Journey of the molecule: from battery waste to paste

Dr Athan Fox, Technology Director

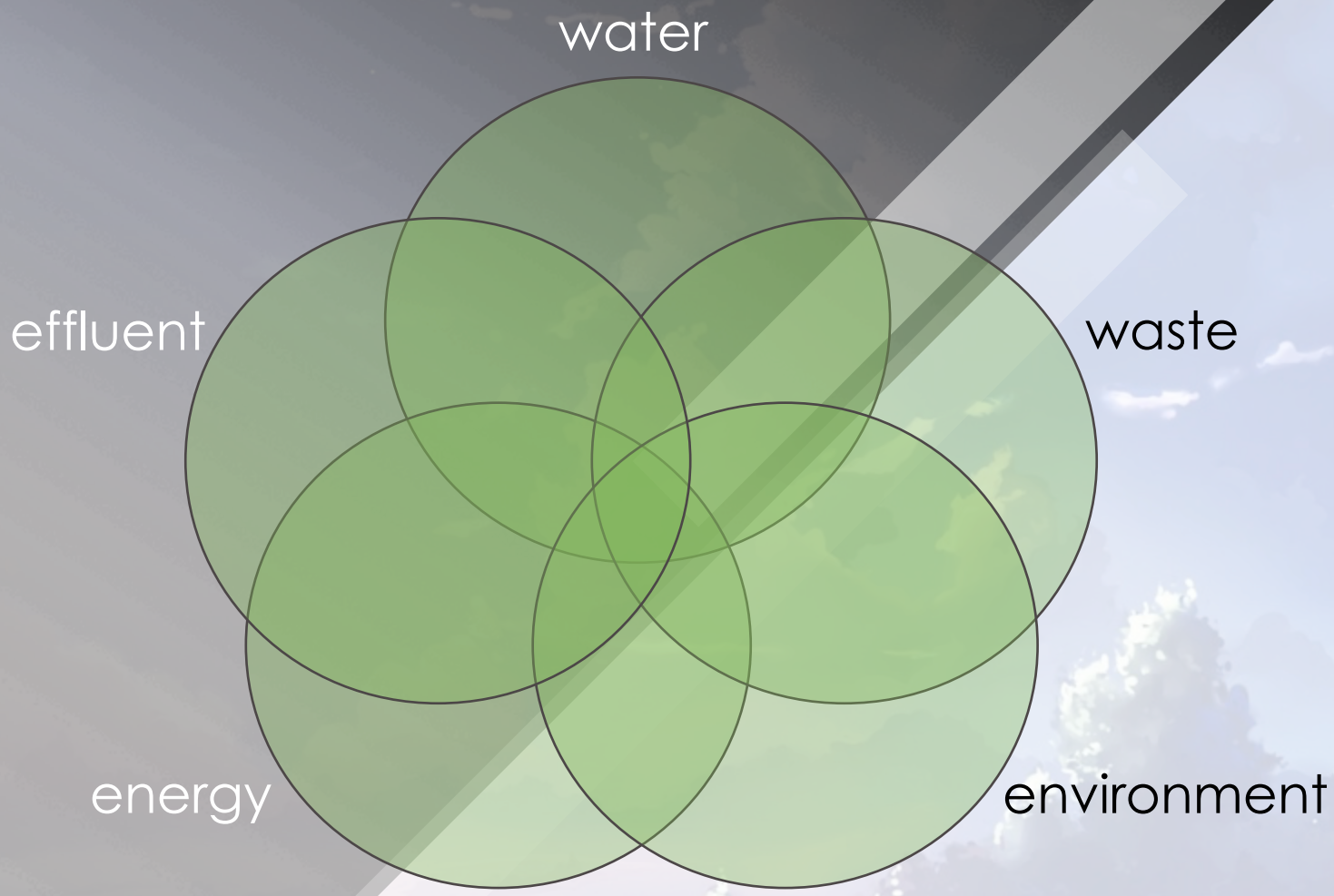
"where will the waste go?"

5th HVM New Materials 2019, 6-7 November Cambridge, UK
www.cir-strategy.com/events

Aurelius Environmental
Tipton DY4 9EZ, United Kingdom

aurelius environmental

The ‘Prodromos’ philosophy…



aurelius environmental

Lead Battery Market

- The lead battery market will reach $95b USD by 2026.
- More batteries on the road means an ever-increasing amount of battery waste.

