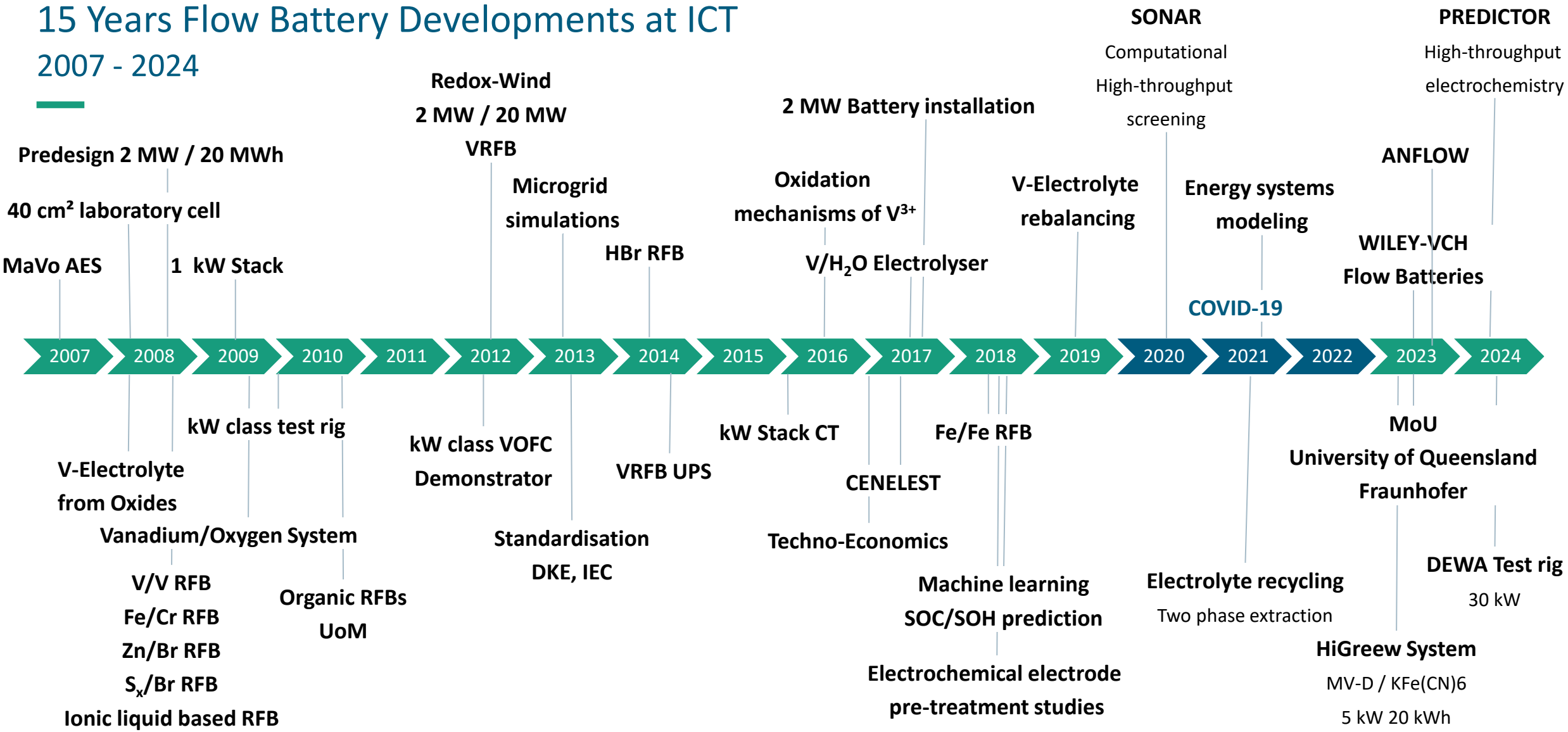
15 Years Flow Battery Developments at ICT

