



READY TO USE CATHODE RuC[®]

General presentation

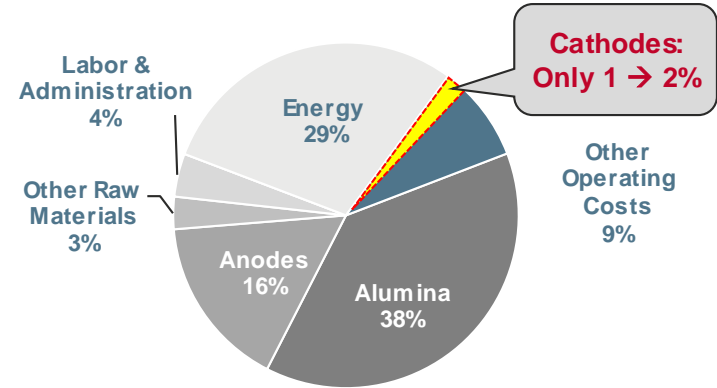
Oscar A. Vera Garcia
Wiesbaden, January 22nd, 2020

The aluminium production is a complex and expensive process

Industry statistics

- Aluminium Production cost¹: [\$1 250 , \$2 200] /t Al
- Electricity contribution: [\$360 , \$640] /t Al
- Rodding costs²: [\$1 100 , \$2 000] /block

Aluminum Smelting Costs Q1 - 2019¹



- Cathodes have small cost but high impact on energy consumption

How can Tokai COBEX help you increase your operational margin ?

¹ Supplied by Harbor Aluminum
² Include steel bar and rodding process

Towards the next generation of cathodic solutions

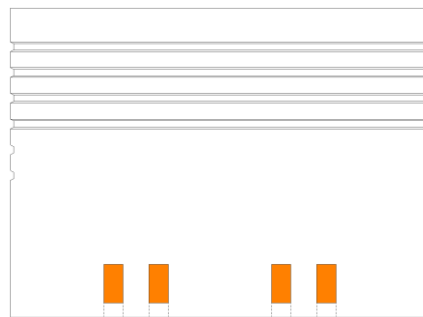
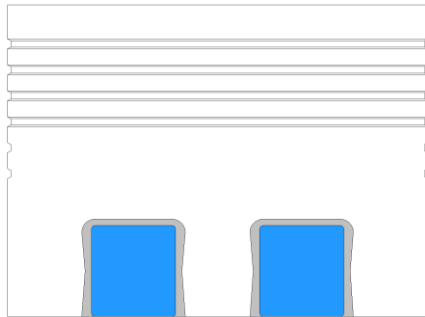
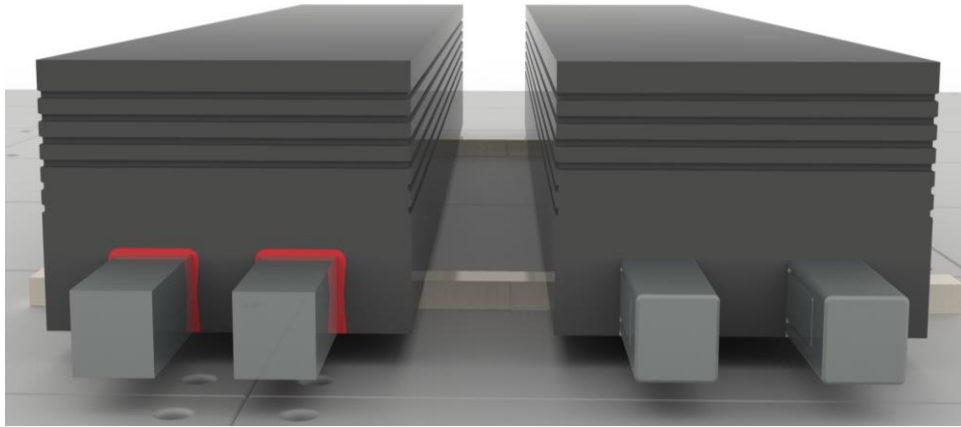
- In February 2016, Tokai COBEX & Novalum started an exclusive collaboration agreement for the next generation cathodic solution.
- The Ready to use Cathode (RuC®) solution is protected by a patent application filed on May 2015 (PCT/IB2015/054325).

