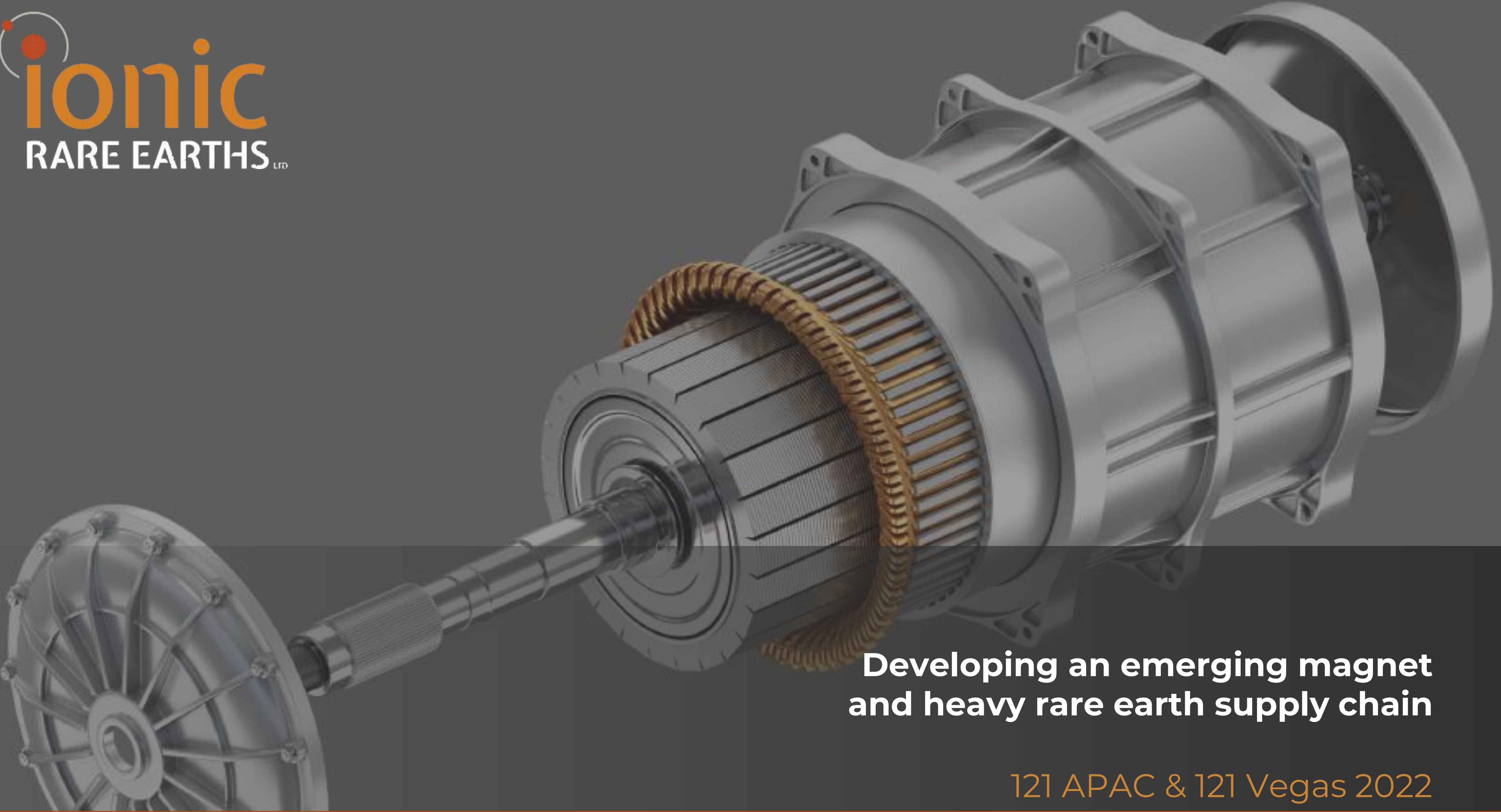
ionic
RARE EARTHS LTD



Developing an emerging magnet and heavy rare earth supply chain

121 APAC & 121 Vegas 2022

Cautionary Statement

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Information in this report that relates to previously reported Exploration Targets and Exploration Results has been crossed-referenced in this report to the date that it was originally reported to ASX. Ionic Rare Earths Limited confirms that it is not aware of any new information or data that materially affects information included in the relevant market announcements.

The information in this report that relates to Mineral Resources for the Makuutu Rare Earths deposit was first released to the ASX on 3 March 2021 and is available to view on www.asx.com.au. Ionic Rare Earths Limited confirms that it is not aware of any new information or data that materially affects information included in the relevant market announcement, and that all material assumptions and technical parameters underpinning the estimates in the announcement continue to apply and have not materially changed.

The information in this report that relates to Scoping Study results and production targets was first released to the ASX on 29 April 2021 and is available to view on www.asx.com.au. Ionic Rare Earths Limited confirms that it is not aware of any new information or data that materially affects information included in the relevant market announcement, and that all material assumptions and technical parameters underpinning the estimates in the announcement continue to apply and have not materially changed.

IonicRE targeting new, secure Rare Earths supply

DEVELOPING A SECURE, TRACEABLE, MAGNET AND HEAVY RARE EARTH SUPPLY CHAIN TO FACILITATE CARBON NEUTRALITY

The Mine – Makuutu

Makuutu is one of **very few global ionic adsorption clay (IAC) deposits** with scale to move the needle on HREO supply

Defined potential to supply **27+ year life of Mine**, with **50+ year potential supply**

Simple mining and low capex processing to produce Mixed Rare Earth Carbonate (MREC)

No radionuclides

The Refinery – Secure Supply

Opportunity to **maximise revenue** from the Makuutu Mixed Rare Earth Carbonate (MREC) product

Collaborate with end users on **development of secure and traceable REO supply chain**

REOs → Metal → Magnets

Magnet Recycling → REO

Life cycle ownership of REOs

The Basket – High Margin

One of the **highest value REO baskets of all projects** in evaluation today

43% magnet REOs (Nd, Pr, Dy, Tb, plus Sm, Gd, Ho)

44% Heavy REOs (Sm to Y)

93% of forecast value derived from magnet REOs plus Y

Major future source of **Scandium** production

Increasing Demand, Reducing Supply – Becoming Urgent

World accelerating to carbon neutrality, with 8-fold demand increase in both EVs and offshore wind turbine forecast by 2030

