IFBF 2025

Stacks for Large-Scale Flow Batteries: What is the Optimal Stack Size?

Thorsten Seipp*, Philipp Schröder, Martin Bayer, Damian Pandel

Motivation

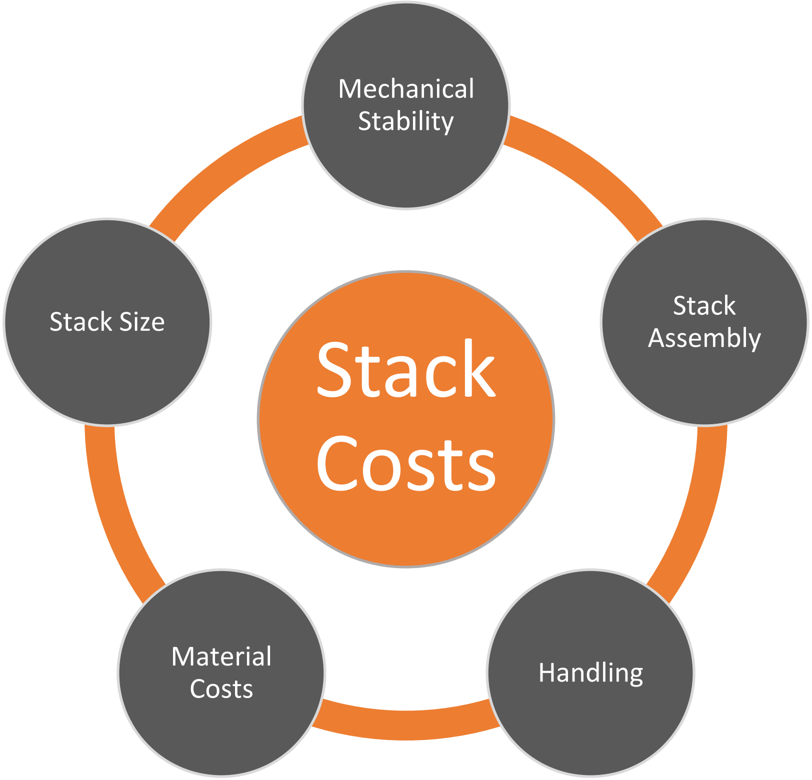
- Cost reduction of stacks crucial for establishment of redox flow technology in energy sector

  → Reduction of costs per kW through scale-up

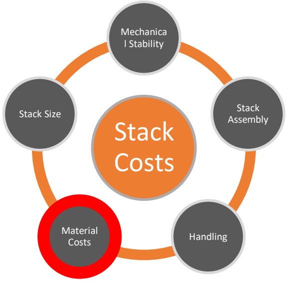
  → Bigger = better? What is the optimal stack size?

Implications of Stack Scale-Up on cost

- Trade-off between stack size, material costs, mechanical feasibility, stack assembly, handling



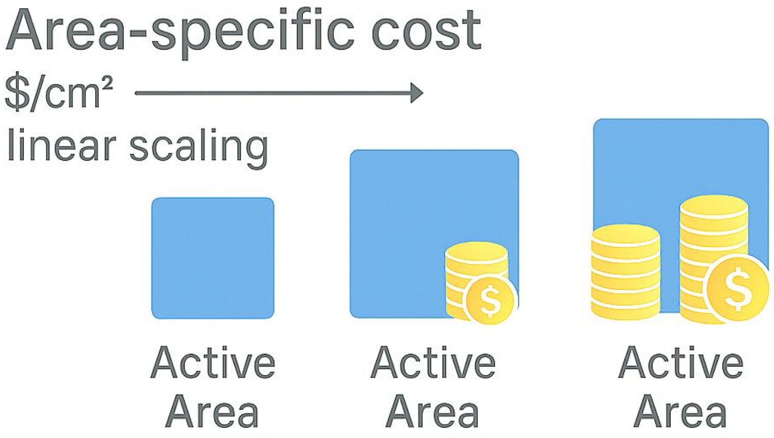
volterion



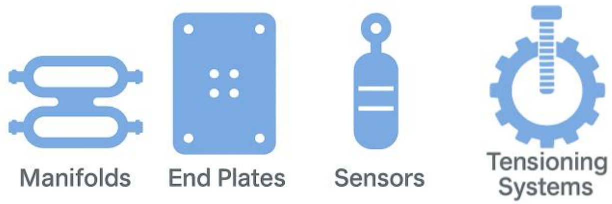
Implications of Stack Scale-Up on cost

Material Costs

- **Active materials:** Membranes, graphite felts, bipolar plates
  - Largest fraction of stack costs
  - Scale linearly with cell area
    - → Power output scales with active area
    - → Cost per kW constant across different stack sizes

