Sustainable Production of Primary Aluminium in Greenland using Green Energy and Alumina extracted from Anorthosite

A sustainable project in the Arctic Region.

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Contents

- Aluminium Production versus Iron Ore, Cement and Steel
- Application and Properties of Aluminium
- Recyclability of Aluminium
- Global Trends and Aluminium Demand Growth
- Substitution of Copper and Steel
- Sustainability: Climate Change and GHG Emissions
- Aluminium from Bauxite - why not from Anorthosite?

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Megatrends supporting demand for aluminium products

Megatrends

- Urbanization
- New middle class
- Environmental Sustainability

Aluminium solutions | **Greener products**

Food production: 30% of emissions

Conserving and protecting food better in storing and transport

Transportation: 25% of emissions

Making cars lighter with aluminium

Buildings: 15% of emissions

Reduce energy consumption and emissions from buildings

Megatrends basis for future growth in aluminium products

HYDRO

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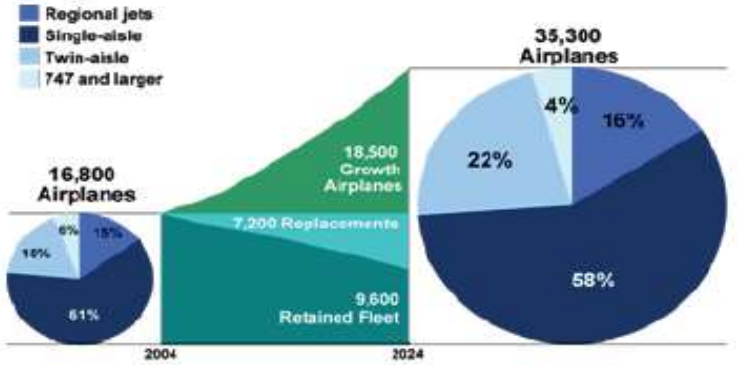
ALCOA

Market Dynamics

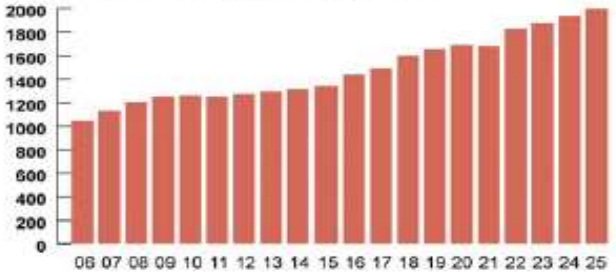
Aerospace



Source: Boeing 2035 Current Market Outlook

Aerospace

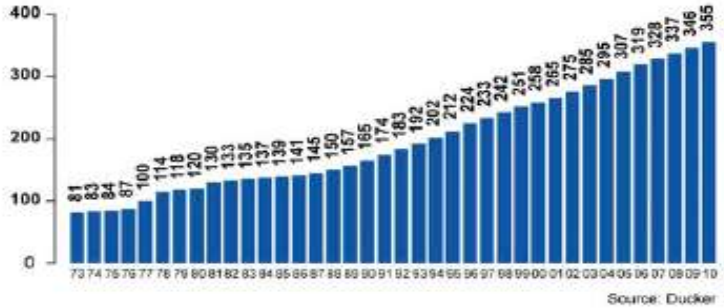
Commercial Aircraft Delivery Forecast
Large Commercial Transports & Regional Jets



Source: Airline Monitor, 01/06

Automotive

North American Light Vehicle Aluminum Content
lbs. per vehicle



Source: Ducker

Oil and Gas

It is all in the Properties of Aluminium

Chemical: Al is a Metal:

-Non-corrosive due to formation of Al_2O_3 surface layer.

Physical: Al is Light:

-Density = 2700 kg/m^3 versus Steel ~ 7800 kg/m^3.

Mechanical Strength is High per Unit weight:

-Al ~ Steel Strength per Unit Weight: $E/\rho \sim 26 - 27$ MPa/kg/m^3

Electrical Conductance: 2 x Cu per Unit Weight:

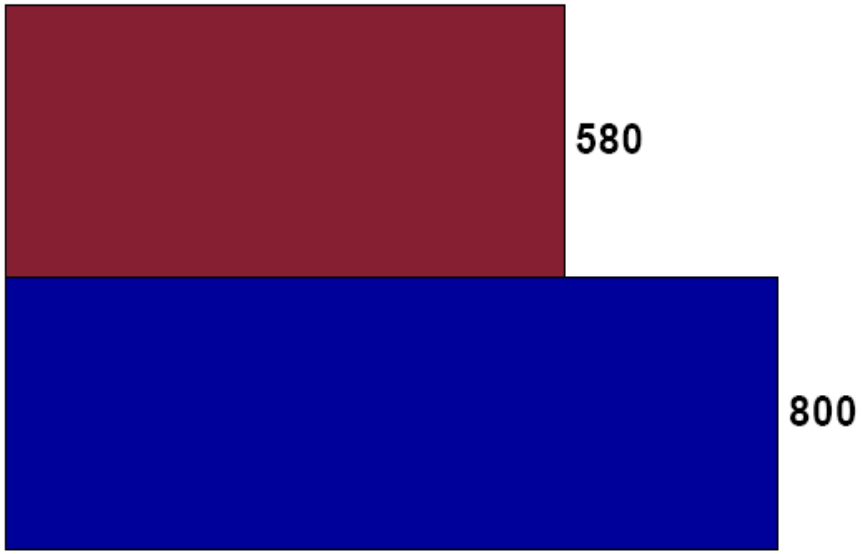
-Conductance per Unit Weight: $\gamma/\rho \sim 13{,}333\ (\Omega\ kg/m^2)^{-1}$

Energy Efficient Recyclability:

Primary Aluminium ~ 285 GJ/tonne, versus:

Secondary Aluminium ~ 15 GJ/tonne;

