



# Electric Vehicle Revolution and Implications for New Energy Metals

**Frank Nikolic**

Market Intelligence, Vale Base Metals

Brazil-Canada at PDAC | 2018



*5<sup>th</sup> Avenue Easter 1900*



*5th Avenue Easter 1913*

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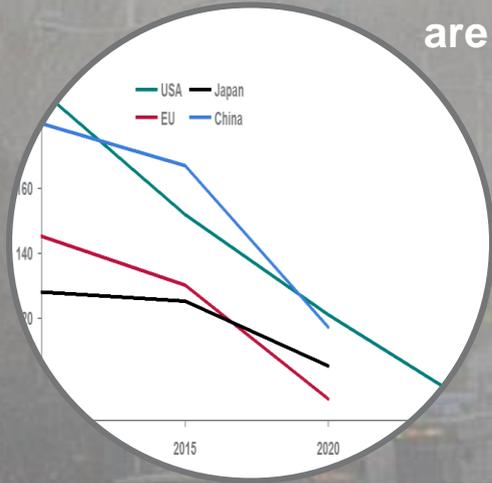
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# Shanghai 2015

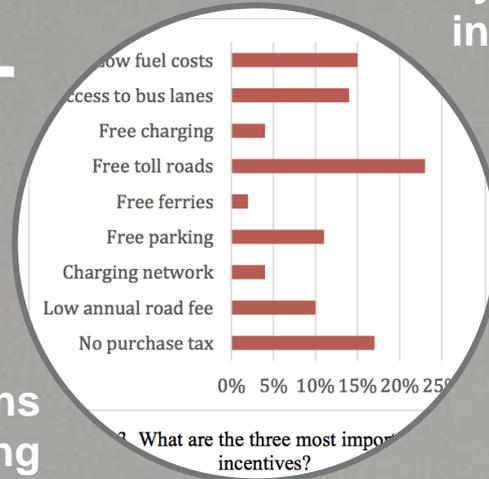


# Our society is moving to a low-carbon future

## Emission regulations are tightening



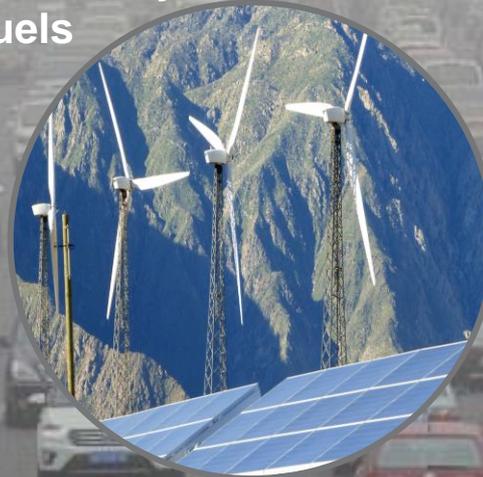
## Monetary & other incentives



## Restrictions on Internal Combustion Cars



## Movement away from fossil fuels



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# Vast amount of capital is being committed



**Volkswagen invests \$40 Billion on electric cars.**

“With the planning round now approaching, we have decided to invest \$40 billion in electric cars over the next five years.” Volkswagen Chief Executive Matthias Mueller. Nov 24, 2017

**\$40 Billion**

**dyson**

Dyson Ltd. says it will build an electric car using solid-state batteries. The British company will invest \$2.6 billion in the car, plus \$1.3 billion to create solid-state batteries for it. Sep 26, 2017

**\$2.6 Billion**



**DAIMLER**

**“We want to shape the profound transformation of the automotive industry from the forefront.”**

“Further fundamental changes will be required for Daimler to achieve its goal of becoming a fully electric company by 2030. Daimler CEO Matthias Manfred Bode said. In the coming years, Daimler will invest €10 billion in the expansion of its electric portfolio and will bring more than ten new electric cars in series by 2022.

**\$10 Billion**

Automotive News - Mar 29, 2017



Coming after an estimated \$2.7 billion investment in electric cars, BMW is joining a miles-long list of luxury carmakers as well as the electric car fraternity.

**\$2.7 Billion**



Tesla and its partners will collectively invest about

**\$5 Billion**

in the Gigafactory. Nov, 2016



**Ford announces \$4.5bn investment in electric vehicles**

“Ford is just the latest in a long line of

**\$4.5 Billion**

demonstrate the clear shift that is being made towards the electrification of transport systems across the global.” Tim Payne, CEO of InstaVolt



**“General Motors believes in an all-electric future,”** said Mark Reuss, executive vice president of product and supply chain.

“General Motors pulled back the curtain on plans for a new fleet of all-electric vehicles that executives believe will push its global EV sales to 1 million annually by 2026 — and generate a profit.” Oct 4, 2017



**JAC Volkswagen & JAC Put \$12 Billion Into Chinese EV Boom**

JAC, a Chinese carmaker, is investing \$12 billion in electric cars under a joint venture with Volkswagen. The investment will see the introduction of 40 locally produced vehicles. Nov 25, 2017

**\$12 Billion**



Up to 25 percent of cars may soon be fully electric, says

**\$1 Billion** in electric vehicle production.

Sep 22, 2017

**TOYOTA**

Toyota, Mazda plan \$1.6 billion U.S. plant will partner on electric vehicle technology. The plant will have a production capacity of about 300,000 vehicles per year. It will produce Corollas as well as a new Mazda crossover vehicle for the North American market. Aug 4, 2017

