



# Designing Li-Battery Cell Manufacturing for Scale

Johan Olofsson, Magnus Wiktorsson, KTH. May 2026

# Battery cell manufacturing is growing, but challenging

Automotive sector employs **2.5 million people** in manufacturing and **7 % of total GDP** in EU

ICE

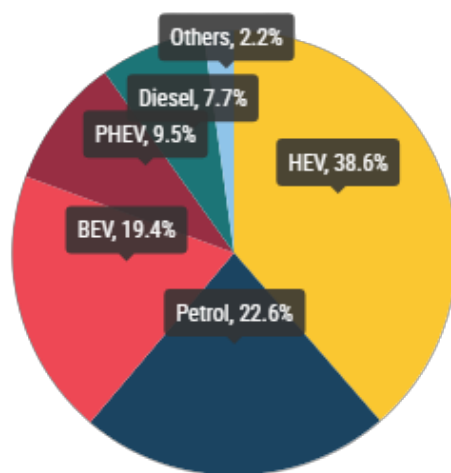
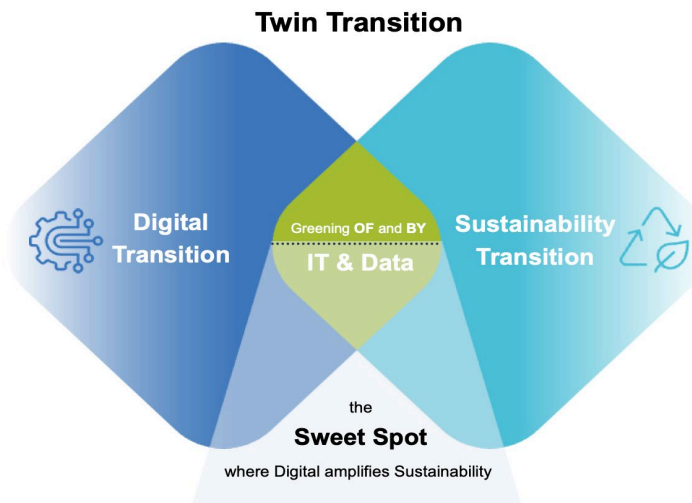


+ more parts  
+ more moving parts

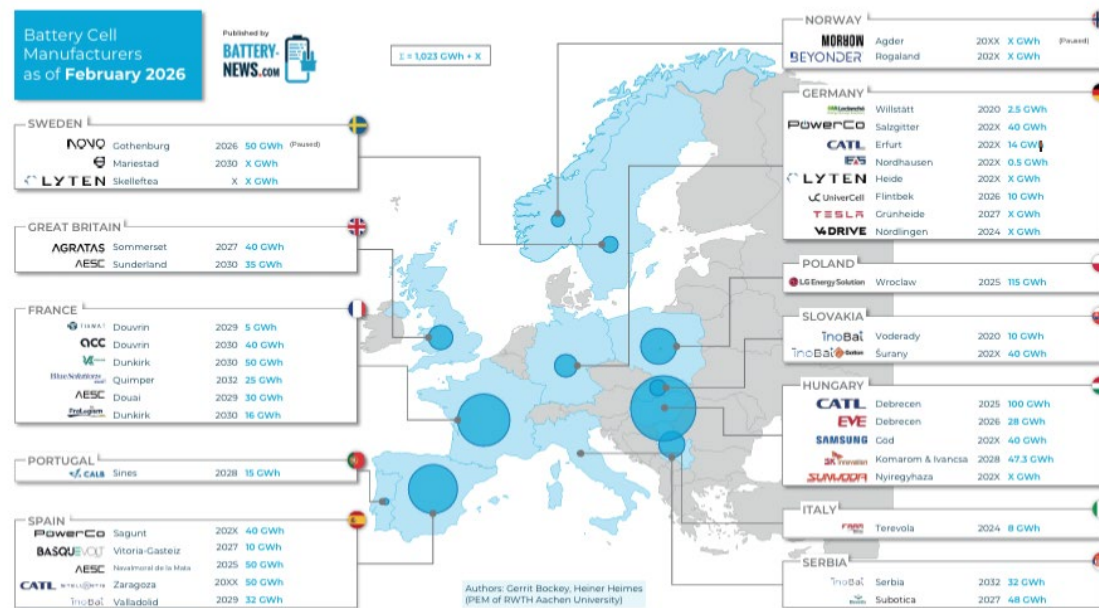
BEV



61% manufacturing labor needed compared to Diesel alternative (inc. battery value chain)\*