RECYCLABILITY



Source: IAI

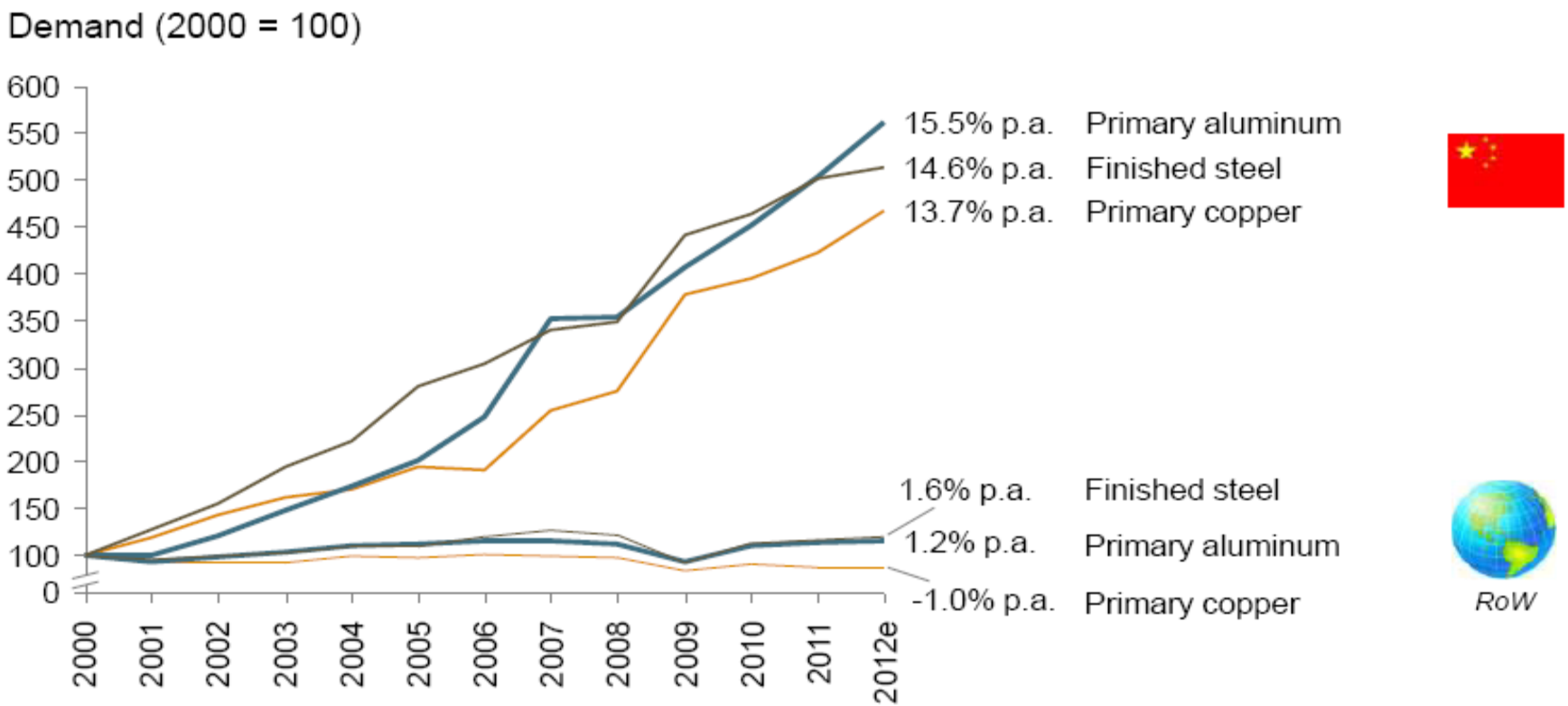
Global Metal Pool (Inventory) (tonnes)

Total Metal Produced (tonnes)

- 73% of all aluminum ever produced is still in use today
- Since 1888, about 800 million tonnes of aluminium have been produced.
- About 580 million tonnes of this amount is still in productive use.
- Recycling the metal currently stored in use would equal 15 years' primary aluminium output.

Strong past aluminum demand

Global consumption increase of aluminum, copper, and steel



Boston Consulting Group

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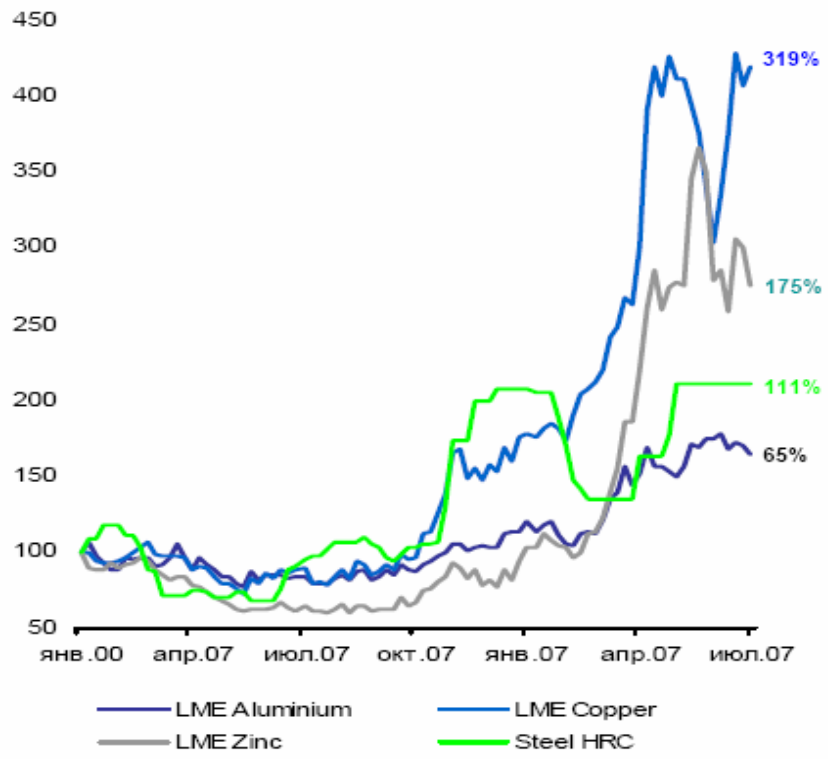
RUSAL