AA/Prof. (UNSW, UQ) Dr.-Ing. Jens Noack

40th Anniversary Flow Battery Innovation Symposium, Oct. 2024, Sydney, Australia

15 Years Flow Battery Developments at ICT

2007 - 2024



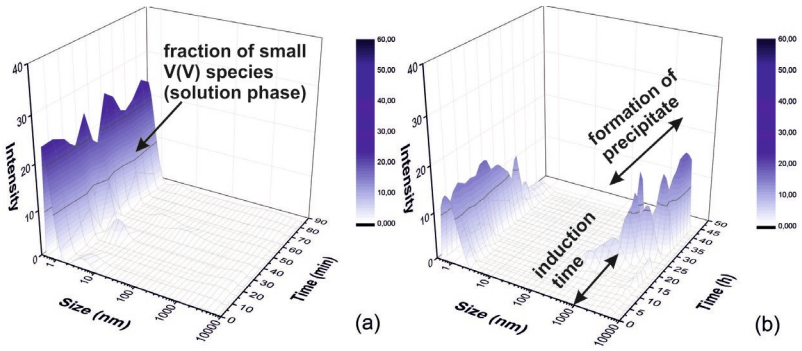
Fraunhofer ICT

15 Years Flow Battery Developments at ICT

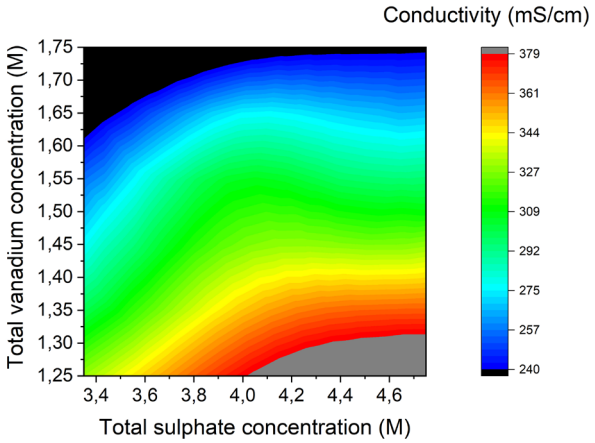
Vanadium electrolyte related topics

Investigations on additives for VFB electrolyte

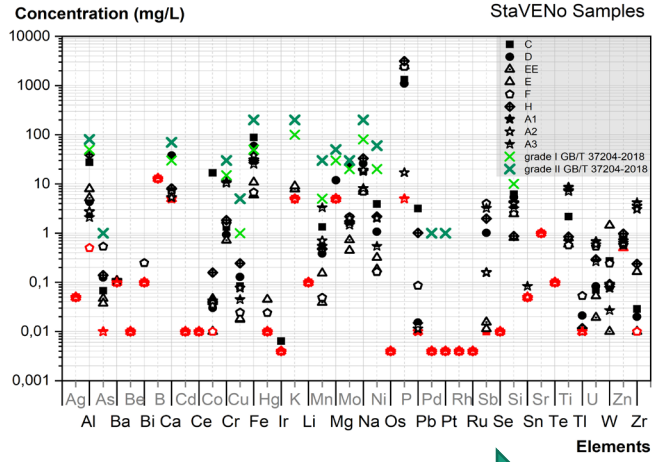
Degradation mechanisms in VFB



Adjustment of vanadium electrolyte formulation for high-temperature applications



Analytical methods for vanadium electrolytes and standardization work for electrolyte composition



2015-2018

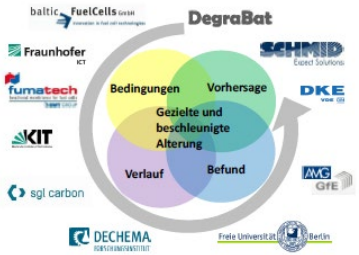
- **Hausspeicher:**

ca. 360.000 €

2018 -2020

- **DegraBat:**

ca. 390.000 €



2020-2023

- **BiFlow:**

ca. 220.000 €

2023

- **NextFloBat**

ca. 80.000 €

2023-2026

- **StaVENo:**

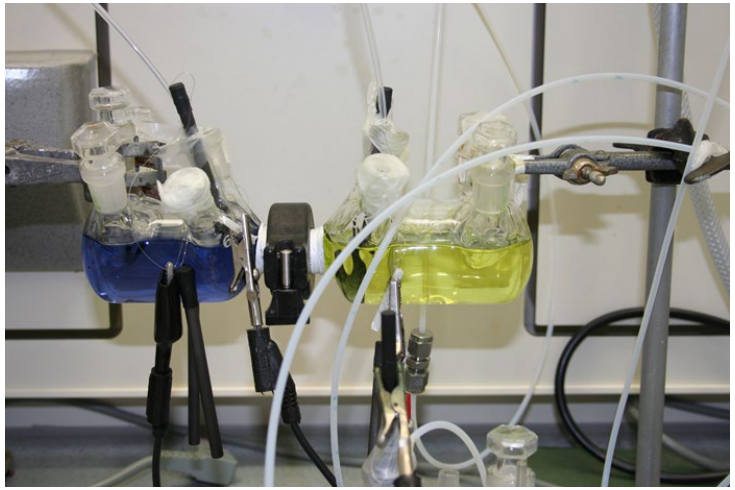
ca. 200.000 €

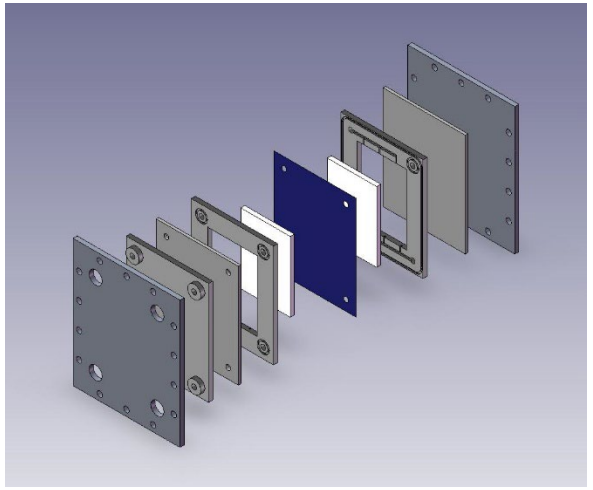
15 Years Flow Battery Developments at ICT

2007 – Fraunhofer MaVo AES

Fraunhofer Project „Marktorientierte Vorlaufforschung - Advanced Energy Storage"

- Study of different storage technologies for different scenarios
- ICT was responsible for electrochemical storage
- Not much public information available
- Build a test cell and produce electrolyte to study behavior of different chemistries





