

The background of the slide is a photograph of an industrial facility, likely a nickel refinery, during sunset. The sky is a deep orange-red, and the sun is low on the horizon, creating a strong silhouette effect. In the foreground, two workers wearing hard hats and safety gear are looking towards the right. The industrial structures in the background consist of various pipes, walkways, and large pieces of machinery.

# BHP

## Nickel West – Energising our future

Transitioning to a global battery material supplier

助力未来- BHP Nickel West 致力于成为具有全球影响力的电池材料供应商

Eduard Haegel, Asset President Nickel West  
Battery Materials Conference, Shanghai  
18 April 2018

Kwinana Nickel Refinery  
Western Australia

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**Eduard Haegel: Asset President – Nickel West**

**18 April 2018**

# Nickel West – who are we?

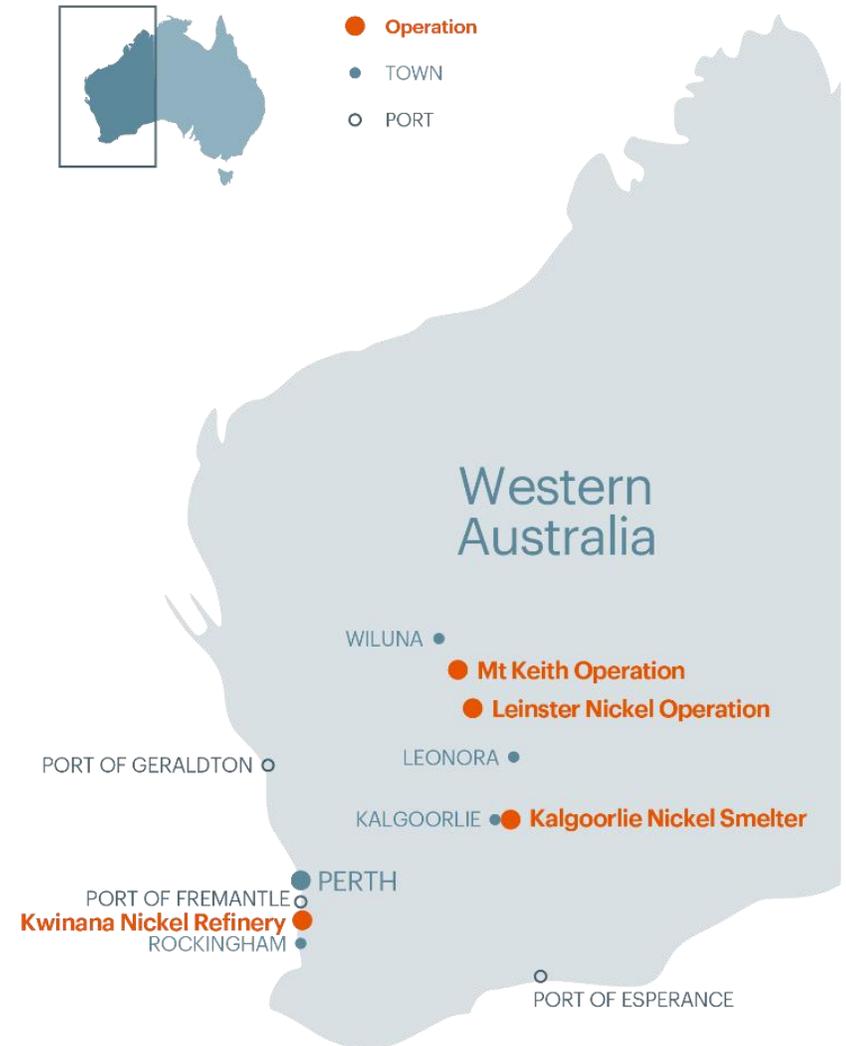
Nickel West is a fully integrated mine to metal producer of Class 1 refined nickel metal.

For almost 50 years, Nickel West has supplied our nickel products to the stainless steel sector.

An internal strategic review identified that Nickel West was uniquely positioned to support the battery market.

This has led to an increase in downstream processing including the planned production of nickel sulphate.

We are aspiring to become a globally significant battery material supplier and looking to grow our cobalt opportunities.



