

# Minimizing Pressure Loss and Shunt Currents in Next-Generation Redox Flow Batteries

IFBF 2025 in Vienna - Austria

Dr. Georg Lieser, 26.06.2025

Beyond Gravity

# SCHMALZ - The global market leader in vacuum automation



**1800**  
employees  
working hard for our customers.

**31**  
locations  
for outstanding customer service worldwide.

**100**  
percent  
family-owned.  
4<sup>th</sup> generation  
114 years of history

**720**  
copyrights  
are proof of our groundbreaking innovations.

**9**  
percent  
of our revenue is invested in innovative ideas and new products.

**7**  
times  
awarded in "Germany's Best Employers" competition.



Headquarter J.Schmalz GmbH  
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Schmalz Inc.  
USA



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India



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China



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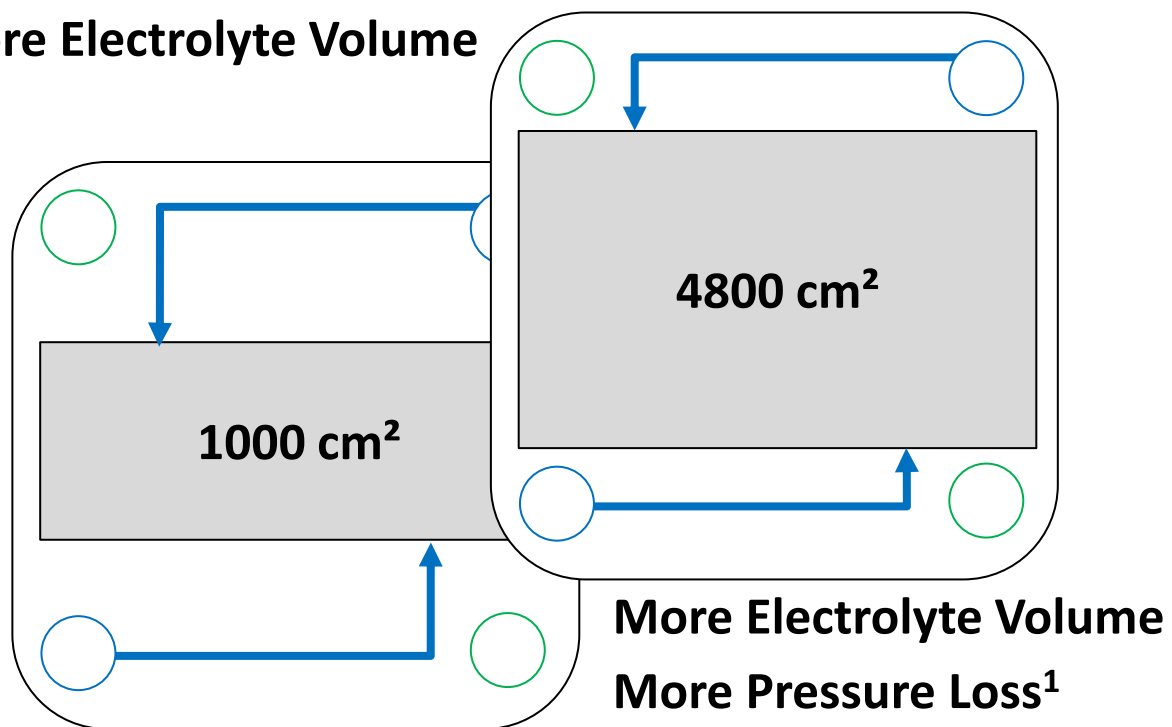
Schmalz SP. z.o.o  
Poland