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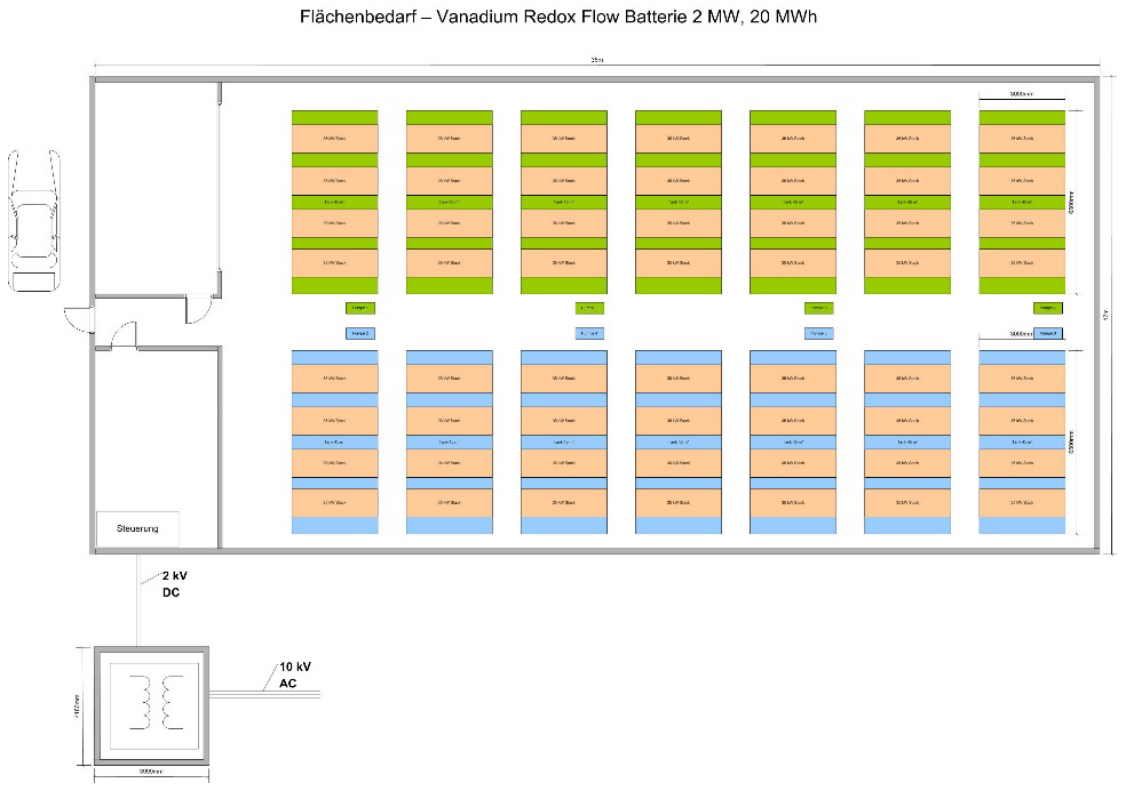
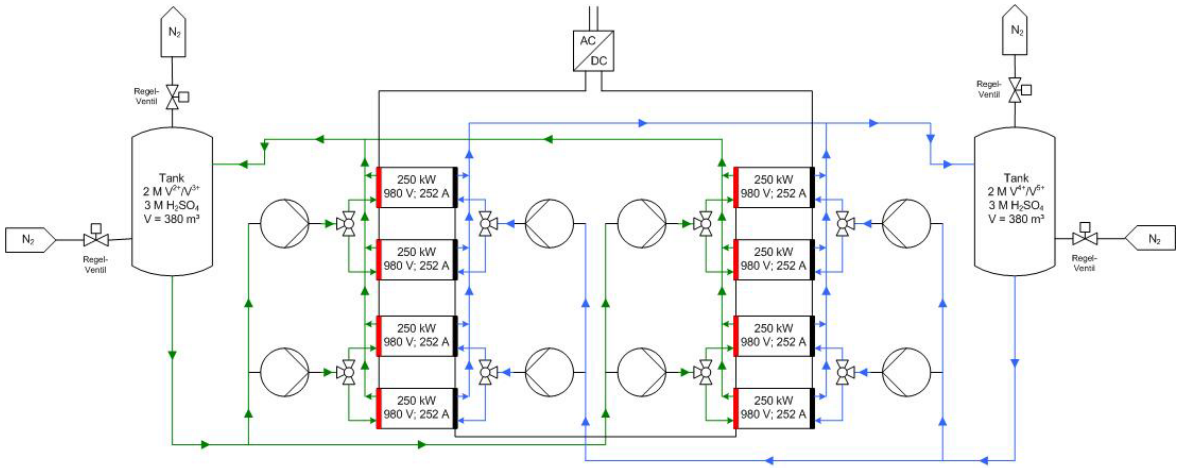
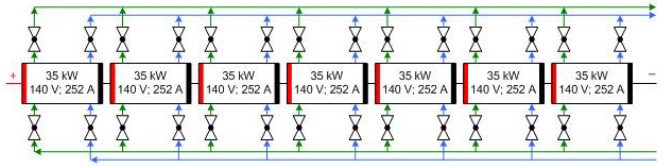
2008 – 2 MW Vanadium Flow Battery – Pre-Design





P = 2 MW; W = 20 MWh; U = 1960 V; I = 1008 A; A = 3600 cm²
100 Zellen / Stack; 7 Stacks seriell / Block; 8 Blöcke



250 kW Block

P = 250 kW; U = 980 V; I = 252 A A = 3600 cm²
100 Zellen / Stack; 7 Stacks seriell

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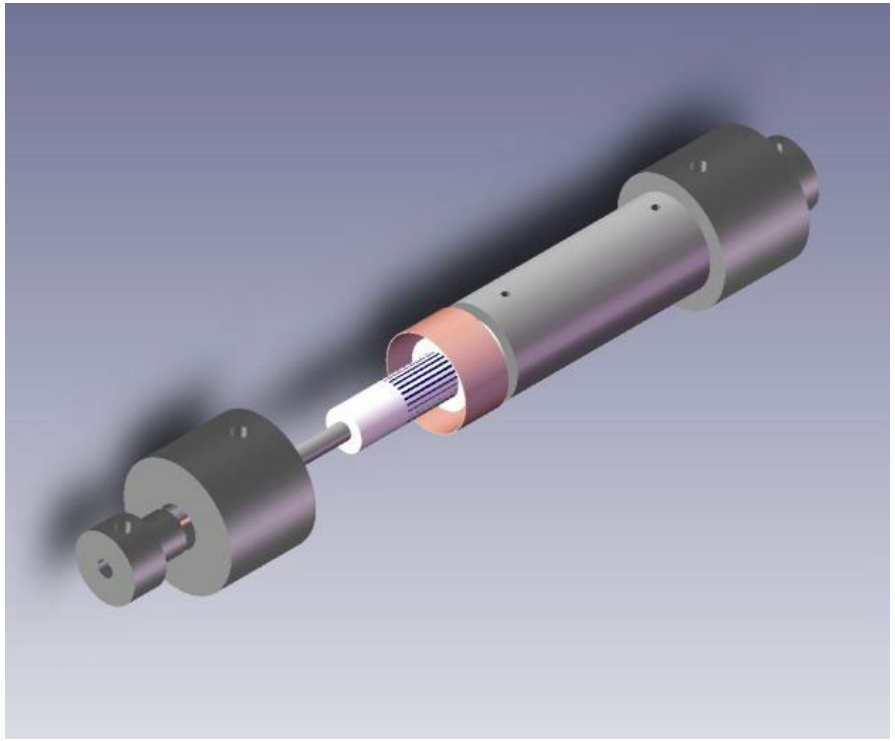
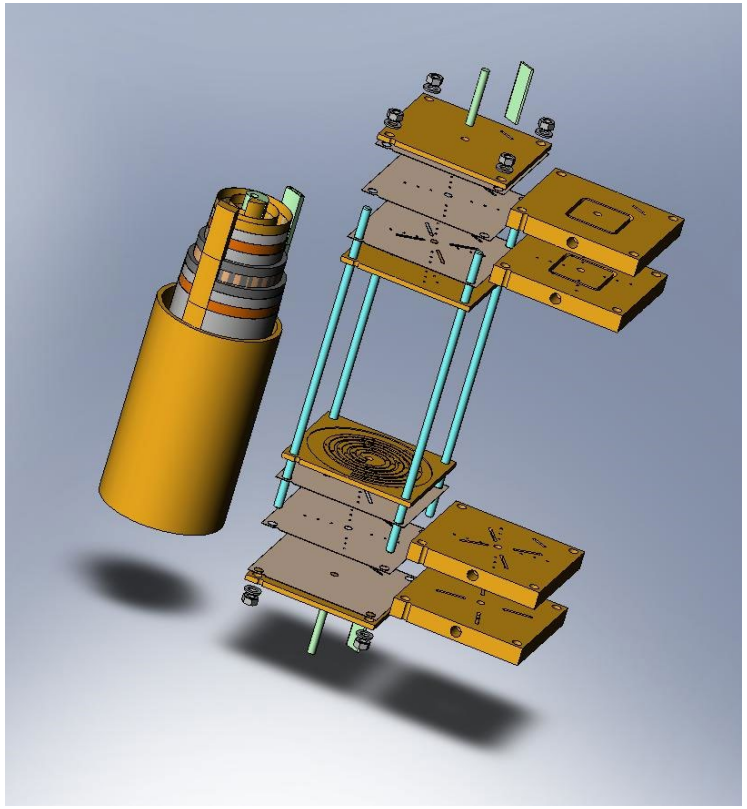
2009 – Alternative cell designs