EU car sales, Q1 2026 (ACEA)

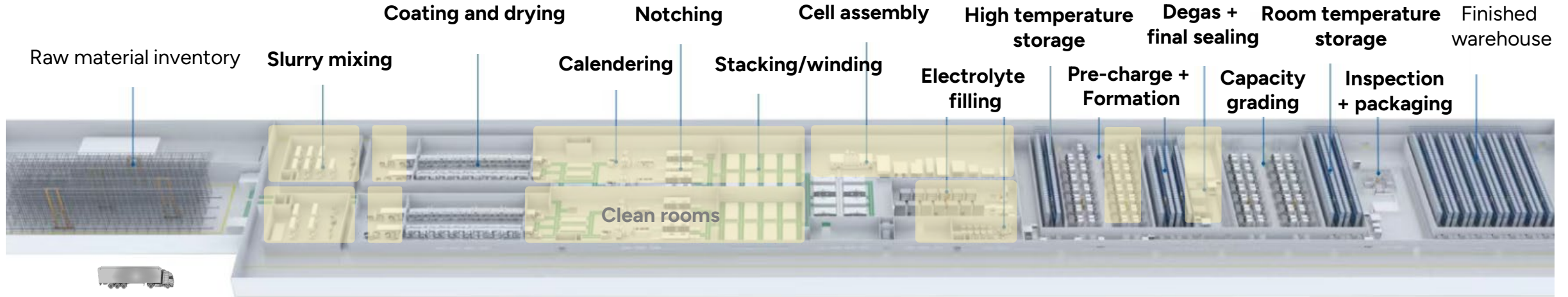


Source: www.battery-atlas.eu; abstract, no claim to completeness

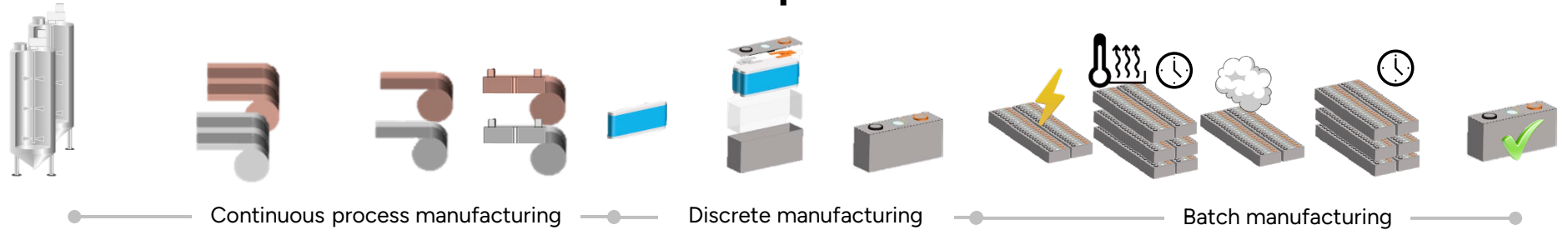
\* Galgóczi, Béla On the way to electromobility – a green(er) but more unequal future? 2023