# Electric vehicle sales are growing rapidly ...

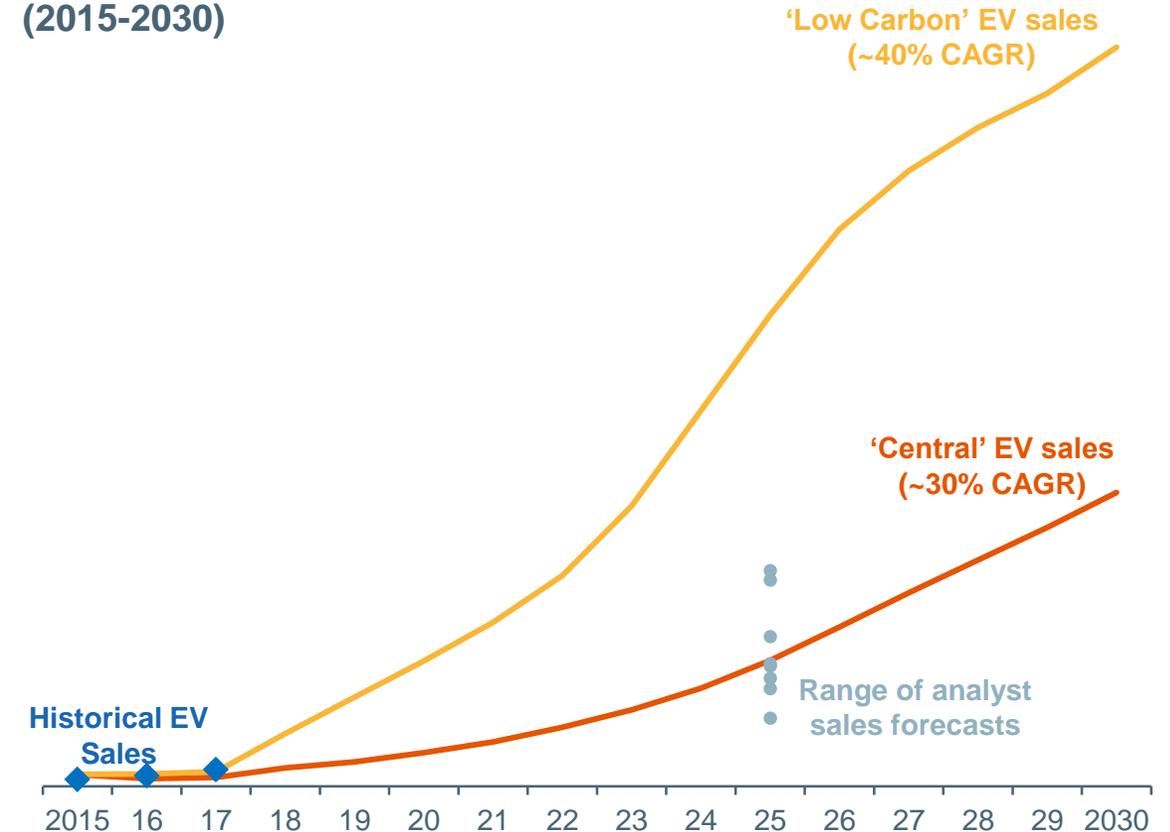
## Global commitments to transition from ICE gathering pace

- >100 of new EV models to be available by the early 2020s
- More countries introduce targets to support EV sales
- We forecast global EV sales to grow at ~30% CAGR by 2030
- With upside of ~40% CAGR captured in 'Low Carbon' scenario

## Key Announcements by Companies

<b>Volvo</b>	Sell only hybrids and EVs from 2019
<b>Daimler</b>	Offer electrified versions of all models by 2022
<b>Ford</b>	Release 40 electrified models by 2020
<b>GM</b>	Release 20 all-electric models by 2023
<b>VW</b>	Introduce 50 new all-electric models by 2025

## Global EV annual sales (2015-2030)



Source: BHP analysis. Analyst forecast to 2025 includes UBS; BoAML; IDTechEx; Liberum; Woodmac; BNEF; Navigant and IHS.

# ...with China leading the way

**Chinese EV production capacity has almost increased fivefold in three years**

**China is clearly now the front runner in EVs production:**

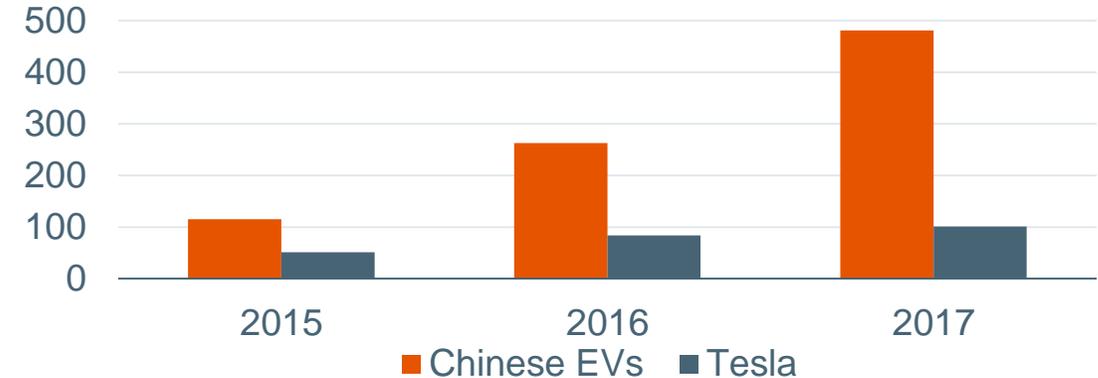
- Supportive policy environment
  - Tax rebate for EVs extended until the end of 2020
  - Subsidy program updated to incentivize longer range EVs
- Strong push towards further electrification of transport