Tubular flow battery design



Spiral wound (swiss roll) design



J. Noack, K. Rennebeck, L. Löwe, J. Tübke, International Symposium on Electrochemistry for Energy Conversion and Storage, International Society of Electrochemistry, Wuhan (Three Gorges), China, 2009

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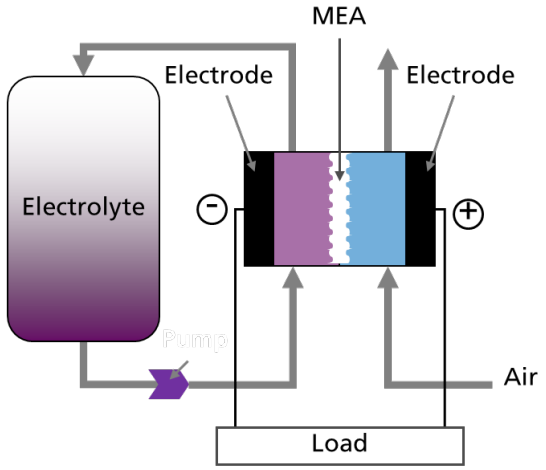
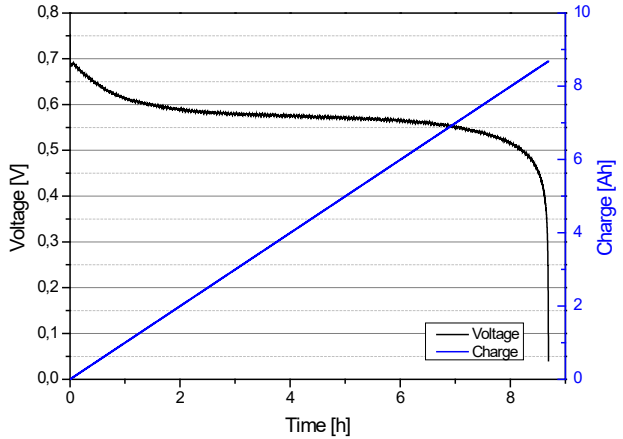
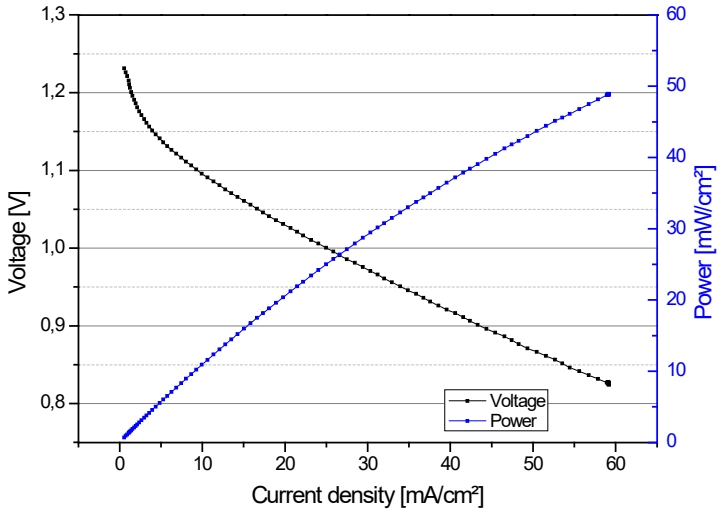
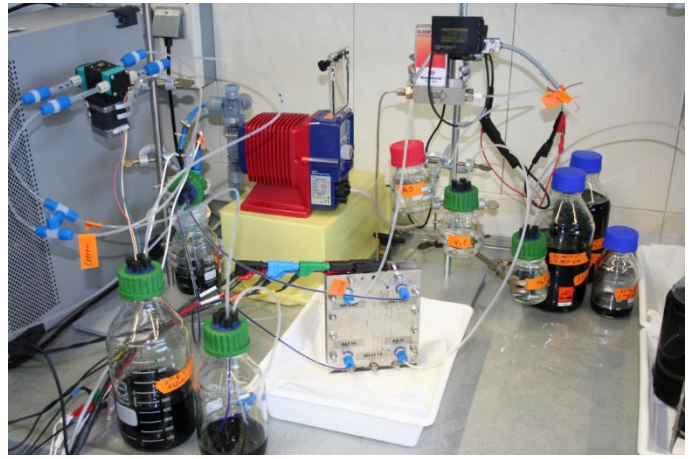
2009 / 2010 Vanadium / oxygen fuel cell (VOFC)





200 mL 80 mL/min1.6 M V^{2+}, 50 mL/min Air, 8.6 Ah, 25 mA/cm²





- 2 mg/cm² Pt 40 % C, NAFION® 117 (Baltic Fuelcells GmbH, Germany)
- 1.6 M V^{2+}, 2 M H_2SO_4, 0.05 M H_3PO_4 (Electrolytically produced by electroreduction of 0.8 M $VOSO_4$, 0.8 M $V_2(SO_4)_3$
- 40 cm² active area
- Graphite felt (GFA5, SGL-Carbon, Germany)
- Graphite composite bipolar plate (FU 4369, Schunk Kohlenstofftechnik GmbH, Germany)