- The lead battery is the **world's most successfully recycled commodity product**…
- but the lead recycling industry is also the world's most polluting industry!

Lead batteries are everywhere. But where will the waste go? And what about emerging technology threats?

There are more than 40 million tonnes of lead metal currently in circulation…

aurelius environmental

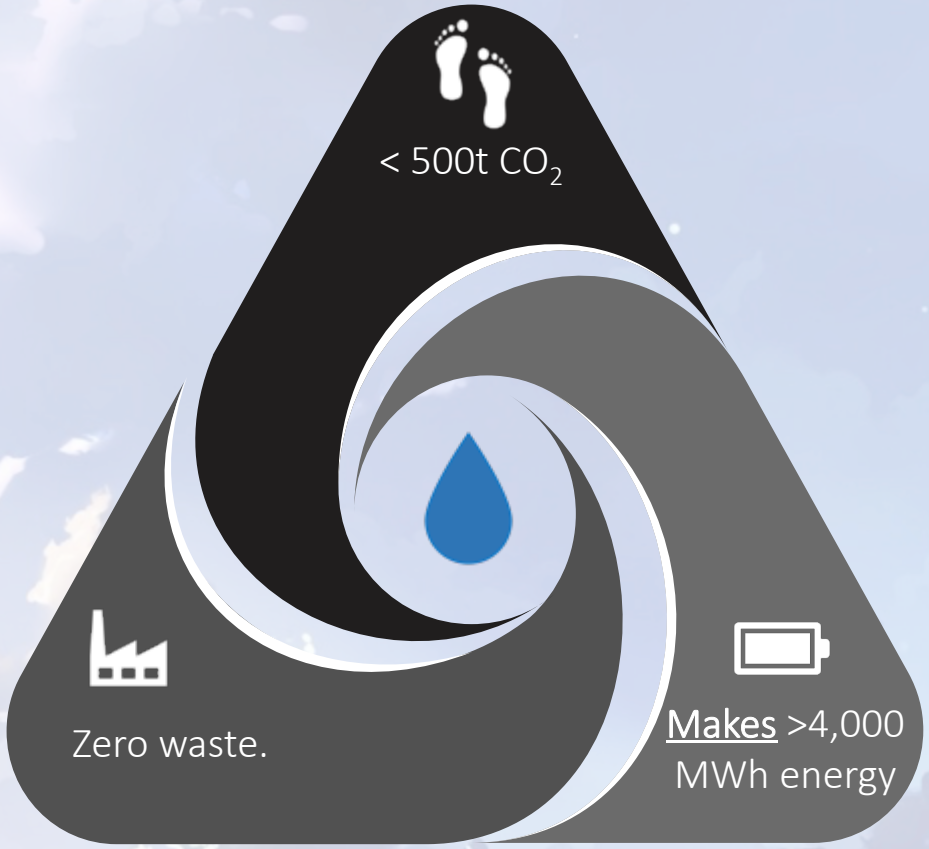
Innovation for Pb Recyclers: the Aurelius process…

Target the paste, using water **instead of fire**

What makes hydrometallurgy different:

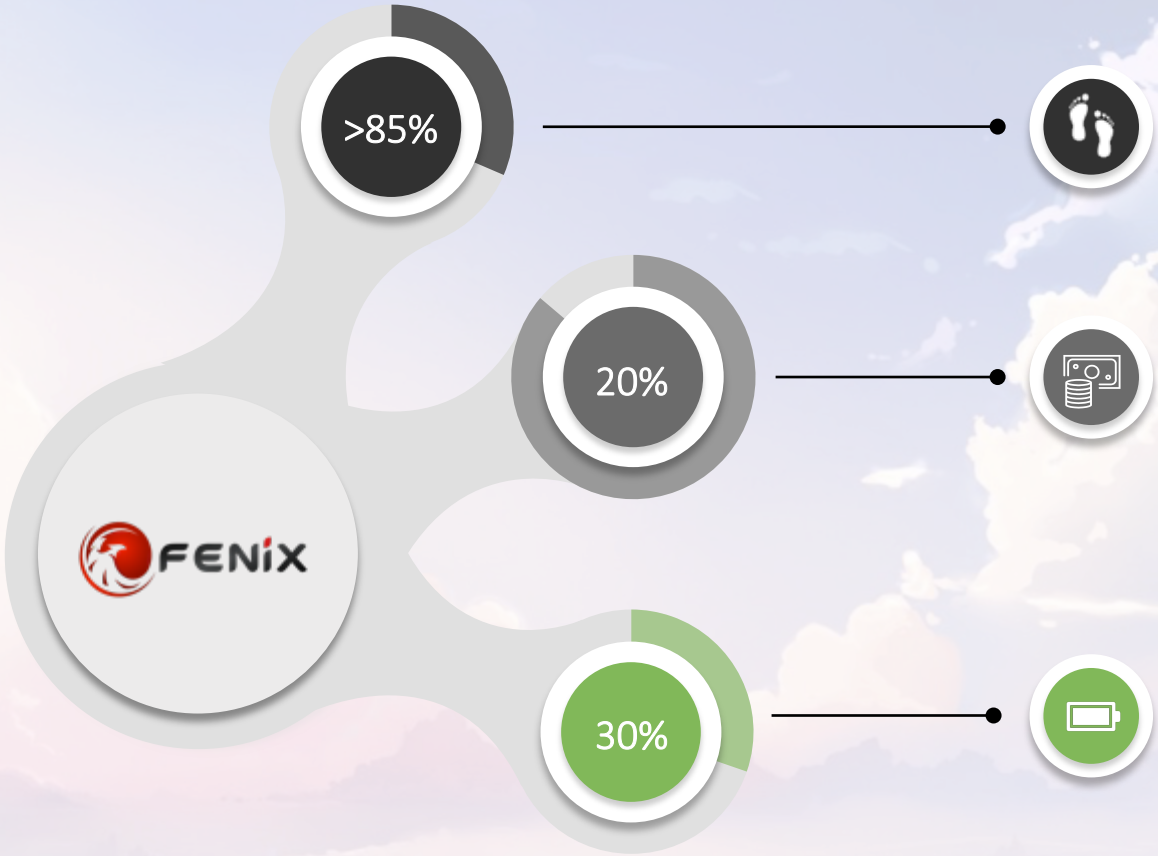
- Spent paste may be converted **directly** into 99.99% leady oxide (Pb/PbO) i.e. without downstream processing of lead ingot…
- Technology Readiness Level 7-8…

- **Zero emissions** – no SOx, no NOx
- **Carbon footprint** reduced by 85%
- **Zero waste**. Incumbent industry's slag cut by >90%.
- **Saves money** – PbO production **currently** $235 USD per tonne. CAPEX 1/7th compared to incumbent technology.



Metrics for 10,000 tonnes processed

Supply chain innovation



The Environment

- Carbon footprint reduced by 85%.
- Waste produced: 0.0%. SOx and NOx: 0.0%.

The Supply Chain

- Pb/PbO (99.99%) produced **directly** from waste.
- Pb/PbO production can be achieved at sub-$200 USD per tonne, with CAPEX reduced to 1/7th.