## Top EV producers

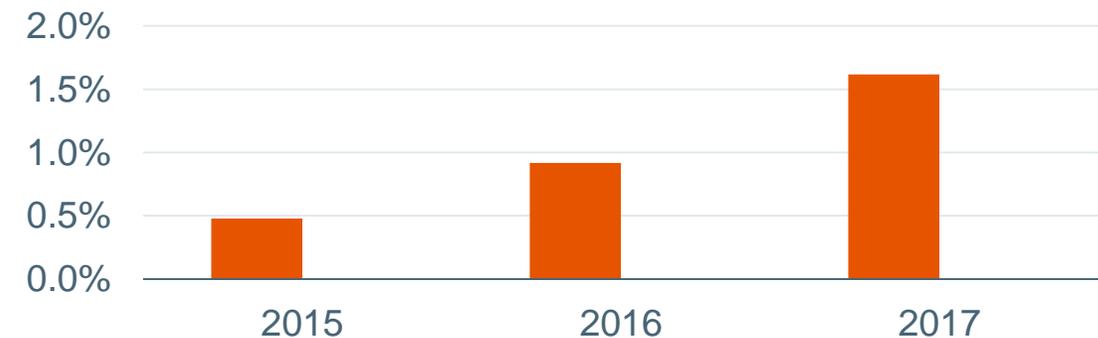
Pos.	Automaker	2017 Mkt. Share	2017 Sales
1st	BYD (China)	10.0%	~109K
2nd	BAIC (China)	9.5%	~104K
3rd	Tesla (USA)	9.1%	~103K

Source: Bloomberg New Energy Finance

**Electric Vehicles production**  
(‘000 units)



**Share of Electric Vehicles in Chinese auto output**  
(%)



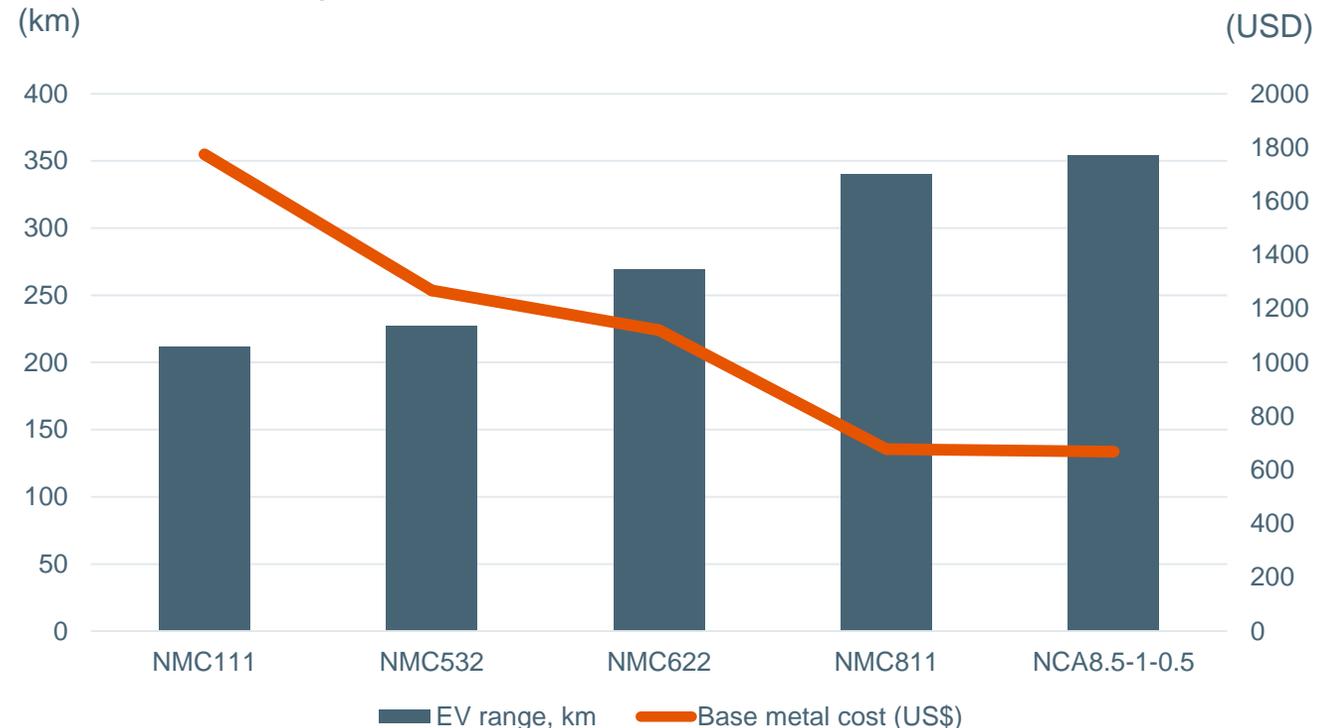
Source: Bloomberg, Company reports

# Together with the adoption of nickel rich chemistries, nickel demand is expected to grow significantly ...

## Lithium-ion nickel-rich chemistries offer the lowest cost battery solution:

- Majority of EV battery producers are adopting Nickel-rich chemistries
- The transition to Nickel-rich chemistries is accelerating
- Highest possible Nickel content has not yet been determined
  - 90% Nickel batteries announced by Samsung
- Nickel-rich batteries (higher intensity NMCs and NCAs) are preferred due to their:
  - superior energy density
  - increased vehicle range
  - lower metal cost.