J. Noack, C. Cremers, K. Pinkwart, J. Tuebke, Konferenzbeitrag, The Electrochemical Society, 218th Meeting, Las Vegas, USA, 2010

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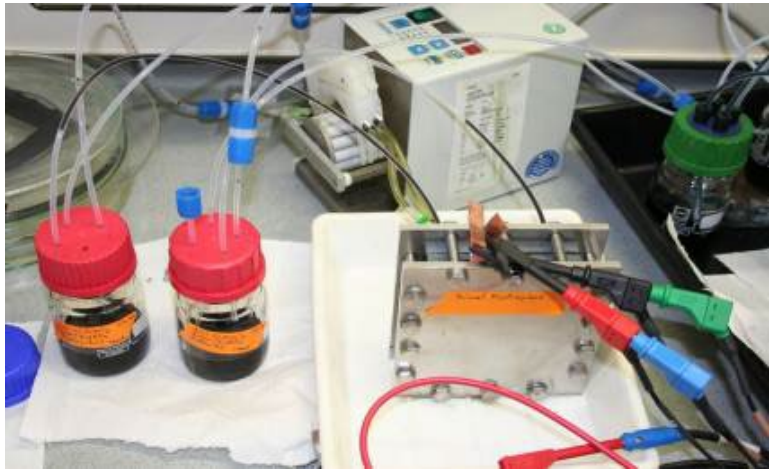
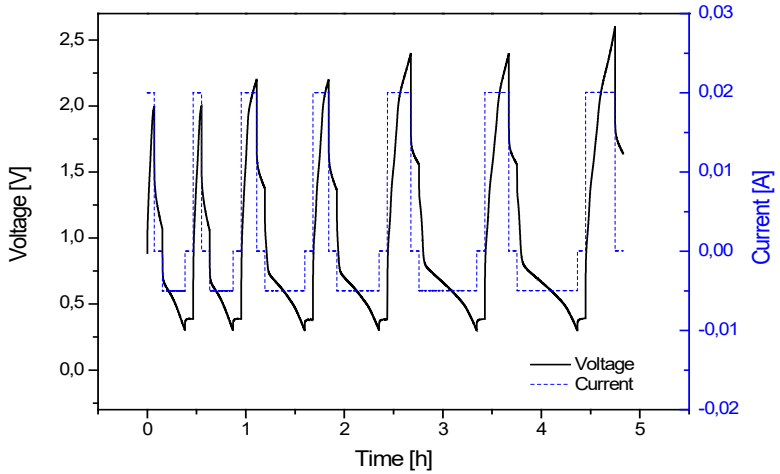
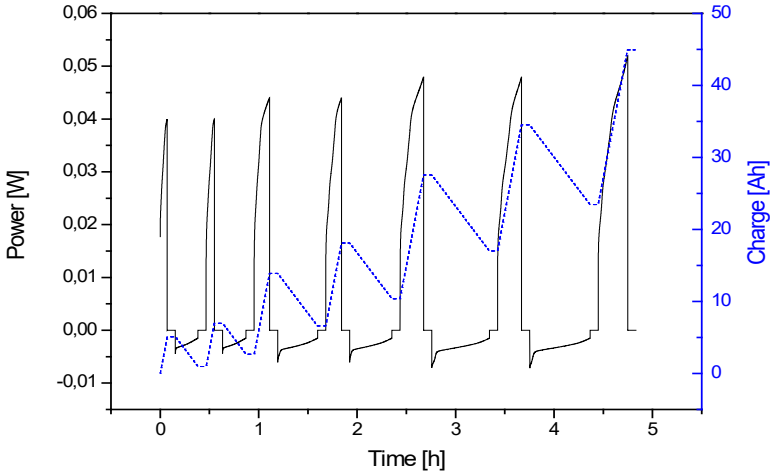
2010 – Organic flow batteries $V(acac)_3$ / acetonitrile







- 20 mA (2 mA/cm²) galvanostatic charge up to 2 V, 2.2 V, 2.4 V, 2.6 V
- 5 min OCV-Measurement
- 5 mA (0.5 mA/cm²) galvanostatic discharge down to 0.3 V

UNIVERSITY OF MICHIGAN

MICHIGAN MEMORIAL PHOENIX ENERGY INSTITUTE

- 10 cm² active area
- Scimat microporous separator
- 0.1 M V(Acac)3, 0.05 M TEABF4
- Acetonitrile

