

PFAS alternatives for batteries

EU Workshop in Brussels
30. January 2024



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

KONCAR

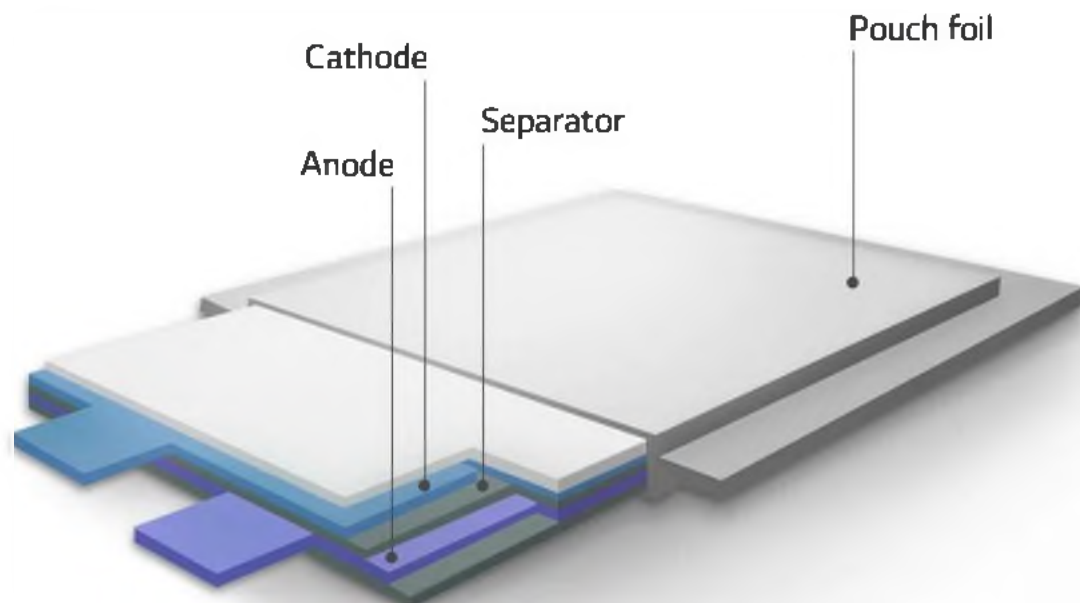
DIAMEN

Scandlines

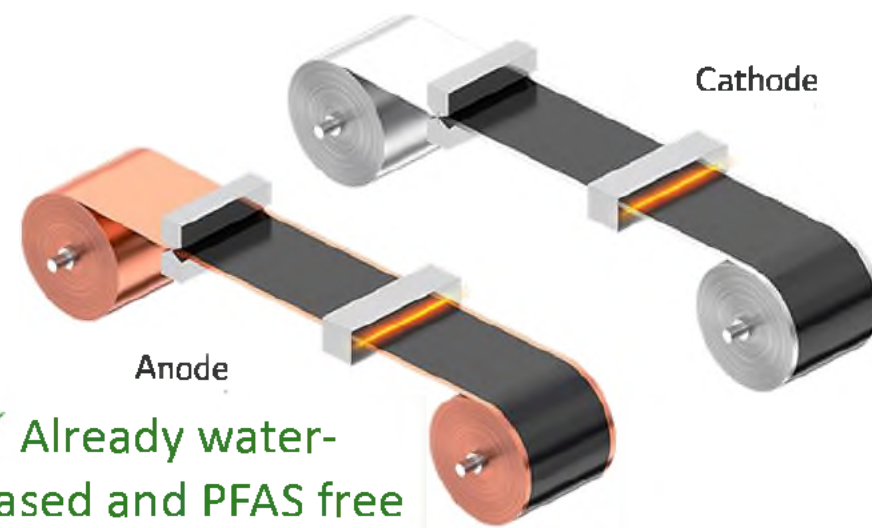
WÄRTSILÄ

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, water and grease



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