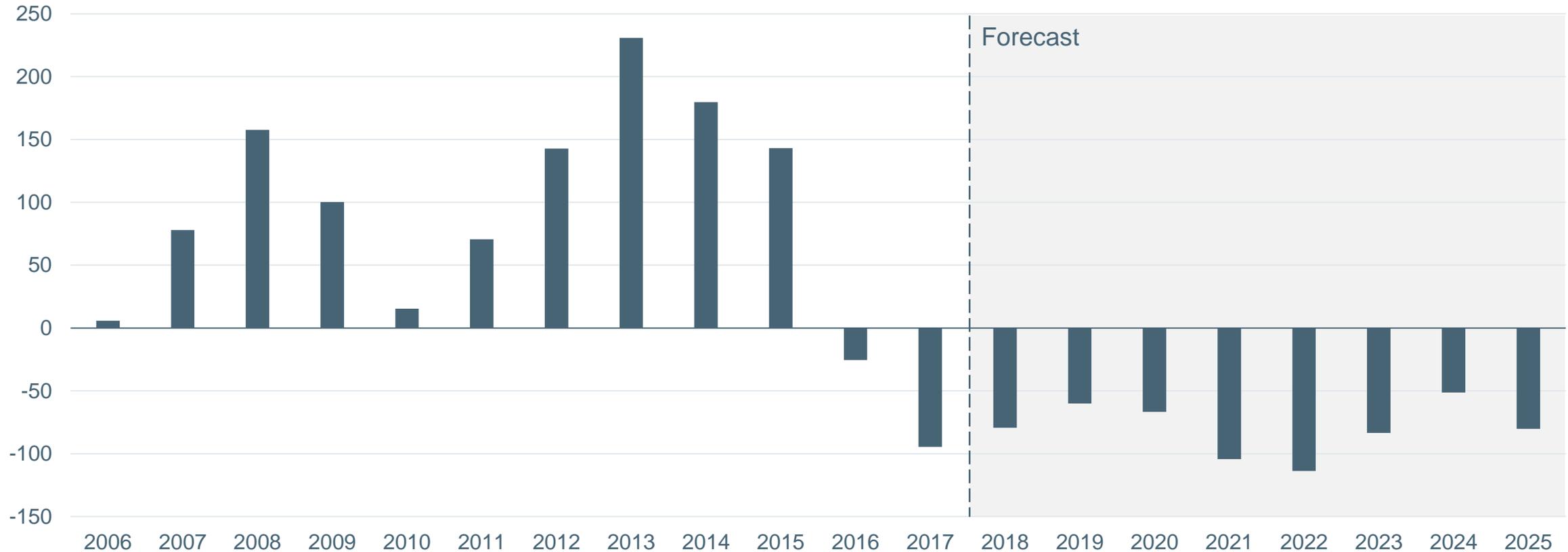
Li-ion batteries: Comparison of EV range and base metal cost using Tesla Model 3 NCA 8.5-1-0.5 battery as reference



EV range for same EV pack weight as Tesla 3  
Base Metal cost for same kWh as Tesla 3 at October 2017 prices.  
Source: Golden Road Inc

# ... just as some observers argue we have entered a prolonged period of undersupply

## Refined Nickel Market Balance (kt)



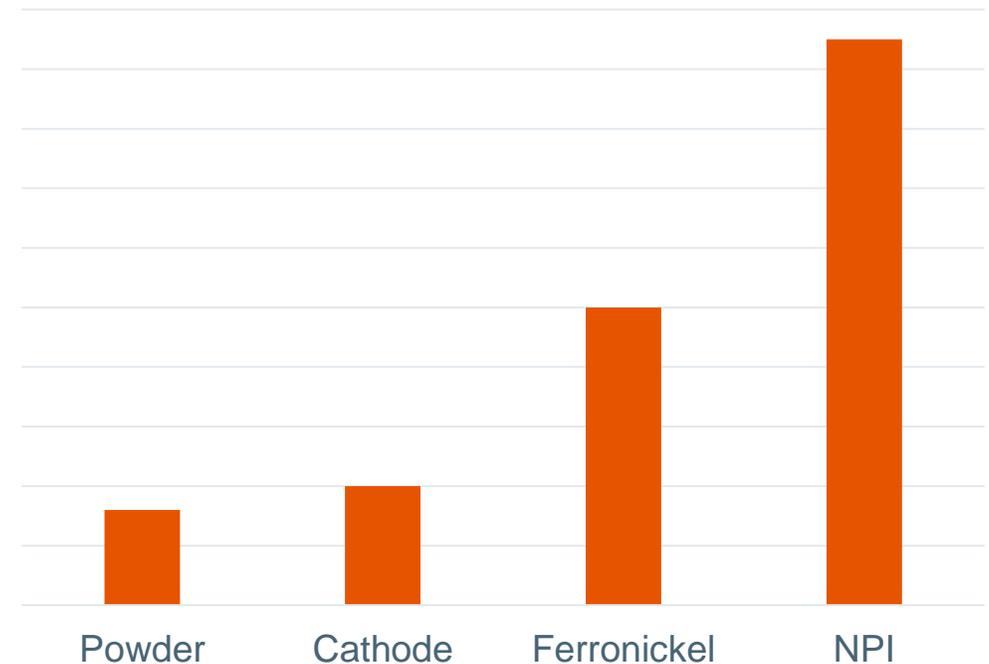
Source: Wood Mackenzie, 2018Q1 Nickel forecast