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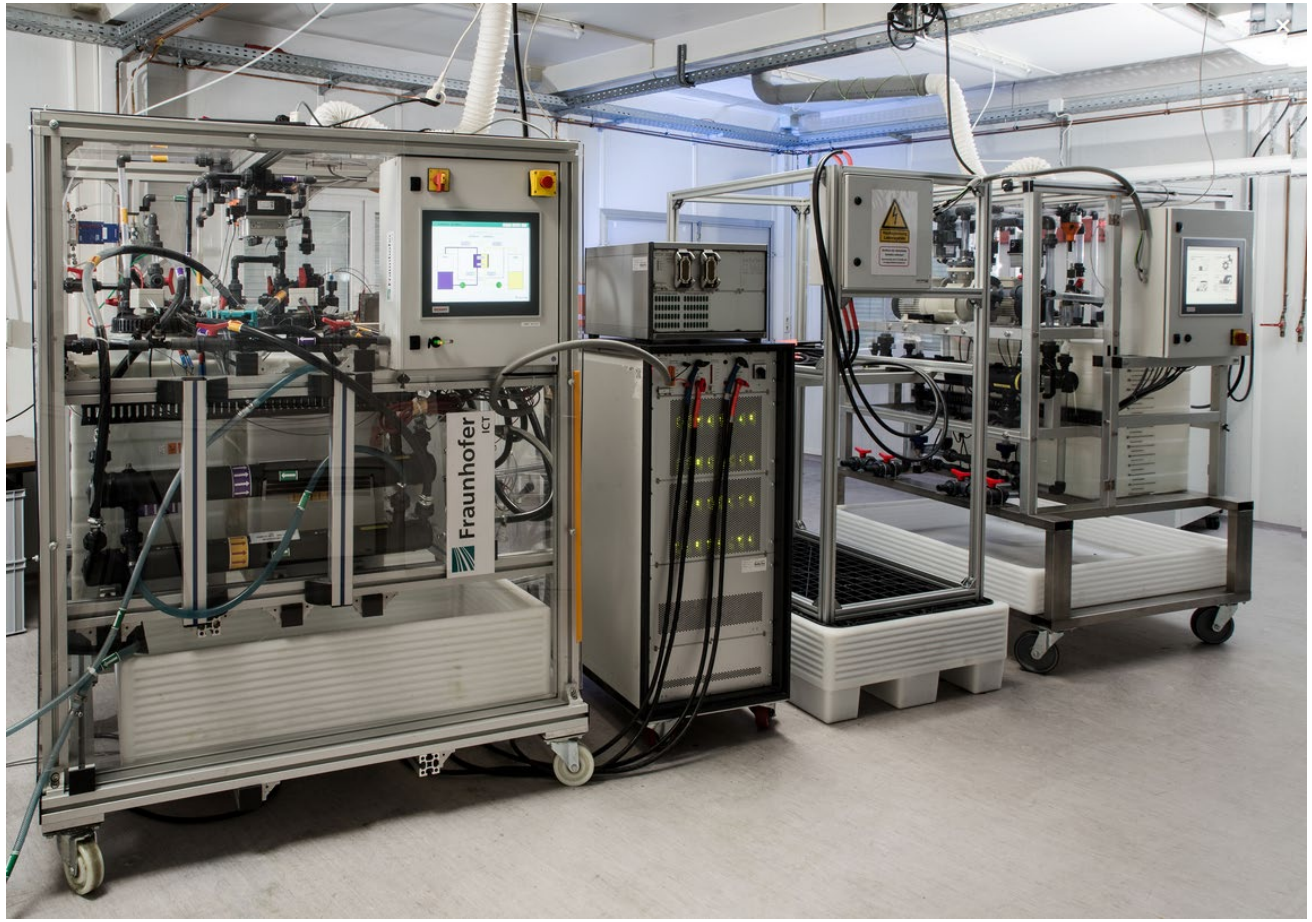
VRFB kW class test systems