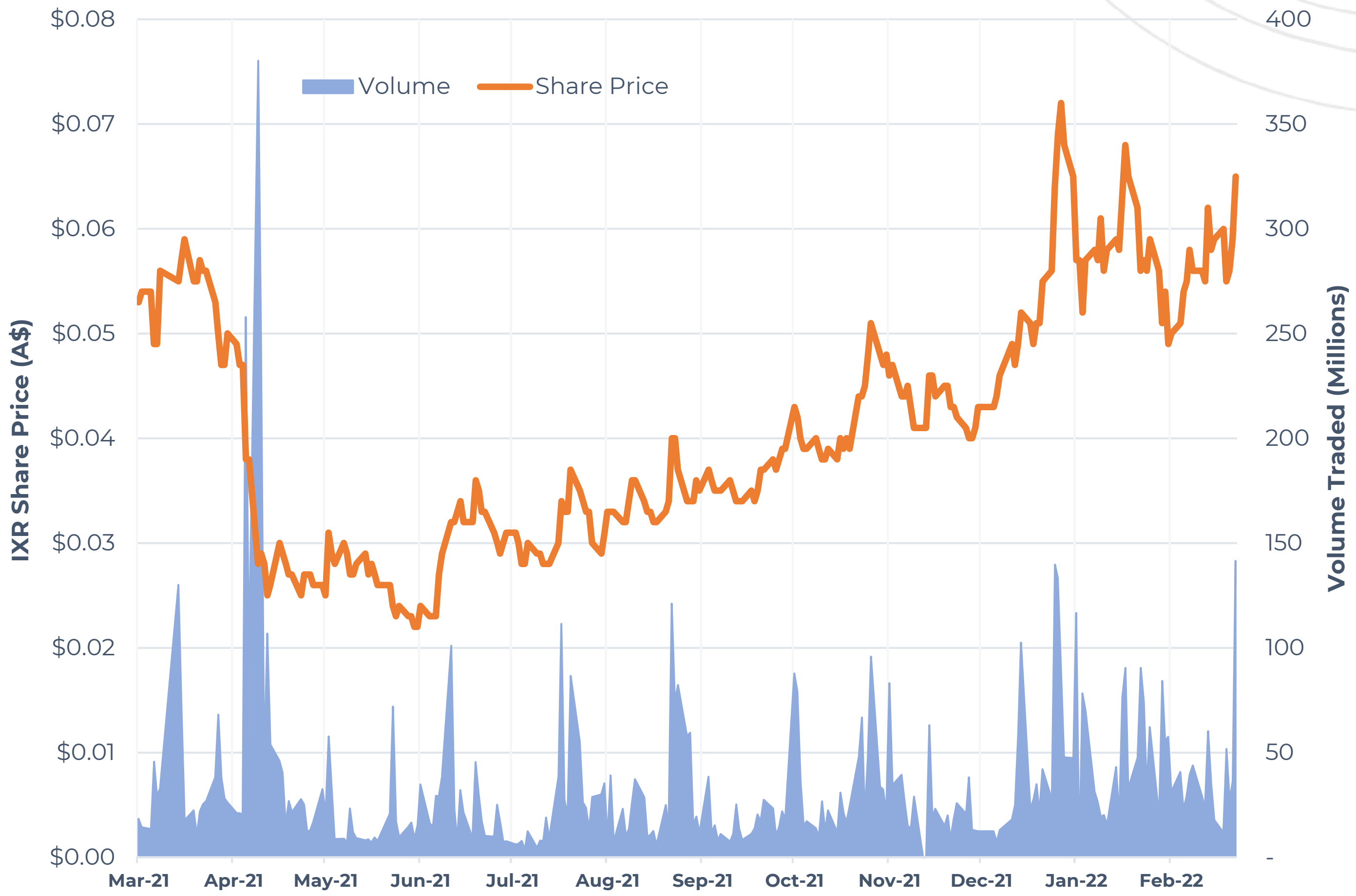
ESG drive globally to **source sustainable critical raw materials**

Limited future HREO supply from declining reserves of IACs in southern China

IonicRE Corporate Snapshot

STRATEGIC VALUE DRIVEN BY THE UNIQUE CREO/HREO BASKET

CAPITAL STRUCTURE (as @ 18/03/2022)	
Shares Outstanding	3,410,899,514
Total Options Outstanding	204,000,000 (exercisable at 1.8 to 6.4 cents)
Total Outstanding Performance Rights	13,500,000
Share Price	A$0.065
Market Capitalisation	A$222 million
52 week share price range	A$0.021 – A$0.073
Cash Balance (31/12/2021)	A$7.2 million
IXR MAJOR SHAREHOLDERS	
Major Shareholders (Top 20) Board, Executives, & Key Advisors	31.6% 11.0%
BOARD AND MANAGEMENT	
Trevor Benson	Chairman
Tim Harrison	Managing Director
Jill Kelley	Executive Director
Max McGarvie	Non Executive Director
Brett Dickson	Company Secretary & CFO



IonicRE Value Proposition

MAKUUTU'S STRATEGIC IMPORTANCE WILL INCREASE LONG TERM

- Long-life, low-CAPEX, high-payability MREC basket asset
- One of very few IACs outside of southern China / SE Asia
- Modular development → responsive to future demand
- Resource Upside → MRE Update planned in Q2 2022
- Very strategic REO basket – 73% magnet plus heavy REO
- MLA planned for Q4 2022 → Planned operations in 2024

PATH TO VERTICAL INTEGRATED RARE EARTH COMPANY

- Addition of SerenTech providing internal REE separation and refining capability
- Refinery Scoping Study underway, due Q3 2022
- Progressing initiatives to deliver secure and traceable new REE supply chains into western markets

MAGNET RECYCLING

- Potential for near term supply of magnet REOs sourced from environmentally favourable magnet recycling
- Chemical extraction technology, unique offering compared to peers
- Early market player in future REO supply chain from magnet recycling, which is expected to grow to 25% of REO supply chain by 2030

"When peering into the outlook for the next decade to come, it becomes quickly apparent that the rapid demand growth of the 2020s will soon be dwarfed by the astronomical demand growth of the 2030s – and therein lies the real defining challenge and opportunity facing the global rare earth industry today.

If the global industry continues to operate myopically – preparing, anticipating and investing only for a three to five-year outlook – the rate of demand growth for magnet rare earths will soon reach 'escape velocity'; a point at which annual demand growth becomes so great (i.e. >6,000 tonnes per annum) that it is simply implausible for the already-lagging supply-side to catch up and keep up."