# This supply gap requires investment in Class 1 refined powder / briquette capacity

## Nickel powder and briquettes are the most cost effective source for nickel sulphate

- Half of the global nickel supply (1000kt) is derived from Ferronickel and Nickel Pig Iron (NPI) from which it is prohibitively expensive to remove iron and impurities
- Nickel cathode (600kt) is slow to dissolve and the use of solvent extraction separation from electrowinning liquor is expensive
- A large scale expansion of High Pressure Acid Leach (HPAL) will require higher inducement prices
- Nickel Sulphate production from the dissolution of refined nickel powder and briquettes (350kt) is more attractive.

Relative nickel sulphate conversion costs by major source type (including capital costs) per tonne of Ni metal



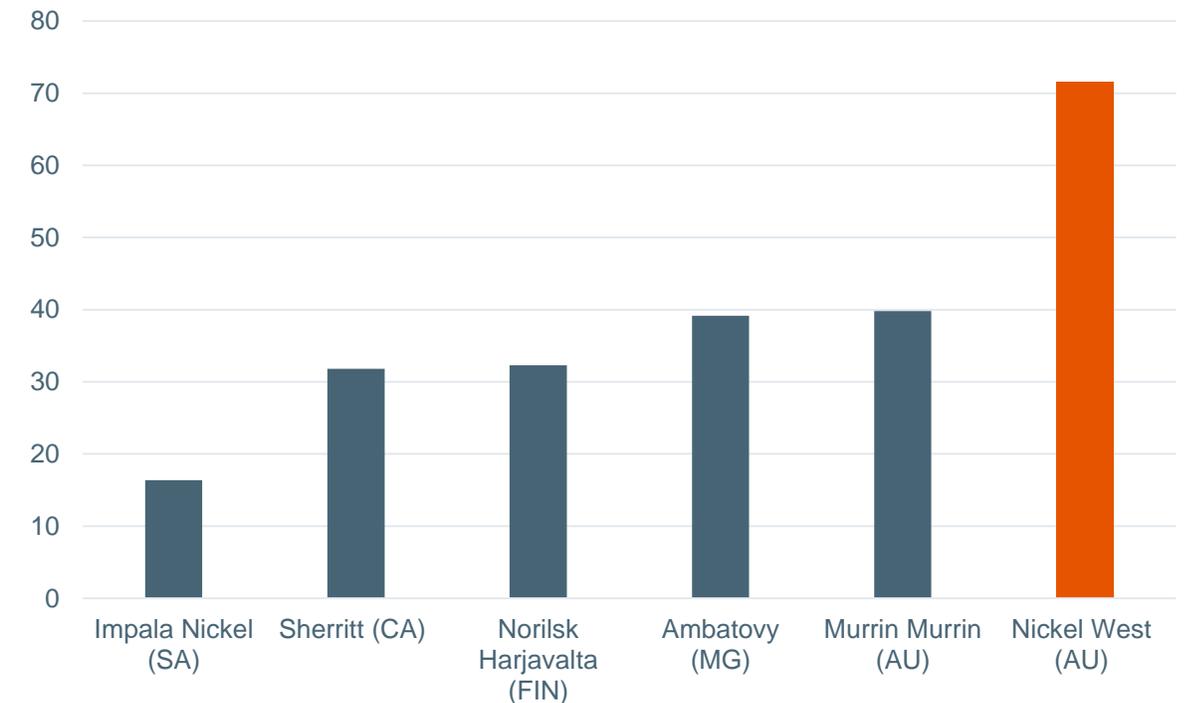
NOTE: Illustrative only, not to scale  
Source: BHP Analysis

# Nickel West is already the world's largest producer of nickel powder and briquettes ...

## Nickel West has an advantaged position to produce nickel sulphate product

- We are already the largest global producer for briquettes and powder
- We have internal access to sulphuric acid from the Kalgoorlie Nickel Smelter
- We are situated geographically close to the Asian market
- Australia's Free Trade Agreements with China, Japan and South Korea are a strategic advantage
- Further refinery capacity expansions are available at relatively low cost.

