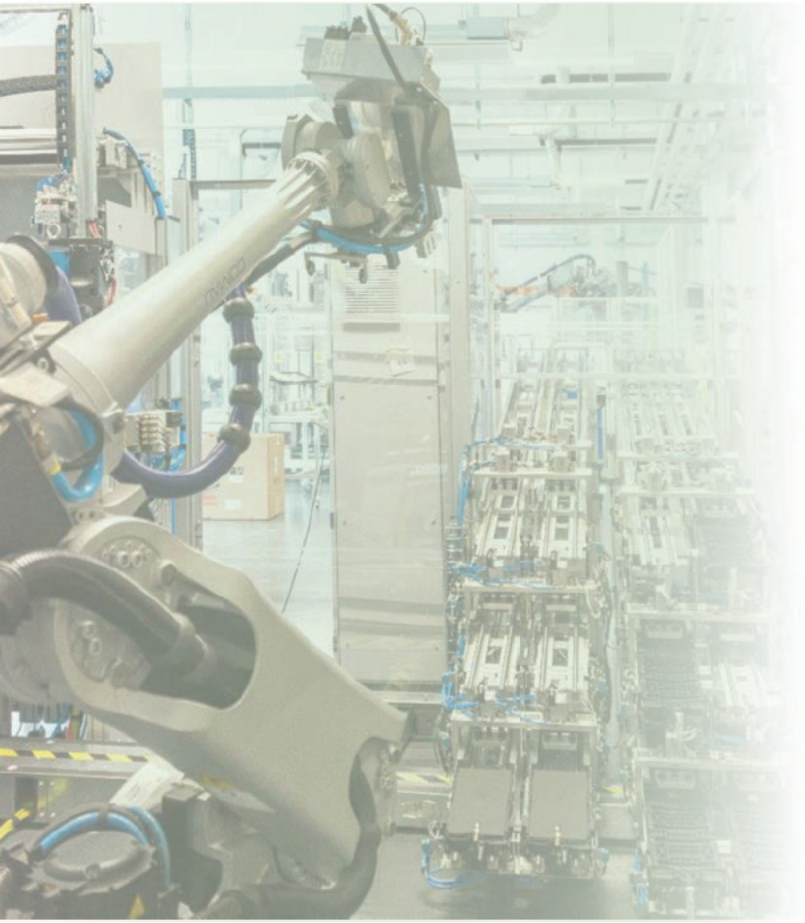
PFAS alternatives for batteries

EU Workshop in Brussels
30. January 2024

Leclanché
Energy Storage Solutions

Leclanché at a Glance



Leclanché is a vertically integrated manufacturer of energy storage solution for heavy mobility & energy

Swiss Quality & German Manufacturing

- 114 years of existence
- 350 people, including 50+ in R&D
- European manufacturer, HQ in Switzerland, production in Germany & Switzerland

Proven sustainable technology

- Over 160 patents covering key IP
- Very low environmental impact

Existing track records

- 170 customers including blue chip customers

ALSTOM · CP Canadian Pacific · KONČAR · DAMEN · Scandlines · WÄRTSILÄ

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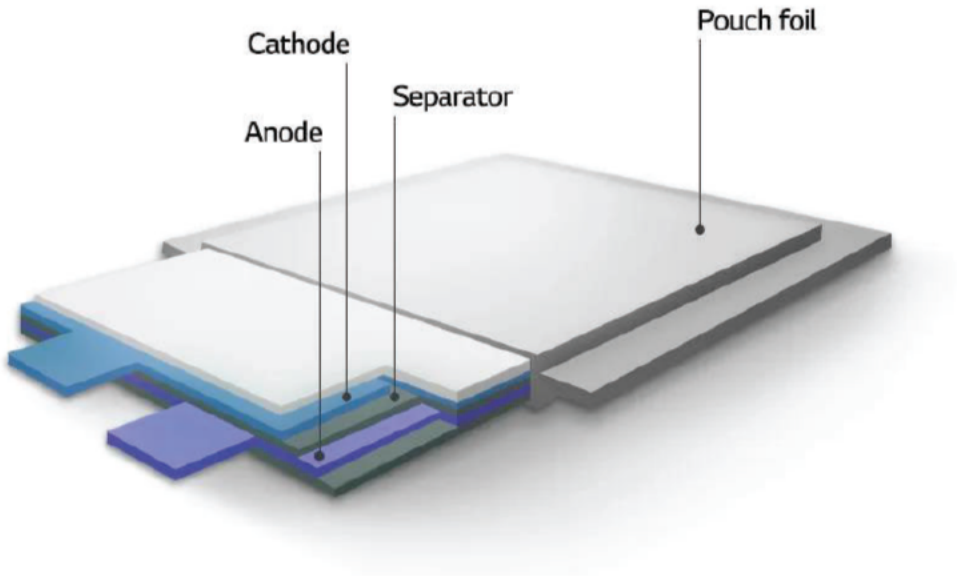
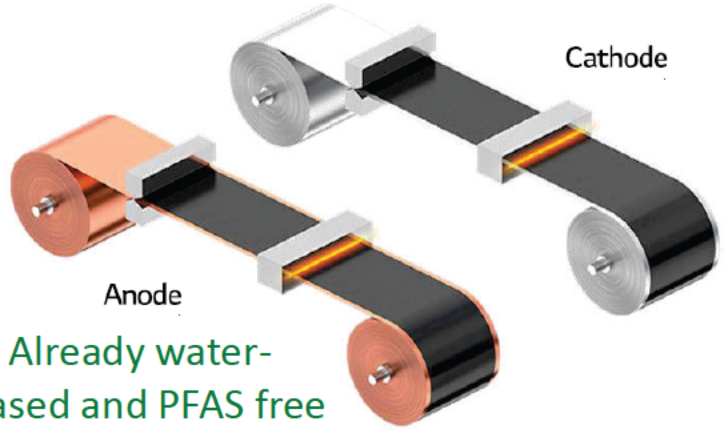
Why are PFAS used in the batteries ?