INCREASED COMPETITIVENESS OF ALUMINIUNM

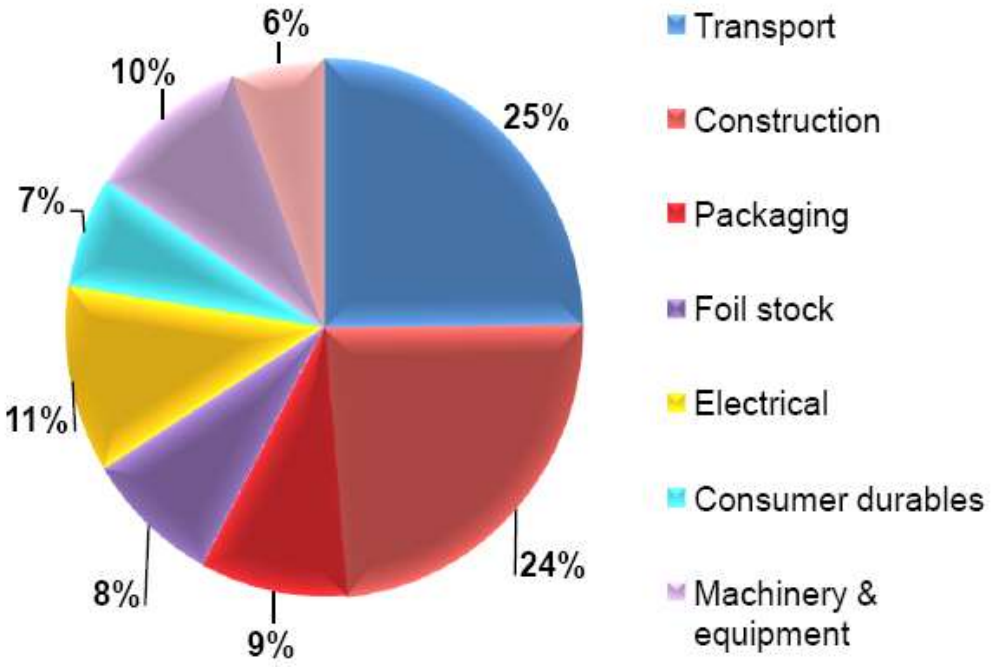
- Competitive price compared to copper, zinc and steel
- Aluminium has become an increasingly attractive substitute of zinc and steel, enhanced by its versatility for end uses (construction, transportation, power, consumer)
- Steel prices have also out-performed aluminium, stimulating demand for aluminium as a lower-priced substitute
- Switching costs make it difficult to go back to other materials once the switch to aluminium is made
- Toughening of international environmental legislation offer more opportunities for the use of aluminium as a light metal

Relative performance for copper, zinc, steel and aluminium
(rebased to 100 as of January 2000)

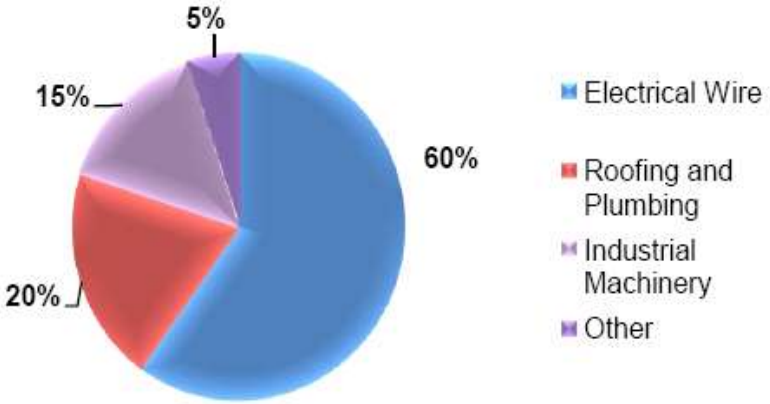


End use – Aluminium has a very diverse range of end uses with potential for substitution over other metals

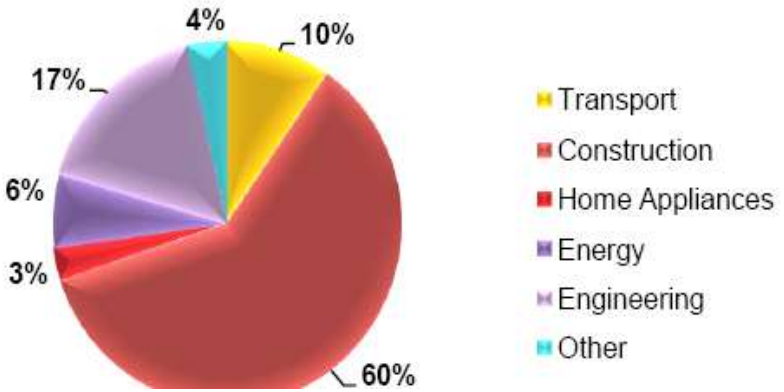
Semi-finished Aluminium consumption by end-use



Copper consumption by end-use



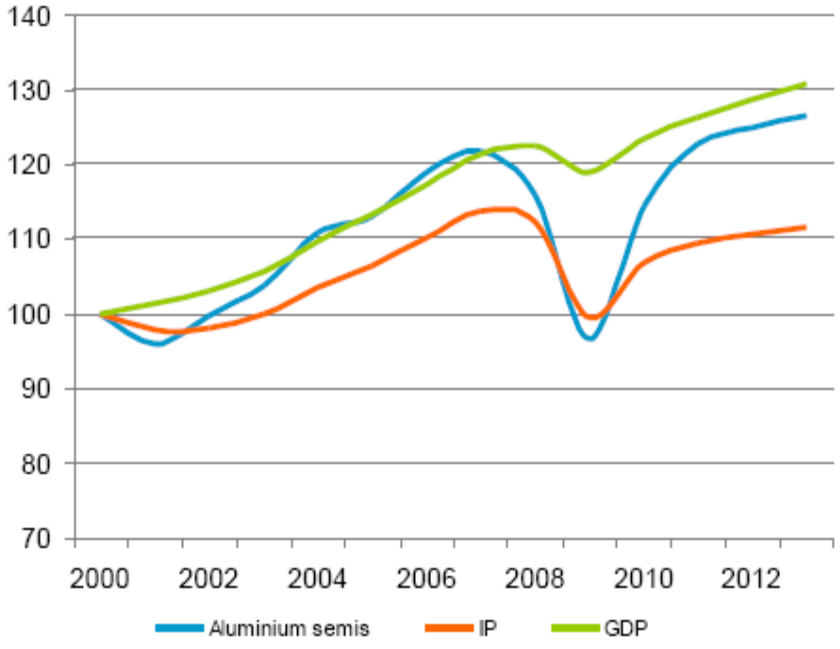
Steel consumption by end-use



Aluminium demand correlating with economic growth, outperforming other base metals