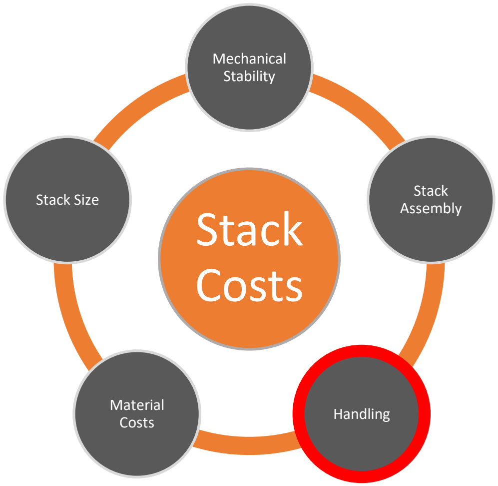


- **Peripheral components:** Manifolds, end plates, sensors, current collectors, tensioning systems
  - Fixed/semi-fixed costs
    - → Larger stacks spread these costs across higher power output
    - → Lower costs per kW



volterion

Implications of Stack Scale-Up on cost



Handling

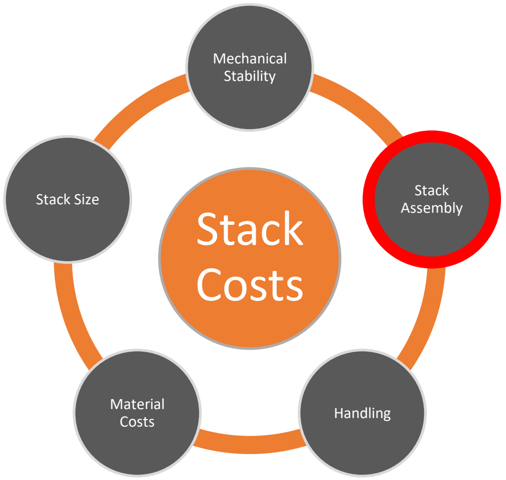
- Larger components slow down workflow and require more precise fixturing or custom handling tools
    - Higher installation cost
    - Higher maintenance cost

- Stack weight >25kg

  → Lifting equipment or two-person teams required, adding labour and increasing setup times

volterion

Implications of Stack Scale-Up on cost



Stack Assembly

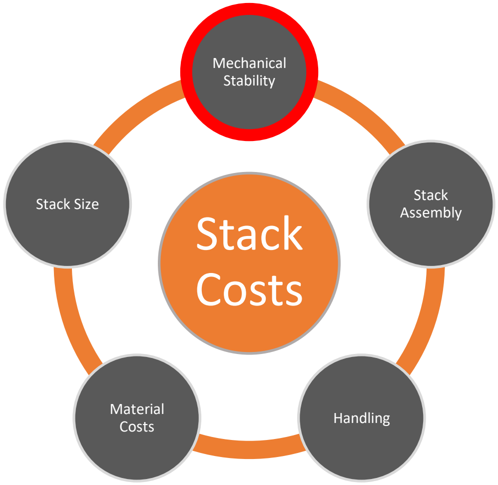
- Repeated set of steps: Membrane placement, electrode alignment, compression
  → Complexity increases with physical size of components

- Membranes and felts become more difficult to handle and align
  → Tendency to stretch or wrinkle

- Thickness tolerances accumulate across larger areas
  → Greater absolute deviations that can complicate sealing and uniform compression