# Cell manufacturing systems – overview

## Processes



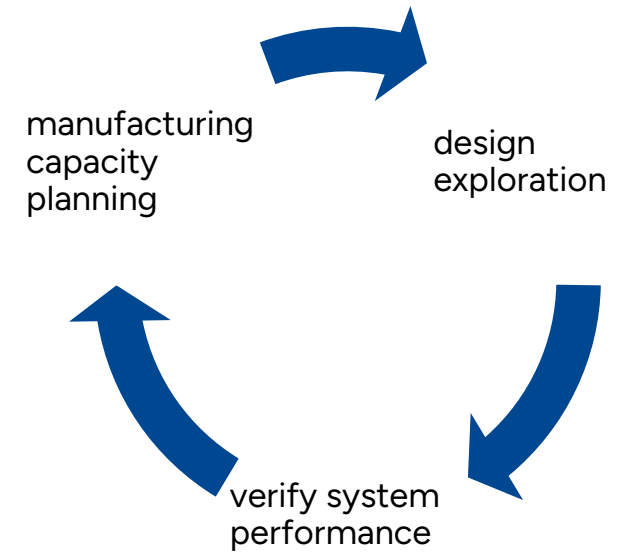
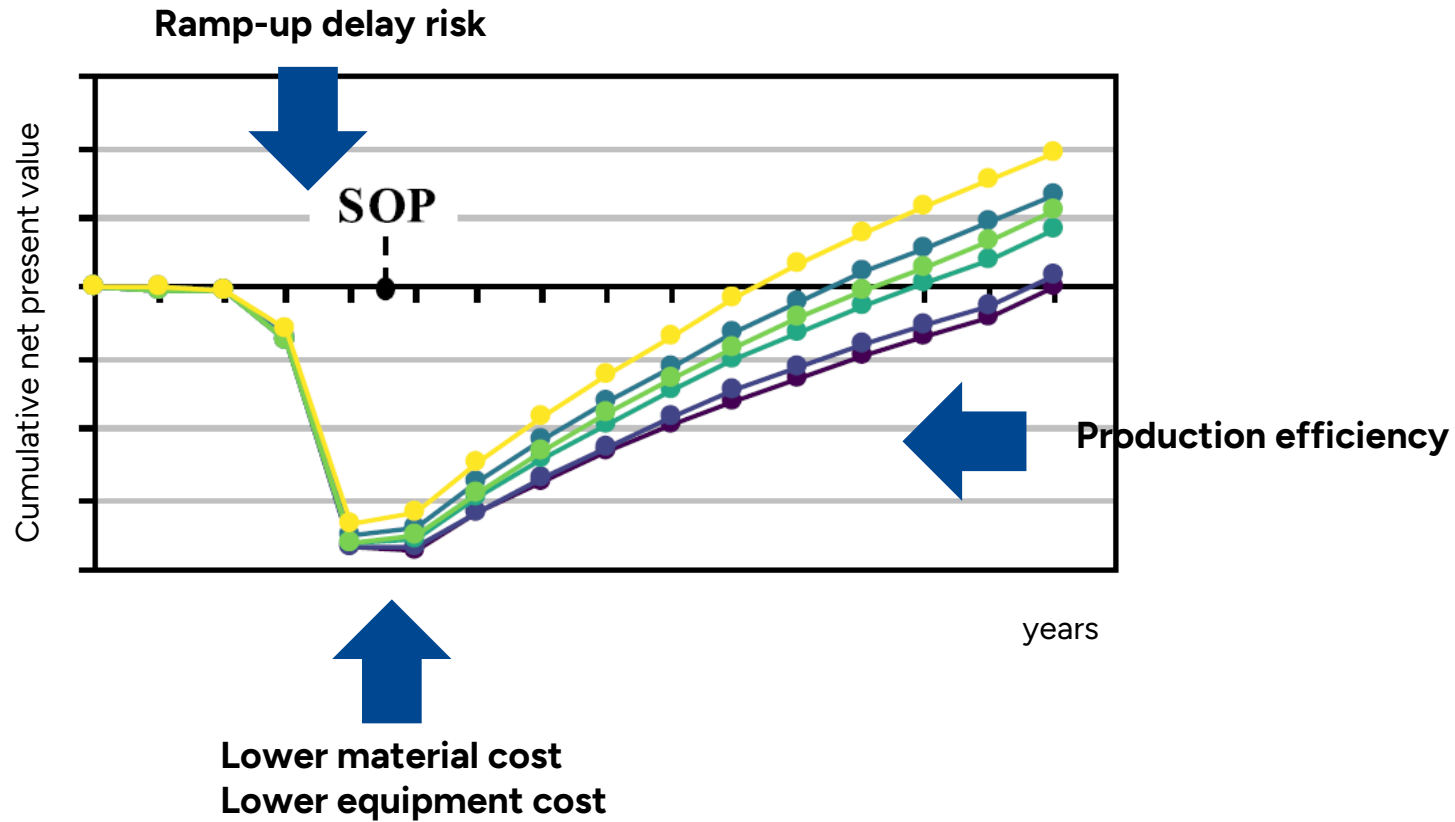
## Intermediate products