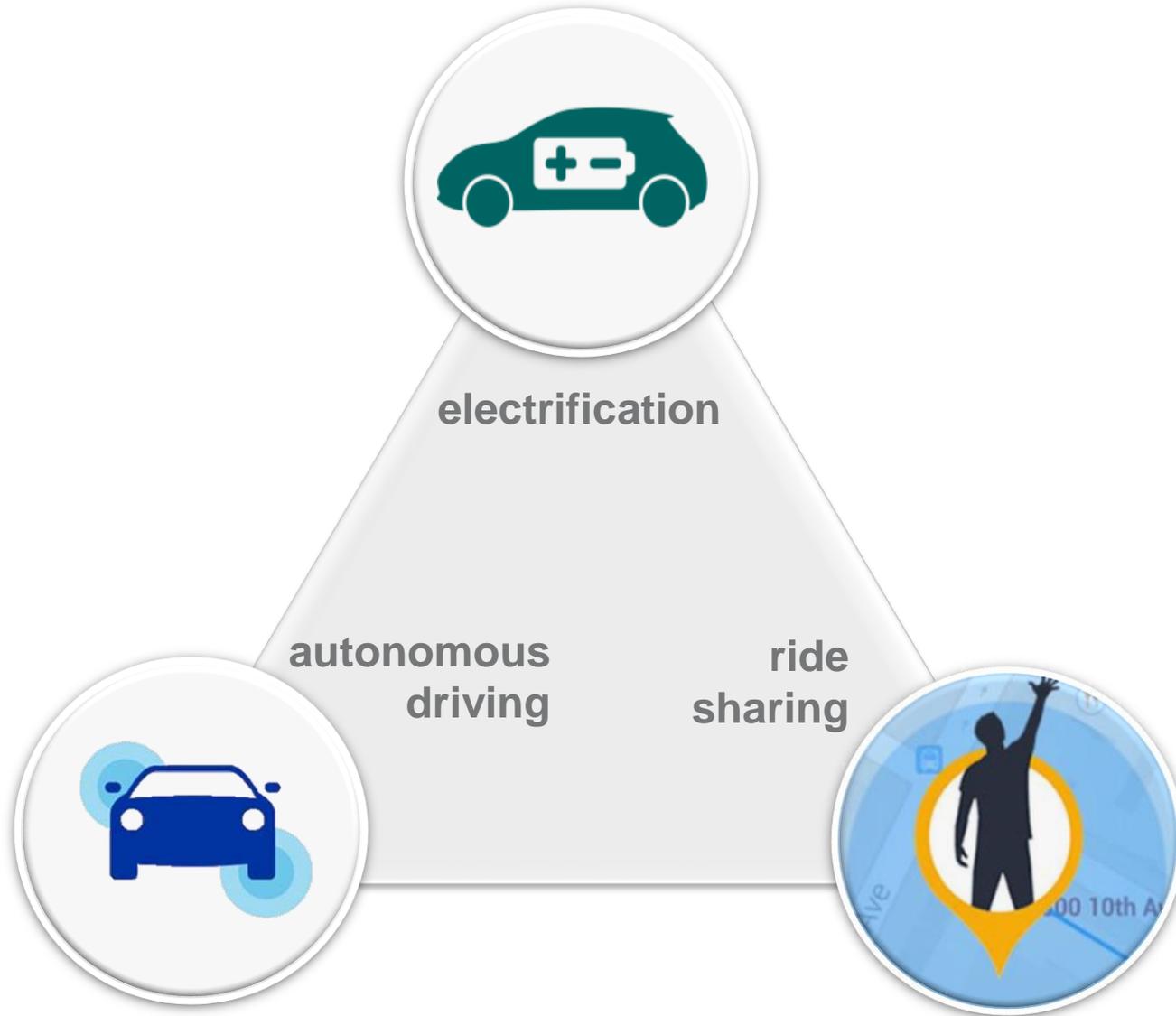
**\$1.6 Billion**



Porsche is making a big bet on electric cars with the upcoming Mission E. The automaker plans to double its investment in electric cars to nearly \$8 billion by 2022.

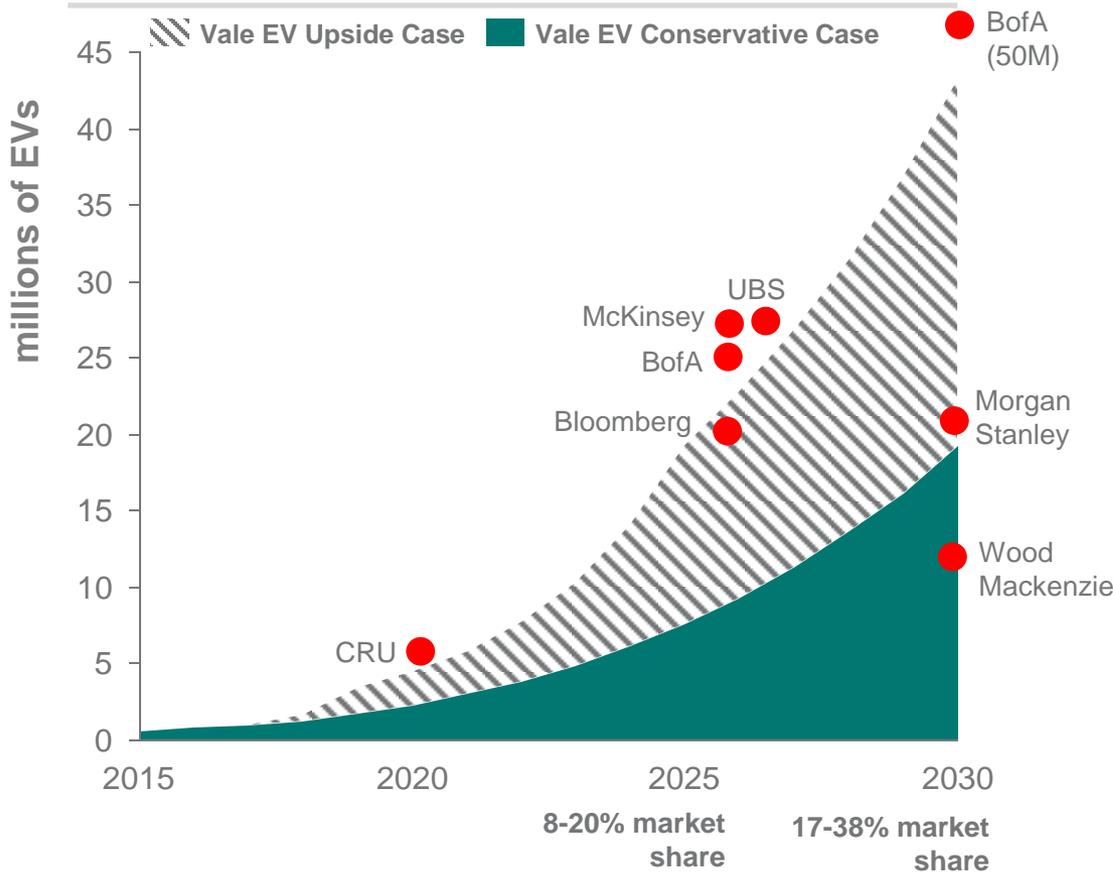
**\$8 Billion**

# The e-mobility movement

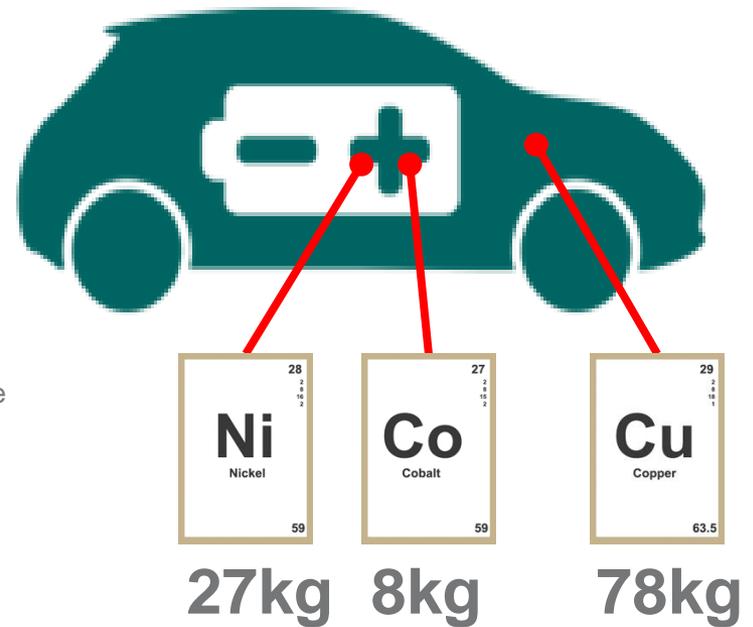


# Electric vehicles will have an increasingly commanding share of the market

# of Electric vehicles  
*Electric Vehicle = PHEV and BEV*



*by 2025, on average, an EV vehicle will contain*



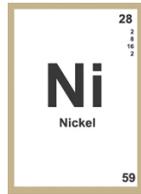
*Upside Case refers to public commitments by various auto manufacturers as well as governments (such as UK/France committing to no ICE sales by 2040, California, China, etc.)*



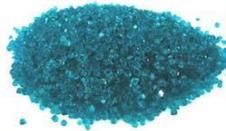
# Implications for New Energy Metals

# New Energy Metals and the Electric Vehicle

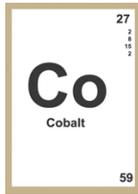
An example of a Nickel-Rich Battery



8 parts



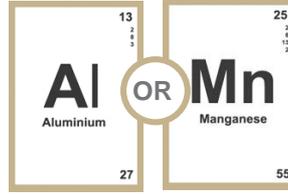
Nickel Sulphate



1 part



Cobalt Sulphate



1 part



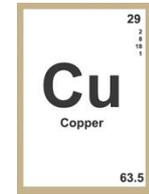
Aluminum or Manganese Sulphate



1 part



Lithium Carbonate



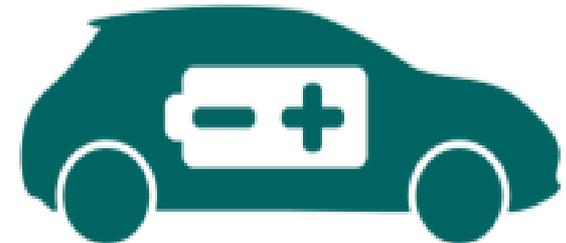
Cathode Material



Cell  
(shell is nickel plated)