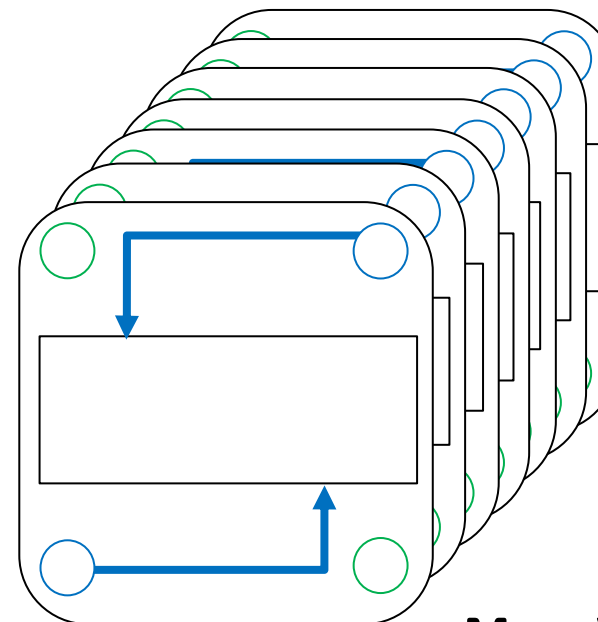
## Scaling a Stack

**More Area**

**More Electrolyte Volume**



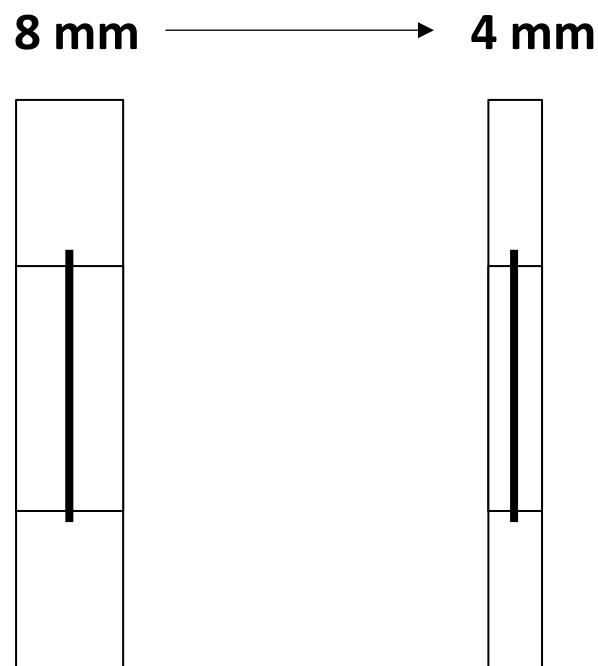
**More Cells – More Voltage**



**More Voltage**  
**More Shunt Current<sup>2</sup>**

1. J. Girschik et al., Chem. Ing. Tech. 2021, 93, No. 4, 523–533  
2. H. Fink et al., Journal of Power Sources, 284 (2015) 547e553

## Motivation for Thin Cells



### Higher Power Density

Improved Ohmic Resistance – Better Efficiency and Electrolyte Utilization  
Improved Mass-Transfer - Higher Velocity in a thinner Cell

### Simplified Design – Material & Component Reduction

Less Frames & Less Sealings (One-Frame Concept)  
Less Carbon Felt (Flow Through) / Less BiPolar-Plate (Flow By)  
Shorter Bolts for anchoring System