Adamas Intelligence, Sept 28, 2020

Makuutu Rare Earths Project

Low Capital, Modular, Ionic Adsorption Clay Project

Harnessing the wide appeal of the Makuutu Basket

MAKUUTU PROVIDES A UNIQUELY BALANCED BASKET WITH 73% CRITICAL AND HEAVY RARE EARTHS

Scoping Study confirms **robust economics** for Base Case CREO and HREO production with **potential to extend beyond 27 + years Life of Mine (LOM)**

Strategic importance of Makuutu (51% IonicRE ownership moves to 60% on completion of FS ~ Oct 2022)

IonicRE has **pre-emptive right** on remaining 40% of the Project

Makuutu is unique and receiving global interest due to **high quality balanced** (CREO + HREO) basket

Classified as **medium Yttrium, high Europium IAC deposit**

Discussions continue with other groups looking to secure long-term CREO/HREO supply, and **potential feed to standalone IonicRE Rare Earth Refinery**

Existing Infrastructure at Makuutu

- Highway and road access to site plus rail
- Nearby 132 kV power infrastructure with readily available low-cost hydropower
- Cell phone communications available across site
- Water available

Significant Exploration upside at Makuutu still to be realised

Already one of **worlds largest Ionic Adsorption Clay (IAC) deposits**

Highly prospective licence EL00147 recently tested via RAB drilling with **assays confirming clay hosted REE mineralisation present**

Phase 4 drilling program completed to increase Indicated and Measured resource base

ESG initiatives ‘front and centre’ at Makuutu

ENVIRONMENT, SOCIAL AND GOVERNANCE (ESG) FRAMEWORK IN DEVELOPMENT TO BUILD LASTING LEGACY

Environmental and Social Impact Assessment (ESIA) submitted in December 2021, feedback in process

Baseline environmental surveys completed

Focus on carbon footprint reduction using renewable power

Rehabilitation plans to ensure net positive climate legacy

Water treatment for reagent recovery and rehabilitation strategy

Rehabilitation to consider development of longer term industrial programs for employment

Aligned with Uganda’s 3rd National Development Plan (NDPIII)

Agricultural Programs to increase productivity

Aquaculture and fish farming

Agroforestry

Community Support Programs identified

Working together to build a future where everyone has a pathway to health and opportunity

Establishment of an Advisory Committee to coordinate community development investment priorities

Key focus being community health and education

Community socio-economic baseline surveys across initial project area underway

Establishing Ugandan team to drive Project activity in country

Community and Stakeholder engagement ramping up

Local support for sub-district health clinics during Covid-19

Makuutu Rare Earth Project Highlights – FS/MLA planned for Q4 2022

STRATEGIC VALUE DERIVED BY THE UNIQUE CREO/HREO DOMINANT BASKET

Ionic Adsorption Clay (IAC) deposit mineralisation is highly desirable given it produces a balanced **basket dominant in magnet & heavy REO**

Globally one of the largest IAC deposits discovered outside of southern China and SE Asia & one of less than a handful of economic size and scale

315 Mt Mineral Resource Estimate[2] with **significant exploration upside** confirmed with mineralisation stretching across 37 km trend – **MRE Update planned for Q2 2022**

High margin basket potential, approx. **73% of basket is magnet + heavy REO (magnet REOs make up 43% of basket)**

Scoping Study[1] completed in April 2021 defined a **very robust base case** with highly attractive 11-year Base Case economic parameters.

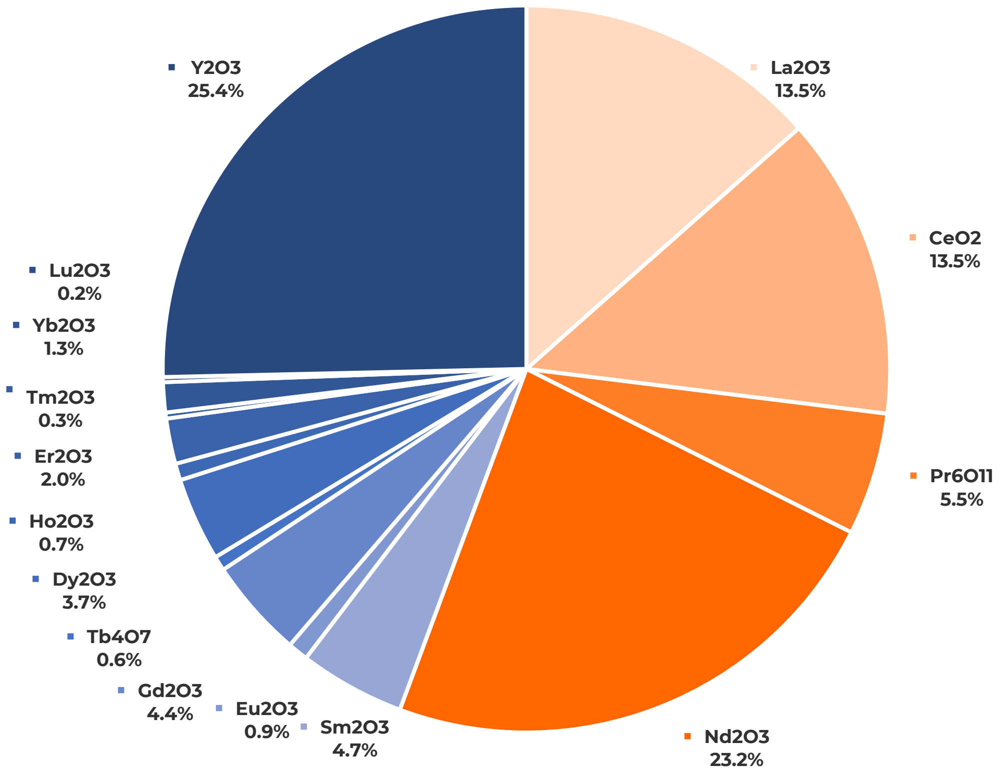
- Post-tax long term free cash flow **US$766 million** over 11 years
- EBITDA of **US$1.28 billion**
- Post-tax Net Present Value (8) of **US$321 million**
- Internal Rate of Return of **38%**
- Pre-production CAPEX requirement of **US$89 million (1 MODULE)** or **US$129 million (2 MODULES)**
- Expansion CAPEX of $212 million funded by Project free cash flow
- Potential upside out to 27 years with inclusion of Inferred resource
- **10% increase in basket REO price leads to 30% increase in post tax NPV(8)**

Feasibility Study underway now – **due October 2022** – to explore more aggressive ramp up to meet global demand for Makuutu's basket and incorporate expected increase to MRE Indicated classification → **MLA in October 2022**

Global Appeal – Strategic importance of Makuutu product basket seen as critical for governments to **deliver carbon neutral policy objectives** & major appeal to **key defence applications**

Scandium upside is significant with MRE containing ~9,450 tonne Sc_2O_3, potential annual production from 25 to ~100 tonnes per annum

MAKUUTU BASKET HIGH VALUE CREO / HREO PRODUCT



[1] Makuutu Rare Earths Project Scoping Study reported to ASX on 29 April 2021. [2] Makuutu Mineral Resource Estimate announced 3 March 2021.

