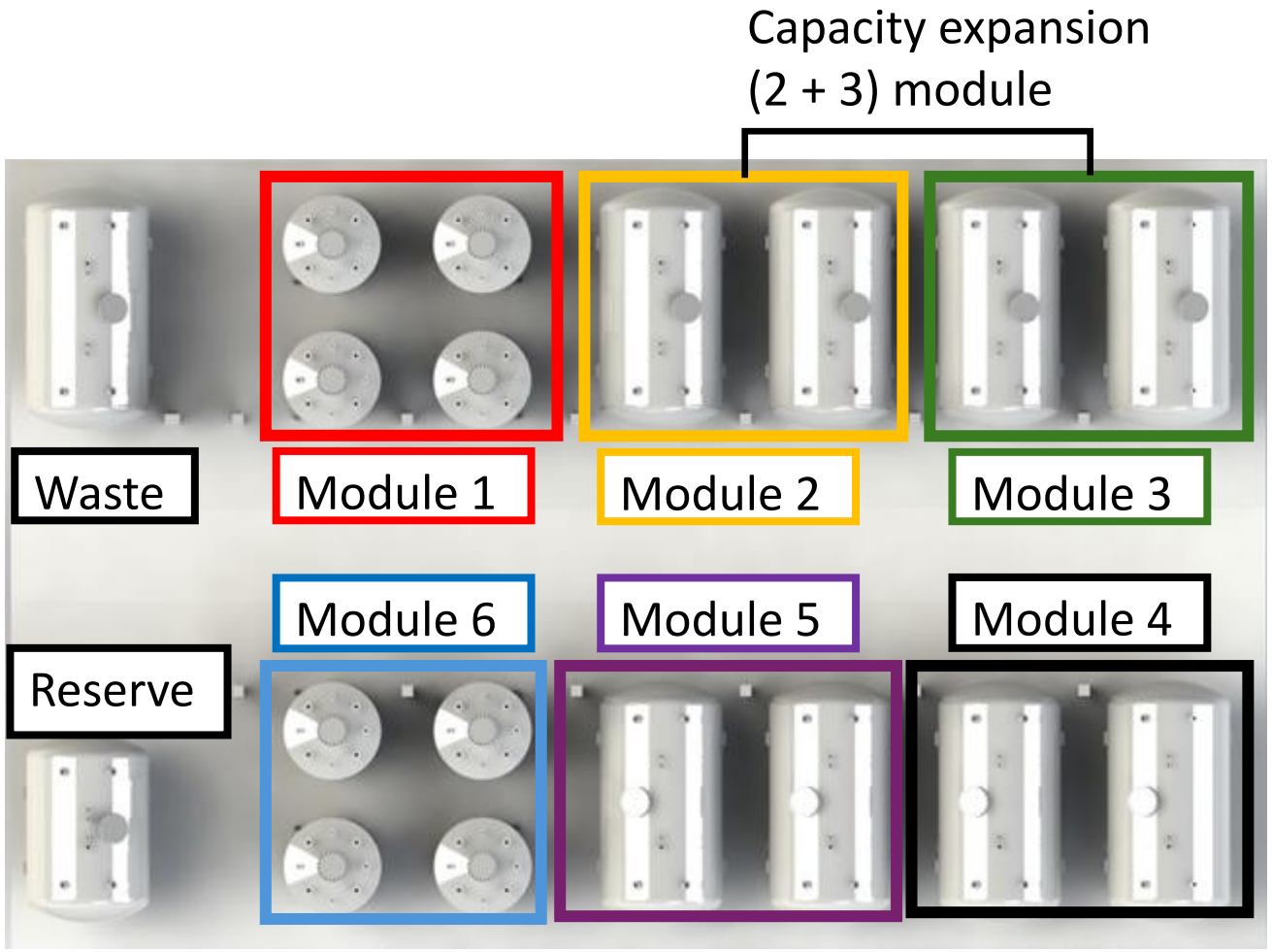
Planned retrofit

Idea

- Module 2 & 3 controlled independently
- Double the capacity of module 2
- One set of converters (module 2)

Insights

- Scale-up after operation
- Possible improved thermal management
- Use-case streamlined for weekend operation
- Possible consequences for battery management system after scale-up