**Cathodic solution without rodding
+
cost saving & productivity benefits**



Towards the next generation of cathodic solutions

Example



Conventional cathode design compared to RuC[®] solution:

- Same cathode dimensions
- Same external machining
- Same cross section of end of steel bar
- Same end connection to flexibles



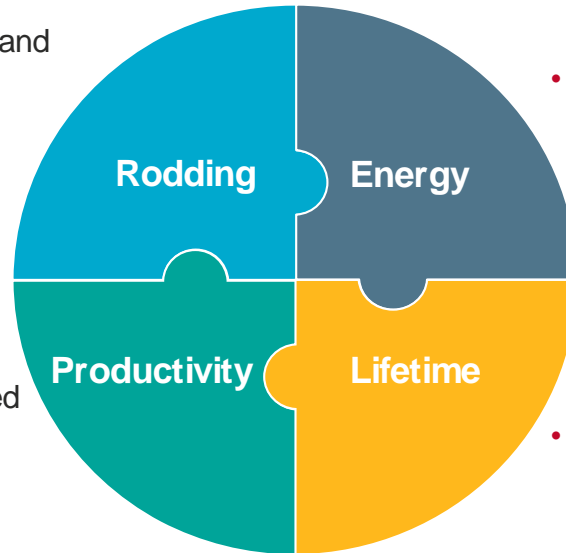
Same cathode assembly design!

RuC[®] will increase your operational margin

Fields of Improvement

- Rodding Elimination
- Significantly reduced health and safety risks
- Installation & connection unaffected
- Increased consistency of cathodic assembly

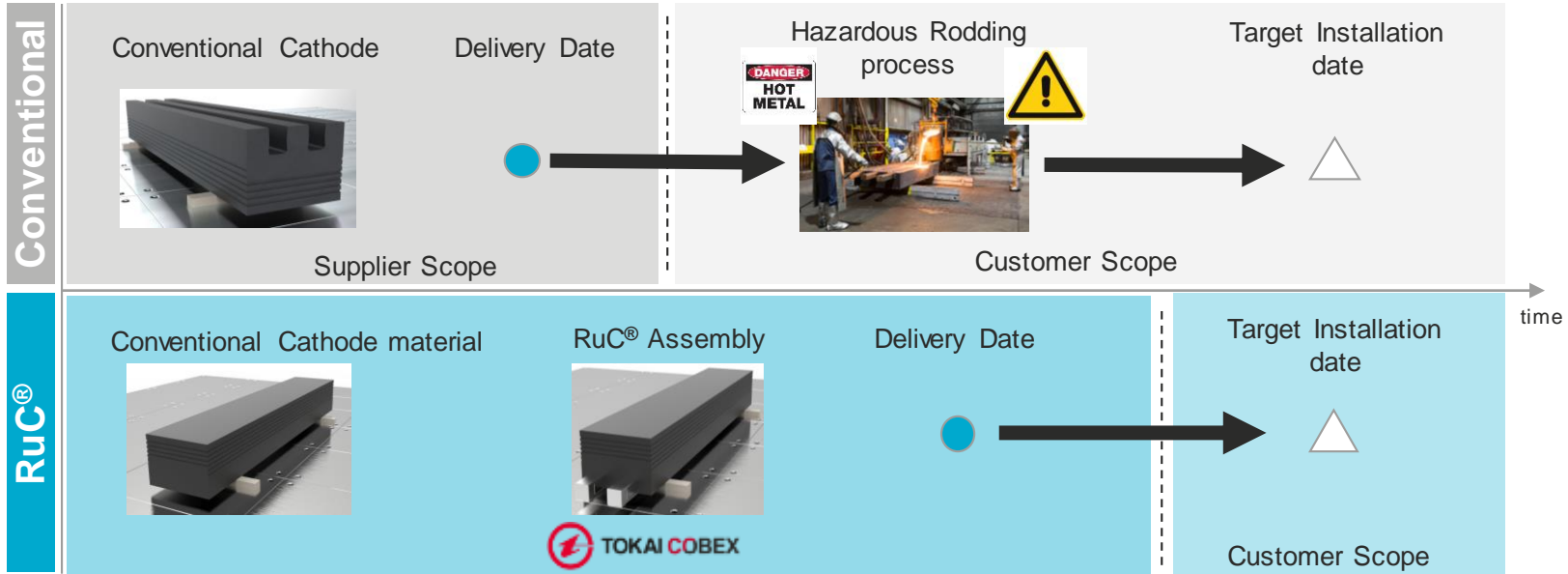
- Improved current density distribution enabling improved Current Efficiency (CE)
- Increased production