Global Briquette and Powder Production FY17 (ktpa)



Source: Public Reports of other producers; BHP Analysis

# with plans to further expand production leveraging lower cost brownfield options ...

## Capital intensity of debottlenecking is a fraction of new build

- UBS<sup>1</sup> estimate new HPAL refinery capacity would cost ~US\$40k/t .
- Nickel West debottlenecking cost to 90kt is expected to be less than US\$5k/t.
- Operating costs are benefiting from scale benefits.
- Increased margin achieved by converting internal matte to metal plus by-products.

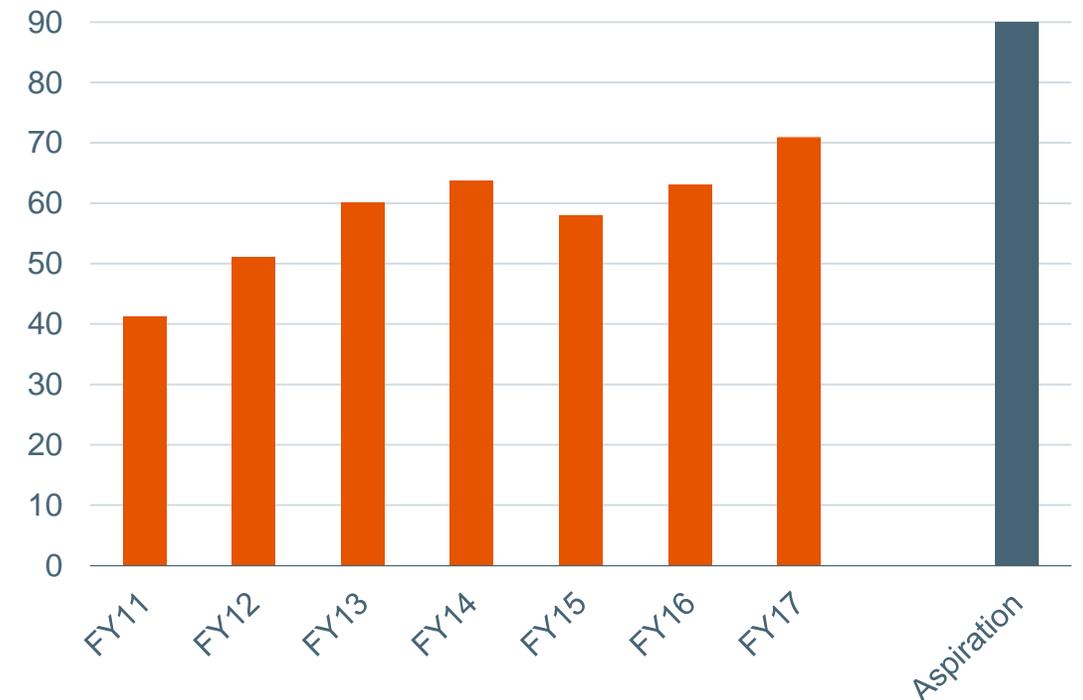
## New infrastructure installed at the bottleneck in April 2018

- 8<sup>th</sup> reduction clave will be commissioned in April 2018.
- New technology agitators improve reduction rate.
- Low cost retrofit to other seven claves planned to further increase reduction capacity.