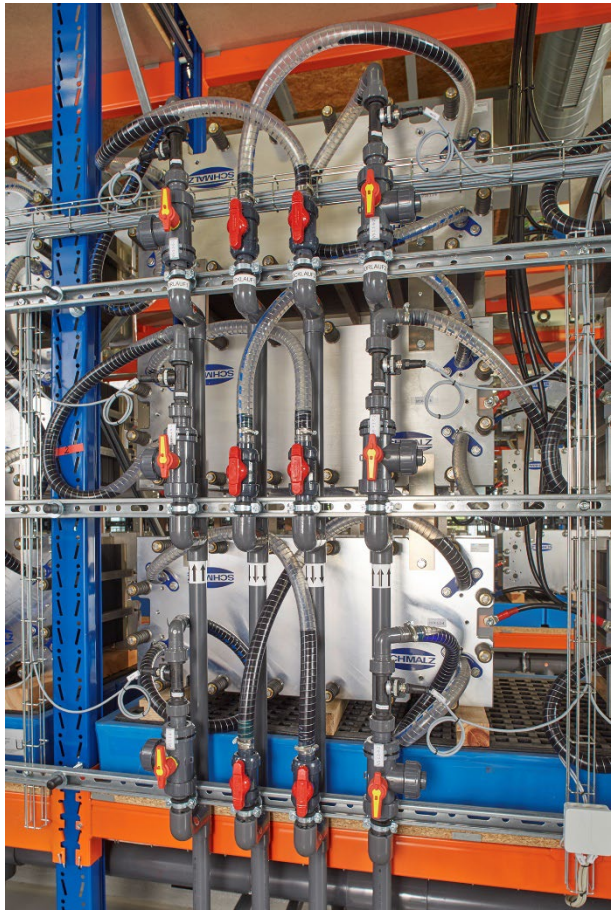


15 Years Flow Battery Developments at ICT

Upscaling to 2 MW / 20 MWh

Funded by the county of Baden Württemberg

Bundesministerium für Bildung und Forschung



15 Years Flow Battery Developments at ICT

Upscaling to 2 MW / 20 MWh

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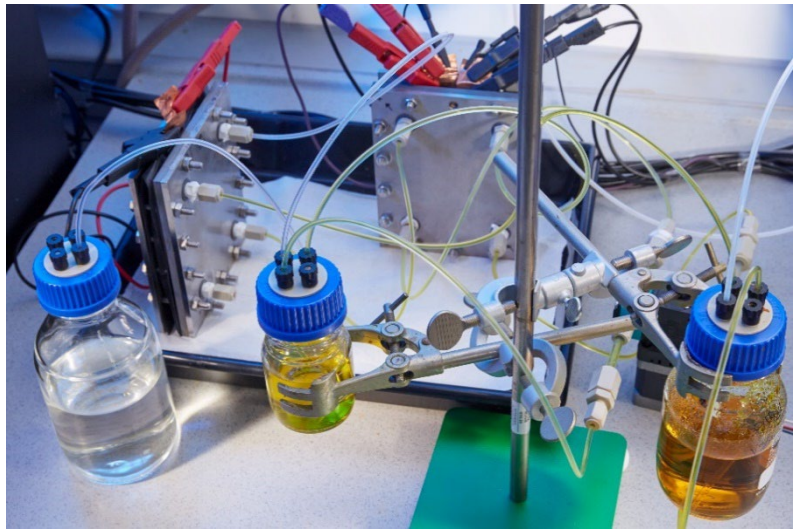
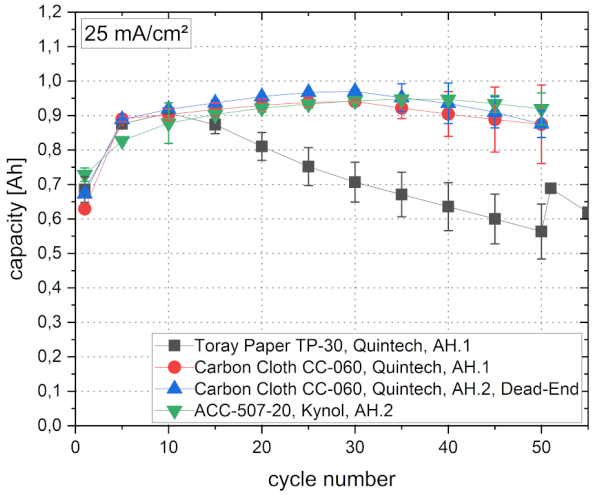
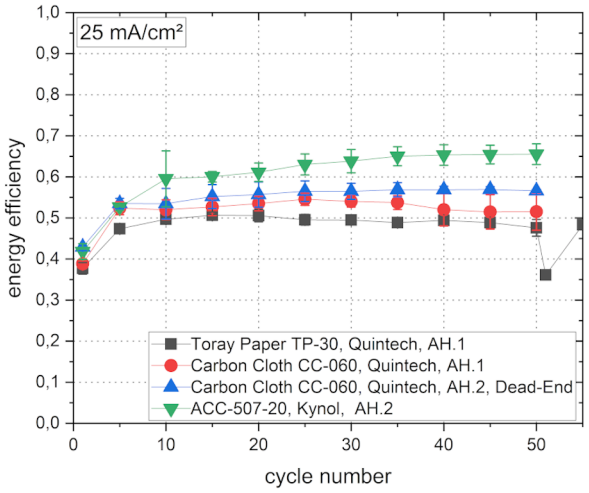
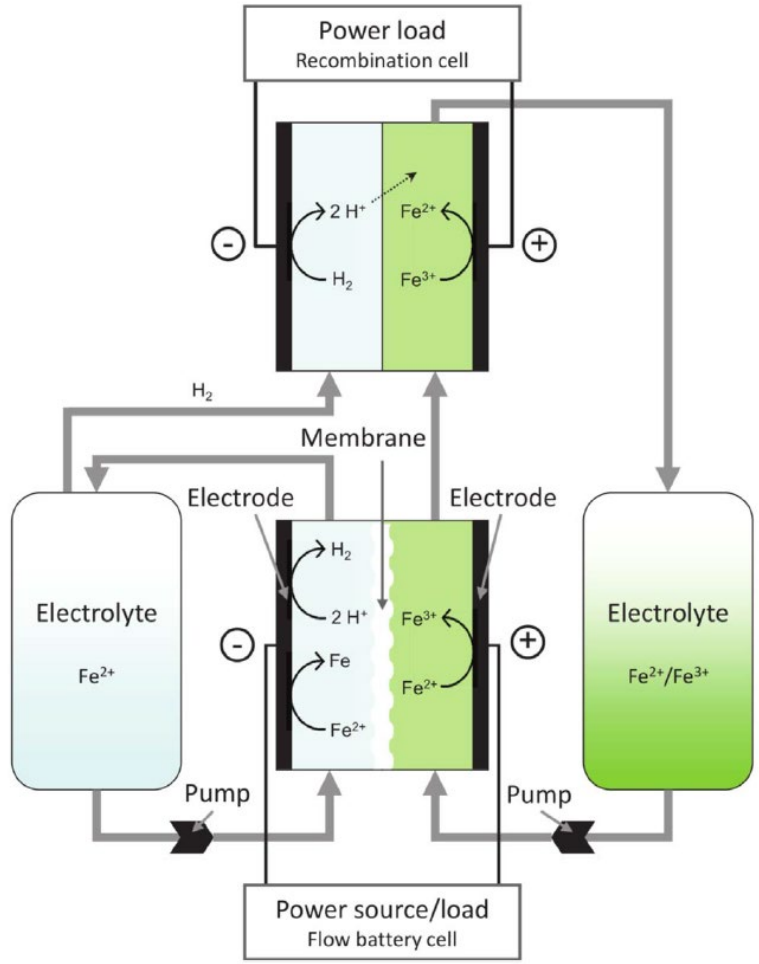
15 Years Flow Battery Developments at ICT

Fe/Fe flow batteries









Anode: $Fe^{2+} + 2e^- \underset{\text{discharge}}{\overset{\text{charge}}{\rightleftharpoons}} Fe$ $\varphi^{0,-} = -0.44$ V

Cathode: $Fe^{2+} \underset{\text{discharge}}{\overset{\text{charge}}{\rightleftharpoons}} Fe^{3+} + e^-$ $\varphi^{0,+} = +0.77$ V

Cell: $2Fe^{2+} \underset{\text{discharge}}{\overset{\text{charge}}{\rightleftharpoons}} Fe + Fe^{3+}$ $U_{cell} = 1.21$ V

15 Years Flow Battery Developments at ICT

2017 - CENELEST

- Combination of basic and applied research
- UNSW developed the Vanadium Redox Flow Battery in early 1980s till today
- Fraunhofer ICT is developing many different Redox Flow Batteries since 2007 and installed Europe‘s largest Vanadium Redox Flow Battery (2 MW/ 20 MWh)

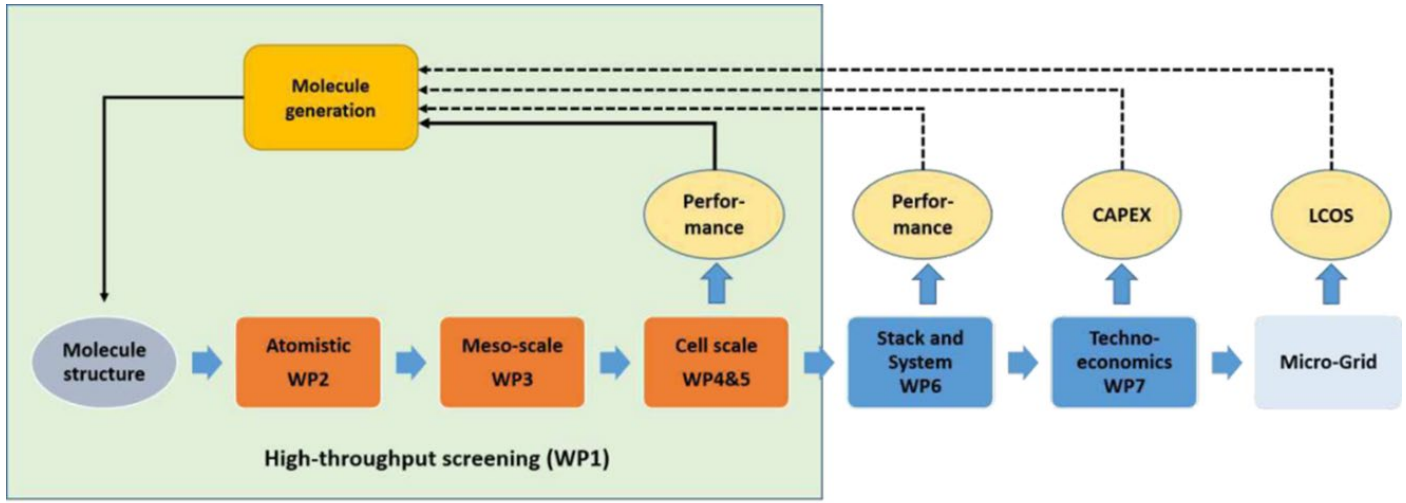
→ Bringing together Fraunhofer applied research and UNSW basic research