World ex. China aluminum demand, IP and GDP

Index 2000=100



World ex. China demand base metals

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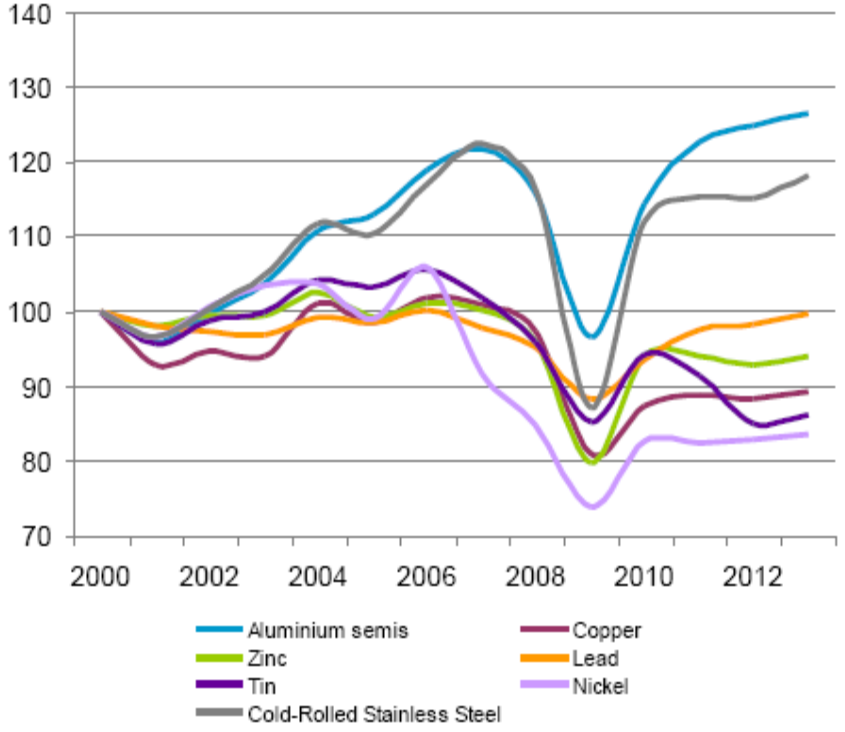
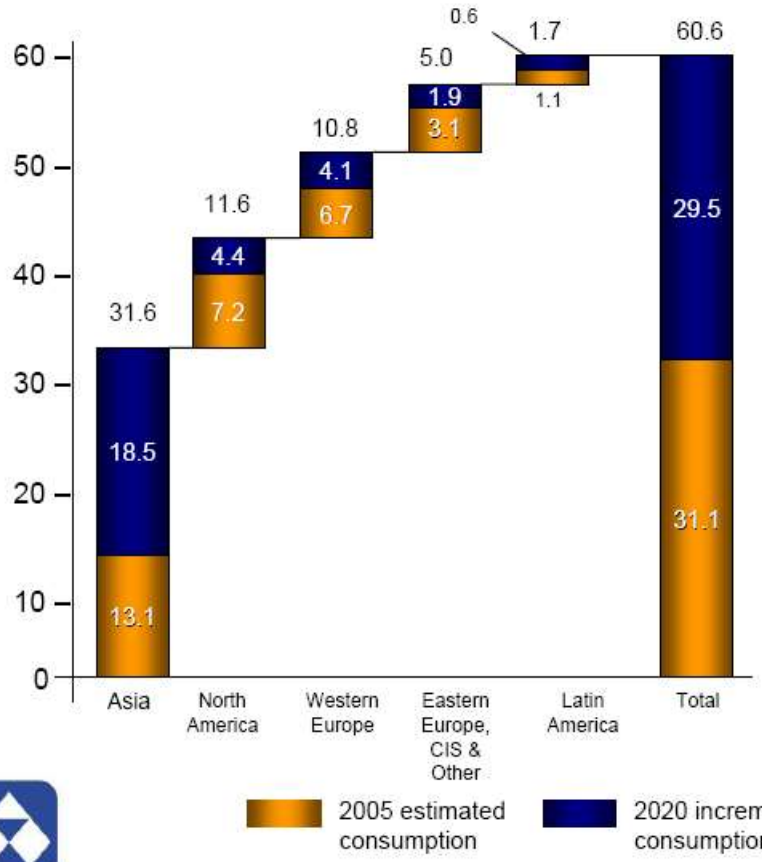
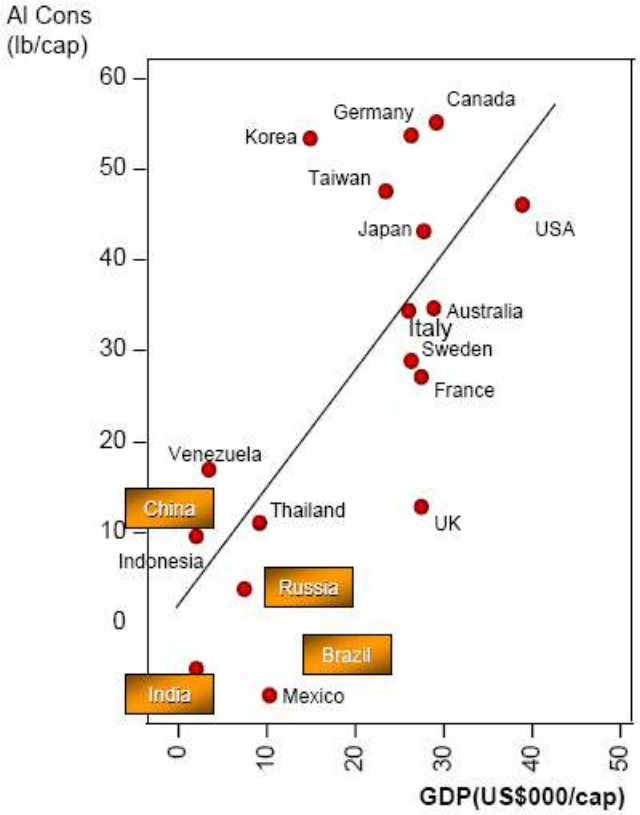


Source: CRU/Global Insight

Projected 2020 World Aluminum Consumption (M Tons)