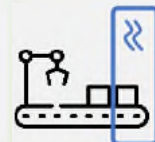
No explosive environment



No solvent recycling



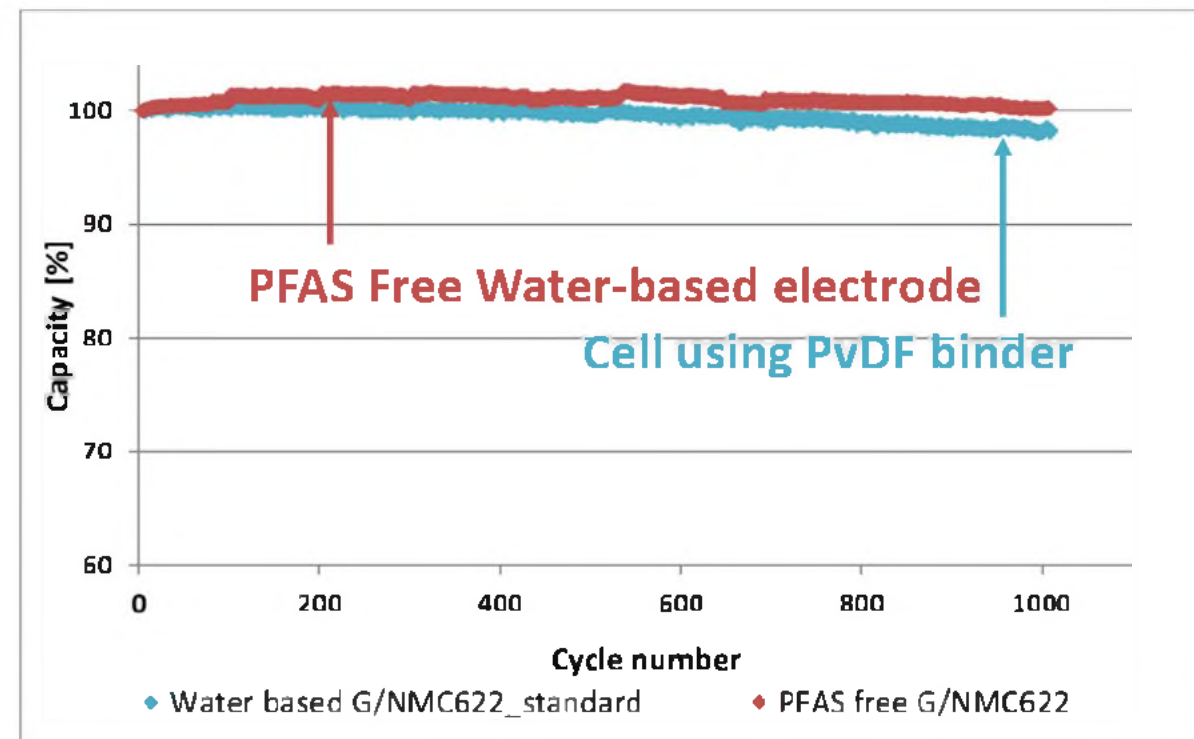
Low drying temperature in coating



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 G/NMC622 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
- ▶ Health and safety of workers is improved since they are not in contact with PFAS or NMP