- Battery cell composition



- PFAS are mainly used as binders for the coating of positive electrode, since they resist to heat, oil, ... and grease



✓ Already water-based and PFAS free

Water based electrode manufacturing without toxic solvents since 2011

2010-2013 : De-Lion German funded project (7.5M€) to demonstrate the ability to replace toxic organic solvent NMP by water at large scale.
Project partners: ZSW (Ulm) and Clariant (München).

2013
Patent US2013/0034651 A1

2023
Patent WO2023/166174 A1

Water based + PVDF as lamination agent

From 2023
Water based & PFAS free

2013
EPFL (CH): 750 kW / 500 kWh

2016
Graciosa (PT) : 7.4 MW / 3.2 MWh

2019
E-ferry (DK) : 3.2 MWh

Leclanché water based binder-process

Standard battery cell Production
using **toxic NMP solvent & PFAS**

Organic solvent-based Process

- Safety risk for employees
- ATEX protection needed
- Solvent recovery system needed
- High drying temperature in coating
- Humidity control space for most of the manufacturing process

Leclanché battery cell Production

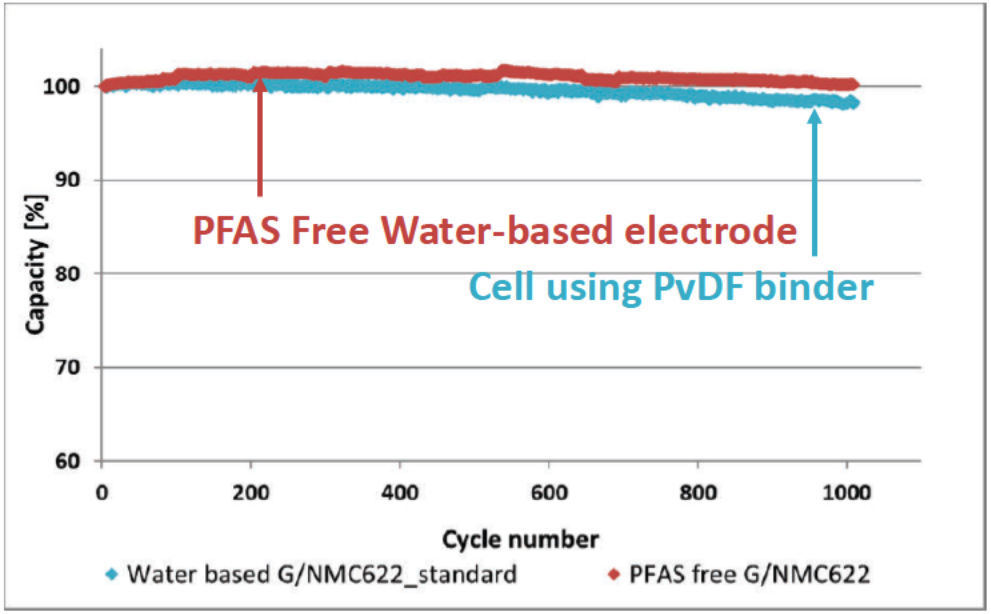
NMP & PFAS FREE

Water-based Process

- Safer working environment for employees
- No explosive environment
- No solvent recycling
- Low drying temperature in coating
- Reduction in humidity control space in the manufacturing process

Comparison with and without PFAS

- Performance of PFAS free cell is similar or better to PFAS-based cell
- Energy Efficiency is improved



Example with the Leclanché 60Ah GNMC622 cell in production at industrial scale with 1C cycling at 100 % Deep of Discharge, compared with a cell using electrodes which contains PvDF binder.