Pack

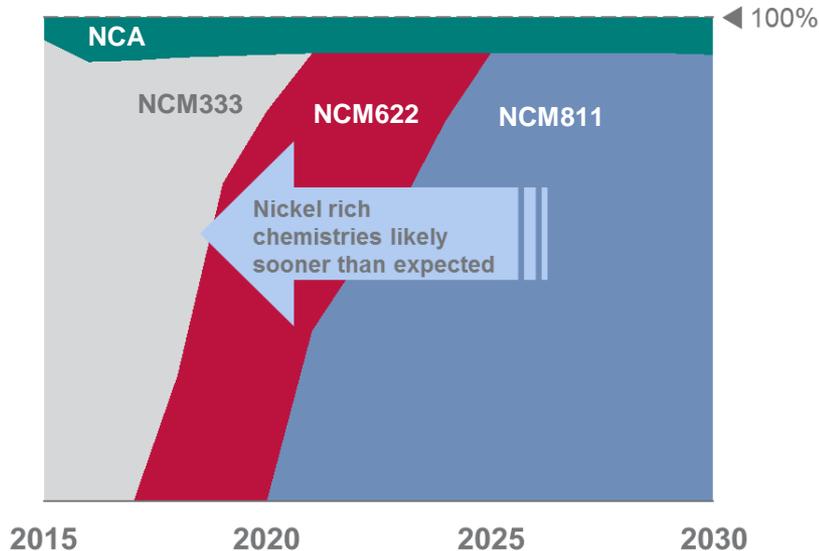


# Key trends for New Energy Metals

## 1 Battery chemistry favors nickel

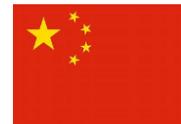
- Increasing nickel content improves energy density (energy storage)
- Increasing nickel content lowers battery costs

Battery Chemistry Distributions



## 2 Battery size is increasing

- Increasing battery size increases vehicle range



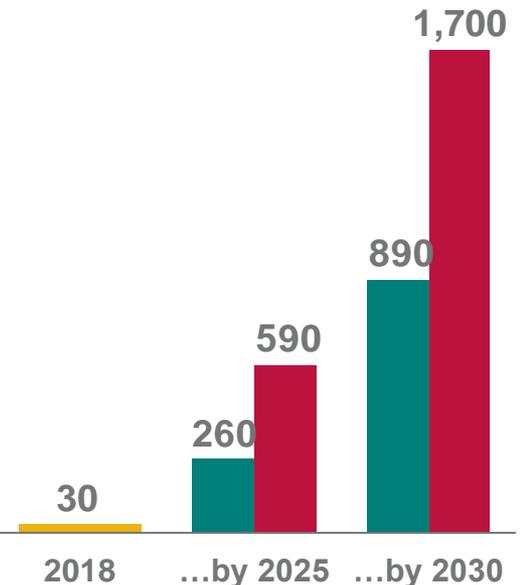
### 2018 China EV Subsidy Rules support >60kWh battery

- <150km range = no subsidy
- 300km range = current subsidy
- >400km range = highest subsidy

# This will have a big impact on future demand for New Energy Metals

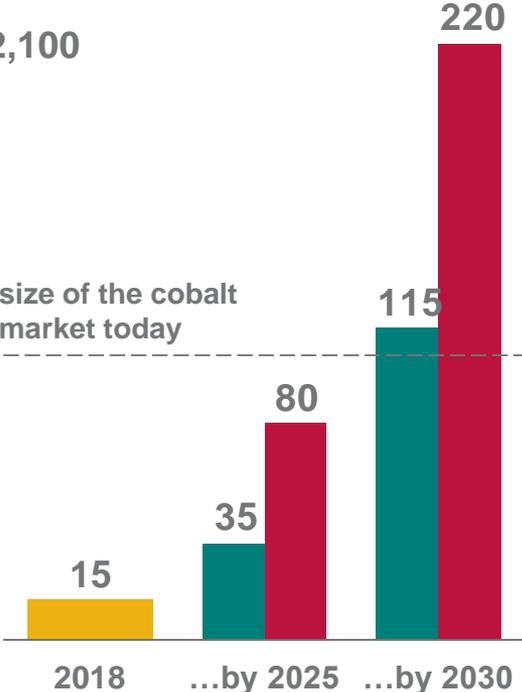
Nickel Demand for NEV batteries (kt)

size of the nickel market today ← 2,100



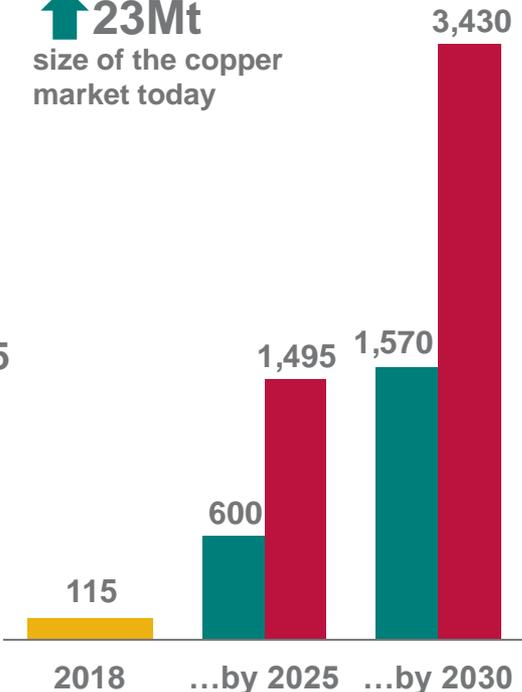
Cobalt Demand for NEV batteries (kt)

size of the cobalt market today ← 105



Copper Demand for NEV but excl. infrastructure (kt)