Battery Performance

- **Energy density increased by a factor of ~30%...**
- **…But why?**

aurelius environmental

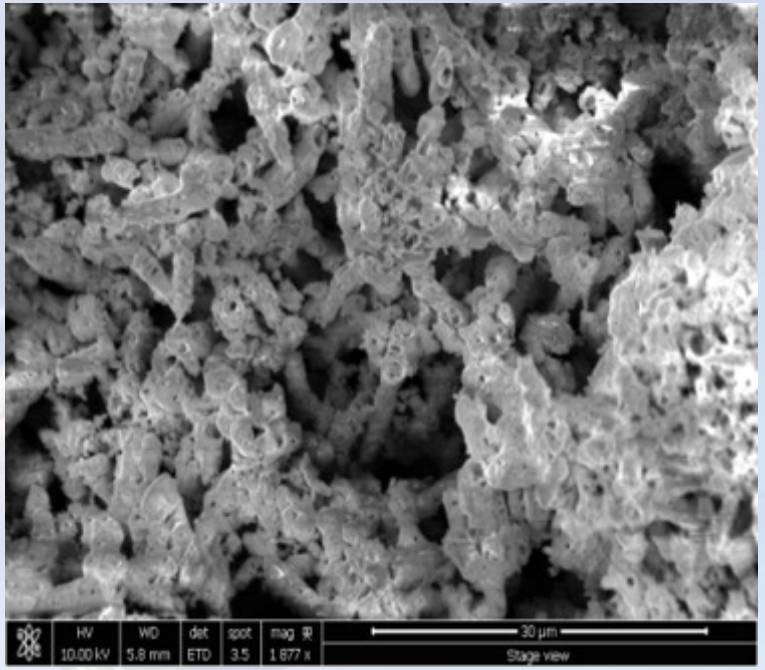
Nanostructured Leady Oxide

- Batteries produced from our PbO are enhanced.
- Cambridge University and Sofia University observed energy density increases of the order of 15 - 30%.
- This is because our lead oxide is **nanostructured**.

Did you know?

- The incumbent industry produces mostly α-PbO.
- But with our process it is possible to tune a- to β - ratio… however the process is not currently fine-tuned.

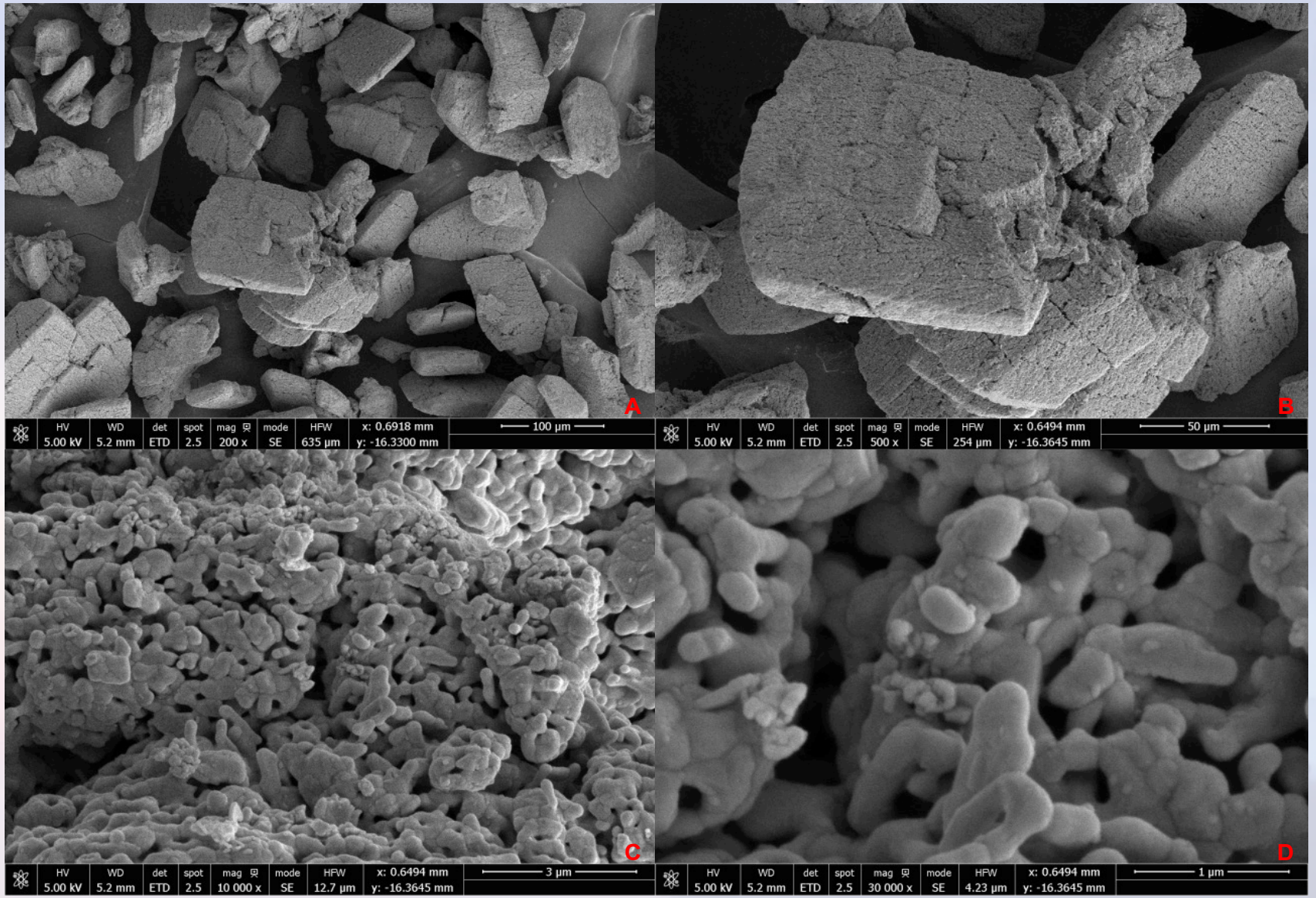
Better batteries from a cheaper, more environmentally sensible, low-energy recycling process.