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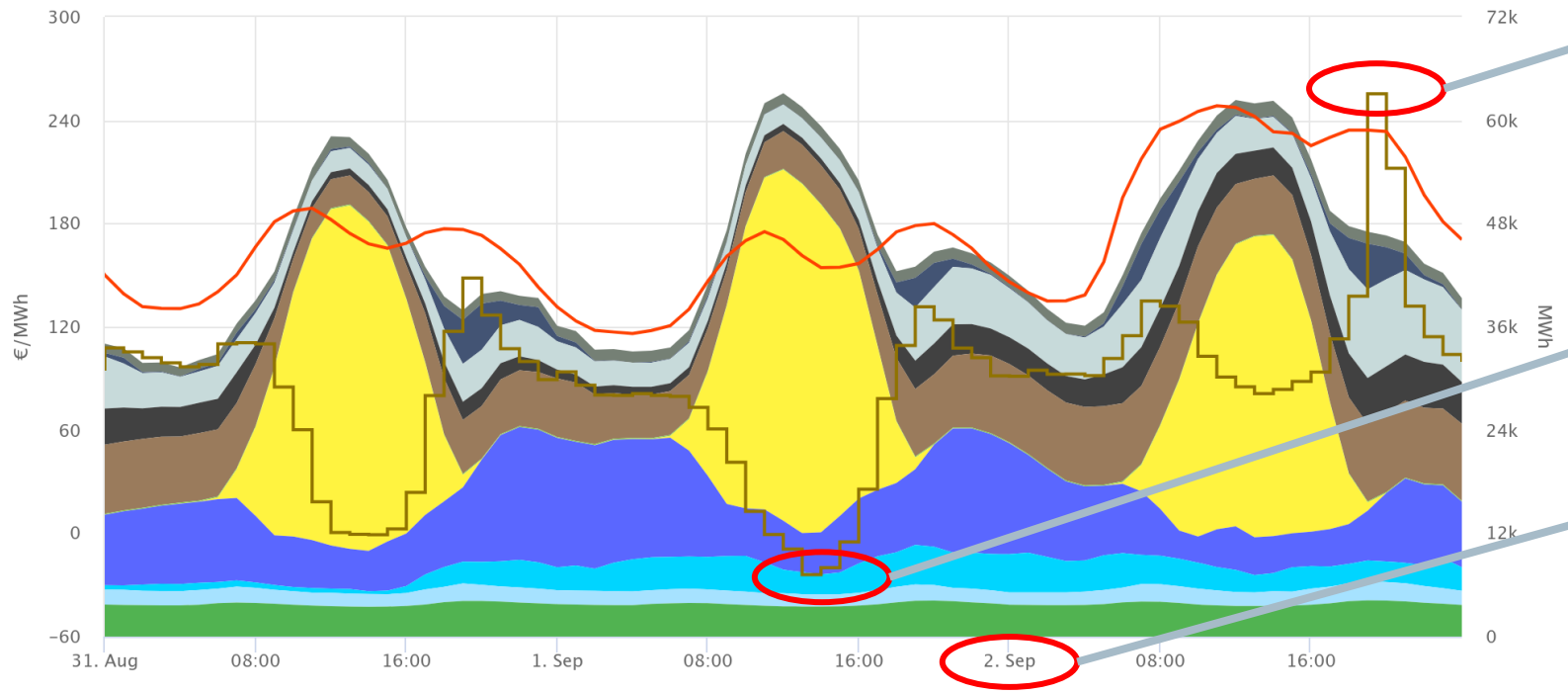
Future

Long-duration energy storage and grid services



Day-Ahead Prize:
255€/MWh

Day-Ahead Prize:
-24€/MWh

End of weekend

Yesterday:
-99€/MWh

Source : [1] https://www.smard.de/en/marktdaten (Intraday Prize Germany between 31.8.24 and 2.9.24)

1. Biomass
2. Hydropower
3. Wind offshore
4. Wind onshore
5. Photovoltaics
6. Other renewable
7. Nuclear
8. Lignite
9. Hard coal
10. Fossil gas
11. Hydro pumped storage
12. Other conventional