↑ 23Mt  
size of the copper market today



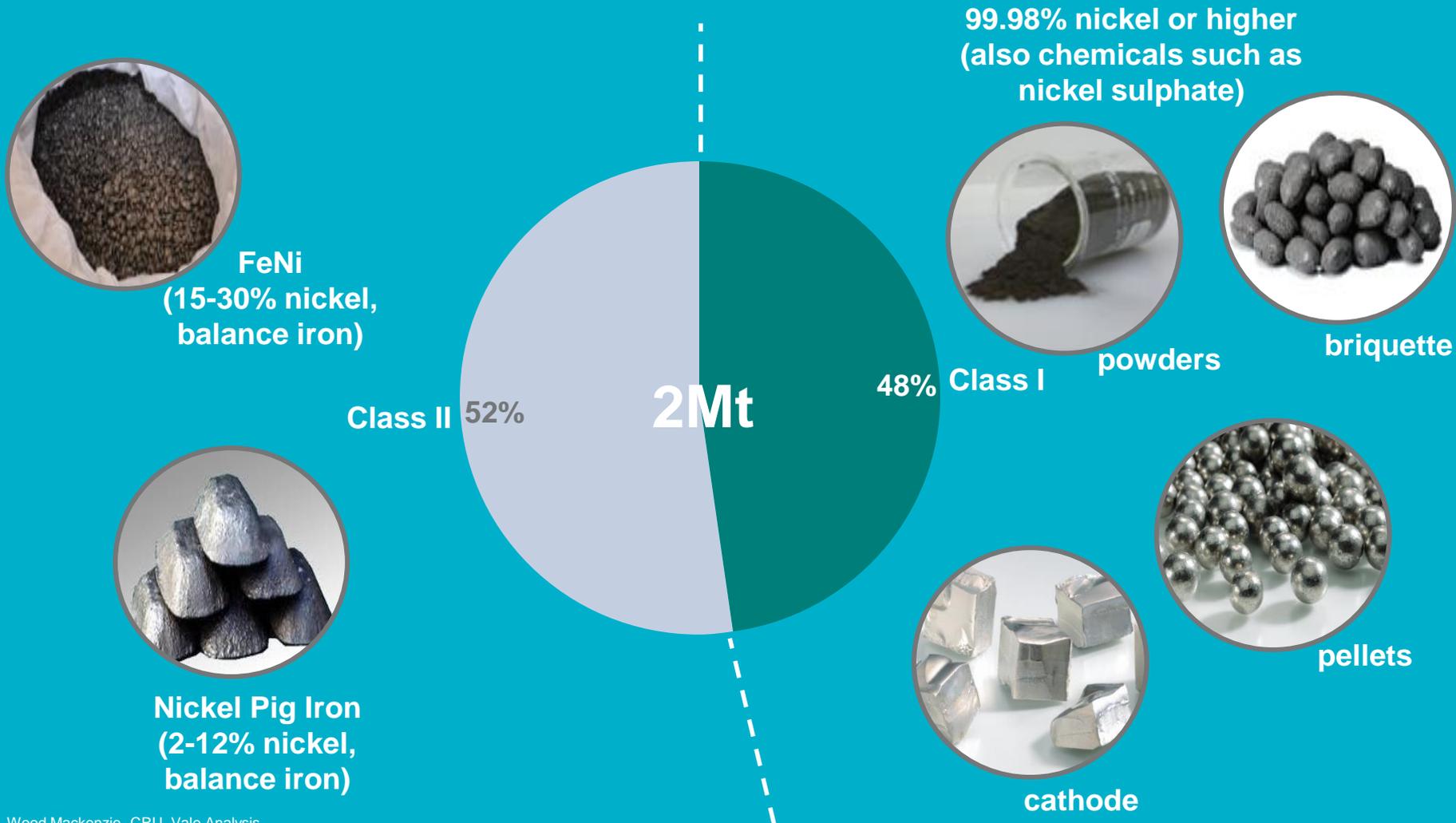
Conservative Upside



note: this is our 'accelerated NCM811' scenario; NEV = New Energy Vehicle. This specifically refers to Plug-in Hybrids and Battery Electric Vehicles

# Not all nickel is the same

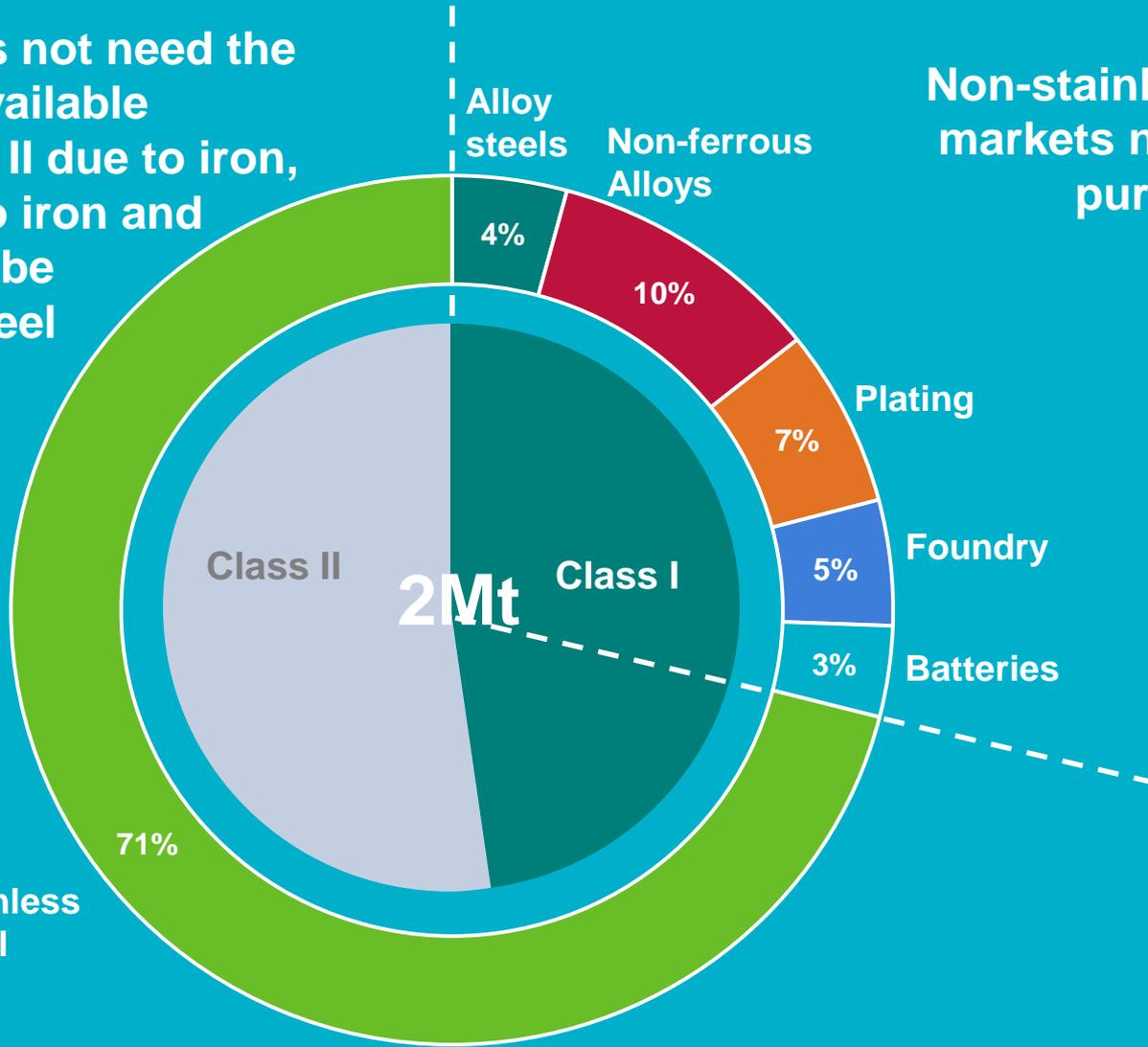
The nickel market is made up of two very different classes of product



# Consumer requirements also come into play

Stainless steel does not need the high purity and if available prefers using Class II due to iron, while Class II due to iron and impurities can only be used in stainless steel (with few niche exceptions)