<sup>1</sup> UBS, 2017

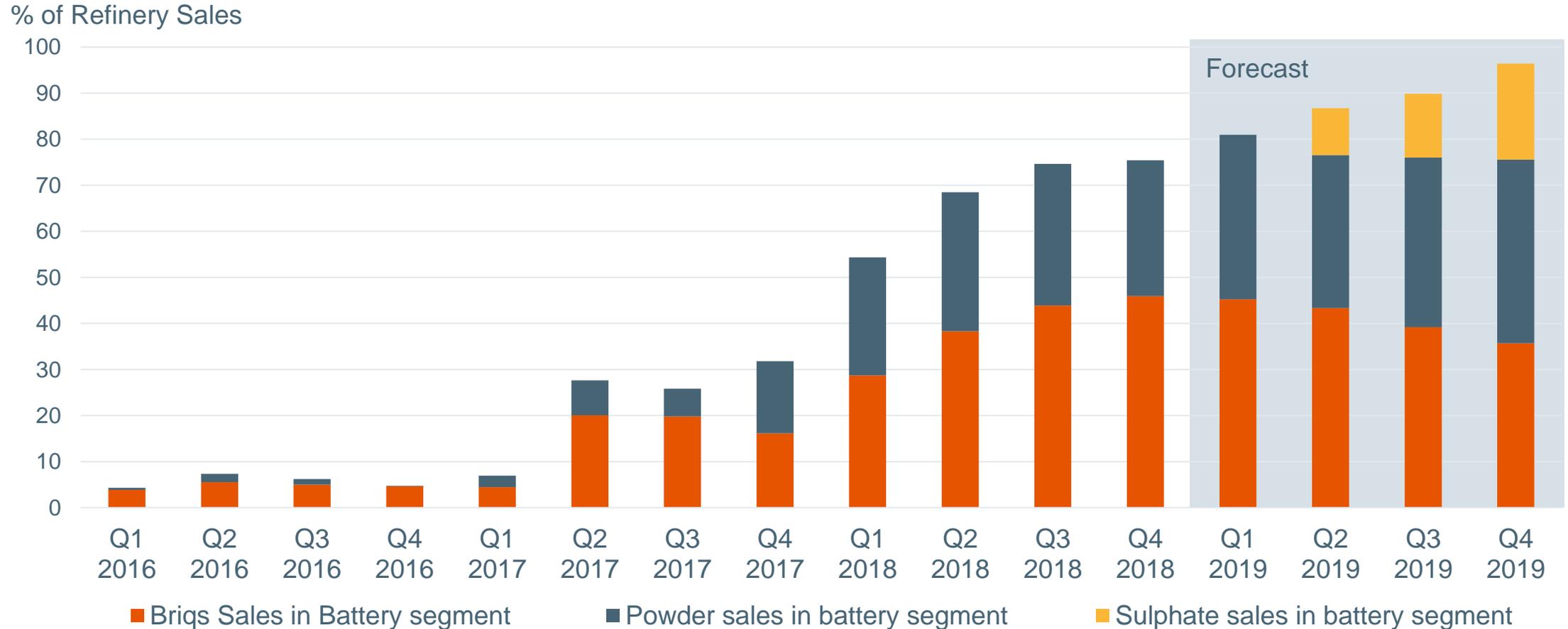
## Record Production in FY17 – Aspirations even larger

### Metal Production (kt Ni)



# ... to meet the anticipated rapid growth in demand for our products from the battery segment

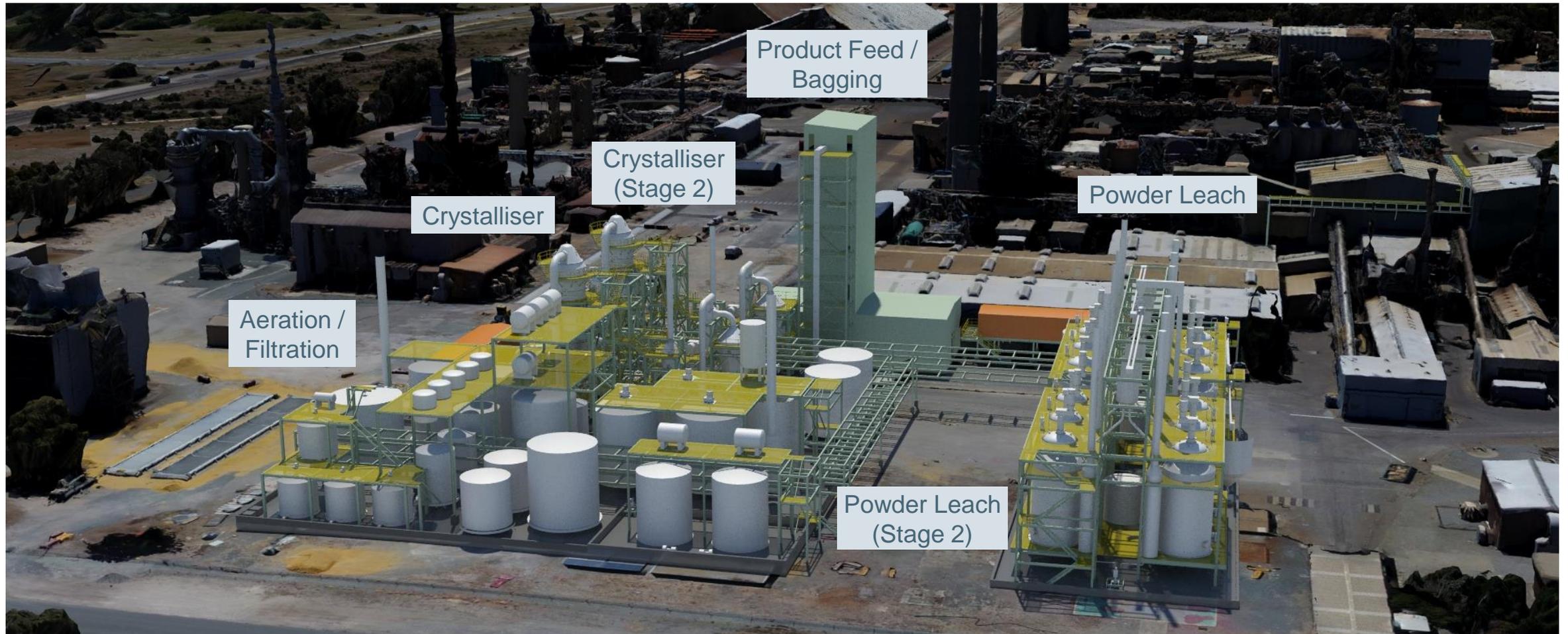
## Expected increasing sales and demand for the battery segment



# Nickel Sulphate Stage 1 (100kt) continues Nickel West's move downstream...



... while Stage 2 to 200kt remains a low cost expansion option that may be triggered by market demand



# Significant interest in offtake has prompted the construction of a mini plant for early delivery of samples

## Very high demand has prompted the construction of a sophisticated mini plant to deliver samples early

- We are constructing a sophisticated mini plant which is a replica of the larger plant design
- Factory Acceptance Testing, commissioning and first production run is taking place
- High purity nickel sulphate samples will be available to customers soon
- We have a high focus on quality and customer.