NMP recovery system from airprotech

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

Leclanché

Energy Storage Solutions

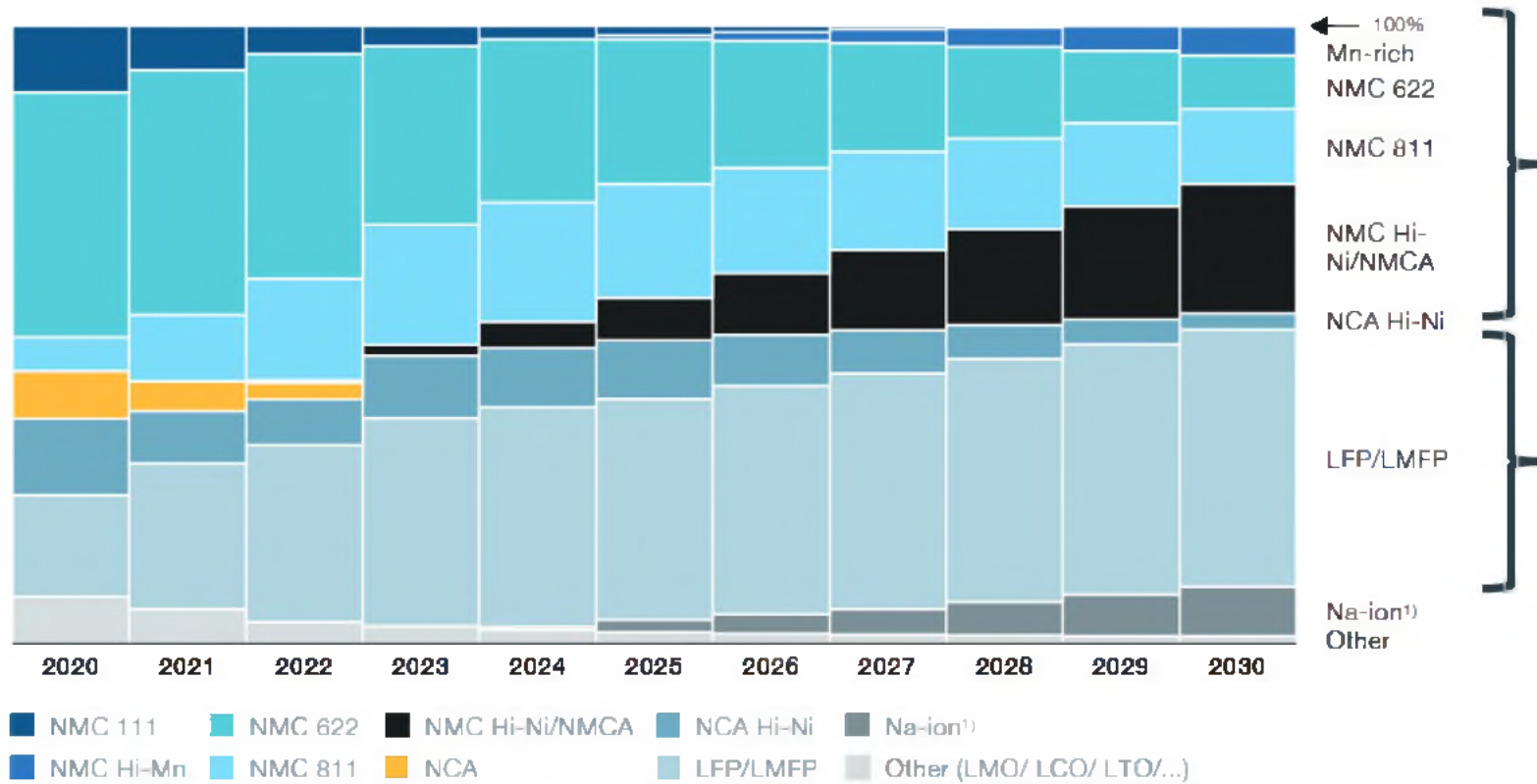
[Redacted]
[Redacted]
[Redacted]@leclanche.com
[Redacted]



Appendix



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



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

Battery cell demand by cathode chemistry, 2020-2030, base-case scenario [GWh/a]

Source: Batteriemonitor 2023 Roland Berger, RWTH Aachen, PEM

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.

Leclanché

Energy Storage Solutions

[Redacted]
[Redacted]
[Redacted]@leclanche.com
[Redacted]

[Redacted]
[Redacted]
[Redacted]@leclanche.com
[Redacted]



**STATIONARY
SOLUTIONS**



**e-TRANSPORT
SOLUTIONS**



**SPECIALTY BATTERY
SYSTEMS**