Non-stainless steel markets need high purity nickel



2Mt

Class II

Class I

Stainless Steel

Alloy steels

Non-ferrous Alloys

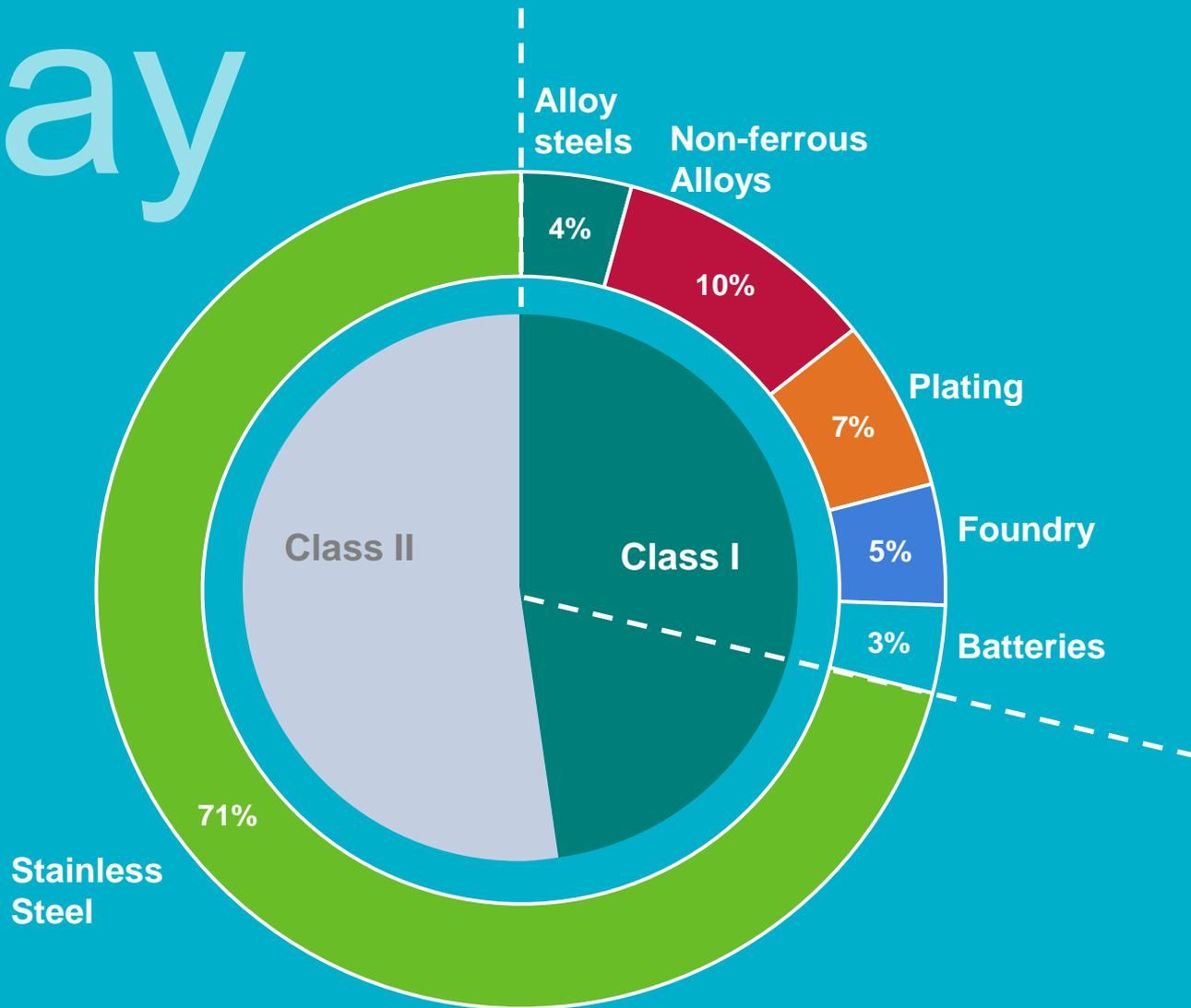
Plating

Foundry

Batteries

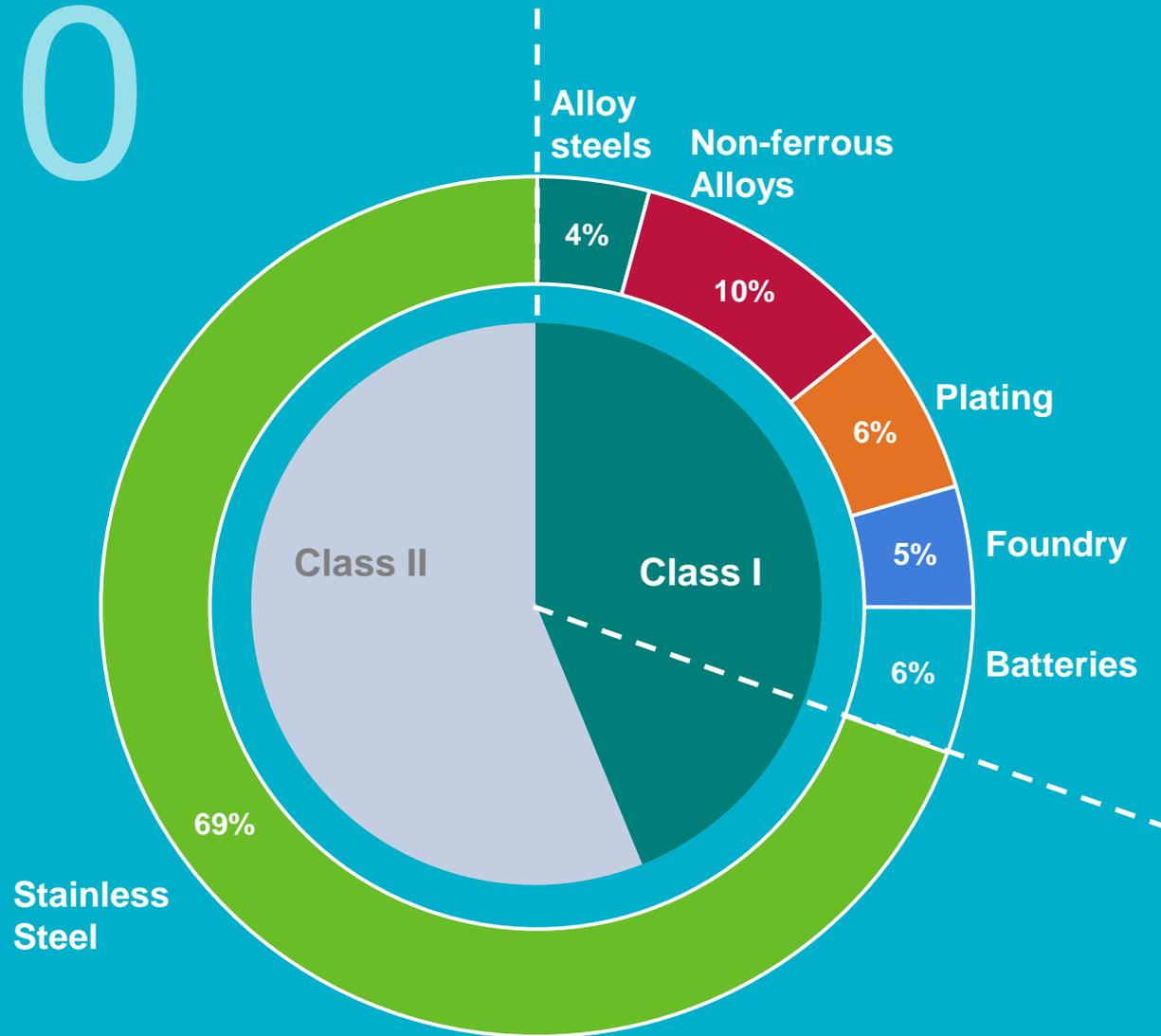