# Nickel West has the potential to grow its cobalt production

To realise this aspiration we need to...

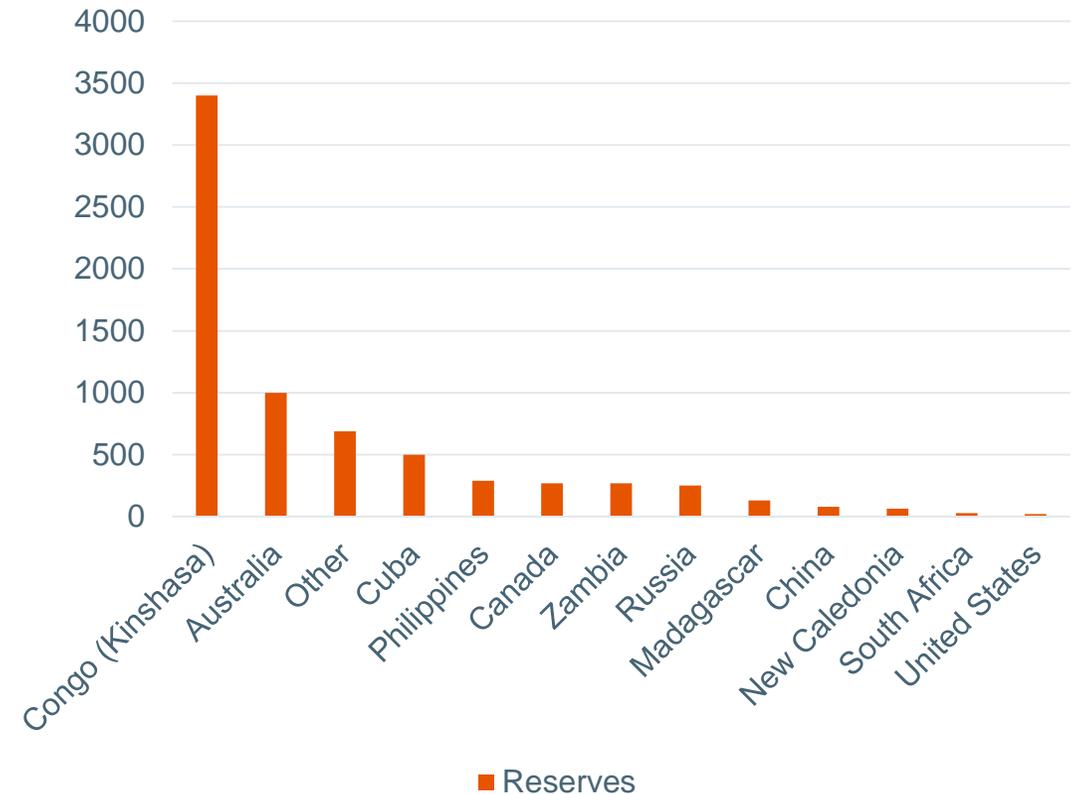
Produce cobalt sulphate at the Kwinana Nickel Refinery

Increase cobalt recovery at the Kalgoorlie Nickel Smelter

Recover cobalt from internal recycle and waste streams

Increase cobalt inputs to our vertically integrated supply chain

World Cobalt Reserves  
(million tonnes)



Source: US Geological Survey, 2016

# Nickel West's Cobalt SX plant would, if successful, produce cobalt sulphate from a high temperature ammonia leach

## Research and development conducted with CSIRO in Perth, Western Australia

- Test work program is nearing completion with no fatal flaws.
- Pilot plant will be operational in Q2 CY18.
- If successful, the flowsheet design will be finalised in H2 CY18.
- This will allow for construction of a demonstration plant to commence by end of CY18.
- Cobalt sulphate would unlock upstream opportunities.



Cobalt test-work, Kwinana Nickel Refinery

# Nickel West is well placed to become a globally significant battery material supplier

## Energising the future with innovation and excellence

- Nickel West is a fully integrated mine-to-market business with end-to-end control of its supply chain.
- We have mineral resources to support the business to at least 2040.
- We produce high quality nickel products to support customers to produce battery cathode.
- Our stage 1 Nickel Sulphate Project at the Kwinana Nickel Refinery remains on track.
- We are pursuing cobalt opportunities and aspire to grow our production, selling this as cobalt sulphate.



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