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Future

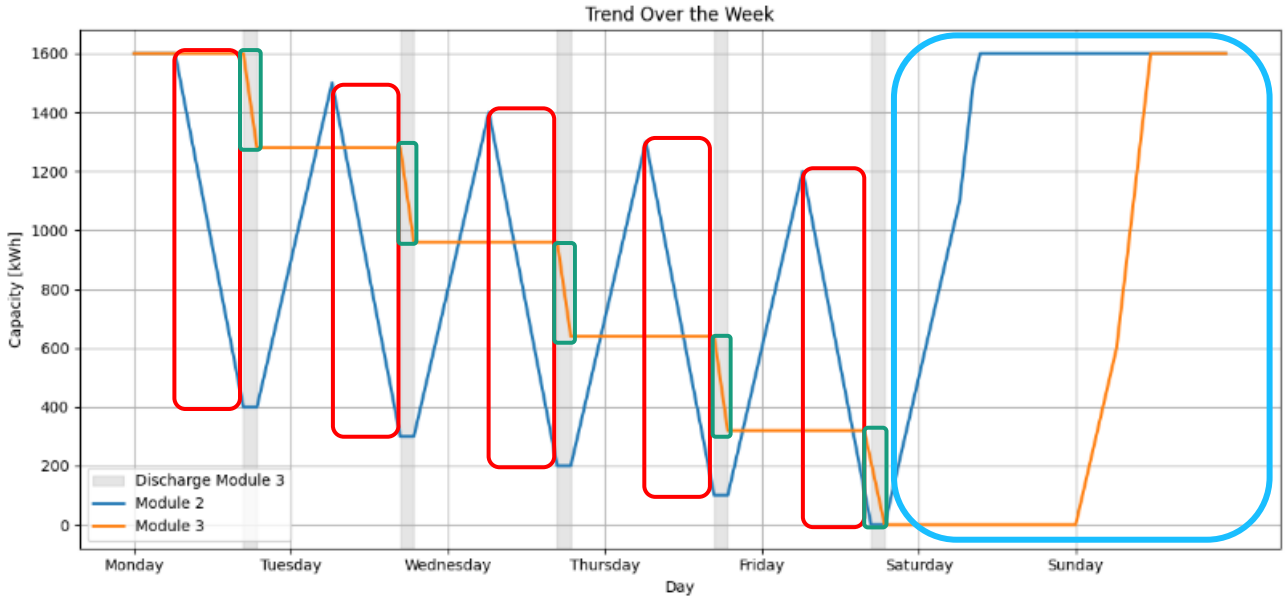
Potential Use-cases

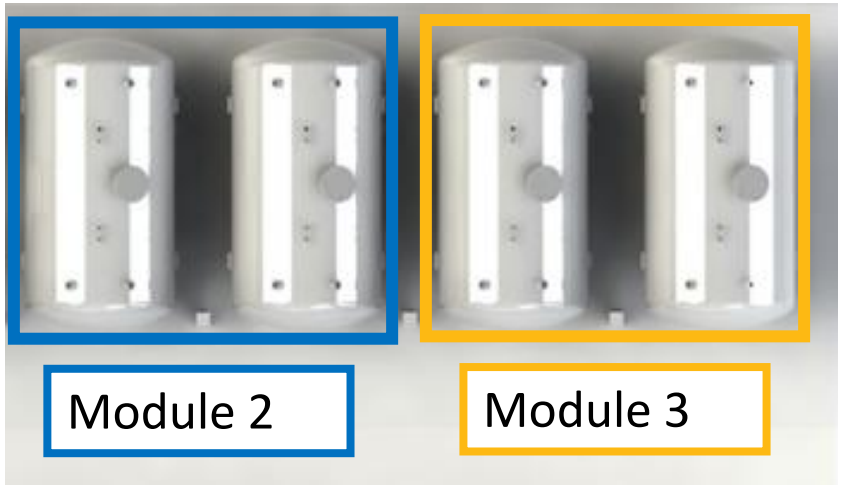
Module 2 discharged until the last two hours of work

Module 3 discharged the last two hours of work (support for module 2)

Module 2 charged in between days with wind turbine power

On Weekend both modules get charged fully





Optimization of energy arbitrage

Rule of thump/method to calculate earnings for specific use-cases

Capacity need for certain use-cases

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What‘s next?

