



out of the furnace and into the leaching pot

Dr Athan Fox, Chief Technology and Innovation Officer

A photograph of a battery with a green top and a white body. The battery has several terminals on top, some marked with a plus sign. On the side of the battery, there is a logo consisting of a square with 'a' and a circle with 'e', followed by the text 'aurelius environmental'. A large green recycling symbol is also visible on the side of the battery. The background is a blurred industrial setting.

 aurelius
environmental

10th anniversary Cleanpower Smart Grids
Conference 2019

www.cir-strategy.com/events

Aurelius Environmental

St Georges Works, Bradleys Ln
Tipton DY4 9EZ, United Kingdom

The Aurelius Story

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

Not a typical start-up...

- Profitable in Year 1 (over 100,000 Euro).
- Business entirely self-funded (no seed funding).
- Exceeded 10M turnover by Year 4.
- Secured grant-funding and sustainability awards.



Horizon 2020
European Union funding
for Research & Innovation

We work with
Innovate UK

Our market

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

Did you know?

- The world's most successfully recycled commodity product... and simultaneously the **world's most polluting industry!**

Lead batteries are everywhere. Where will the waste go?



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

The Incumbent Industry

- Lead batteries are recycled by smelting (pyrometallurgy).
- Smelting converts waste battery paste into lead ingot.
- The ingot is used to manufacture lead oxide, PbO.

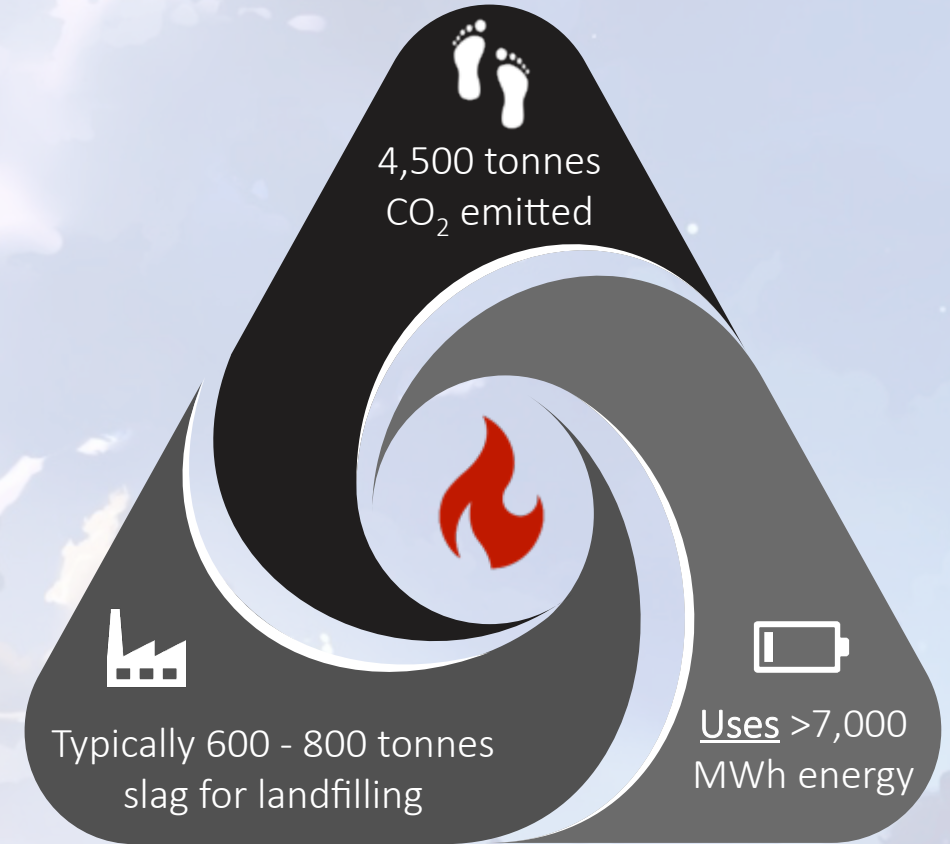
Lead smelting is energy intensive

1,100°C to process

High impact

carbon footprint, SO_x, NO_x and lead particles.

Although the majority of pollutants are caught (at a cost), the process produces slag, which is typically landfilled.



Metrics for every 10,000 tonnes processed... but global capacity is 16 – 18 million tonnes!