- Reduced Specific Energy Consumption (SEC)
- Reduced cathodic resistance whilst maintaining thermal balance

- Additional cathode material and more even current density distribution extend pot life

Rodding and Installation



No Customer rodding! Customer's rodding risks eliminated.

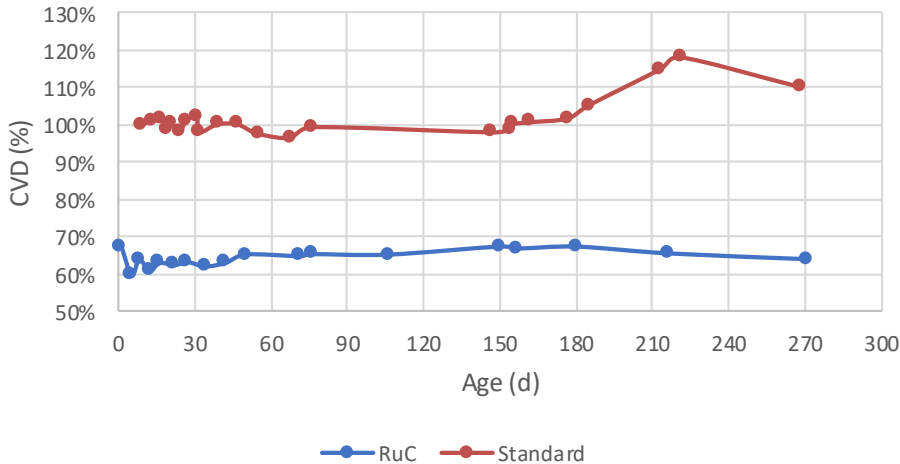
Significant improvement in time from Delivery to Installation.



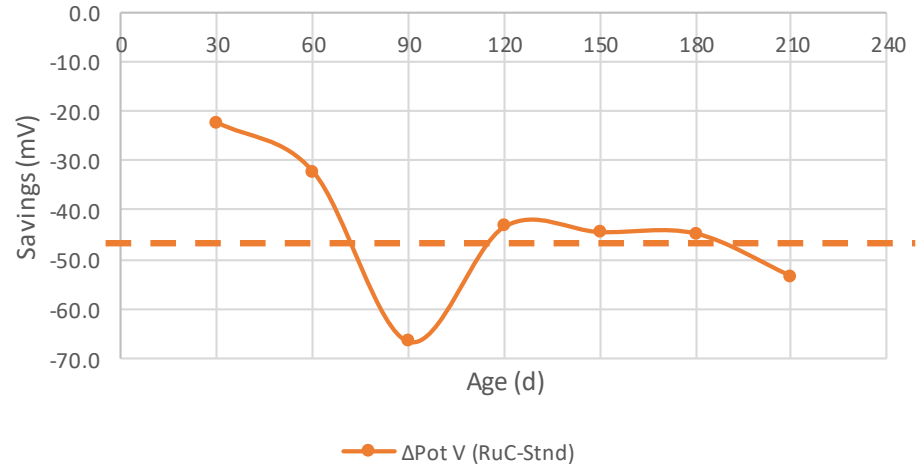
CVD and Pot voltage measurements

- Example 3: 3.57 kA/bar, 36% CVD savings, average of 48 mV saved in the pot voltage after stabilization

CVD comparison



Δ Pot Voltage savings



Reduced CVD and Pot Voltage → Lower Energy Consumption



Estimated extra 2 - 3 years lifetime

- More even current density distribution at the cathode working surface
 - Less localised erosion
 - Lower average wear rate