# Nickel Market

## Today



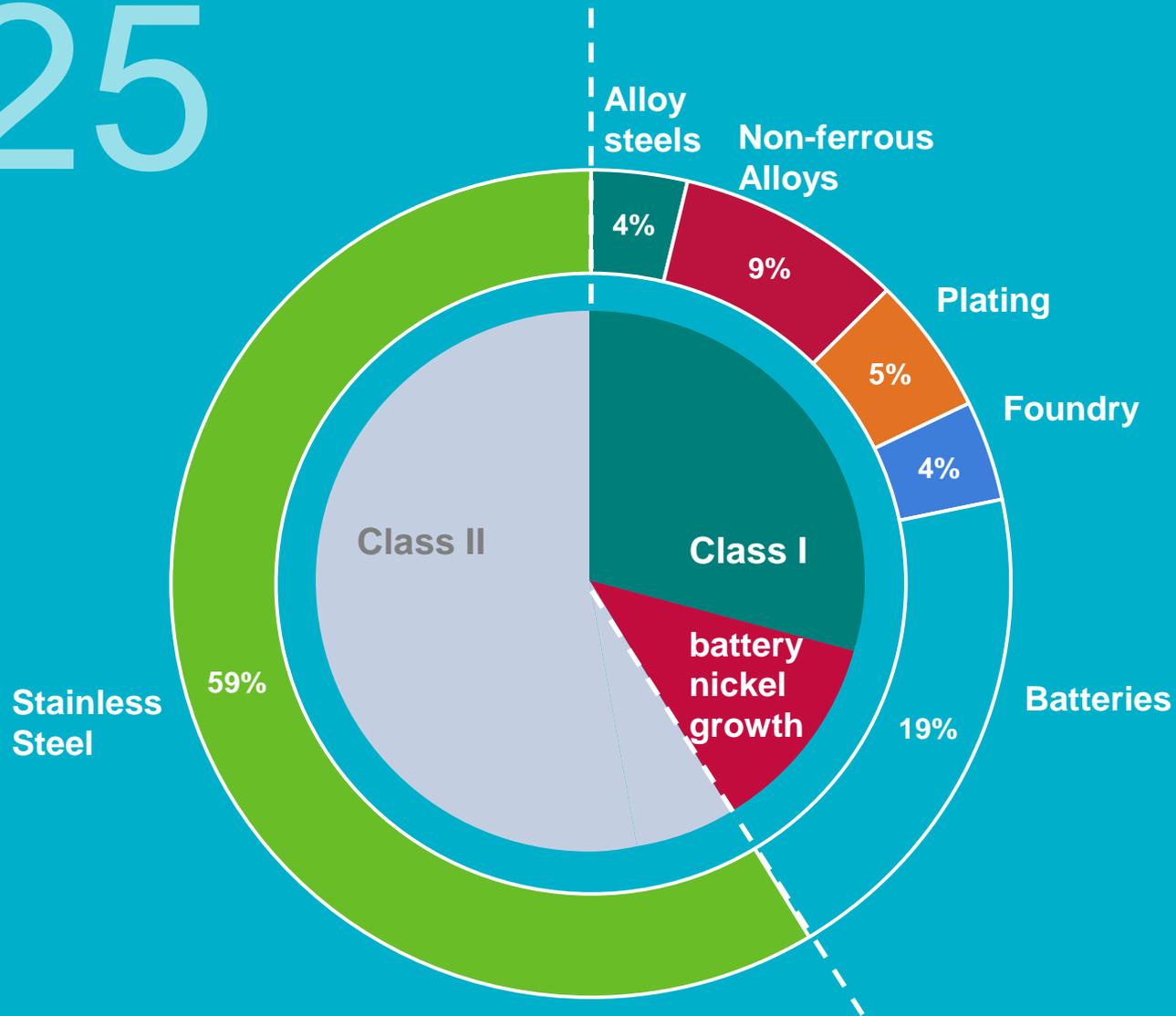
# Nickel Market

# 2020



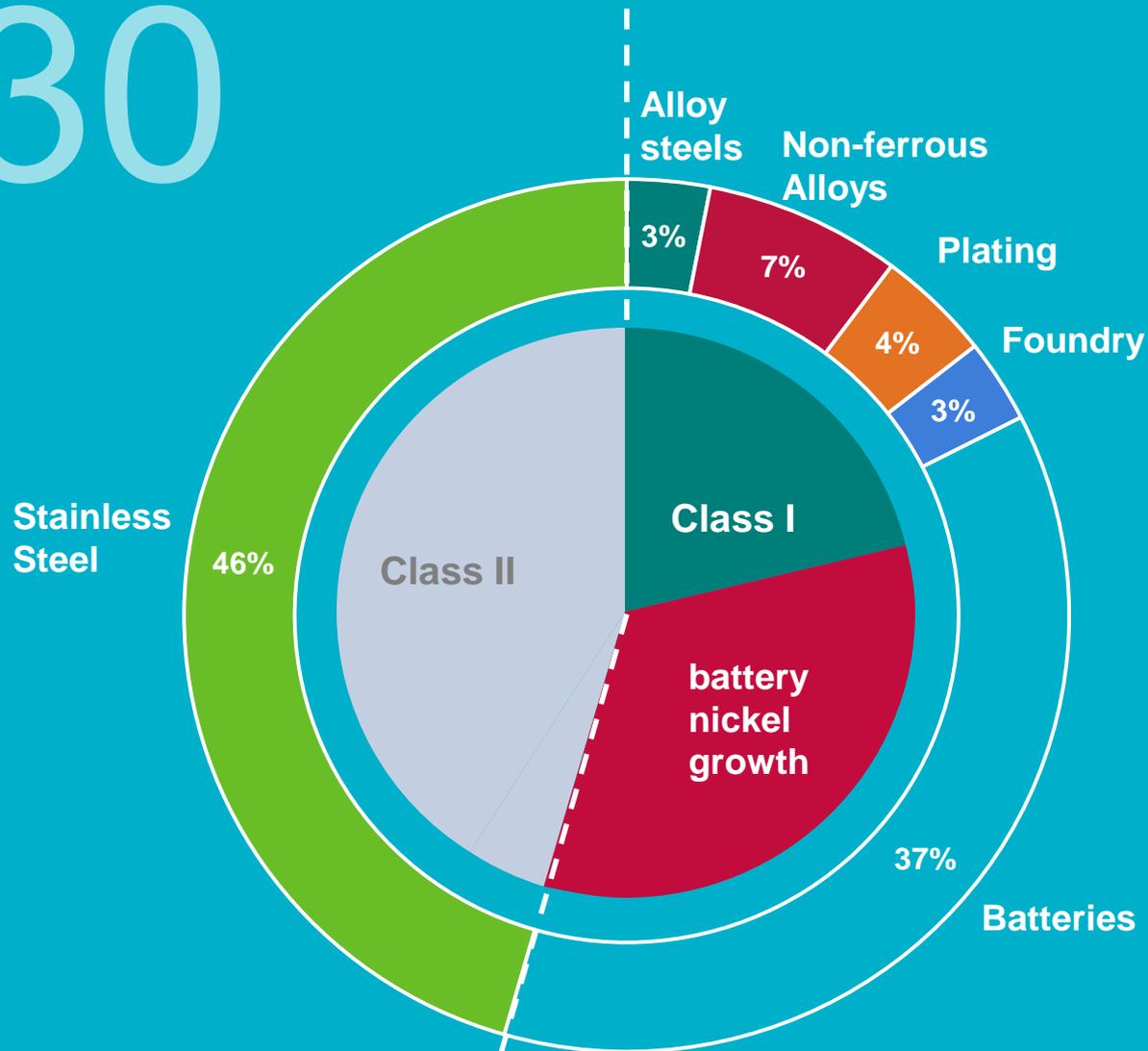
# Nickel Market

# 2025



# Nickel Market

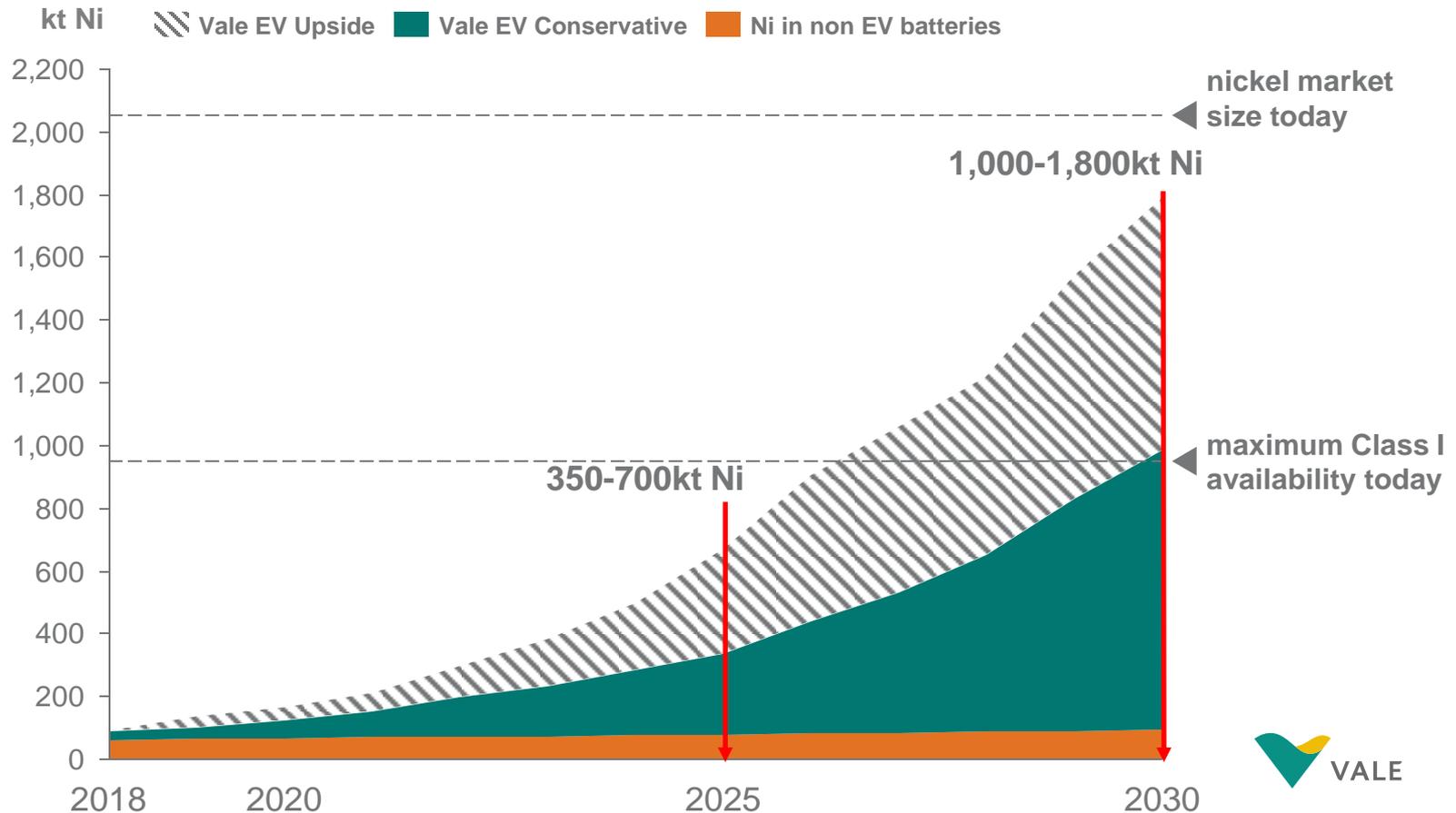
# 2030



Source: Wood Mackenzie, CRU, Vale Analysis