Impact on existing and future Gigafactories

- **Existing equipment can be used with Water-based PFAS free chemistry**
- **Existing Gigafactories:** OPEX is reduced by:
  - Reducing heating temperature by 50-60°C
  - Working in standard environment instead of humidity controlled
  - No need of expensive PFAS
- **New Gigafactories:** CAPEX is reduced by:
  - Removing NMP recovery equipment
  - Removing ATEX protection
  - Reducing dry room size

NMP recovery system from airprotech

- Health and safety of workers is improved since they are not in contact with PFAS or NMP

Synthesis and next steps

PFAS-free battery using water based

- Remove toxic solvent and associated emission
- Reduce CO2 footprint for battery production in Europe
- Protect investment in existing equipment – no change needed

Next steps for Leclanché

- License the technology to assist the battery industry in shifting towards more environmentally friendly batteries
- Find investor to scale up production

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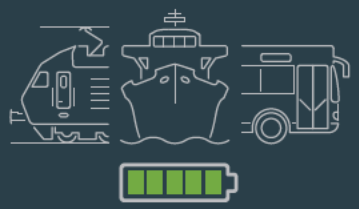
[redacted]@leclanche.com

STATIONARY SOLUTIONS



e-TRANSPORT SOLUTIONS

SPECIALTY BATTERY SYSTEMS

Appendix

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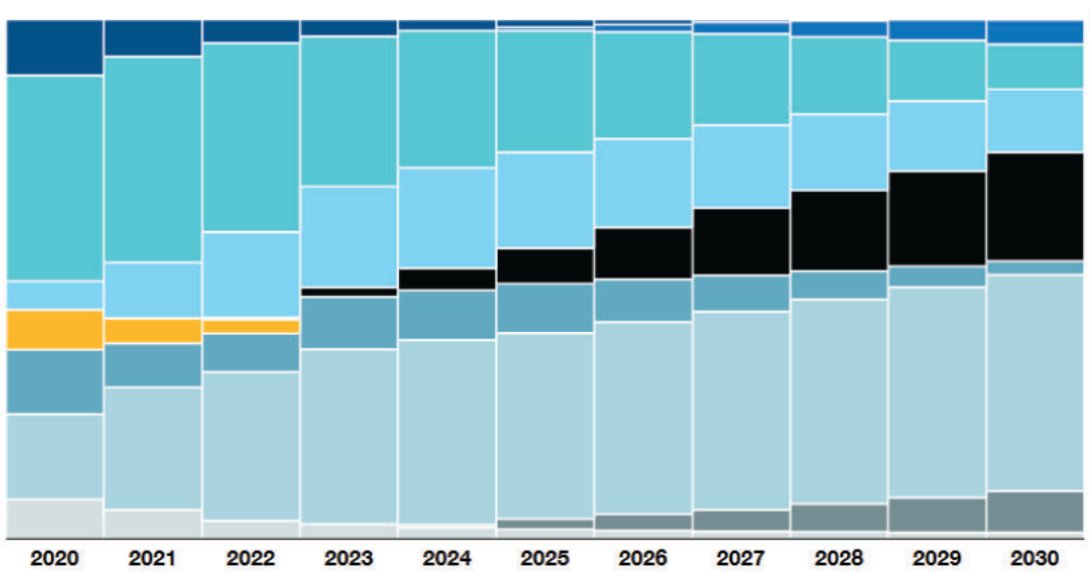
PFAS free alternative available for Li-ion (wet-process)



1) Na-ion share consists of the two cell chemistries nickel-based and Prussian white

Battery cell demand by cathode chemistry, 2020-2030, base-case scenario [GWh/a]
Source: Batteriemonitor 2023 Roland Berger, RWTH Aachen, PEM

NMC chemistry

- Anode already water based
- Cathode using PFAS in general, technology exists to move to PFAS free

LFP chemistry

- PFAS free alternative already available

Availability of water-based binder suppliers

- Water based binders for Leclanché cathodes are coming from large and well-known material suppliers manufacturing binders for water-based process for Li-ion electrodes for several years and available in Europe.
- There are multiple suppliers for each type of binder, making availability and scaling not a problem.

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@leclanche.com

@leclanche.com

STATIONARY SOLUTIONS

e-TRANSPORT SOLUTIONS

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