IonicRE Basket is a highly strategic basket with High Value

DOWNSTREAM PROCESSING TO REO AND VALUE ADDED PRODUCTS UNLOCKS SIGNIFICANT UPSIDE

IonicRE progressing & evaluating downstream REE separation and refining circuit

Test work underway to feed into **process modelling and optimisation** – iterative process

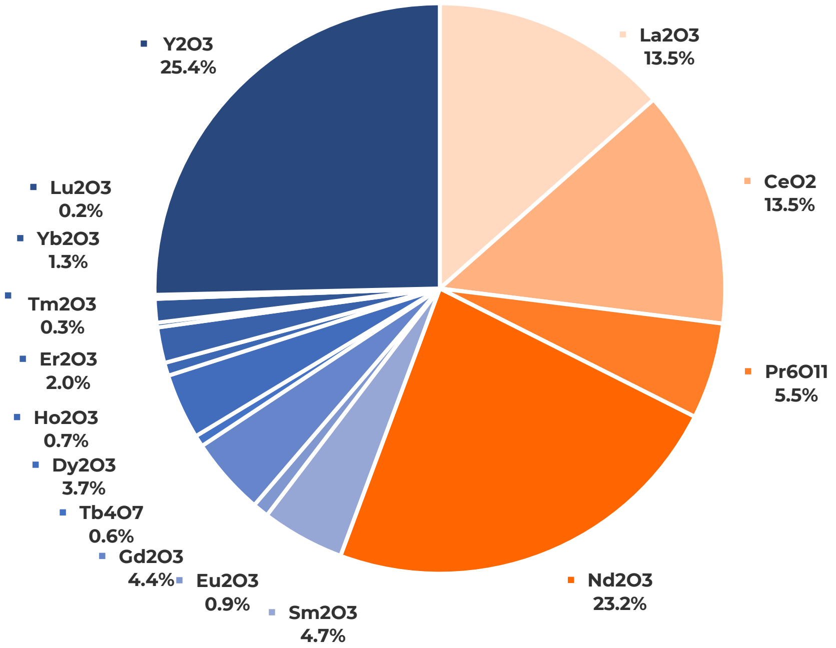
Exploring opportunities to value add beyond REOs

- **MREC product** typically has payability ~ 60-70% (~ US$62-72/kg) depending upon destination
- **Refined REO** payability increased to 100% (~US$103/kg)
- Value added **metals and alloys** creates significant step change in revenue potential from (~US$142/kg)

Scandium upside represents potential increase of 20-25% additional revenue potential from Makuutu LOM

Rare Earth Oxide		Makuutu Basket Composition	REO Pricing (China) Argus Metals 15-MAR-2022 US$/kg
La_2O_3	%	13.5%	$ 1.52
CeO_2	%	13.5%	$ 1.58
Pr_6O_{11}	%	5.5%	$ 169.00
Nd_2O_3	%	23.2%	$ 182.50
Sm_2O_3	%	4.7%	$ 5.20
Eu_2O_3	%	0.9%	$ 31.50
Gd_2O_3	%	4.4%	$ 112.50
Tb_4O_7	%	0.6%	$ 2,340.00
Dy_2O_3	%	3.7%	$ 480.00
Ho_2O_3	%	0.7%	$ 305.00
Er_2O_3	%	2.0%	$ 69.00
Tm_2O_3	%	0.3%	$ 850.00
Yb_2O_3	%	1.3%	$ 16.30
Lu_2O_3	%	0.2%	$ 805.00
Y_2O_3	%	25.4%	$ 16.10
Sum Total		100%	
Magnet REO	%	43%	
LREO	%	56%	
HREO	%	44%	
CREO	%	54%	
Basket Value	US$/kg		$ 102.55

MAKUUTU BASKET CONTENT HIGH VALUE CREO / HREO PRODUCT



Note. Rounding Applied to nearest 0.1%.

Tier-One In-Country Infrastructure already there – supports low CAPEX development

EXCELLENT LOCAL INFRASTRUCTURE SUPPORTS LOW CAPEX DEVELOPMENT

LOGISTICS

Approximately **10 km from Highway** 109, connecting Makuutu to both capital city Kampala and Port of Mombasa, Kenya

Approximately **20 km from rail line** connecting to Port of Mombasa

POWER

Large hydroelectric generation capacity (+810MW) within 65 km of Makuutu Project area will deliver **very low-cost power** (US$0.05/kWh), plus further capacity being developed

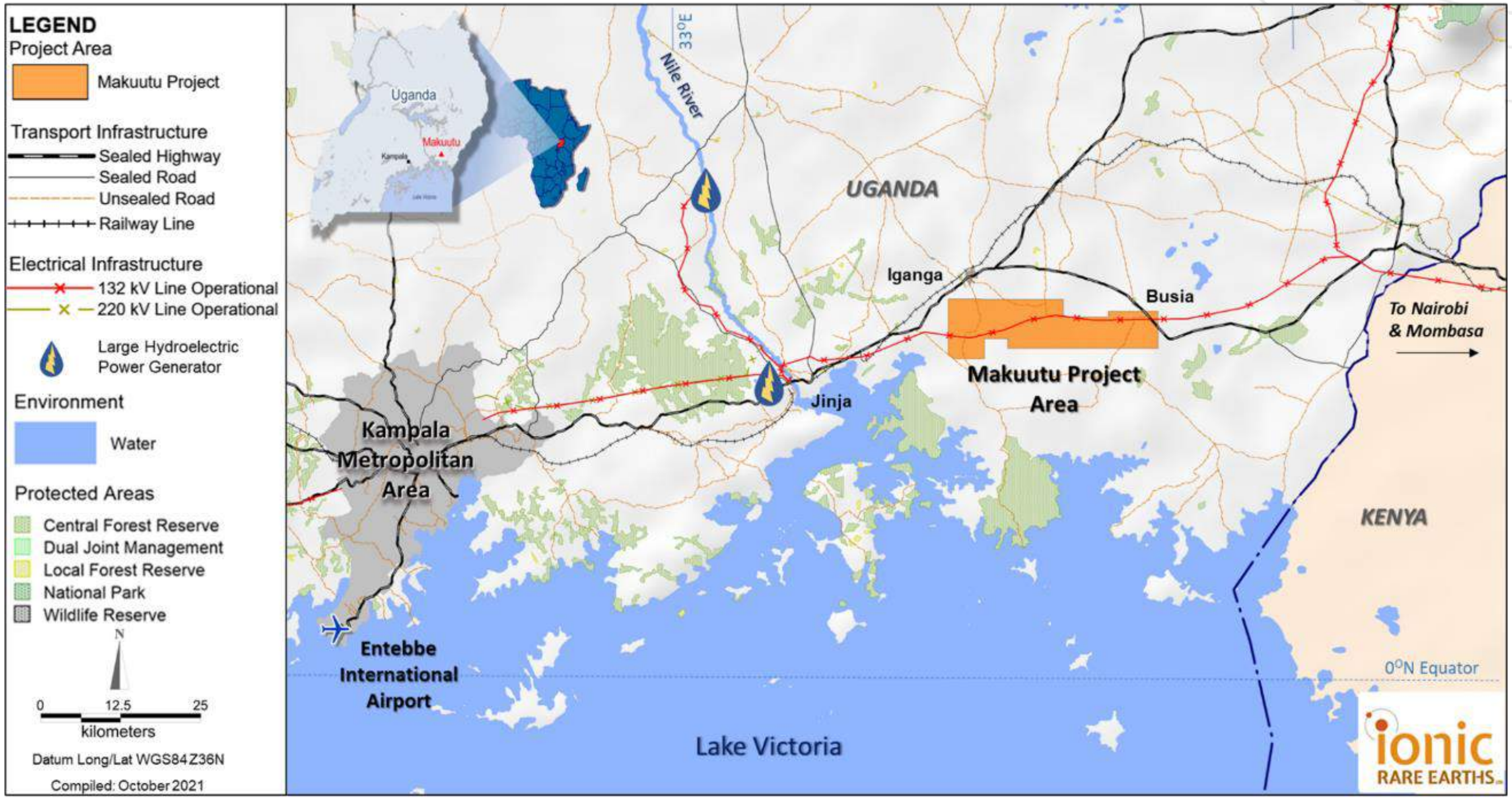
Existing electrical grid infrastructure immediately adjacent to site to provide stable power

