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# Economic analysis of sustainable material flows for next-generation lithium ion batteries

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## Introduction

Electric car sales neared 14 million in 2023, 95% of which were in China, Europe and the United States. **Increasing EV sales** continue driving up global battery demand, with fastest growth in 2023 in the United States and Europe.

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Powering these EVs requires high-performance **Li-ion Batteries** (LIBs) that are **safe, economical, long-lasting, and energy-dense**, with a demand increasing from about 330 GWh in 2021 to 550 GWh in 2022

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Developing of **cobalt-free electrodes** will reduce environmental impacts associated with batteries materials, while avoiding reliance on critical raw materials, such as cobalt, will boost electrification of European transport system

## HYDRA HYbriD power-energy electRodes for next generation lithium-ion bAtteries

Aims at developing high-performance and sustainable LIBs with the following properties:

- 750 Wh/L energy density
- 5C of maximum charging rate
- 15C of maximum discharging rate
- 2000 deep cycles of life time
- cost below 90 €/kWh

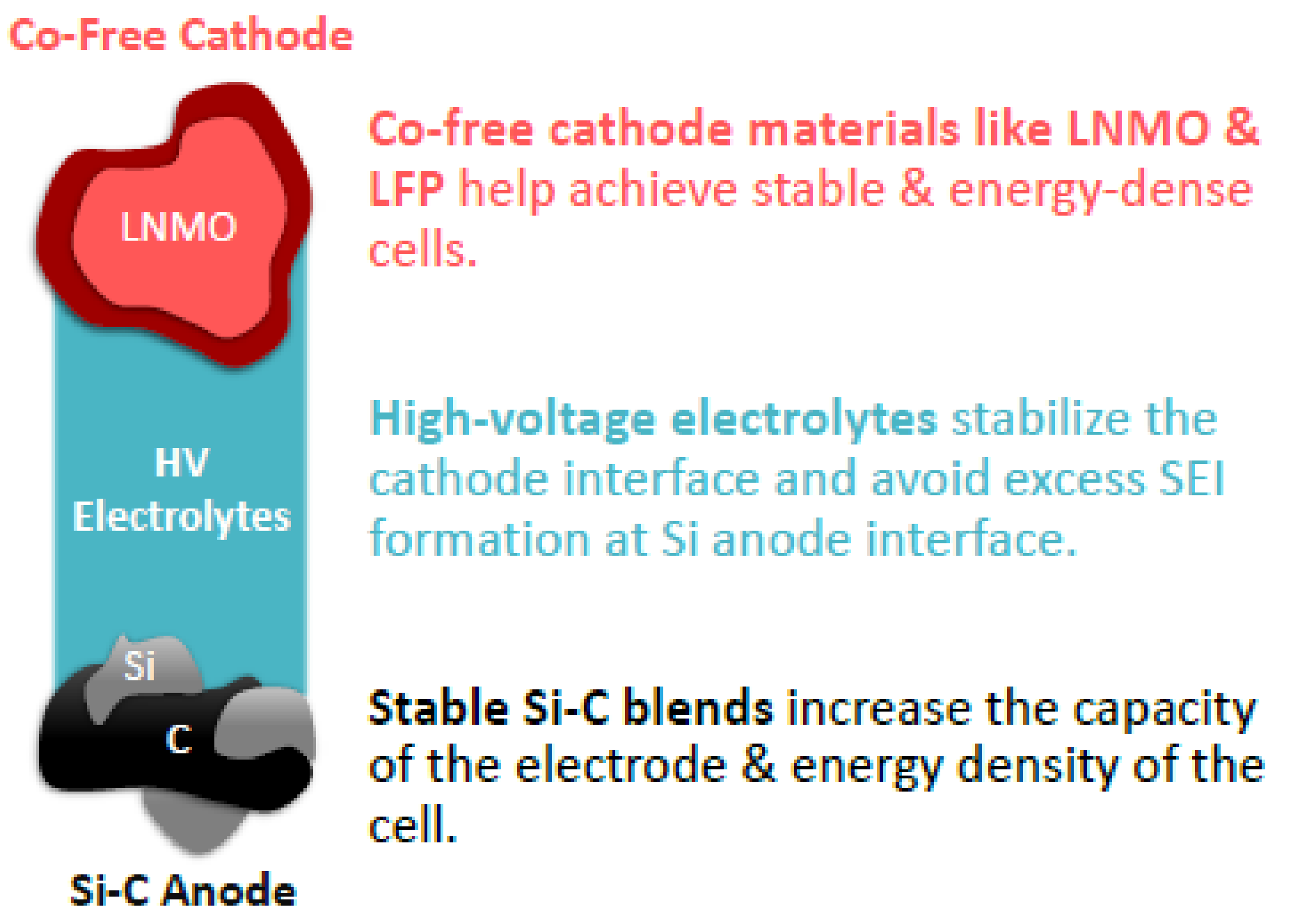


Fig. 1 Hybrid Co-free electrode materials

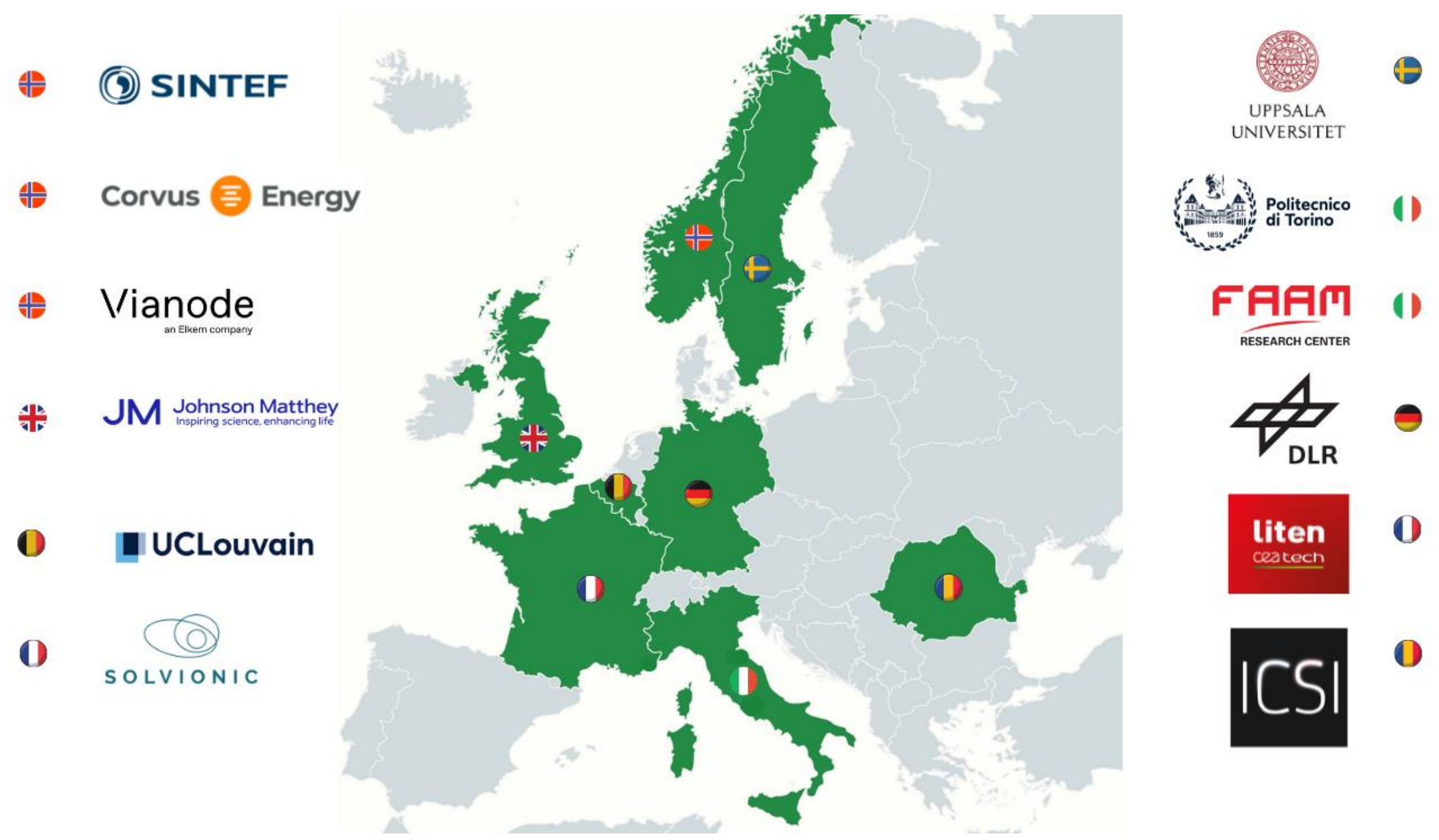


Fig. 2 Consortium of HYDRA project

## Methodology

Data from other work packages and public data was used in a costs of production economic model adapted for cell manufacturing as follows:

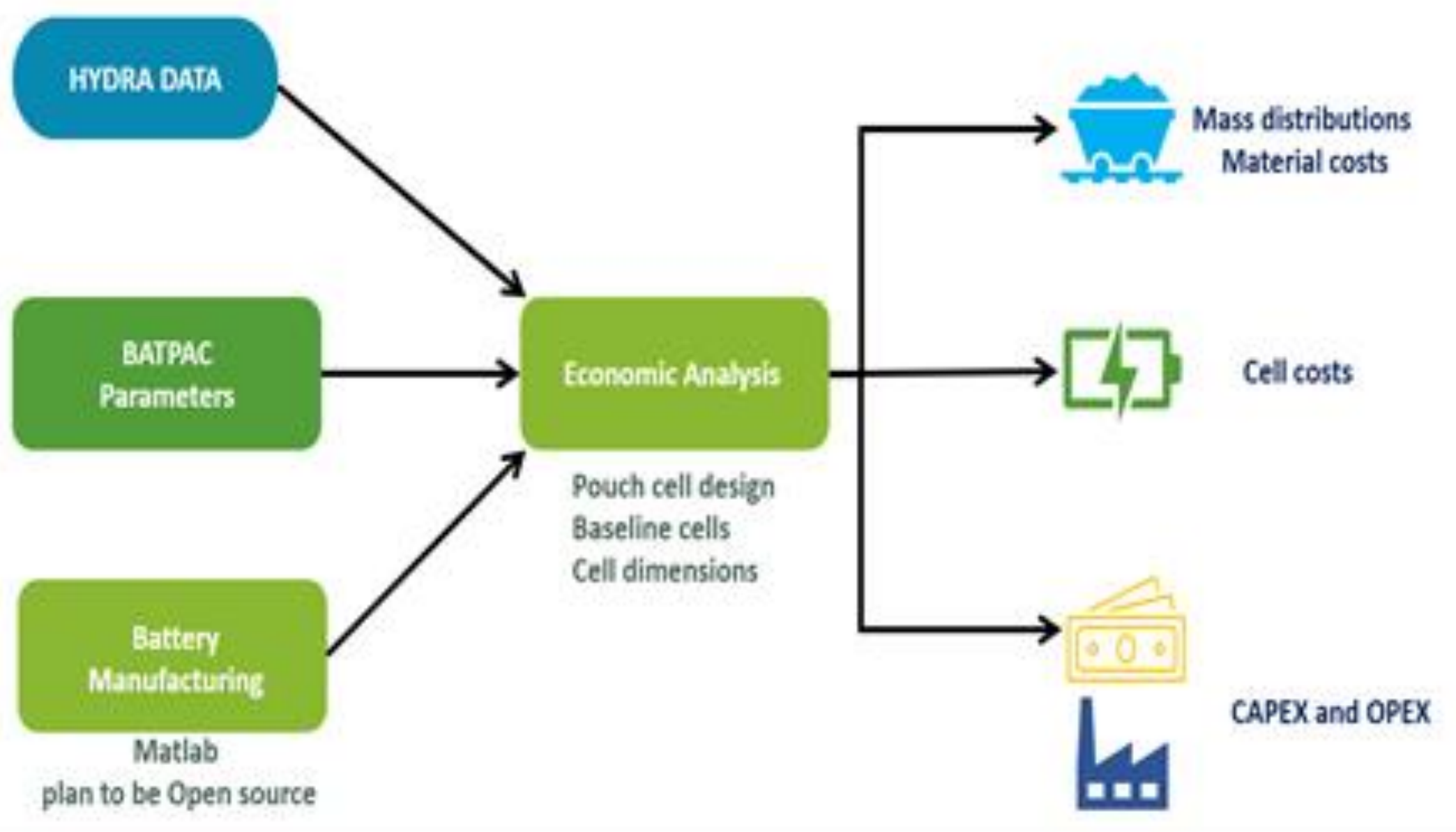


Fig. 3 Flowchart of economic value chain assessment

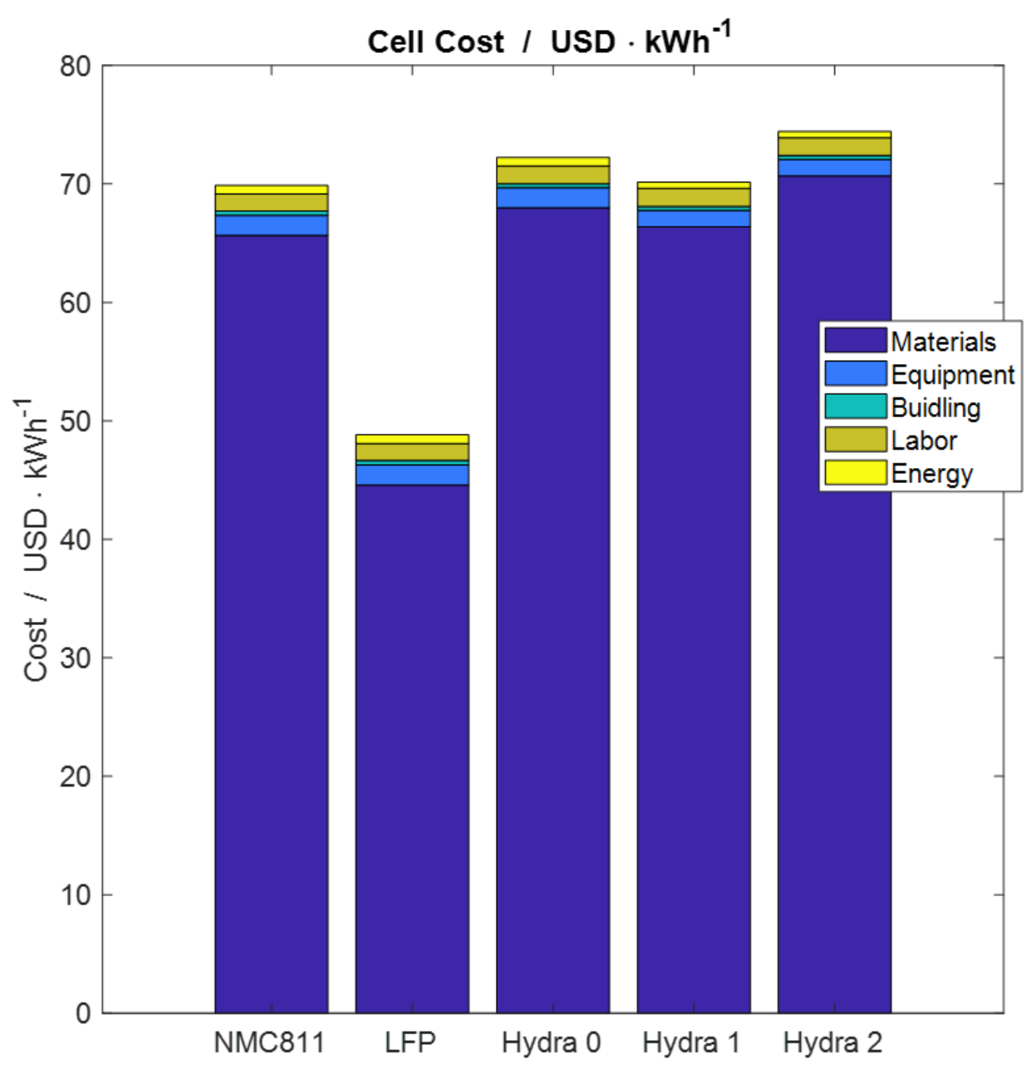
**Considered batteries chemistries:**

LFP NMC811 HYDRA0 HYDRA1 HYDRA2

| Cell | Positive electrodes | | | Negative electrodes | |
|---|---|---|---|---|---|
| | LMNO | LFP | Binder solvent | Graphite | Silicon |
| HYDRA 0 | 100% | 0% | NMP | 100% | 0% |
| HYDRA 1 | 98% | 2% | water | 92% | 8% |
| HYDRA 2 | 98% | 2% | water | 88% | 12% |

## Results and discussion

Materials are the primary driver of cell costs, emphasizing their significance in achieving cost-effective cells:



HYDRA cell materials, regardless of specific chemistries, have a cost of about **65 €/kWh**, which is comparable to NMC811 cell materials.

HYDRA 1 cells are slightly cheaper compared to HYDRA 0 because of the blending of LFP in the cathode.

HYDRA 2 cells are more expensive because of the addition of more silicon in the negative electrodes.

Fig. 4 operative costs for batteries manufacturing

It is crucial to include only the necessary amount of **silicon**, as underutilized silicon in the blend contributes to unnecessary costs.

By utilizing **water-based solutions** instead of traditional organic solvents, costs can be reduced by approximately $17 million for an 8 GWh production line, significantly impacting the affordability of battery cells.