Aluminum Consumption vs. GDP Per Capita

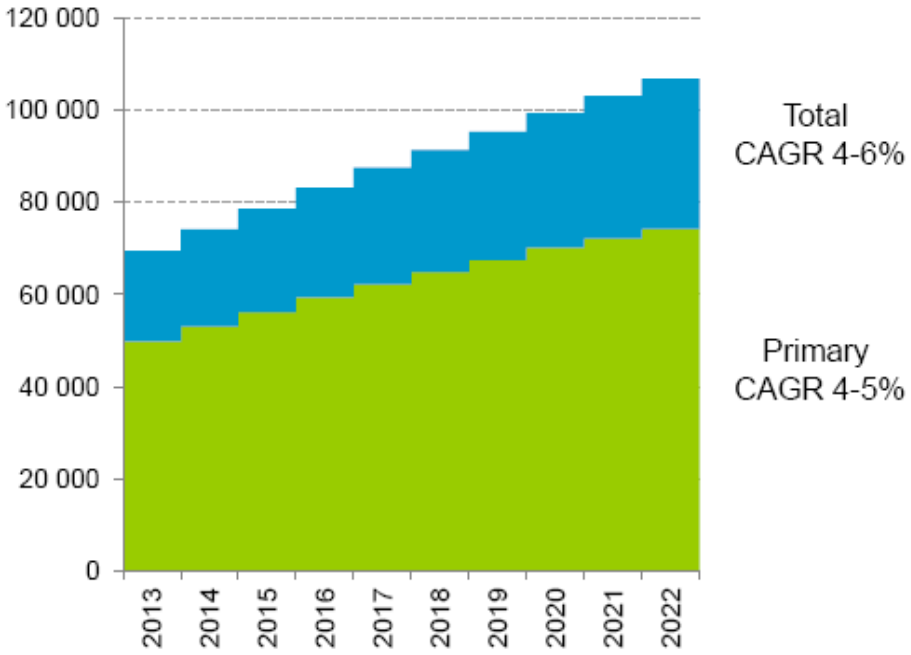


Significant Long-Run Growth Potential

Source: McKinsey

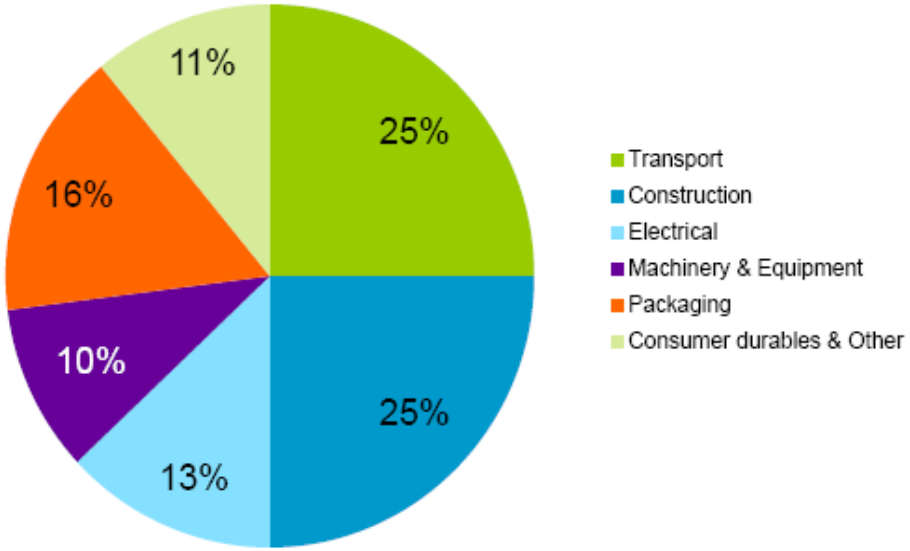
Global semis consumption will give upstream aluminium demand growth

Global consumption ('000 mt)