WATER

Plentiful fresh water within and near project area (water harvesting)

WORKFORCE

No camp required – low-cost professional local workforce available



Phase 4 Drill Program and Mineral Resource Estimate Update

REMAINING DRILL ASSAYS OVER Q1 2022 TO CULMINATE IN MATERIAL UPGRADE OF MAKUUTU MRE IN Q2 2022

Phase 4 infill drilling program completed (8,200 m, 432 holes) with **366 of 432 holes reported / 1 Tranches pending** to feed into **MRE update planned for Q2 2022 – all holes to date have returned REE clay above MRE cut-off grade**

67 RAB drill holes (Phase 3) announced in July **confirmed extension of mineralisation east to EL00147, between previous identified radiometric anomalies, and to northwest (EL00257)**

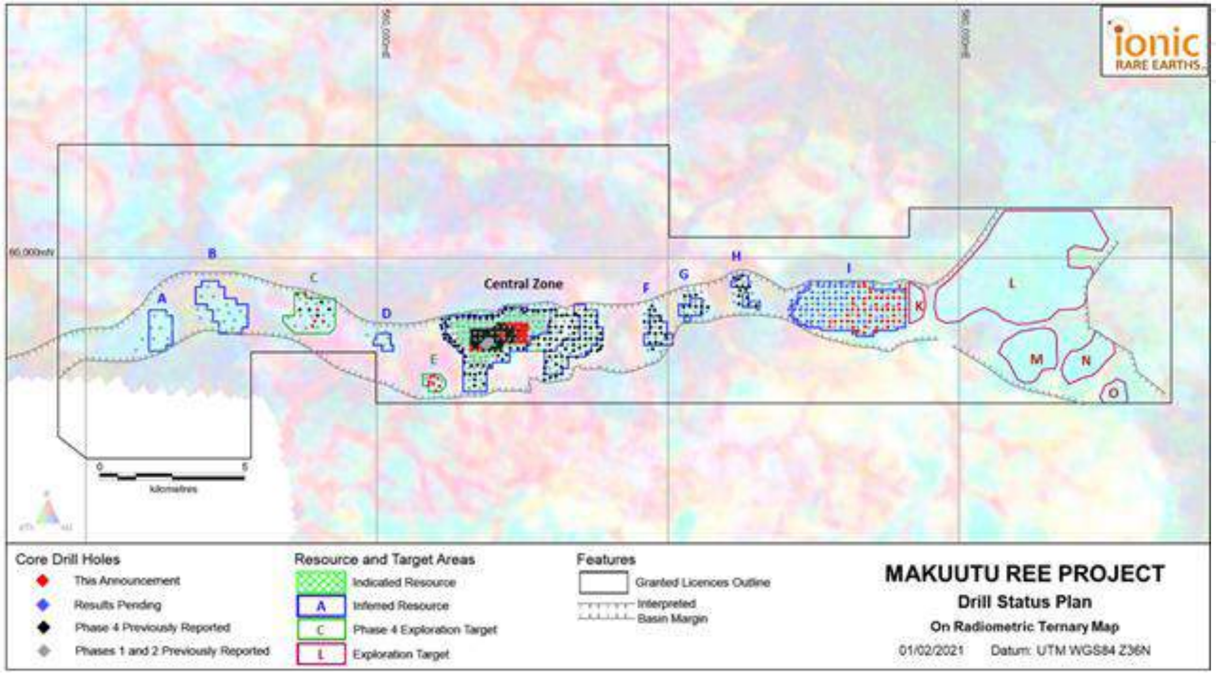
279 drill holes (4,754 metres) completed between October 2019 and October 2020 defining **JORC MRE[1] of 315 Mt @ 650 ppm** Total Rare Earths Oxide (TREO), at a cut-off grade of 200 ppm TREO-CeO_2

Objective to deliver a material **increase in Indicated and Mineral Resource classification** to support Feasibility Study in 2022

Near term exploration extension from areas that haven't yet converted (Areas C, E, Central Eastern Zone) so expecting total MRE will increase

Shallow, near surface IAC mineralisation, with clay layer averaging 5 to 12m thick under cover approximately 3m deep. Average hole depth ~17m

Longer term, **numerous exploration targets identified** for drilling in 2022/2023



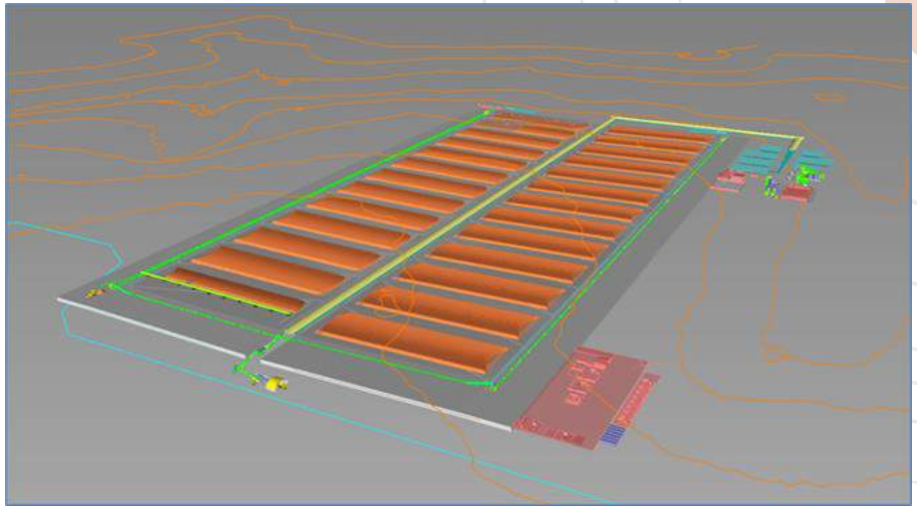
Category	Estimation Domain	Tonnes (Mt)	TREO (ppm)	TREO no CeO_2 (ppm)	LREO (ppm)	HREO (ppm)	CREO (ppm)	Sc_2O_3 (ppm)
Indicated	Clay	66	820	570	590	230	300	30
Inferred	Clay	248	610	410	450	160	210	30
Total Resource	**Clay**	**315**	**650**	**440**	**480**	**170**	**230**	**30**

[1] Makuutu Mineral Resource Estimate reported to ASX on 3 March 2021. [2] Phase 3 RAB results announced 15 July and 20 July 2021.