volterion

Implications of Stack Scale-Up on cost



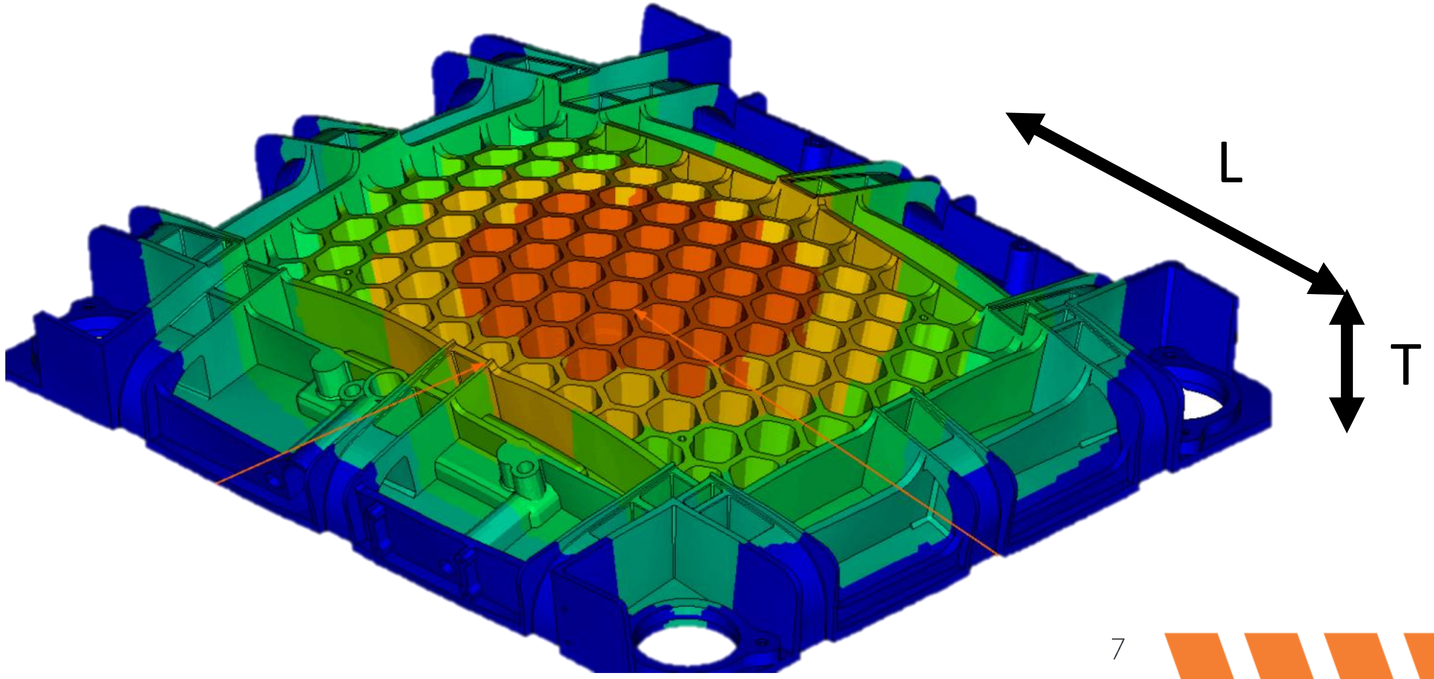
Mechanical Stability

- As active area increases, higher compressive force required to ensure uniform pressure and sealing

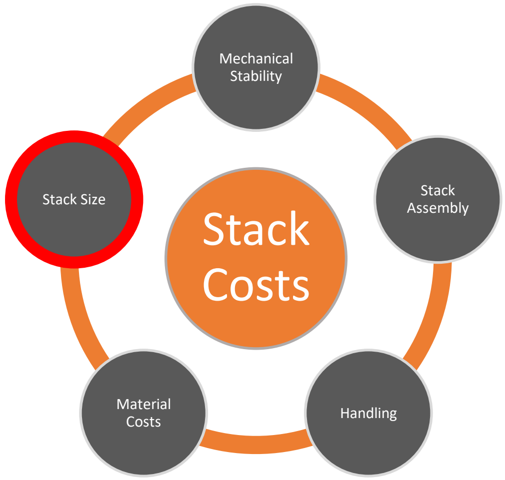
  → Endplates must be reinforced by increasing their thickness and switching to higher-stiffness materials

- Endplate costs rise more than proportionally with size

  → Diminishing returns in cost savings, potentially reversing economic benefits of scaling up



volterion



Implications of Stack Scale-Up on cost

Additional Considerations about Stack Size

- Uniform electrolyte distribution increasingly complex with larger areas
  → Flow imbalances can reduce the effective active surface and lower output.