Our lead oxide is nanostructured. It lends itself to superior electrochemistry.

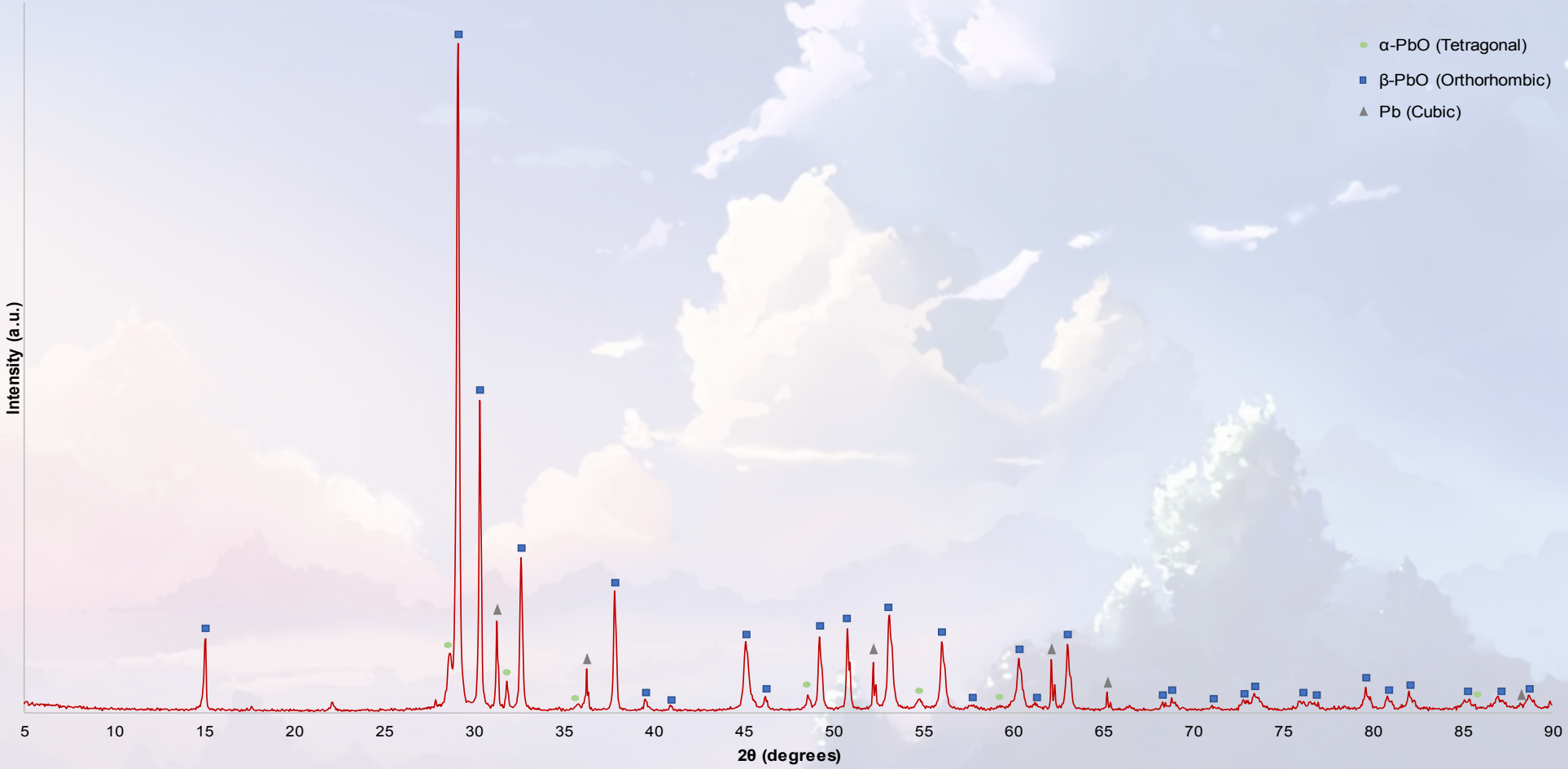
aurelius environmental

Alpha PbO, >95% (Pb 1-2%)