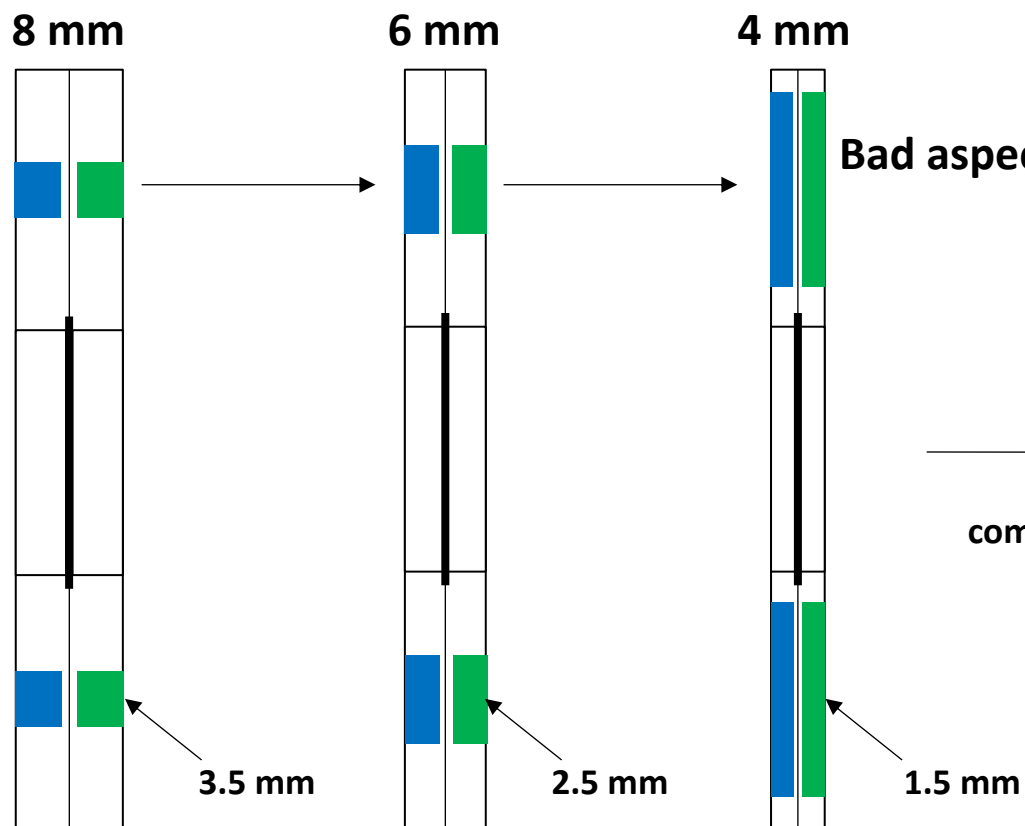
### Additional Savings

Weight of Stack – Transport / System Integration  
Improved Space Utilization – Transport / System Integration

*„The thinnest Cell with the best Pressure Loss  
and best Shunt Current Protection will win“*

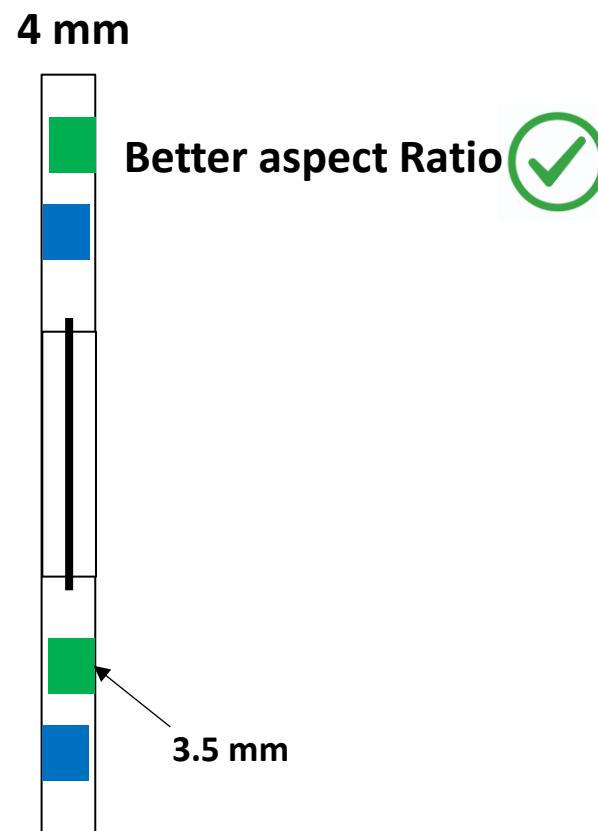
# Reducing Cell Thickness

## Half Frame Concept



Bad aspect Ratio (X)