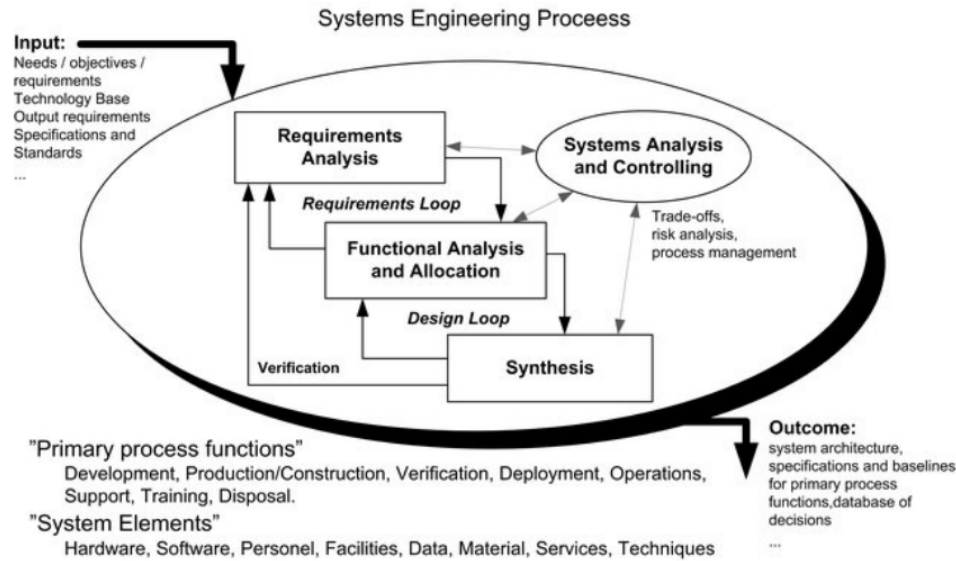
## Characteristics

- Capital intensive
- Scale of manufacturing system
- Converging + diverging material flows – matrix production
- High level of automation
- Mixed process / discrete manufacturing
- Energy intensive