aurelius environmental

Beta PbO, >91% (Pb 1-2%)



aurelius environmental

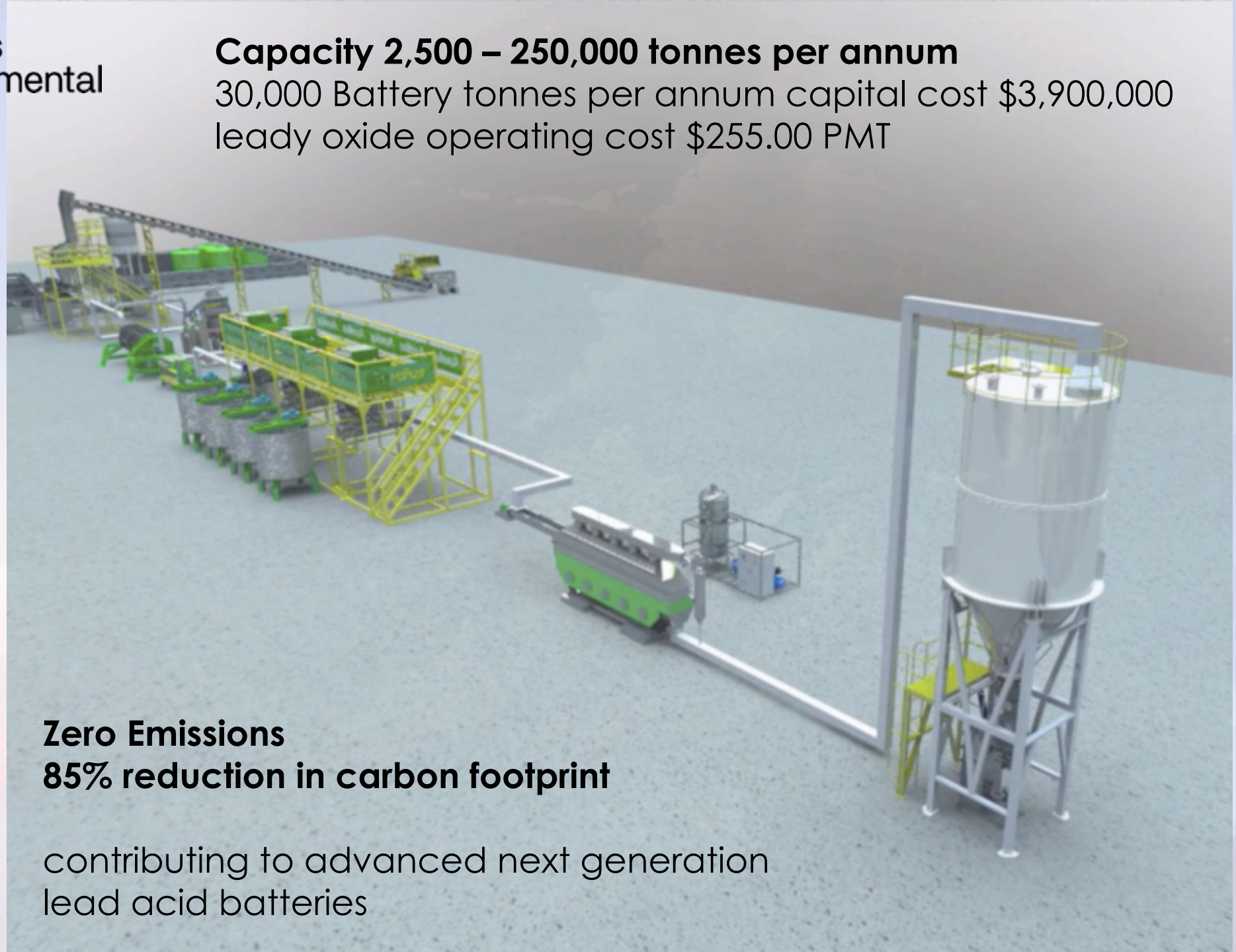
The Aurelius Plant

From waste…

…to paste!