The Aurelius way

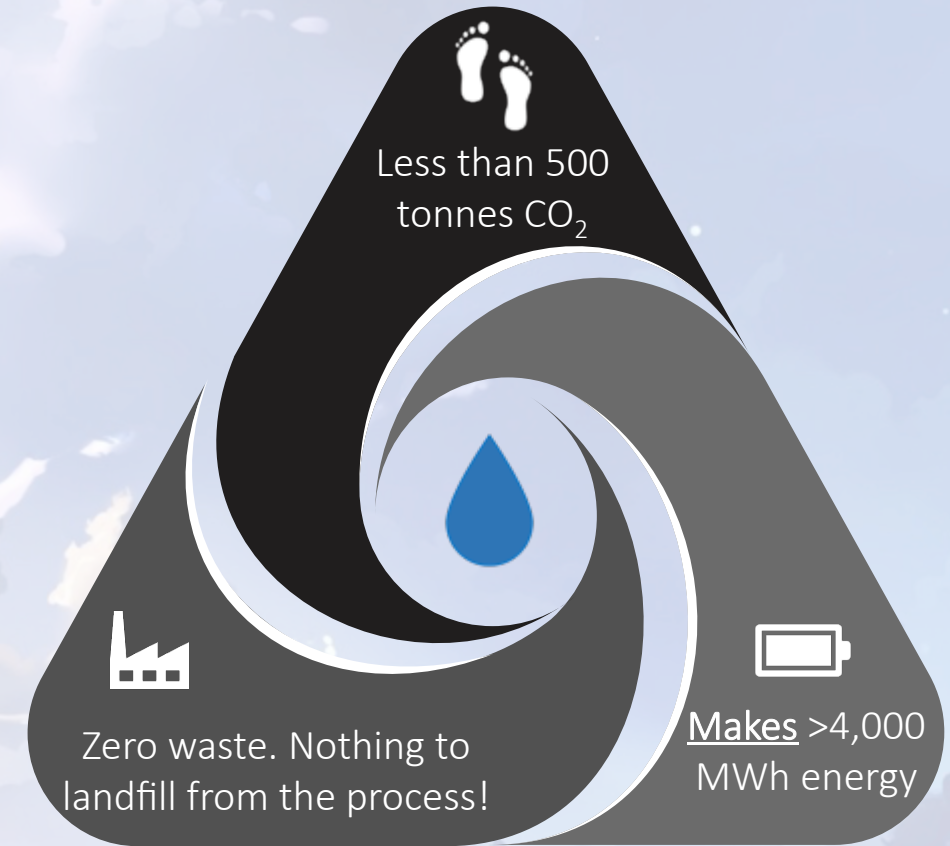
Our process is using water  instead of fire 

What makes us different:

- Spent paste converted **directly** into PbO (we cut out the step where lead ingot is produced & converted into PbO).
- We do not consume energy. In fact, we release energy...

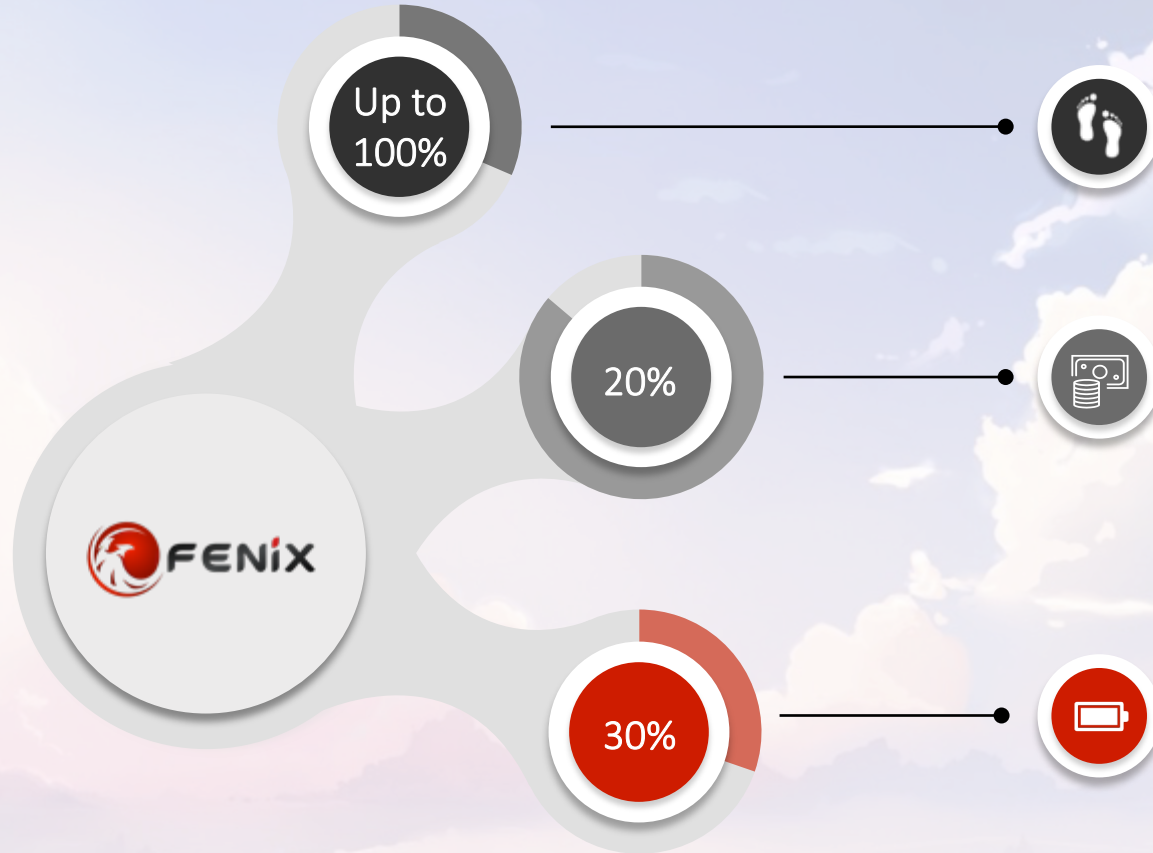
The benefits:

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



Metrics for every 10,000 tonnes processed...

Value Proposition Summary



The Environment

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

The Supply Chain

- PbO produced **directly** from waste.
- 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???**

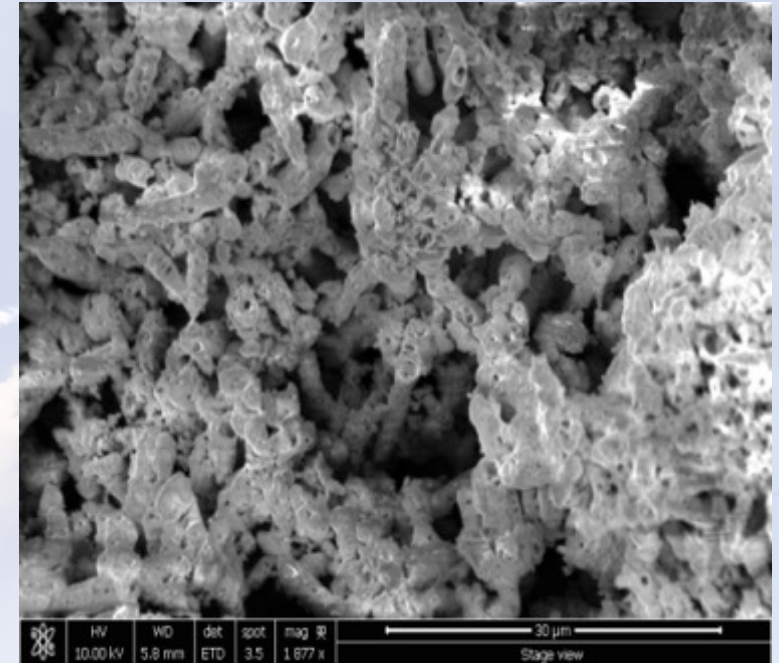
The Icing on the Cake

- Batteries produced from our PbO are enhanced.
 - Cambridge University observed energy density increases of the order of 30% and improved cycling.
 - This is because our lead oxide is **nanostuctured**.
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Did you know?

- The incumbent industry produces mostly α -PbO.
 - But with our process it is possible to tune α - to β - ratio.
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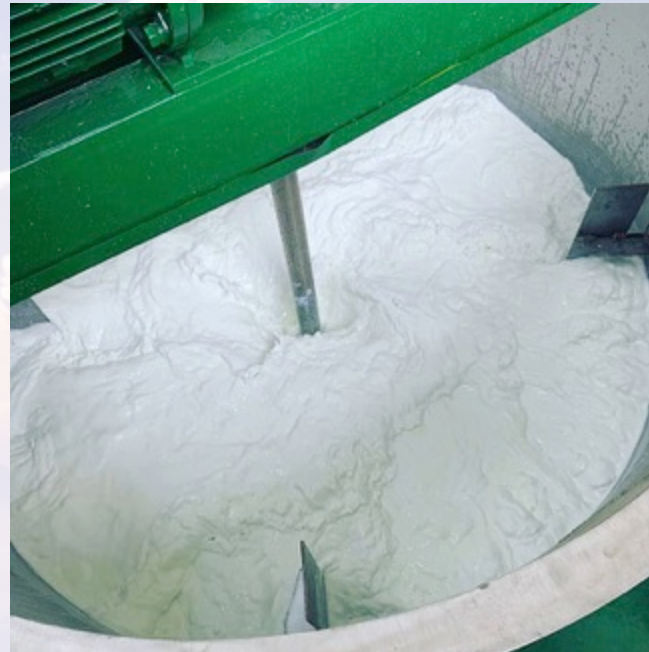
Better batteries from a cheaper, more environmentally sensible, low-energy recycling process.