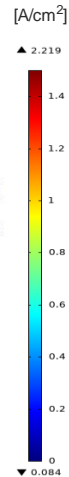
Standard cathode top view



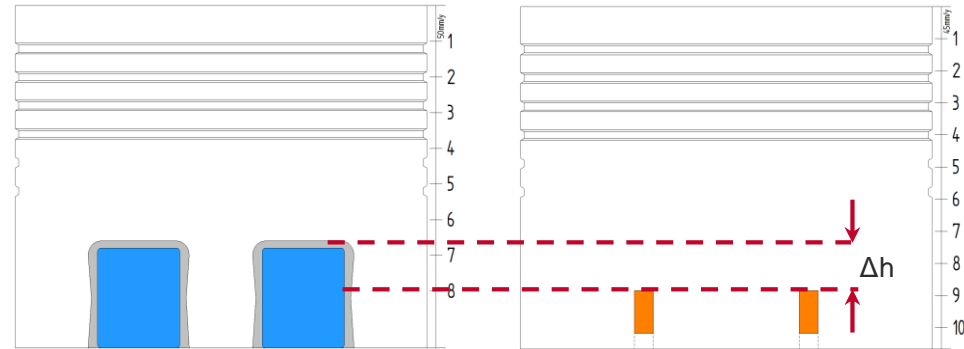
RuC® solution top view



Modelling comparison of current density distribution



- Additional cathode material between aluminium and collector bar
 - Leading to improved usage cycle



Cross section showing differences in Collector bar dimensions

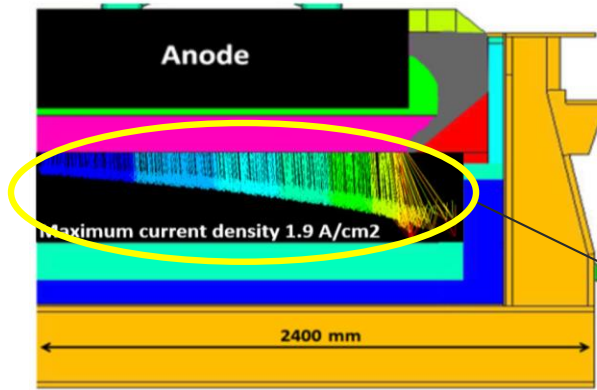
Δh : additional cathode material → extended lifetime!

Fewer linings gives a reduced average annual lining cost

Productivity – Estimated Benefit example



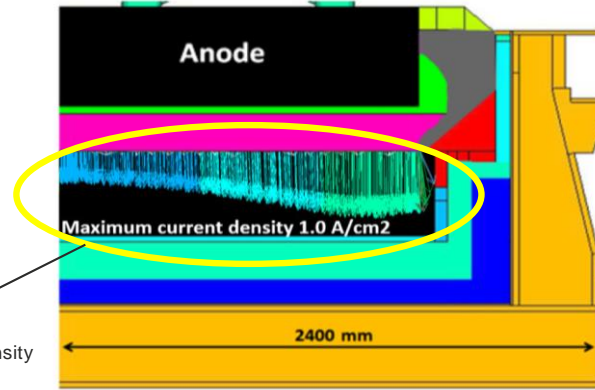
Conventional cathodic solution



max. 1,9 A/cm²

- Conventional current density distribution:
 - Standard Current Efficiency (CE)
- Limited current creep

RuC[®] solution



max. 1,0 A/cm² (-45 %)

- Better current density distribution
 - Potential Current Efficiency (CE) improvement (0,5 – 1 %)
- Enables current creep

Modelling shows current density distribution vectors

Higher Current Efficiency (CE) → Additional metal production



Rodding	Energy	Lifetime	Productivity
Full Rodding avoidance	20-150 mV Pot voltage reduction	Additional lifetime: estimated 2-4 years	+0,5% up to +1% CE Improvement
Significantly reduced Health and Safety risk	25 – 55 \$/mt Al cost saving in production process	High Cu recycling value >80% of Cu-LME	Additional metal output
Plug & Play solution	Specific CO ₂ reduction		Potential current creep ~10%