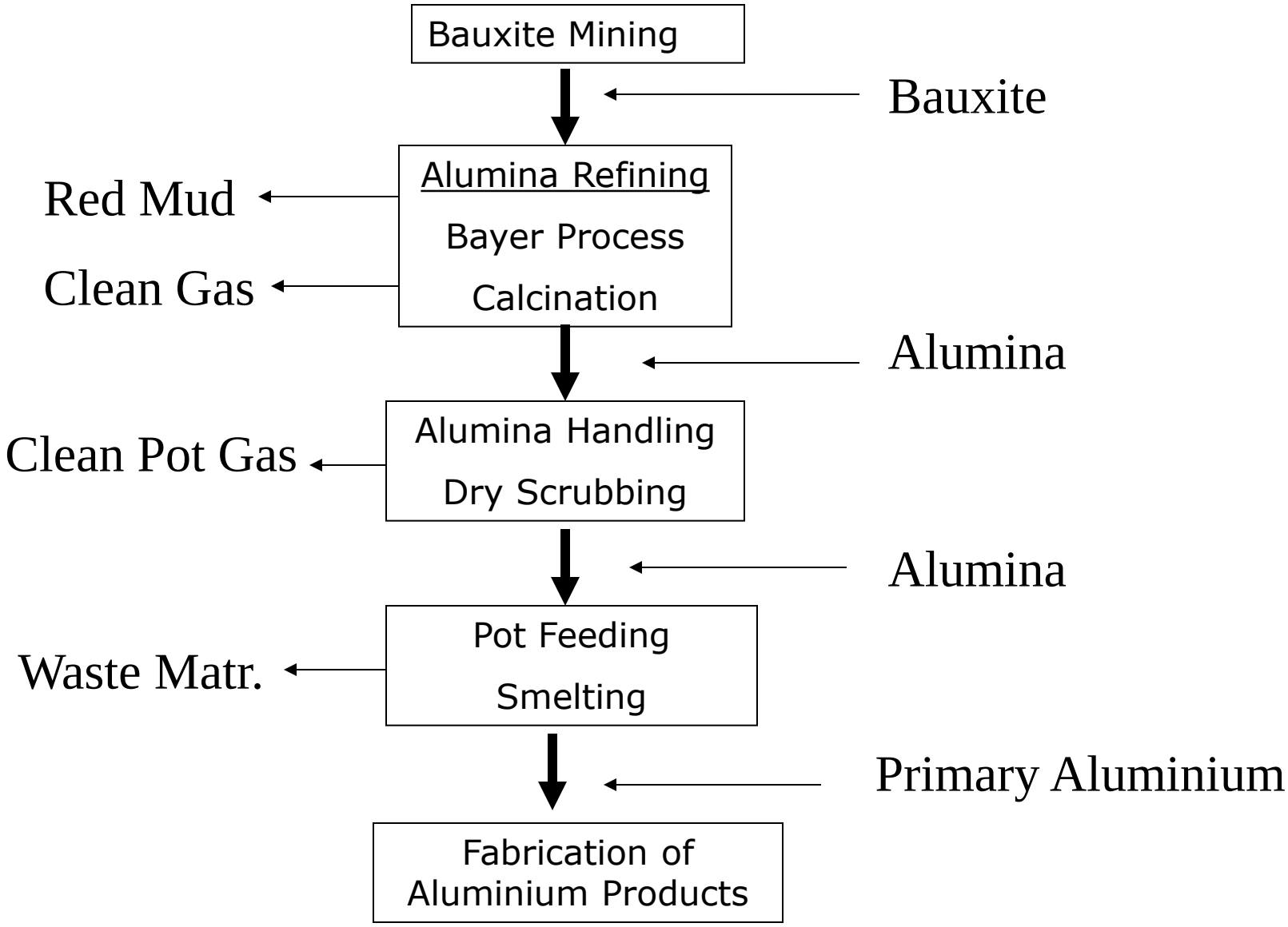


Source: CRU

Semis consumption by end-use



Aluminium Industry Structure



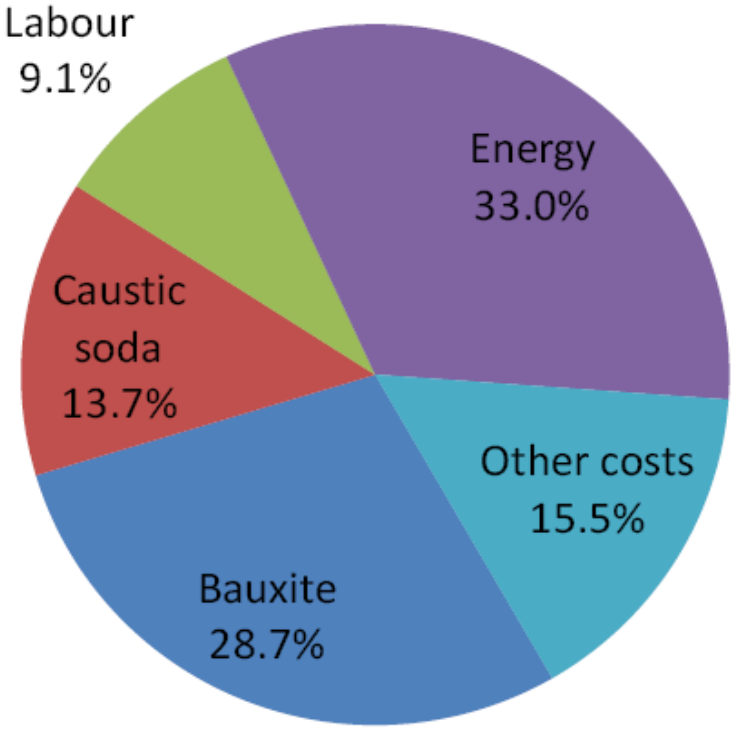
Bauxite –> Alumina –> Primary Aluminium

Distribution of aluminium production and bauxite reserves in the World

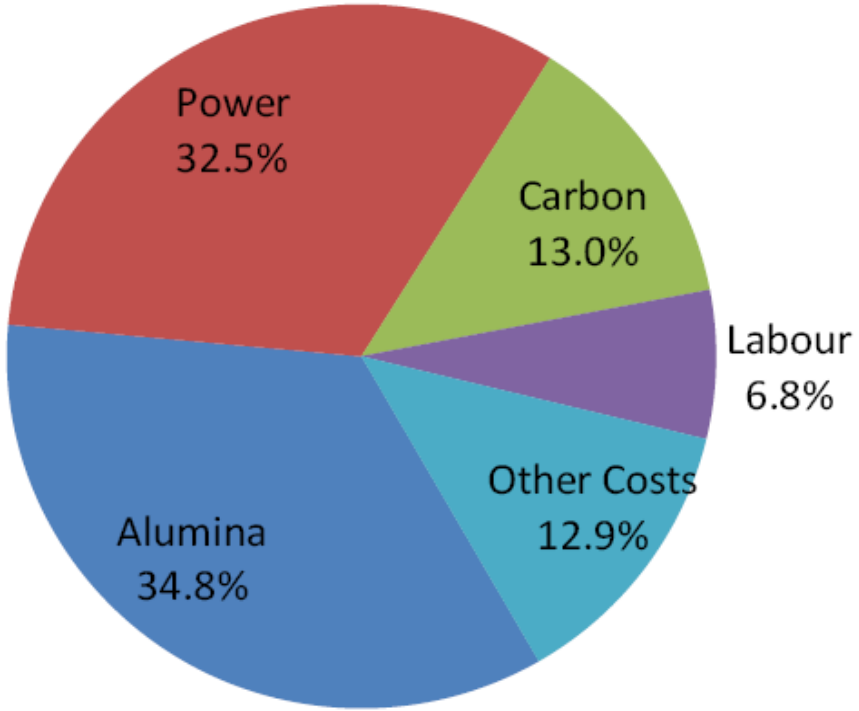
Regions	Aluminium production	Bauxite reserves
China	51 %	3 %
North America	13 %	<1%
CIS	9 %	1 %
Middle East	7 %	1 %
Europe	5 %	9 %
Asia excluding China	5 %	14%
Central & South America	5 %	25%
Australia	4 %	21%
Africa	1 %	26%