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

The Aurelius Plant

- Due to be commercialised in 2019 (Q3).
- We collect and process >10,000 tonnes of battery scrap per year.
- We also supply battery processing technology (for example desulphurisation), fully developed in-house.



From waste...



...to paste!

The Process in a Nutshell

STEP 1: Drain batteries

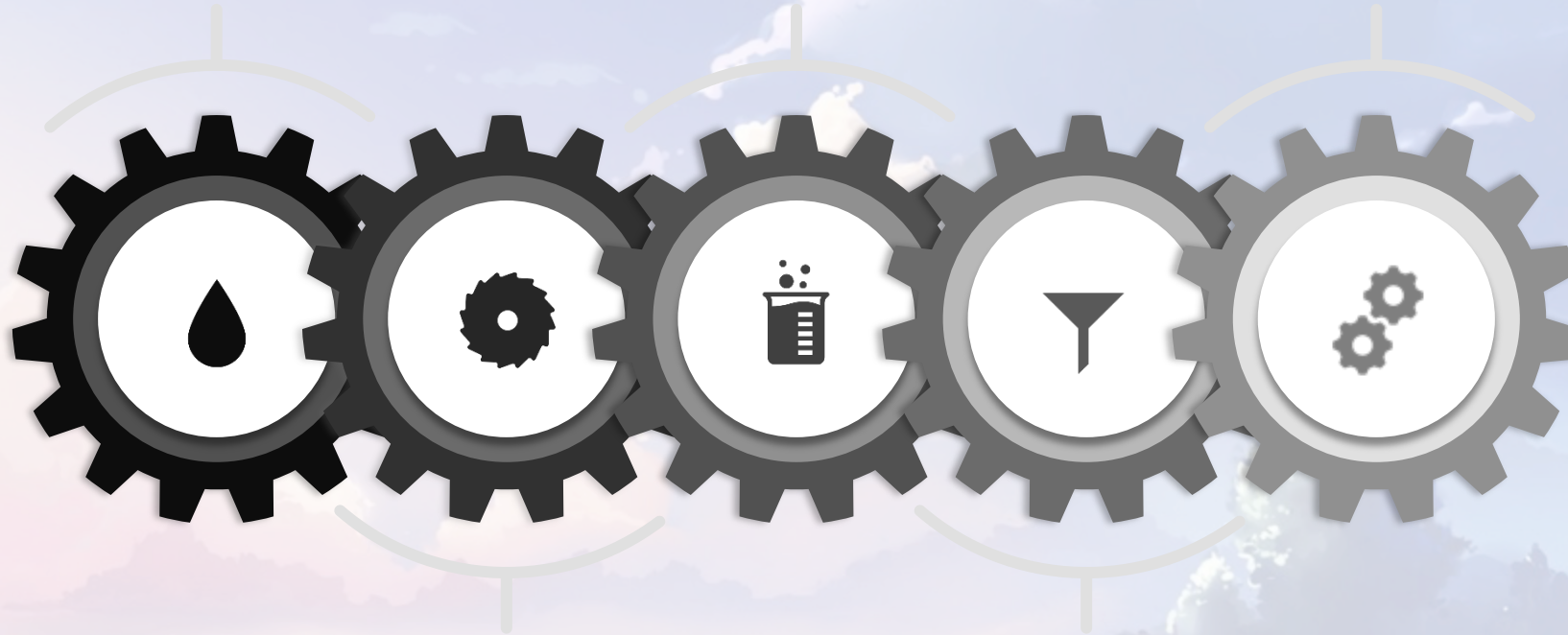
Remove waste acid. Convert to Na_2SO_4 or $(\text{NH}_4)_2\text{SO}_4$.

STEP 3: Leaching

PbSO_4 and other Pb salts are converted to lead citrate.

STEP 5: Calcination

Nano-crystalline Pb/PbO produced. %Pb and $\alpha:\beta$ ratio controlled.



STEP 2: Crush and Separate

Component parts removed (plastic, plates, grids and paste).

STEP 4: Filtration

Lead citrate is removed and trace metal impurities are eliminated.

Step 5 (Calcination) in Action



Our Journey





CEO
Miles Freeman



Managing Director
Johdie Harris



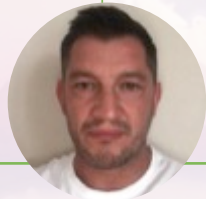
CTIO
Dr Athan Fox



Finance Director
Chris Hulland



Engineering Director
Steve Andrew



Operations Director
Spencer Lowe



Technology Associate
Dr Peter Knight



Academic Partner (Cambridge)
Prof Vasant Kumar



3 Post-Docs and 1 Aurelius engineer working on our projects at Cambridge University

Thank you for your attention

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