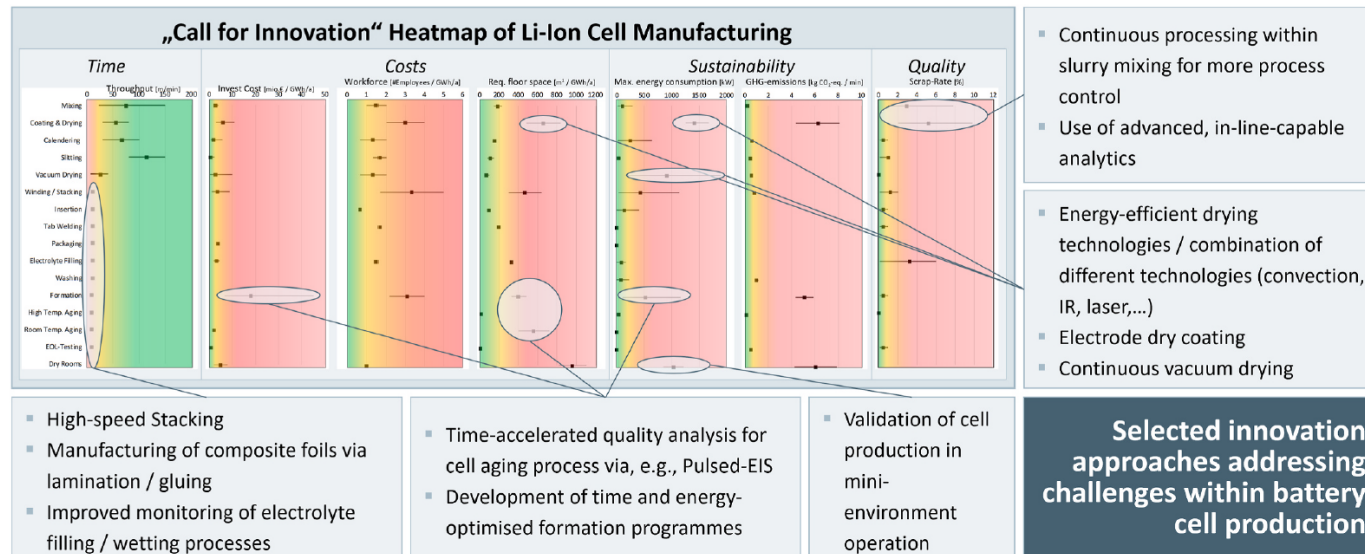
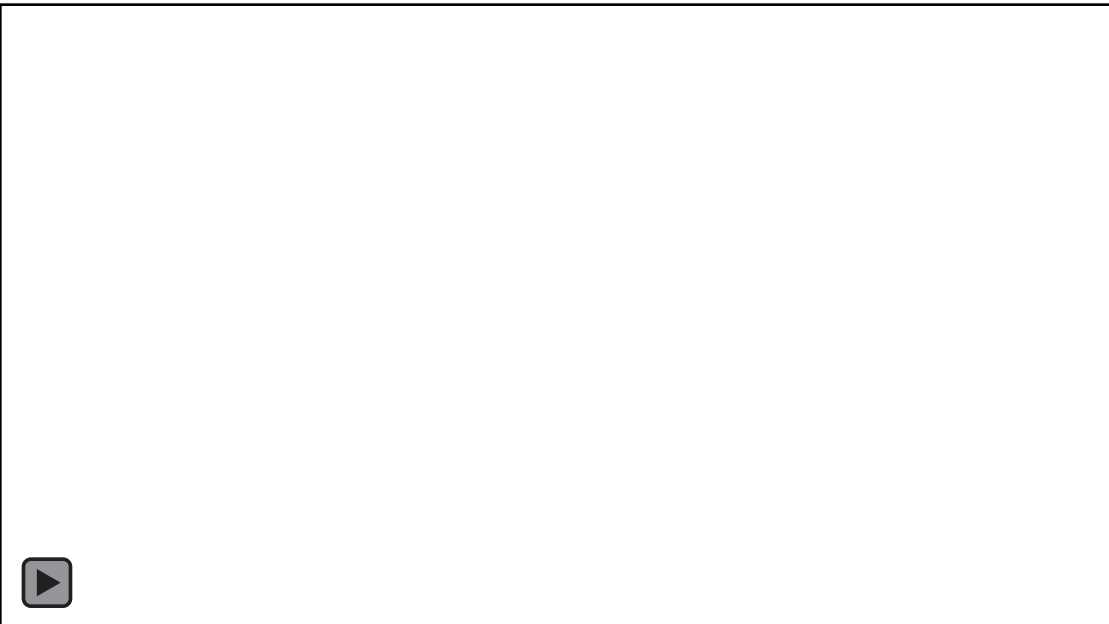
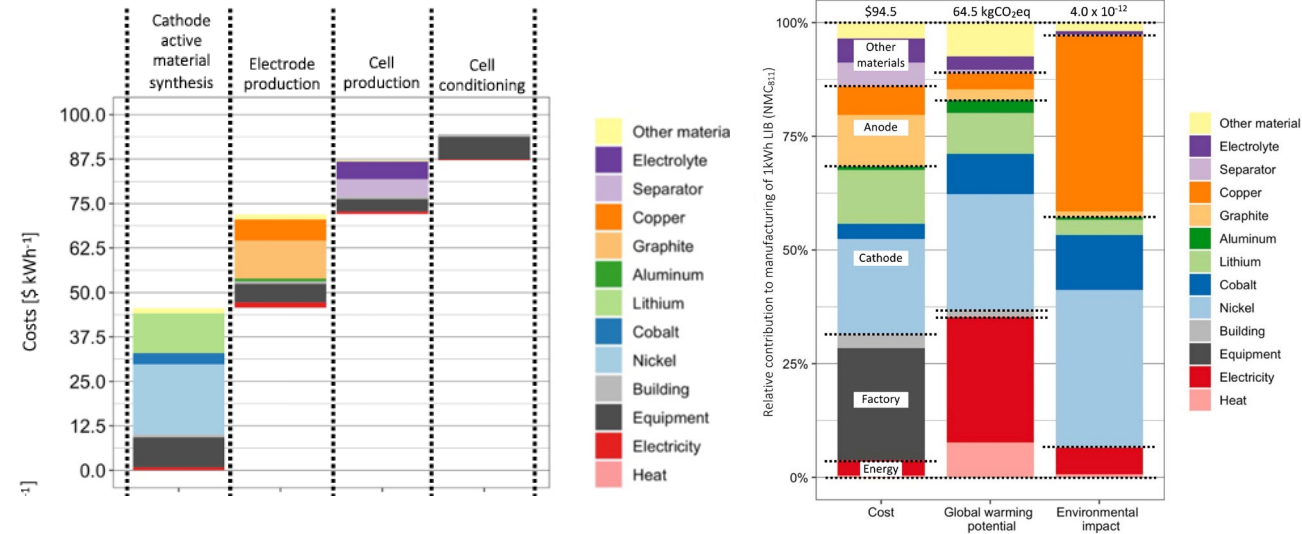
# Need of Cell manufacturing ramp-up proficiency