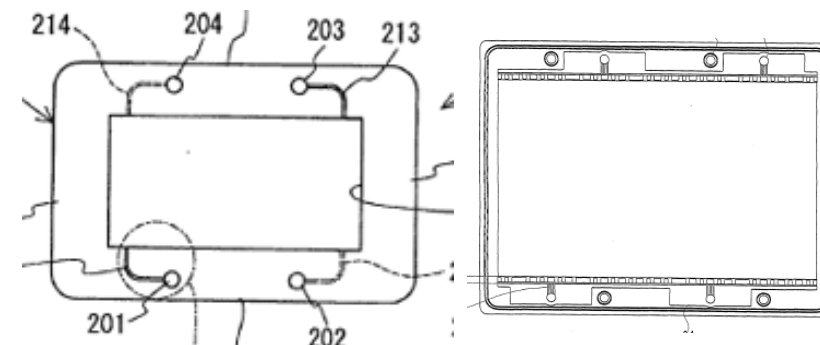
## 1-Frame Concept



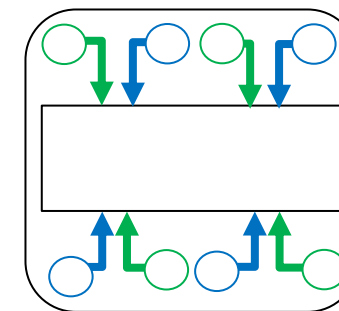
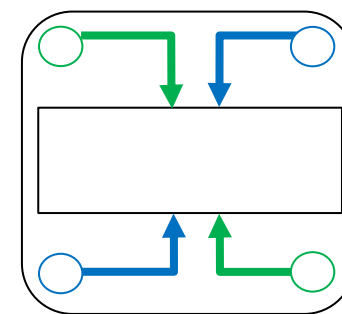
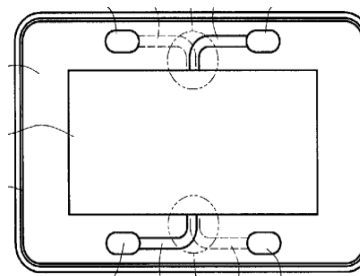
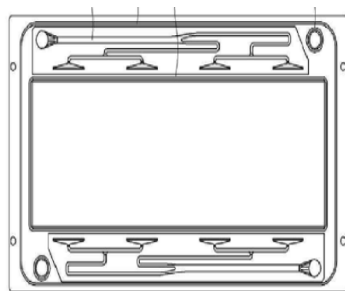
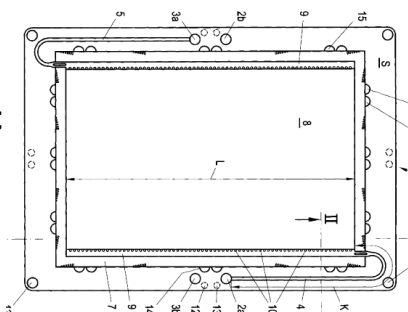
Workaround  
2 half cells  
combined into 1 Frame

# Flowframe - Topologies

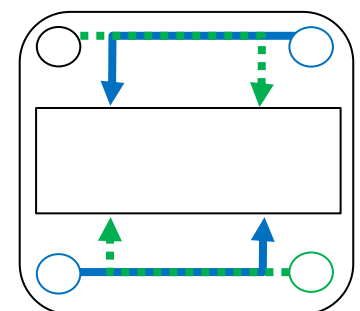
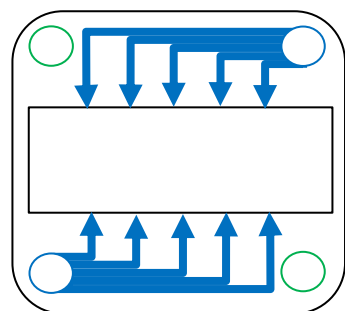
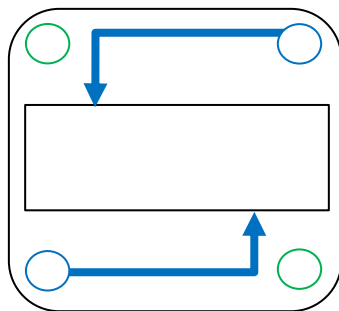
The unknown KPI in Stack Design:  
Mäander Depth vs. Cell height