OPEX - Factor Cost Structure

Ala refining and Al smelting costs dominated by raw materials and energy costs



Alumina refining costs



Primary Al smelting costs

Note: Other costs include other materials and sustaining capital

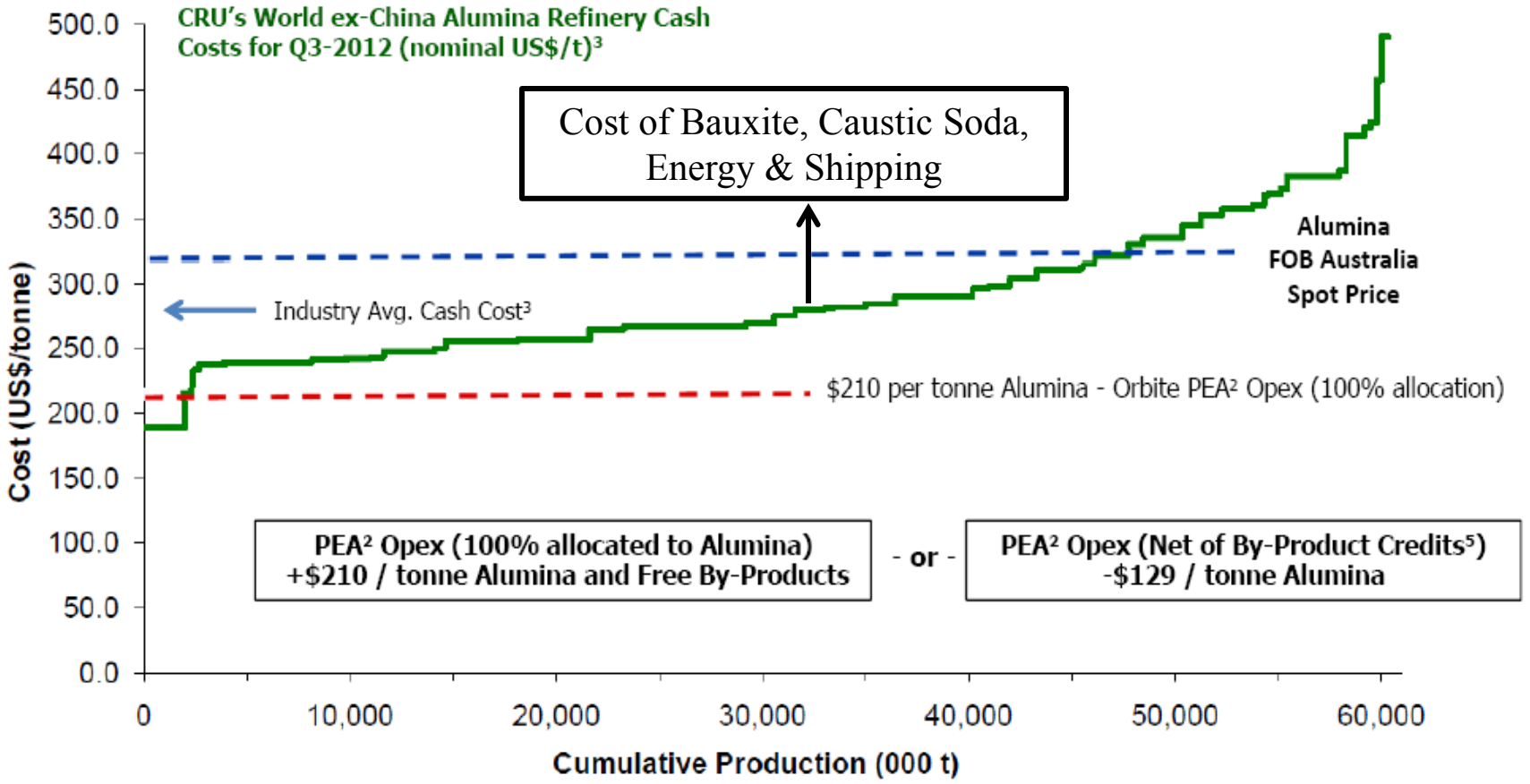
Cash Cost Drivers - OpEx

1) Bauxite
   - India - Prevented exploitation by Forrest Land Declaration;
   - China - Is running out of Good Domistic Quality;
   - Indonesia – Will build domistic Alumina Refinery;
   - Guinea – Expensive to build domistic Alumina Refinery;

2) Alumina
   - Increased Bauxite Cost;
   - Increased Caustic Soda Cost;
   - Increased Energy Cost if using HFO?
   - Globalization of Emissions Trading Scheme (ETS);
   - Transportaion from Southern- to Northern-Hemisphere;

3) Primary Aluminium
   - Increased Alumina Cost;
   - Increased Carbon Cost for Anodes;
   - Globalization of Emissions Trading Scheme (ETS);

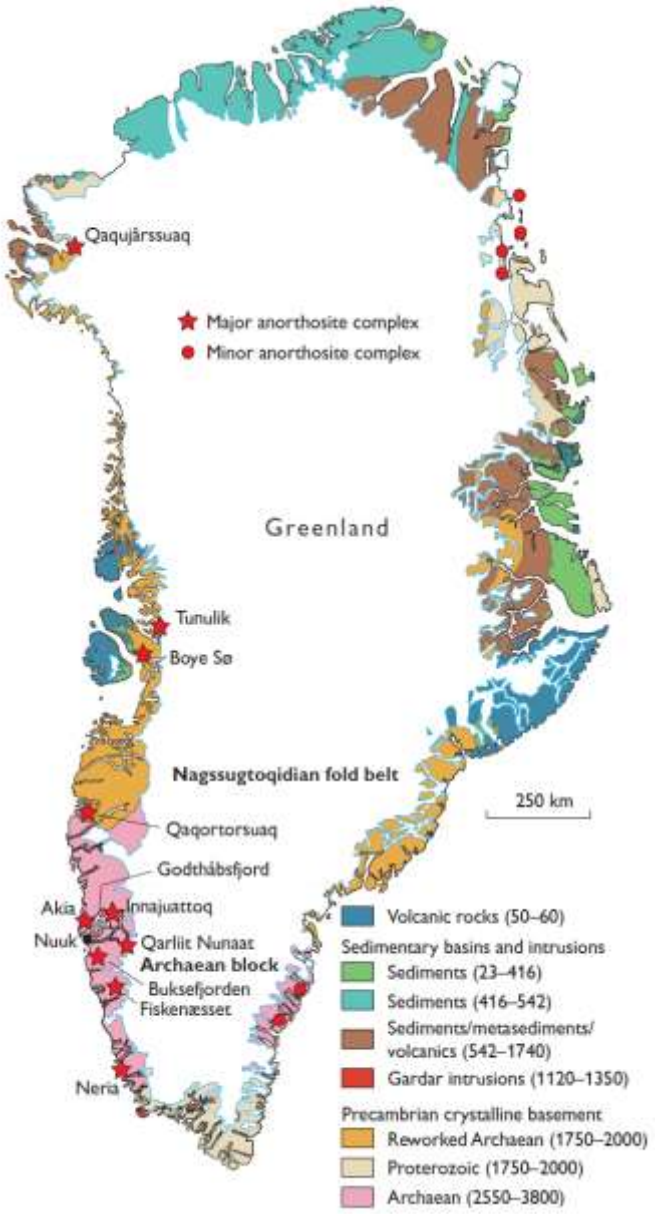
SGA OPEX[2] versus Alumina Industry Cost Curve[3]

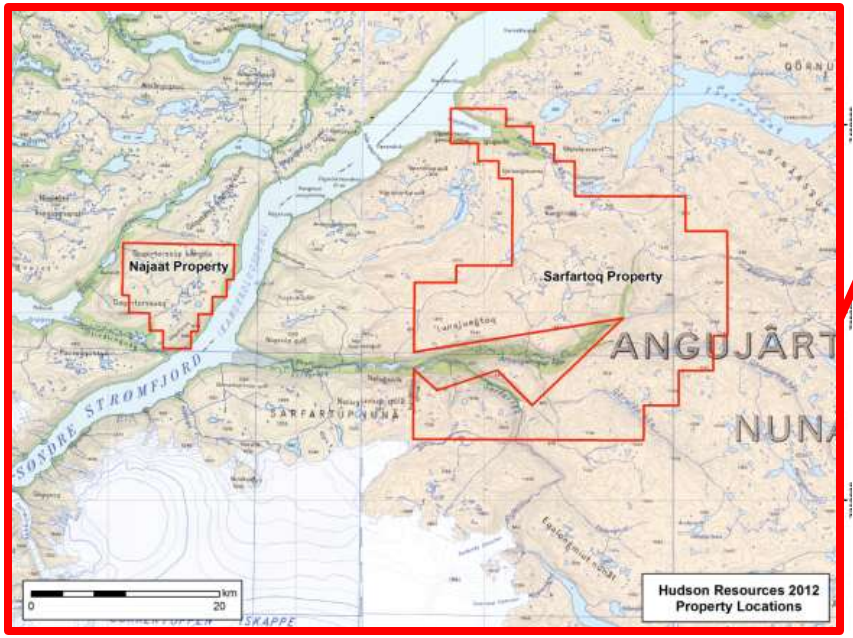


Greenland have two **Comparative Advantages** for producing Aluminium:

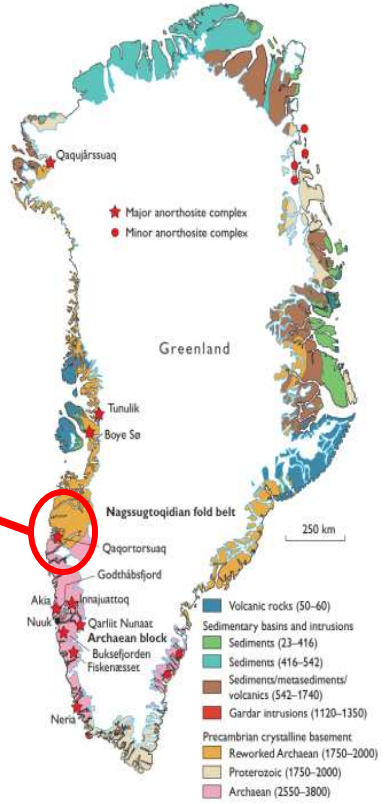
1) **Hydro-Electric Power** to supply about 13 kWh/ton of Primary Aluminium produced.

2) **Anorthosite Raw Material** for producing 2 ton of Alumina – for each 1 ton Aluminium.




Nájaat Property
Sarfartoq Property
ANGUJÂRT
NUNA
SARFARTUP NUNA
SØNDRE STRØMFJORD
km
0
20
Hudson Resources 2012
Property Locations


Sisimiut
Ilulissat
Maniitsoq
Nanortalik
Atammik
Nuuk
Kangerlussuaq
Aasiaat
Heliport
Town
Village
Glacier / Inland ice
Ice free land
Summer skiing area


Qaqujârssuaq
Major anorthosite complex
Minor anorthosite complex
Greenland
Tunulik
Boye Sø
Nagssugtoqidian fold belt
250 km
Qaqortorsuaq
Godthåbsfjord
Akia
Innajuattoq
Nuuk
Qarliit Nunaat
Archaean block
Buksefjorden
Fiskenæsset
Neria
Volcanic rocks (50–60)
Sedimentary basins and intrusions
Sediments (23–416)
Sediments (416–542)
Sediments/metasediments/
volcanics (542–1740)
Gardar intrusions (1120–1350)
Precambrian crystalline basement
Reworked Archaean (1750–2000)
Proterozoic (1750–2000)
Archaean (2550–3800)

Anorthosite Mining

Anorthosite

Alumina Refining

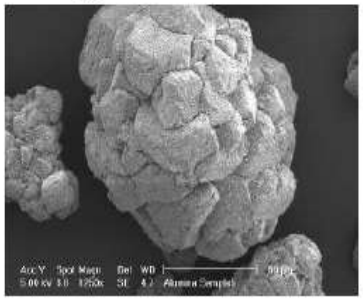
HCl Process

Calcination

Cleaned Gas

Grey Mud Tailings

Virgin Alumina



Alumina Handling

& Dry Scrubbing

Cleaned Pot Gas

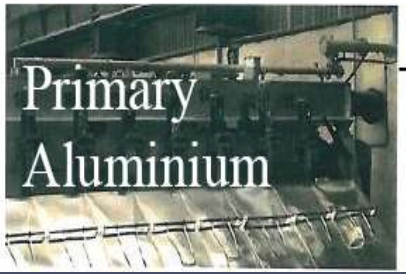
HF in Air

Pot Feeding

Smelting

Secondary Alumina

– HF Re-cycle



Spent Pot lining etc.

Export for Fabrication of Aluminium Products

”Some people see the world as it is and ask why?

I see the world as it could be and ask why not?”

Robert Kennedy, former Secretary of Justice, USA.

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Al Smelter in Greenland: Project key figures

DTU

Construction phase – hydro power	~	5 years
Construction phase – transmission network and furnace	~	2-3 years
Annual aluminum production	~	400,000 tons
Direct employment during the construction phase	~	2,600 persons
Employment in connection to structural investment and services during the construction phase	~	500 persons
Employment at the aluminum plant and hydro power plant during the operational phase (including apprentices)		650 persons
Other employment during the operational phase		500 - 600 persons
Number of hydro power plants		2
Total installed hydro power plant capacity		> 650 MW
Annual electricity production		> 5.5 billion kWh
Total length of power transmission cabling		> 240 km
Total estimated plant cost (hydro power plants, transmission network and aluminum plant)	~	20 billion DKK
Total estimated structural investment(Harbour, roads, accommodation etc. in Maniitsoq)	~	2.3 billion DKK

Source: www.aluminium.gl

Project Phases, Time Horizon & Financing

Stage 1: Power

- Develop **Hydro-Electric Power Project:**

Time : Year 1 – 7:

Financing: Project Financing (Governments, Institutional and Private Investors)?

Stage 2: Aluminium

- Establish **Primary Aluminium Smelter:**

Time: Year 3 – 10:

Financing: Global Aluminium producer sourcing Alumina from elsewhere?

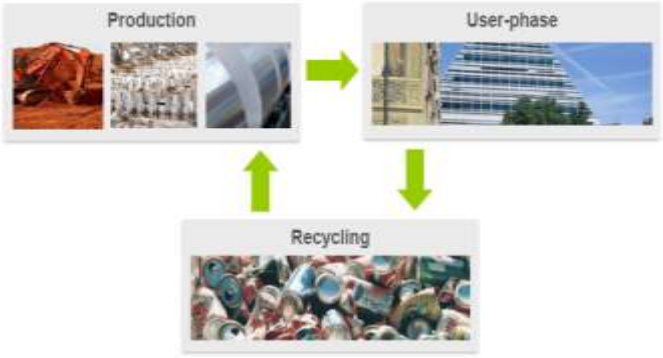
Stage 3: Alumina

- Develop **Alumina** production from Anothosite **("White Mountain"),** when proven to work in Pilot/Demo Scale:

Time: Year 1 – 15:

Financing: EU/KIC, Private and Institutional Investors?

Why not Greenland – 2021?



Thanks for your attention!

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