# Selected fundamentals of systems' understanding

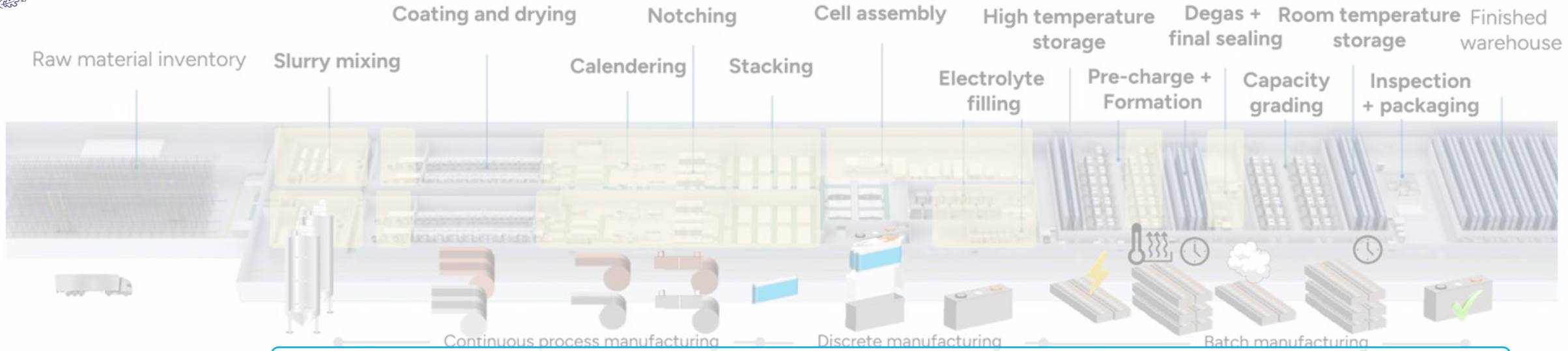


## LCA and cost models





# Cell manufacturing – projects for systemic performance



	Raw material inventory	Slurry mixing	Calendering	Stacking	Electrolyte filling	Pre-charge + Formation	Capacity grading	Inspection + packaging	Finished warehouse
Cost + Energy	Clean & dry room :	Line balancing, buffer dimensioning and identification of decoupling points							
	Equipment CAPEX :								
	Building + utility CAPEX :								
	Energy intensity :								
System	Labor intensity :								
	Shelf-life material output :								
	Material storage practicality :								
	Allows for stop and go :								
Variation	Material flow intensity								
	Material flow complexity								
	Availability + uncertainty :								
	Performance + uncertainty :								
Quality + uncertainty :									
Flexibility, new cell design :									

Line balancing, buffer dimensioning and identification of decoupling points

High room design + ASRS dimensioning

Peak power harmonization

WiP material flow design, validation and optimization of layout

Warehouse + Internal logistics validation and optimization

Matrix production dispatching flexibility in conveyor system

Automation validation and optimization

WMS material flow traffic control

What-if scenario new product recipe

# Towards holistic manufacturing system decomposition and design

Maximize long-term ROI

Industry 5.0 objectives

- Social and environmental Sustainability
- Robustness
- Flexibility

LCA

PBCM, Process based cost modelling

Domain expertise

Empirical production data from "open source" industrial sized machine equipment

DES models, Objectives and scope set by AD

**Examples:**

- Line balancing
- Throughput analysis
- Material flow design and factory layout

Axiomatic design (methodology used for manufacturing system decomposition)

Customer needs

Problem space ambiguity

Solution space ambiguity

Functional requirements

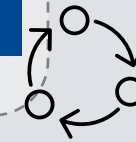
Design parameters (alternatives)

Simulations: manufacturing system designs

Simulation decomposition (efficient exploration of solution space)

Physical solution

Simulated system performance, design alternatives for sub-systems might add on new functional requirements due to need for interoperability.