using average between conservative and upside case

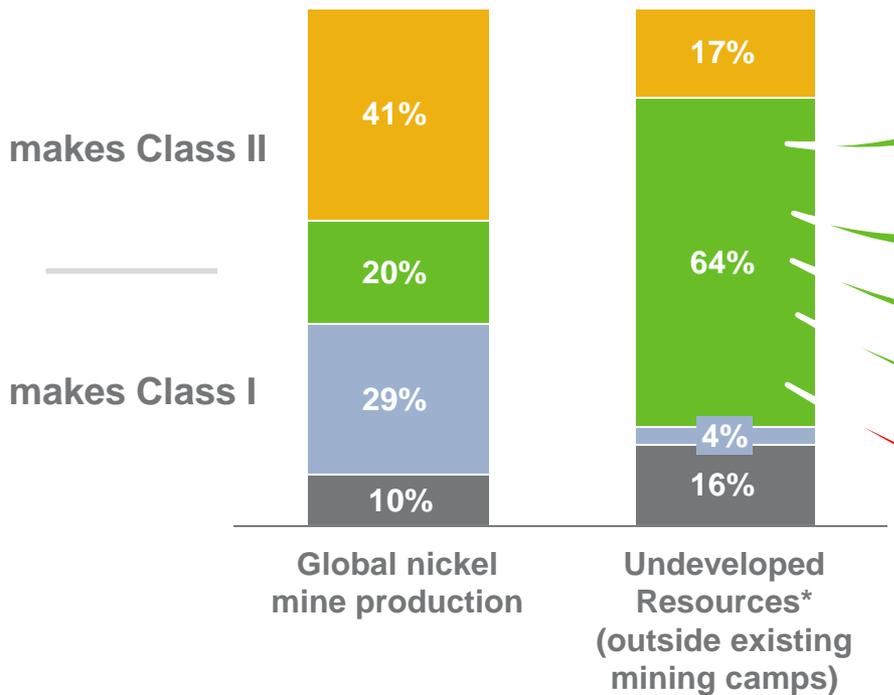
# Batteries will be a paradigm shift in nickel demand, particularly if we consider battery suitable nickel units

Nickel demand for the Battery Market (kt Ni)