aurelius environmental

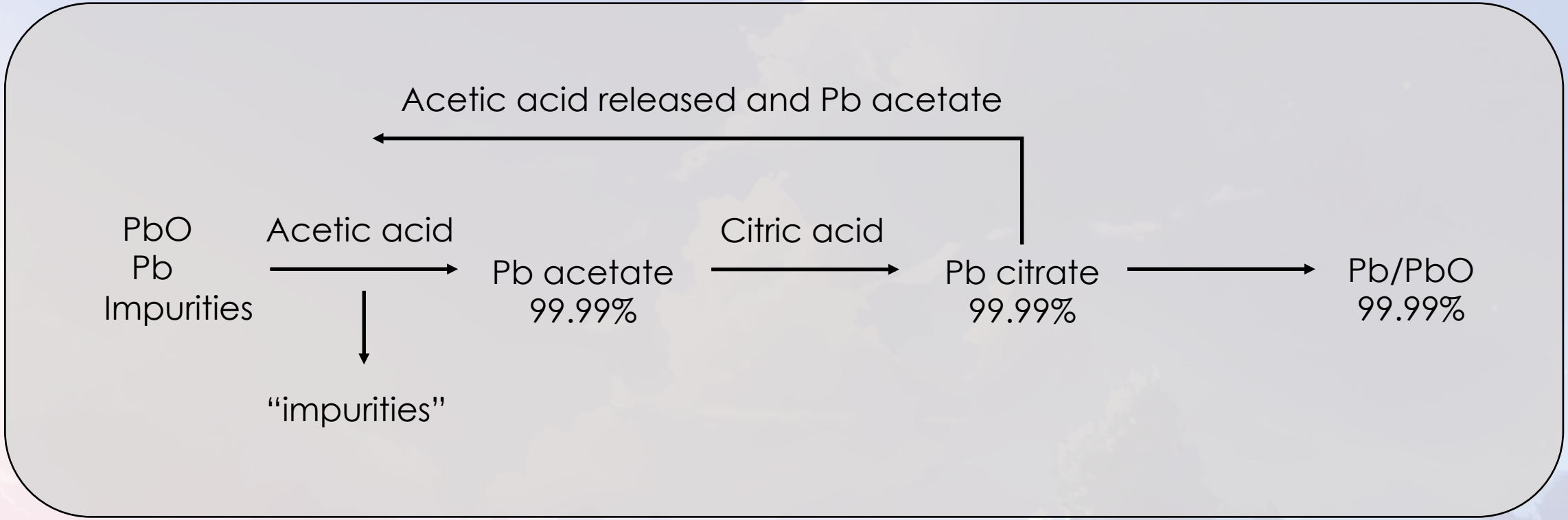
Capacity 2,500 – 250,000 tonnes per annum
30,000 Battery tonnes per annum capital cost $3,900,000
leady oxide operating cost $255.00 PMT



Zero Emissions
85% reduction in carbon footprint

contributing to advanced next generation lead acid batteries

Journey of the Pb molecule



aurelius environmental

Citric acid from waste?

aurelius environmental

Resource Value Recovered

aurelius environmental

The Aurelius Story

Our objectives: to catalyse a global recycling revolution
to bring about a world without waste

Technology start-up…

- Profitable from Year 1 (2015)
- Business entirely self-funded (no seed funding)
- Processing more than 10K tonnes of used lead batteries
- Secured grant-funding and sustainability awards

UNIVERSITY OF CAMBRIDGE

Rushlight Awards

AWARDS FOR EXCELLENCE 2018
Fork Lift Truck Association
finalist

European Commission

Horizon 2020
European Union funding
for Research & Innovation

We work with Innovate UK

EUREKA
innovation across borders

Thank you for your attention

Athan Fox, CTIO
a.fox@aureliusenviro.uk

aurelius environmental