Project Development Activities

MAKUUTU FEASIBILITY STUDY PROGRESSING TOWARDS COMPLETION Q4 2022

- **Metallurgical testwork ramped up**
  - Accelerated variability bottle rolls, heap leach columns, mineralogy programs progressing towards geometallurgical model for Makuutu, with broad scale variability columns planned for Q2
  - **Heap leach columns demonstrating successful scale up**
    - 1m → 2m → 3m with plans to explore 5m columns in Q2
- **Process Model developed** for flowsheet trade-off analysis and optimisation of desorption chemistry, along with **3D Process Plant Model**
- **Engineering at 56% completion** – finalising the design for the plant and determining quantities to support the estimating activities
- **MRE update** to feed into mine planning to commence in Q2
- ESIA feedback and ongoing community consultation sessions and hearings with **outcome expected Q2 2022**
- Resettlement Action Plan progressing with planned completion mid year
- Exploring options for **more aggressive ramp up** to align with demands from potential partners on magnet REO supply chain
- **Mining Licence Application** planning underway for Q4 2022
- Planning for Demonstration Plant post MLA
- Continuing to build capacity in Uganda adding project resources to team
- Extensional / field exploration programs being evaluated



3D Model developed for Makuutu

1m and 2m Heap Leach Columns at ANSTO

3m Heap Leach Columns at ANSTO

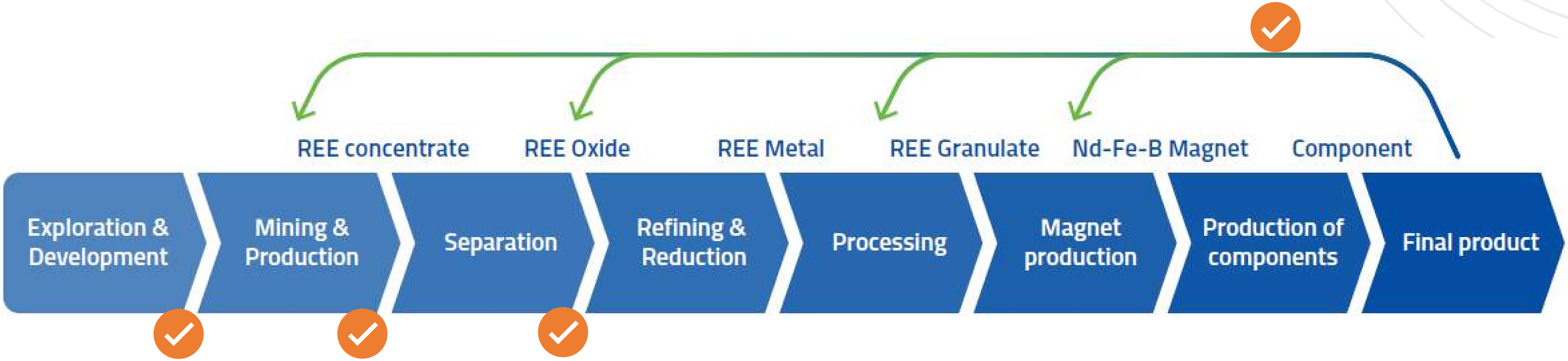
Makuutu Timeline to Production

ACCELERATING MAKUUTU TOWARDS PLANNED PRODUCTION IN 2024

ACTIVITY	2022				2023				2024	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Resource Drilling Assays (Phase 4)										
Metallurgy Testwork										
MRE Update										
ESIA (submitted Dec 2021)										
Feasibility Study										
Landowner Agreements										
Funding Agreements										
Mining Licence Application										
Final Investment Decision										
Site Early Works										
Construction										
Mining Commences										
Commissioning										
Plant Production										

REE Supply Chain and IonicRE Capability to date

IONICRE ADDING CAPACITY TO BECOME MORE INTEGRATED IN NEW FUTURE RARE EARTH SUPPLY CHAINS



1. Makuutu Rare Earths Project

- Low Capital, modular development enables IonicRE to bring on highly sought-after basket of REEs
- Expandable with free cash flows and growing market demand
- MLA planned for late 2022
- Commencing operations in 2024

2. IonicRE Refinery

- Under Evaluation now assessing potential economics
- Targeting separation of MREC from Makuutu to produce refined REOs for downstream conversion to metals and alloys
- Potential to receive MREC feed or HREO products from other producers

3. Magnet Recycling

- Low capital development to recycle spent magnets and swarf to produce separated and refined 99.99%+ REOs
- Near term magnet REO production capacity (Nd, Pr, Dy and Tb – potential for Sm, Gd, Ho)
- Modular recycling plants located in numerous jurisdictions

Rare Earth Magnets and Motors: A European Call for Action A report by the Rare Earth Magnets and Motors Cluster of the European Raw Materials Alliances.