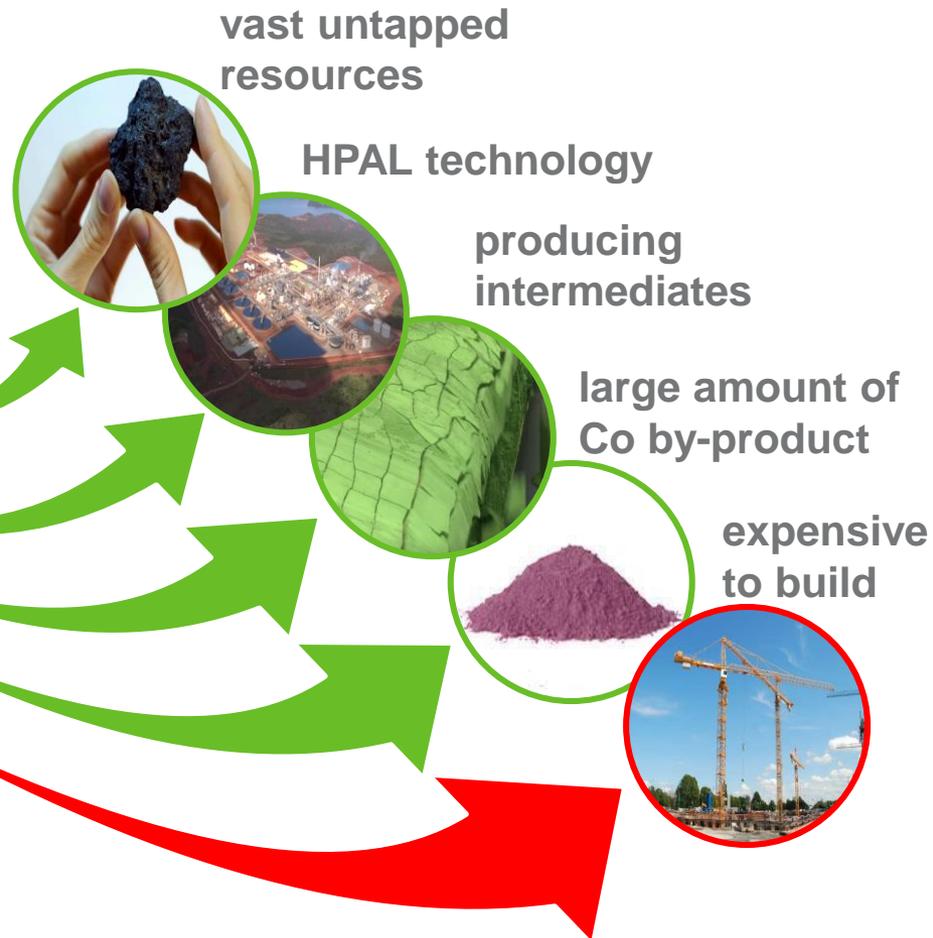


# Nickel supply will grow to meet the needs of the battery market

World nickel production and undeveloped resources

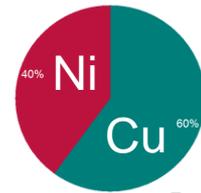
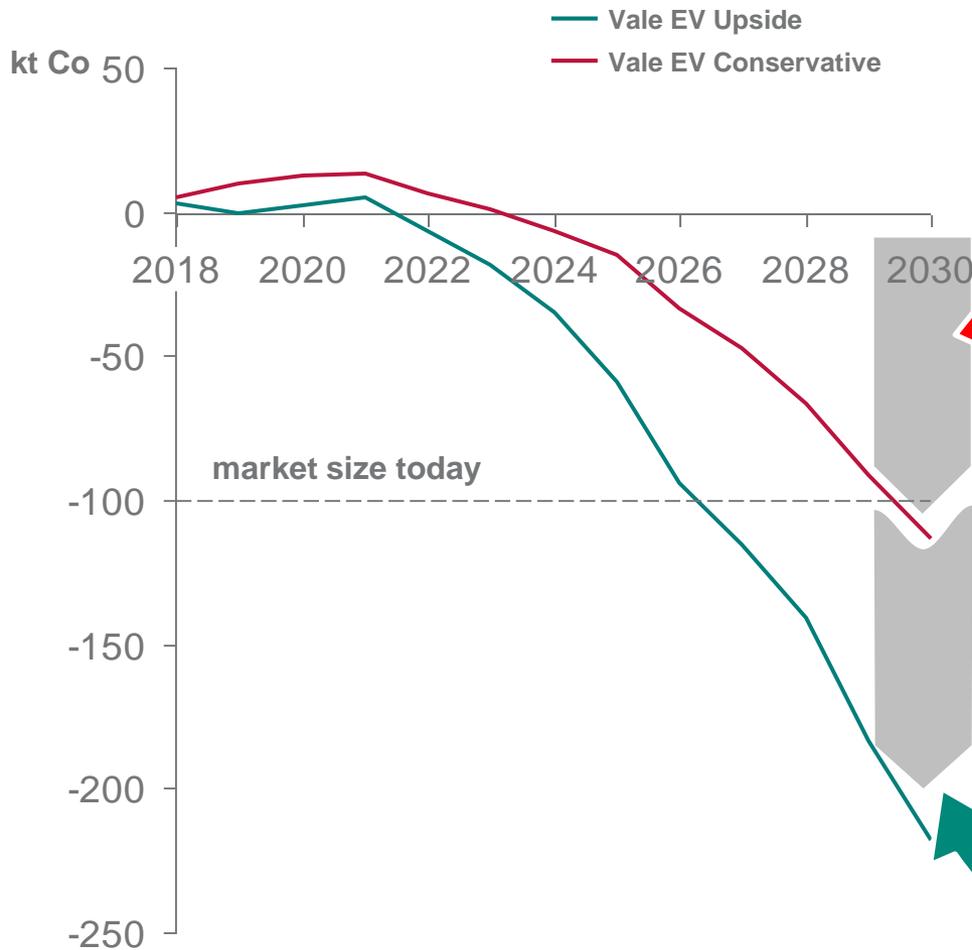


■ Saprolite    ■ High Grade Sulphides  
■ Limonite    ■ Low Grade Sulphide

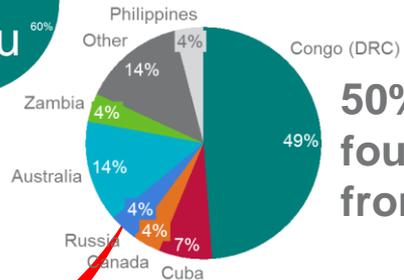


# Cobalt supply is inelastic, although it will come with nickel there is significant risk tied to Cu DRC

Cobalt Market Balance with no Supply Response

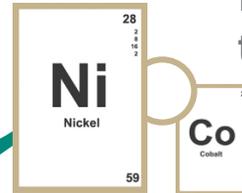


Co is a byproduct of Cu and Ni



50% of Co is found and comes from the DRC

Future of Co is tied to Ni given HPALs



Still need DRC – which introduces a lot of risk

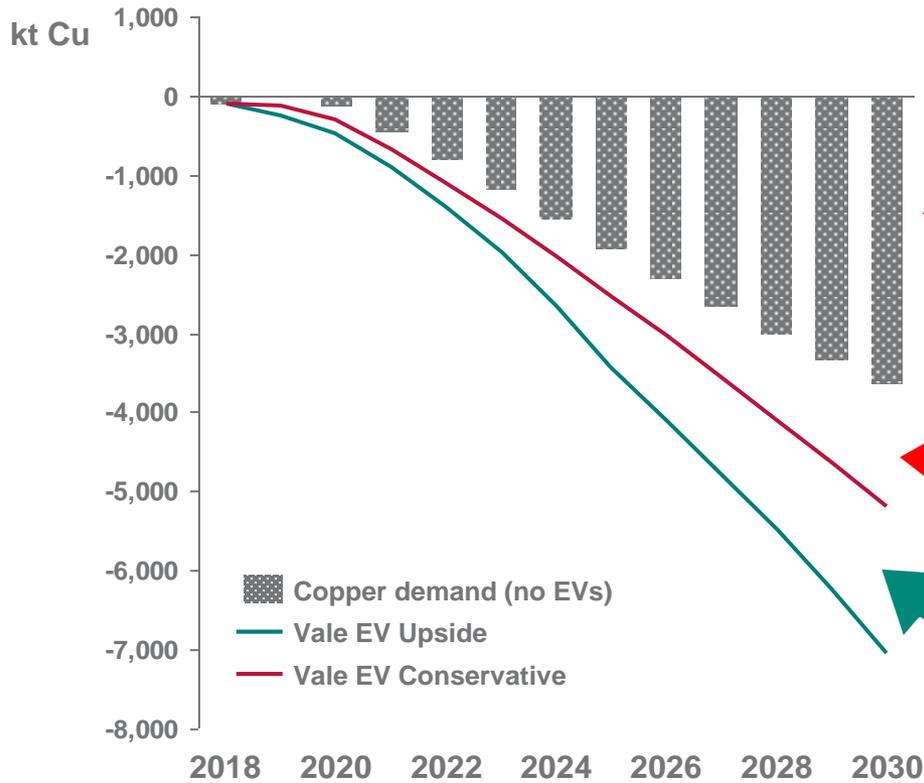


Recycling only relevant post 2030

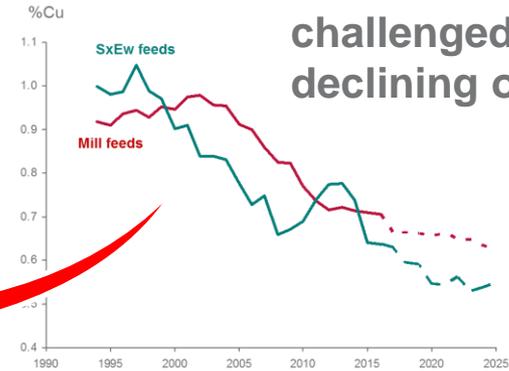


# EVs and infrastructure additive to copper demand – next wave of projects needed

## Copper Market Balance with no Supply Response



Copper Market ~22Mt



challenged with declining ore grades



next wave of projects needed



current prices supportive for investment

# Closing Remarks

- **We are at a precipice of an Electric Vehicle revolution**
- **Electric vehicles will usher in an age of New Energy Metals**
- **Nickel for EV batteries will become a significant part of demand and a key driver for growth**
- **Supplying the right nickel units will be a challenge but there is a vast untapped resource accessible with established technologies**
- **Cobalt will come with the nickel but still needs DRC which is a risk**
- **Copper needs the next wave of projects**



For a world with new values.