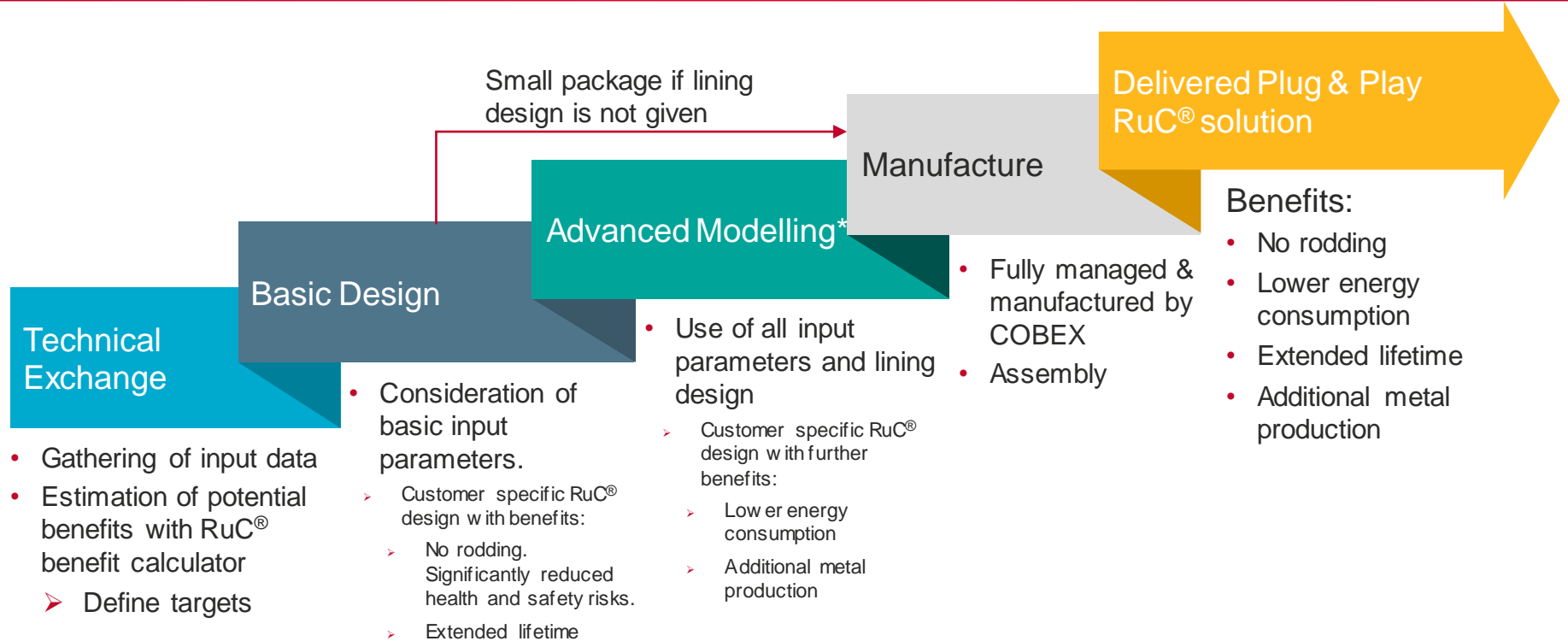
Value creation

- Overall SEC reduced by [100, 600] kWh/t Al
- Range \$6 000 - \$15 000 of additional value per cathode block over lifetime*

* Estimated benefit based on Tokai COBEX cost assumptions of Al production, specifically; energy, alumina & Al LME price. Current creep not considered

Customer Specific Solutions

Typical RuC[®] project



* Advanced modelling requires additional information from customer and a detailed thermo-electrical analysis of lining design

Overview of RuC[®] worldwide

Status January 2020

- RuC[®] projects already in operation for a wide range of technologies (Söderberg, AP, GAMI, Alusuisse, Kaiser, NEUI, VAW) and line currents (110 kA, 180 kA, 220 kA, 330 kA, 400 kA and coming soon 600 kA).
- >500 RuC[®] blocks delivered to 9 customers.
- Intermediate autopsy after 1.6 years confirmed the robustness of the design and the good energy performance.
- Measured SEC savings up to 400 kWh/t, CVD savings up to 100 mV.
- Oldest RuC[®]-G1 cell: 3.5 years.

Thank you for your attention!

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