China Dominates Global REE Separation & Refining Capacity

ALL HEAVY RARE EARTH ROADS LEAD TO CHINA .... UNTIL NOW

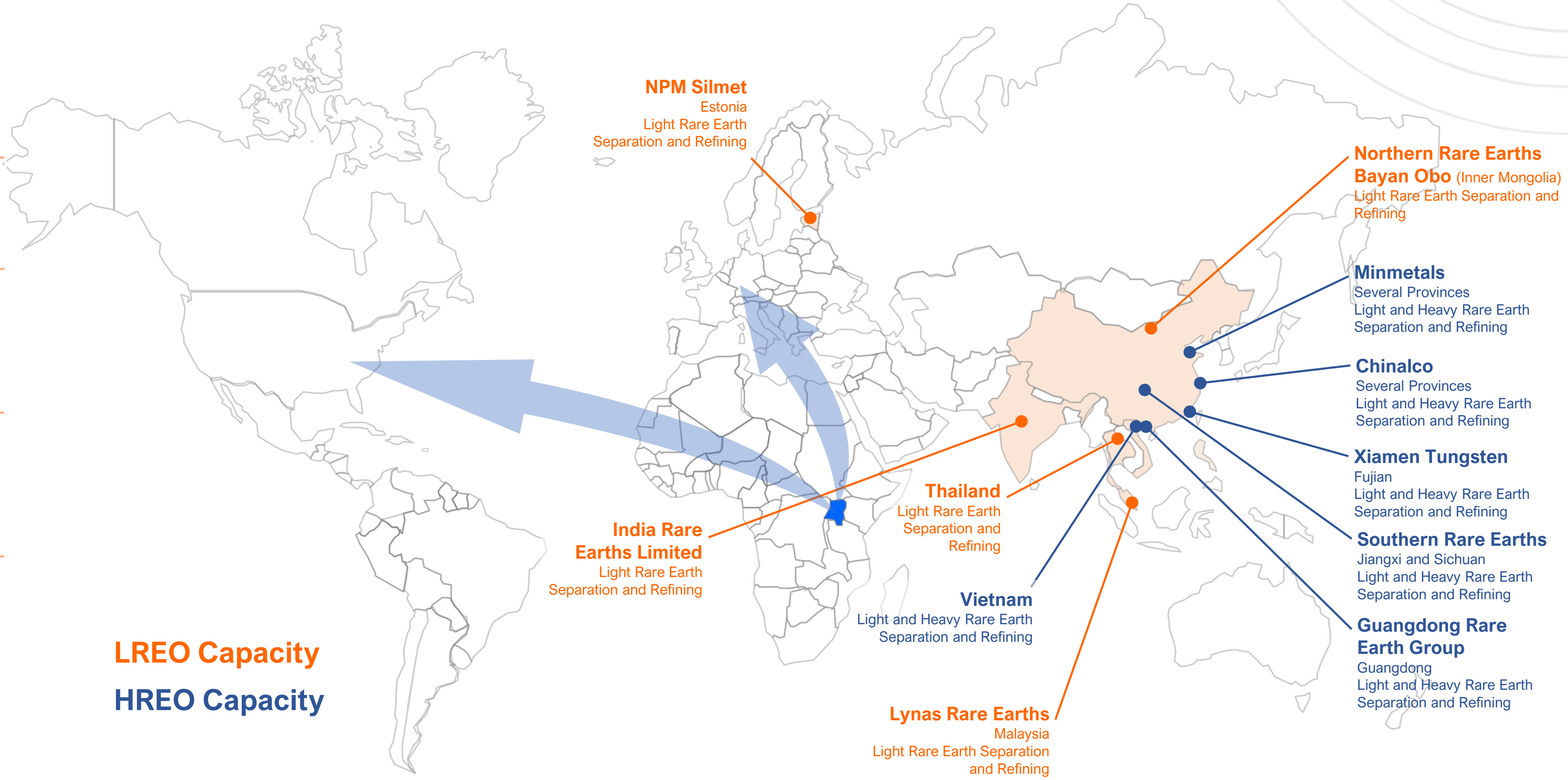
Global HREO separation and refining capacity operated and controlled by China[1]

Small capacity identified in Vietnam

HREO separation and refining plants under consideration but no committed timelines as yet

IonicRE evaluating a number of global locations to base heavy rare earth refinery

IonicRE to advance Rare Earth Refinery to Magnets Initiative (including Recycling) in to sell product to partners in EU and US



[1] Argus Analytics.

Standalone Refinery to unlock value of balanced basket REOs

DEVELOPMENT SUPPLY CHAIN TO PRODUCE REOs OF INCREASING DEMAND AND DECREASING SUPPLY

- Rare earth separation and refinery facility developed to take advantage of long life, secure and traceable supply source from Makuutu
  - Plan to ramp up to ~ 4,000 tonnes per annum of REO
  - Long life potential producing a basket with suite of individual REEs that will appreciate in near / long term
  - Increase of Makuutu MRE → extension of life → increased appeal to go downstream
- Potential to source additional HREO feed stocks (as heavy MREC products) by other REE mines for additional revenue generation
- Inclusion of magnet recycling increased Nd, Pr, Dy and Tb production capacity longer term
- Facilitate the value of the refined REOs into downstream industry
  - Opportunity for OEMs to participate in secure and traceable supply chain
  - Various industrial opportunities to create JV's in new industrial applications
- Maximise revenue upside from development of the Sc market

Rare Earth Element	REO Production Capacity[1] (t/annum)	Major Applications and Uses
Lanthanum (La)	580	Battery alloys, metal alloys, auto catalysts, petroleum refining, polishing powders, glass additives, phosphors, ceramics, and optics
Cerium (Ce)	550	Battery alloys, metal alloys, auto catalysts, petroleum refining, polishing powders, glass additives, phosphors, and ceramics
Praseodymium (Pr)	220	Permanent magnets, battery alloys, metal alloys, auto catalysts, polishing powders, glass additives and colouring ceramics
Neodymium (Nd)	1,000	Permanent magnets, battery alloys, metal alloys, auto catalysts, glass additives and ceramics
Samarium (Sm)	180	Magnets, ceramics, and radiation treatment (cancer)
Europium (Eu)	35	Phosphors, optical fibres, flat panel displays
Gadolinium (Gd)	170	Ceramics, nuclear energy, and medical (magnetic resonance imaging X-rays)
Terbium (Tb)	25	Permanent magnets for high temperature applications, fluorescent lamp phosphors, defence applications
Dysprosium (Dy)	140	Permanent magnets, defence
Holmium (Ho)	30	Permanent magnets, nuclear energy and microwave equipment
Erbium (Er)	75	Nuclear energy, fibre optic communications, and glass colouring
Thulium (Tm)	11	X-rays (medical) and lasers
Ytterbium (Yb)	65	Cancer treatment and stainless steel
Lutetium (Lu)	10	Age determination, medical and petroleum refining
Yttrium (Y)	1,000	Battery alloys, metal alloys, phosphors, catalytic converters, ceramics and defence
Scandium (Sc)	120	High strength, low weight aluminium scandium alloys, solid state energy storage, 3D printing, high intensity lighting

REE Value Chain and Demand to 2030

DEMAND FOR NEW SUPPLY OF Nd-Fe-B PERMANENT MAGNETS FOR EVs & OFFSHORE WIND

- Rare earths are amongst the most resource-critical raw materials: they are of highest economic importance and at the same time feature a high supply risk – **supply chain dominated by China**
- NdFeB magnets play a vital role in the industrial economy of the world, with about 130,000 tonnes produced in 2019 worldwide which corresponds to **a market value of about US$7.5B**
- In 2019 ~ 5,000 tonnes of rare earth permanent magnets were used in EVs worldwide
- **By 2030, the number may rise to between 40,000 and 70,000 tonnes on a global scale**
- A global EV market worth about **US$700B – US$1,100B (and growing!)** would depend on securing access to sustainably produced rare earth magnets – a **comparatively small but specialised market of about US$2.3B – US$3.4B billion**
- Wind turbine generator supply will add to demand, with **expected addition of 235 GW (25% CAGR) to 2030**