Precision Engineering and Metrology

Manufacturing Machines and Processes

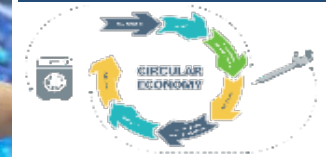
Human-Robot Systems

Enablers of Advanced Production

Production Logistics

Production Management

Circular Manufacturing Systems



## Context: Four examples of production engineering in Battery Life

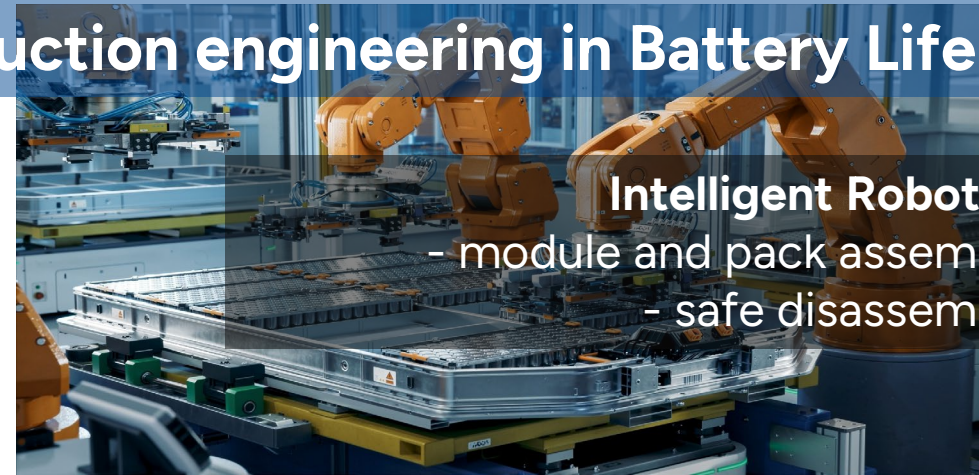
### Inspection and Metrology

- in-line monitoring of quality
- advanced analytics, ML for QA



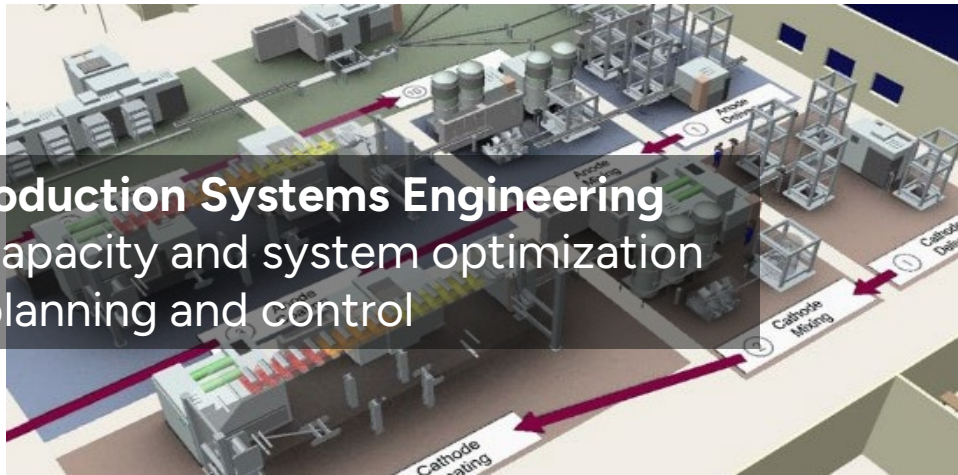
### Intelligent Robotics

- module and pack assembly
- safe disassembly



### Production Systems Engineering

- capacity and system optimization
- planning and control



### Battery Circularity

- information management
- traceability and reverse logistics



Battery materials

Cell concepts

Electrode

Cell assembly

Forming and ageing

Cell to module

Module to pack

Pack to system

System integration

System in use

Reverse logistics

Recycling



# Thank you for the attention!

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