Mäander Height  
< 2 Half Cells



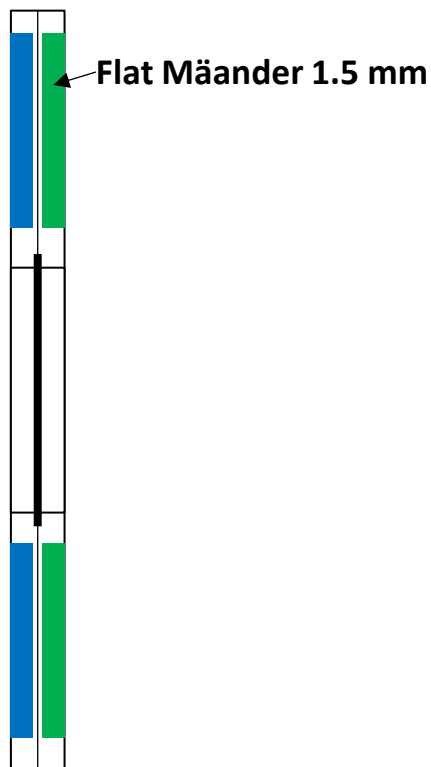
Mäander Height  
< 1 Half Cell



# Very Thin Cells – Flat, Deep, Ultra Deep Mäander

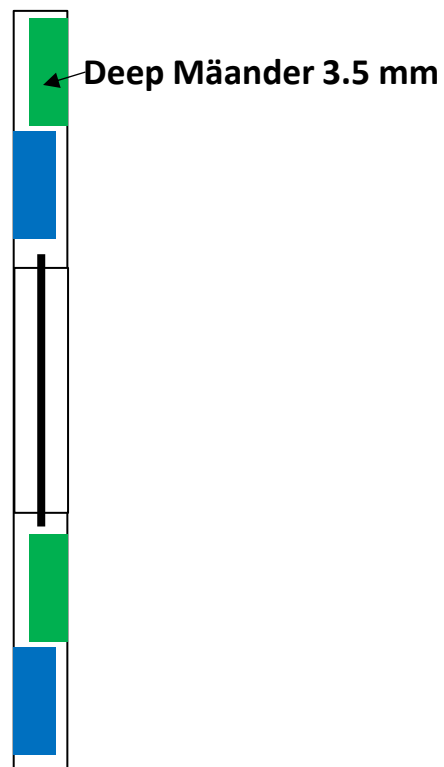
2 Half Cells

4 mm



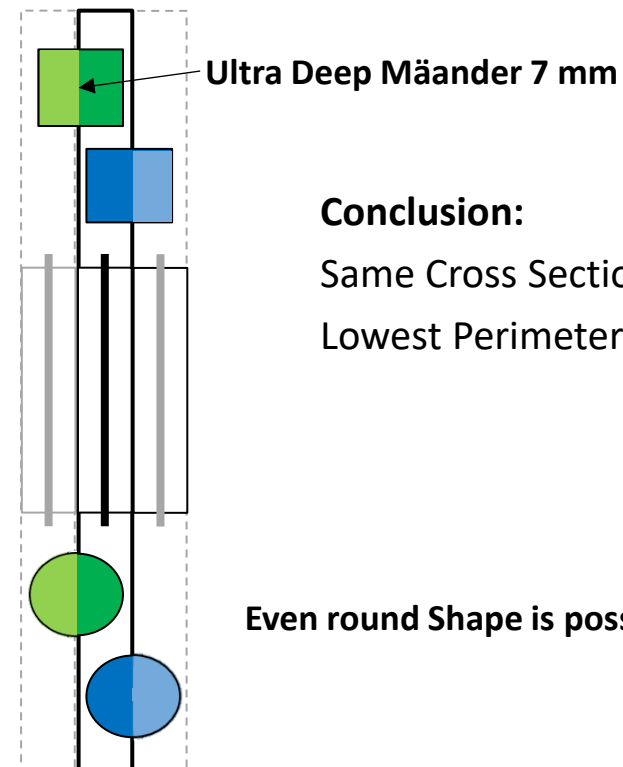
1-Frame Concept

4 mm



Ultra Deep Mäander\*

4 mm



**Conclusion:**

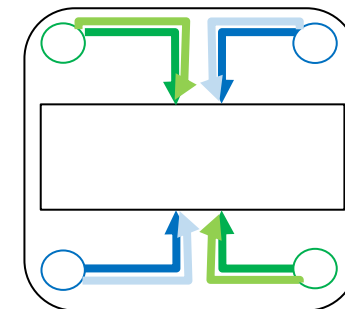
Same Cross Section = Same Shunt Current  
 Lowest Perimeter = Lowest Pressure Loss

\* Strong Simplified Drawing

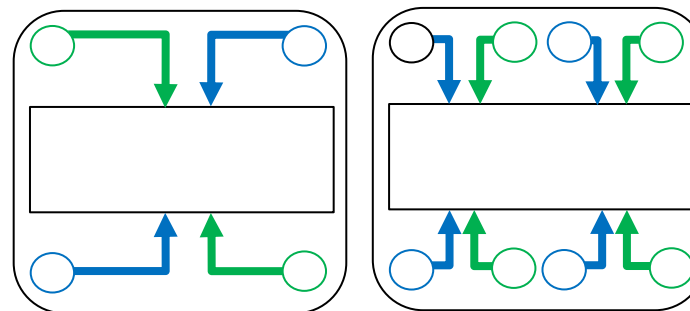
# Flowframe – Topologies: Ultra Deep Mäander