- Larger stacks can lead to system-level savings by reducing the number of external connections, cables, and auxiliary interfaces

- Smaller units enable partial operation during maintenance
  → Simplifies diagnostics, since faults can be isolated to smaller functional blocks

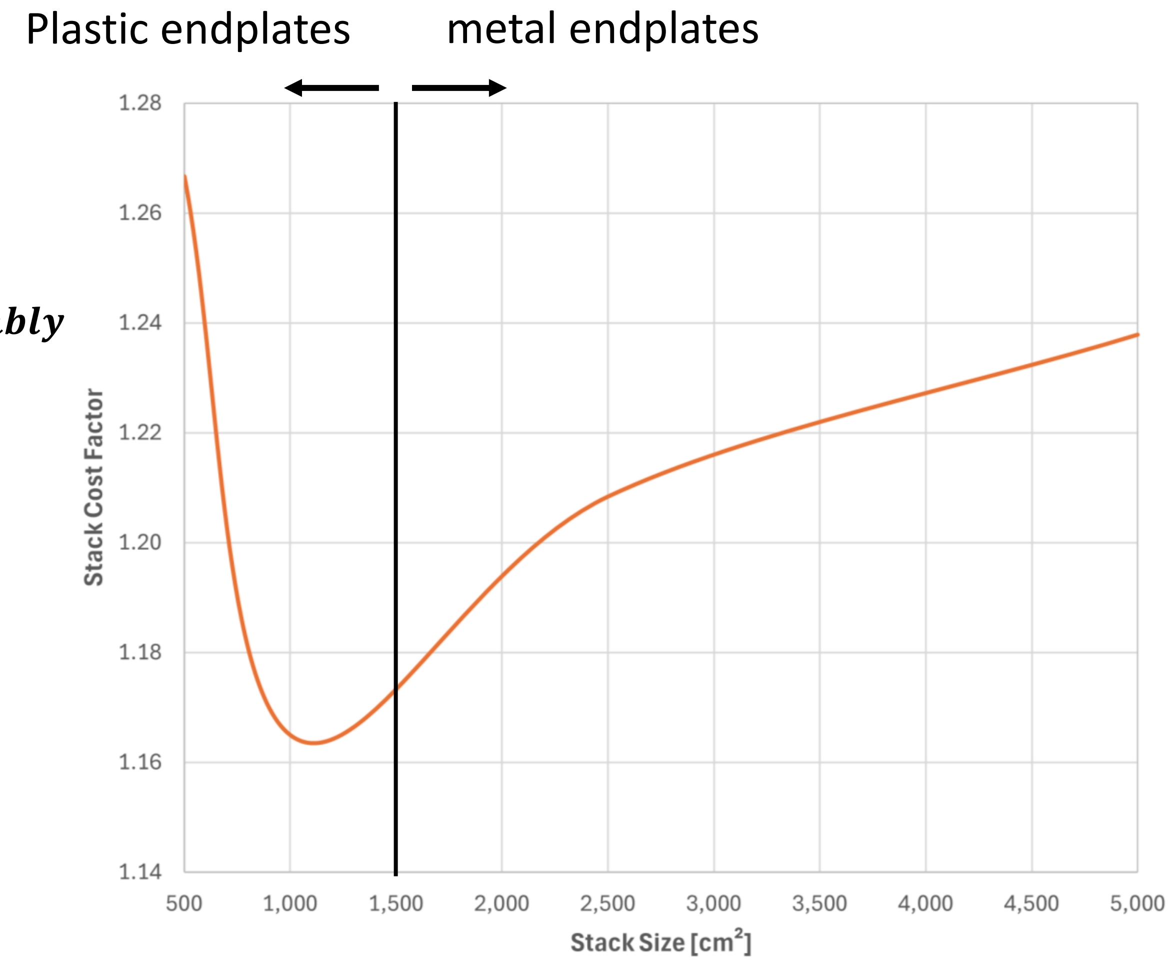
Cost Calculation Methodology

Definition of Stack Cost Factor

$$C_{total} = C_{active\ material} + C_{periphery} + C_{tension} + C_{assembly}$$

$$C_{Stack\ Cost\ Factor} = C_{total} / C_{active\ material}$$

- Stack with $C_{Stack\ Cost\ Factor}$ close to 1 (theoretical limit) favourable due to higher cost efficiency



volterion

What matters for system integration?

Target: MW-Sized flow batteries

500 kW

Comparison on power block level,

not on single stack size

vs.

500 kW

- Cost per MW
- Assembly time
- Integration flexibility
- Installation and maintence
- Failure rate

Thank you

Thorsten Seipp

Volterion GmbH & Co. KG
Carlo-Schmid-Allee 3
44263 Dortmund
GERMANY

Thorsten.seipp@volterion.com
www.volterion.com