Retrofit

- Module 2 + 3 340 kW converter power
- Module 2 + 3 (90 m³ + 90 m³) = 180 m³
- Around 7 MWh capacity
- Plans already submitted

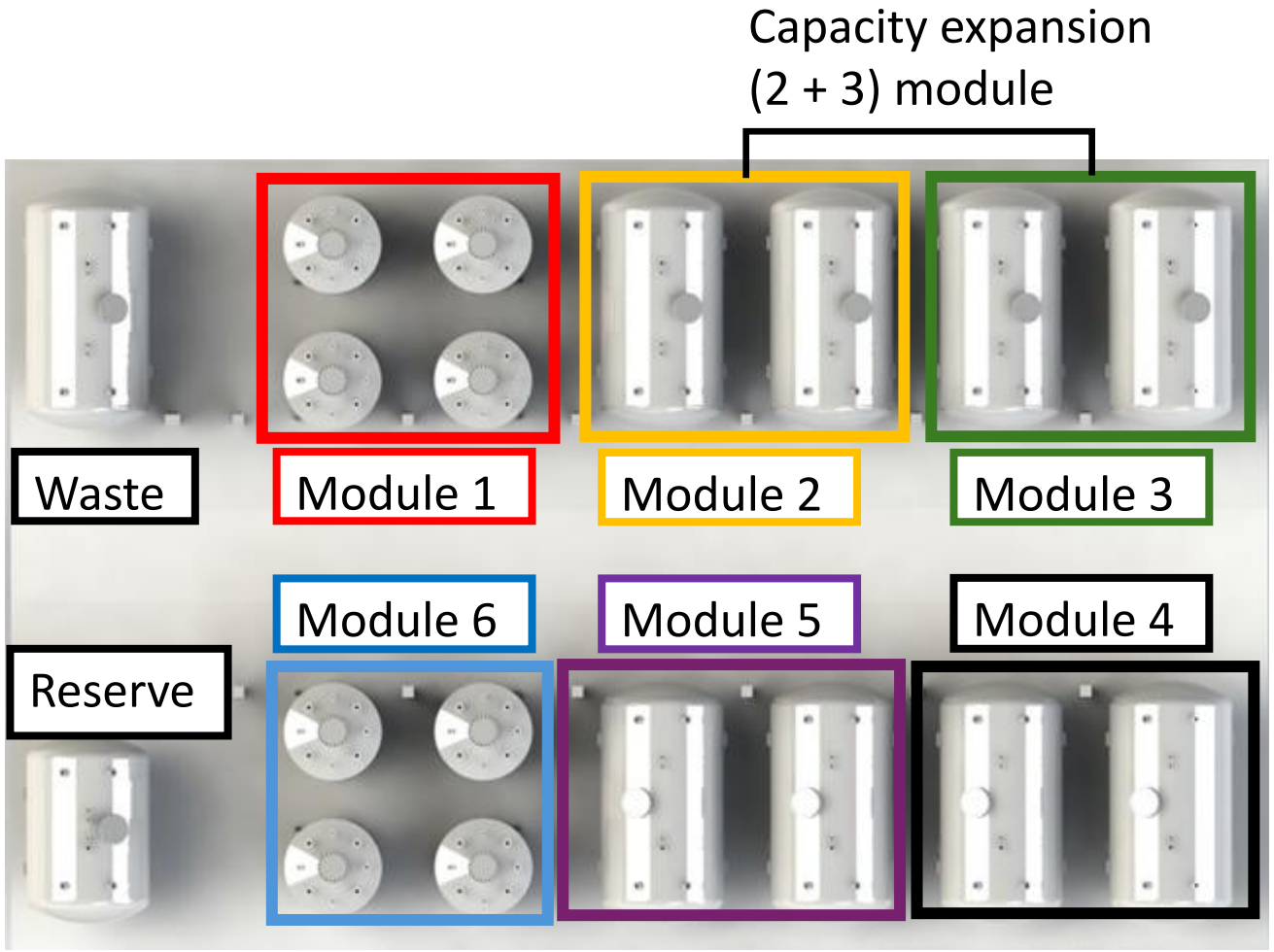
Integration of Module 1

- Module 1 160 kW/60 m³
- Module 2 + 3 340 kW/180 m³

→ 500 kW/10 MWh battery in 2026

Further Advancement of facility

- Exchange 4 kW Stacks with 10 kW Stacks
- 250 open spaces for stacks
- Module 6 becoming big test rig 10+ kW



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Special thanks to Siemens AG and TRUMPF SE + Co. KG