Mäander Depth  
up to 4 half Cells

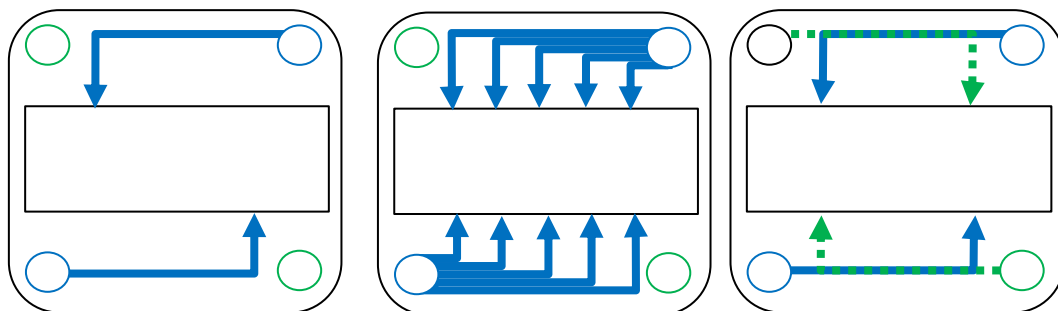
The unknown KPI in Stack Design:  
Mäander Depth vs. Cell height



Mäander Depth  
up to 2 half Cells



Mäander Depth  
up to 1 half Cell



## New development Stack 4.0 10 – 100 kW

Improved Technology with higher Energy Density due to higher Efficiency, reduced Volume and Costs.

### Suitable for different electrolytes:

Inorganic; Organic; Hybrid (e.g. gas).

### Various Flow Technologies:

Flow Through or Flow By  
or hybrid concept.

### Higher operational Power Density:

250 mW/cm<sup>2</sup> → 400+ mW/cm<sup>2</sup>.

### Ultra Deep Mäander:

Shunt current to Pressure Loss Ratio.



### Stack ends:

Combination of Iso Plate, Metal-end-Plate,  
hydraulic connection.

### Component reduction (One Frame):

Only one Frame per Cell required (50% Reduction).  
Thinner Electrodes or BiPolar Plate Material.

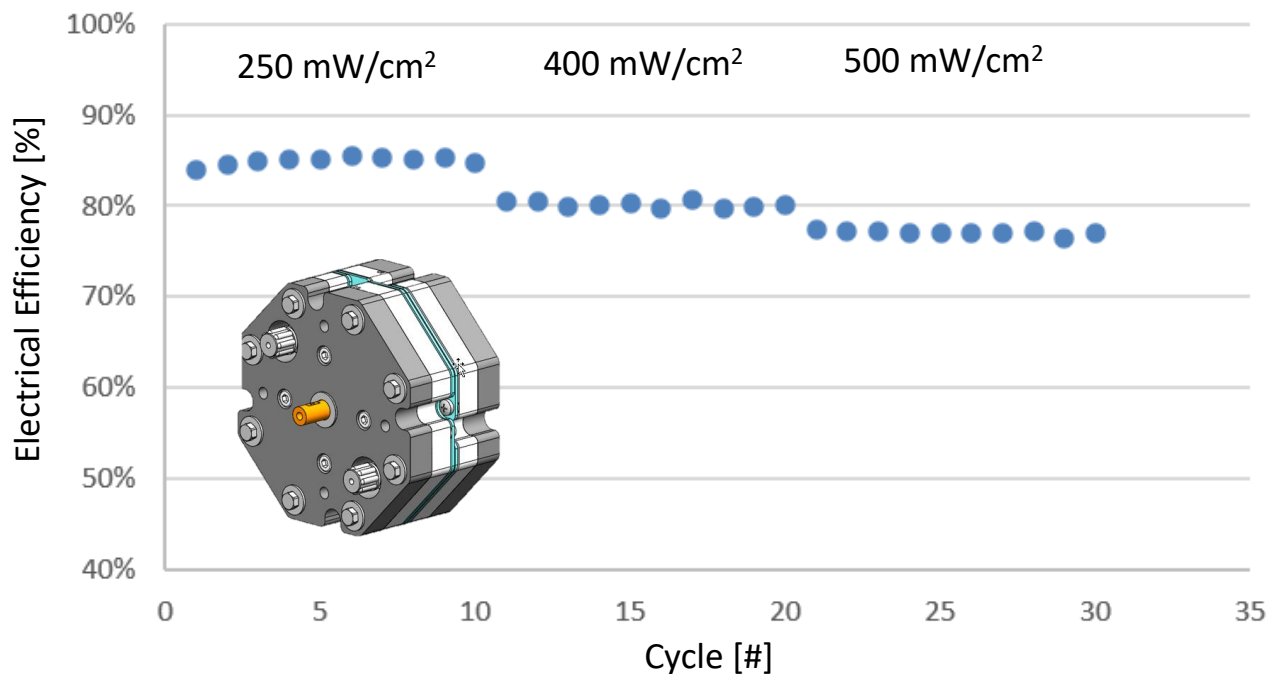
### Reduction of electrical Resistance:

Thinner Cells and improved active Materials.

# Flow Through and Flow-By

Results from our electrochemical Laboratory (VRFB)

Flow-By Performance



	250 mW/cm <sup>2</sup>	400 mW/cm <sup>2</sup>	500 mW/cm <sup>2</sup>
Flow Through (AEM)	81 % (EE)		
Flow By (CEM)	85 % (EE)	80 % (EE)	77 % (EE)



„Beigle“ (Project Start 01.06.2025)  
Development of a 25 kW Stack

# Roadmap – Stacks with Ultra Deep Mäander

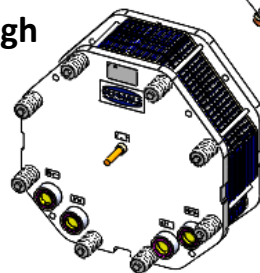
A new Stack Platform.

## Generation 4

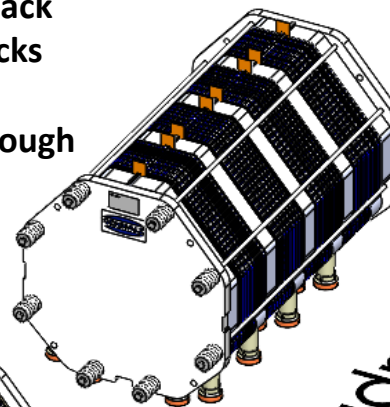
## Generation 3



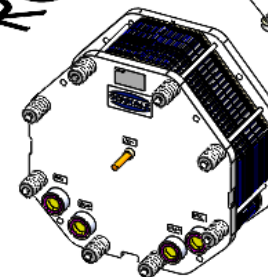
10 kW Stack  
Flow Through  
40 Cells



40 kW Stack  
4 Substacks  
40 Cells  
Flow Through

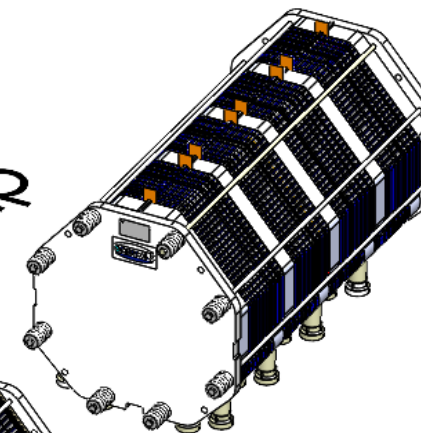


Roadmap



25 kW Stack  
50 Cells  
Flow By

100 kW Stack  
4 Substacks  
50 Cells  
Flow By



## Summary

*„The thinnest Cell with the Best Pressure Loss  
and Best Shunt Current Protection will win.“*

**Ultra Deep Mäander**

-

**Low Pressure Loss  
Shunt Current Protection**

**Cost Improvement**

-

**Less Material and  
Components**

**10 – 100 kW**

-

**New Stack Platform  
Various Electrolytes**

**DR.-ING. DIPL.-CHEM. GEORG LIESER (LSSB)**  
Research & Development

**J. Schmalz GmbH**  
Johannes-Schmalz-Str. 1  
72293 Glatten, Germany

[WWW.SCHMALZ.COM](http://WWW.SCHMALZ.COM)



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