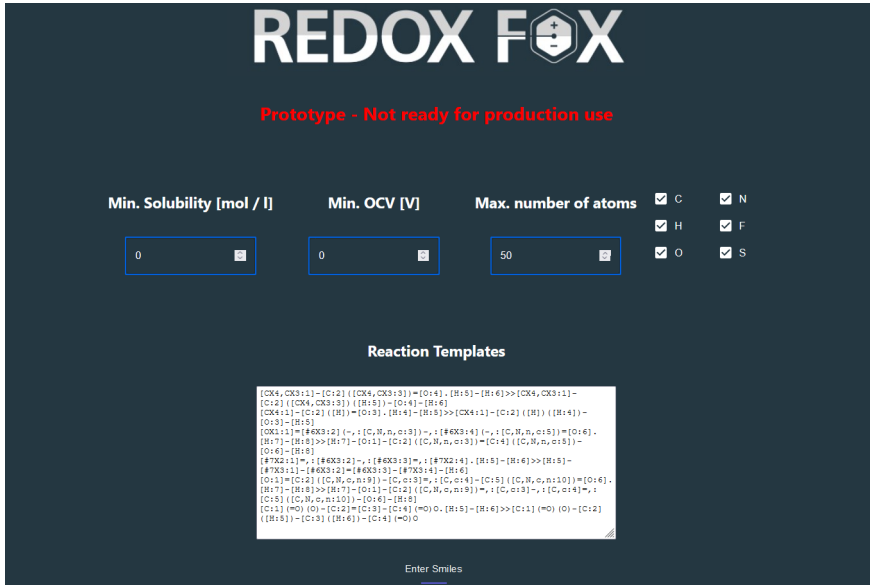
15 Years Flow Battery Developments at ICT

2020 - SONAR

H2020-LC-BAT-2019-2020 (LC-BAT-3-2019)
Project start: January 2020
Project end: December 2023 (4 Years)

Partner: 7 Institutions, 4 Universities, 2 Research Organisations, 6 Companies (IEB)
Coordinator: Fraunhofer Gesellschaft (Germany), Jens Noack + Carolyn Fisher
5 Countries, 3 EU Countries, 1 H2020 Associated country (Switzerland), 1 External (Australia)
Project funding: 2.8 M€ 2.4 M€ (EU), 430 k€ (UNSW Australia)





https://redoxfox.scai.fraunhofer.de/

15 Years Flow Battery Developments at ICT

2023 – FhG ICT - UQ

Fraunhofer ICT

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

MoU attended by Hon. Dick Cameron, Queensland Treasurer and Minister for Trade and Investment

Cooperation on Iron Flow Batteries

15 Years Flow Battery Developments at ICT

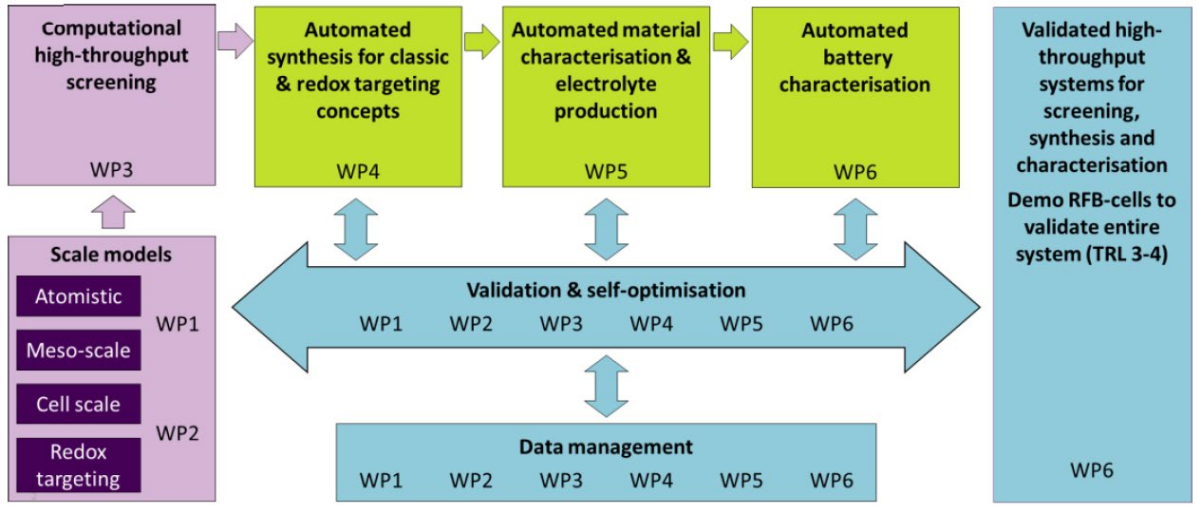
2024 - PREDICTOR

High-throughput screening, synthesis and characterisation of active materials for flow batteries

Marie Skłodowska-Curie Actions

Partner

1. Fraunhofer ICT / Germany
2. Fraunhofer SCAI / Germany
3. Technical University of Denmark
4. Software for Chemistry & Materials SCM / Netherlands
5. University of Turku / Finland
6. Centre national de la recherche scientifique (CNRS) / France
7. Karlsruhe Institute of Technology / Germany
8. University of Cambridge / UK
9. ENEROX / Austria
10. Accelerated Materials Ltd. / UK
11. Züricher Hochschule für angewandte Wissenschaften (ZHAW) / Switzerland
12. +12 additional associated partners



- 17 PhD students
- 4.8 M€ funding EU + CH + UK

Contact

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Flow Batteries
Applied Electrochemistry
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