CAPEX and OPEX were estimated from economic modelling of a theoretical Gigawatt-scale production line:

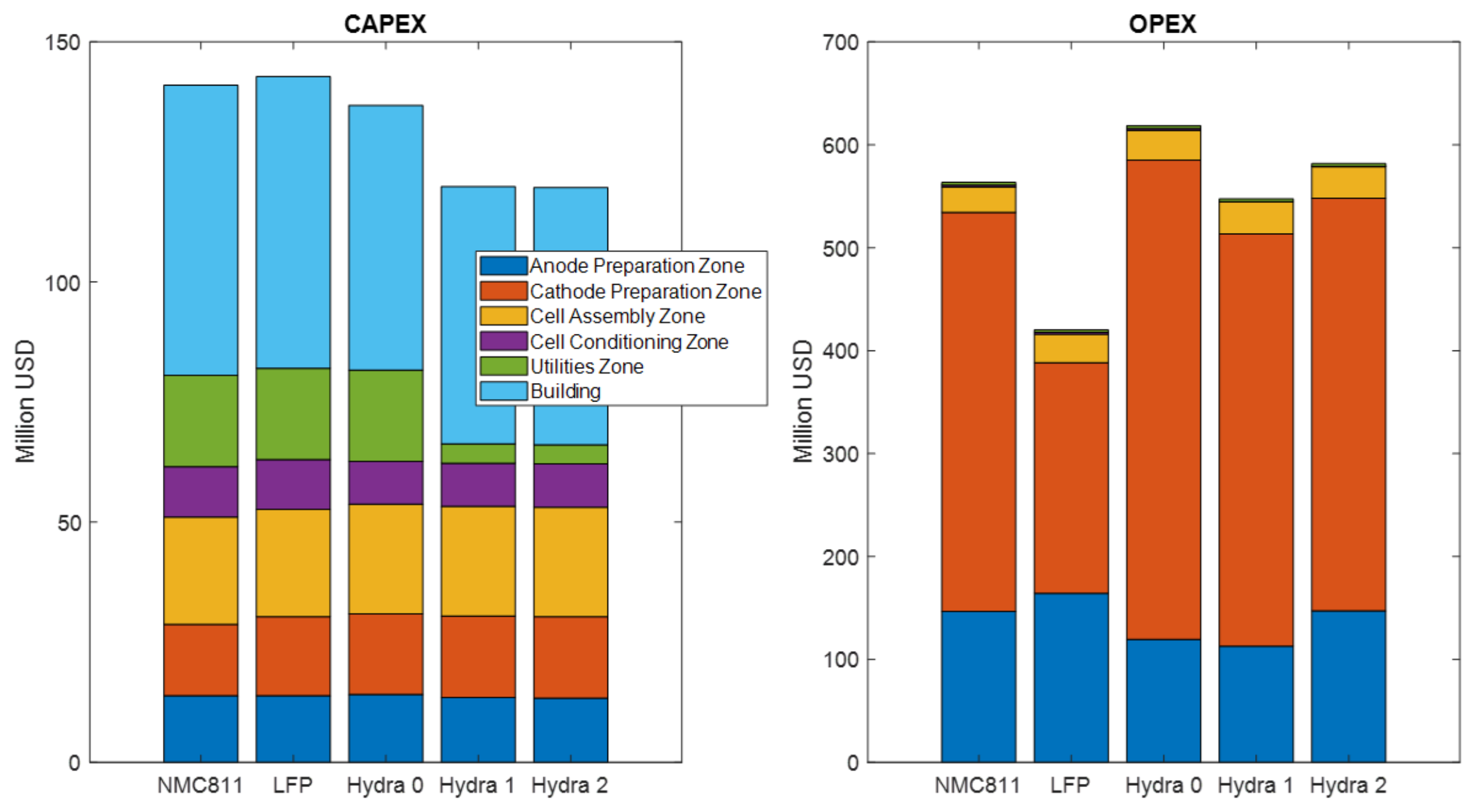


Fig. 5 CAPEX and OPEX of batteries manufacturing

Avoiding the use of the NMP solvent lowers the CAPEX of the HYDRA1 and HYDRA2 production lines. The OPEX is less affected.

## Conclusions

- ✓ The application of LFP active materials, which is cheaper than other cathodes materials, and the limitation of silicon content in the anodes, reduced the overall cost of HYDRA cells manufacturing.
- ✓ A significant breakthrough emerged in the form of aqueous processing of cathode materials, showcasing potential for cost reduction in the HYDRA system.
- ✓ By focusing on improving its efficiency, reproducibility, and stability at scale, the industry can fully exploit the cost reduction potential offered by water-based binder solutions.
- ✓ The production cost target of 90 € per kWh is feasible within the HYDRA development paradigm.

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