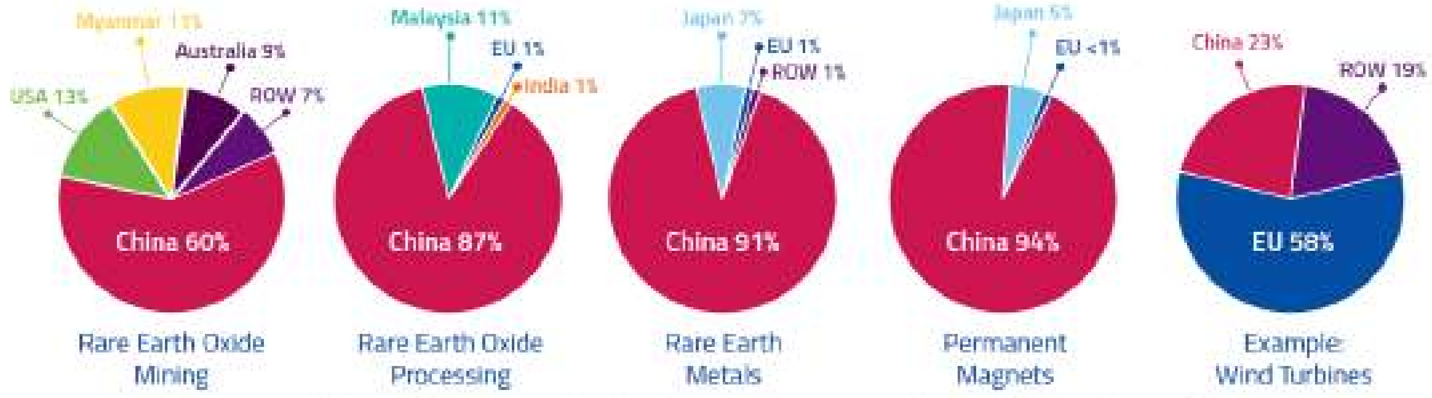


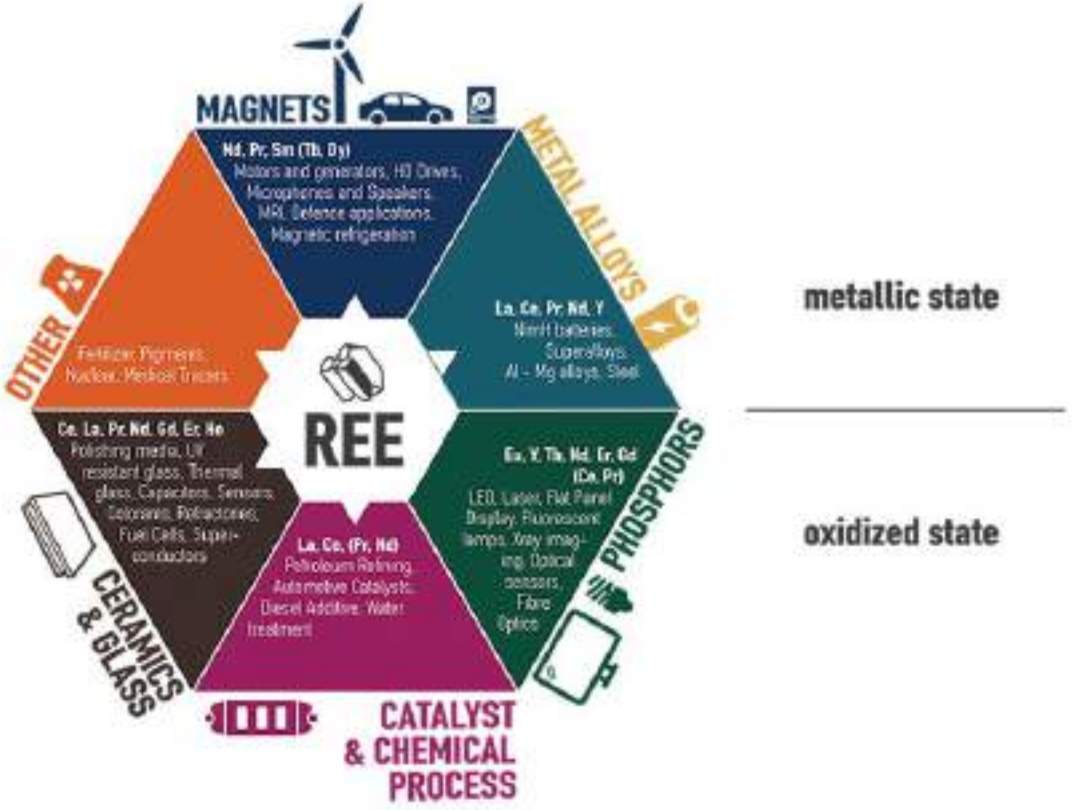
Fig. 3: From rare earths mining to wind turbine manufacturing: estimated market shares in 2019. Sources: Team analysis and Roskill 2018; Adamos Intelligence 2019; Petaves 2017; Carrara et al 2020; IEA 2021; USGS 2021.

Rare Earth Magnets and Motors: A European Call for Action A report by the Rare Earth Magnets and Motors Cluster of the European Raw Materials Alliances, Oct 2021.
Argus Analytics Oct 2021.

IonicRE Vision – Facilitating Manufacturing

DEVELIVERING MAGNET & HEAVY REO SUPPLY CHAIN TO CREATE NEW INDUSTRY AND JV's

- Through the availability of long-life, low-cost MREC from Makuutu, IonicRE aiming to **develop relationships with key industry participants to generate EU and US based manufacturing activity**
- **Initial focus on permanent magnets** used in Electric Vehicles, Offshore Wind Turbines and Defence
  - Expanded out shortly after to cover other magnet REO applications with Sm, Gd and Ho
- Longer term **focus in heavy rare earth growth opportunities**
  - Niche heavy rare earth applications and high-end technologies – communications, medical, laser optics
- Providing a secure and traceable supply of magnet and heavy rare earths – **Seeds of Technology** – to **facilitate new R&D to propagate new applications and innovations with partners**
- Development of **new age alloys for new technologies - Aluminium-Scandium alloys** in light weighting transportation
- Facilitating **Life Cycle ownership of Rare earth processing**
  - Magnet recycling and redeployment of magnet REOs back to new high quality, high intensity applications



NdFeB Magnet Recycling

DEVELOPING CAPACITY ON RARE EARTH SEPARATION, REFINING AND RECYCLING

- IonicRE in process of acquiring Seren Technologies Ltd (ASX: Dec 2021) to be a leading magnet recycling company
- The pilot plant scale plant has processed rare earth waste magnets received from supply chain stake holders and achieved extraction of recycled REE content to produce oxides at purity of 99.9%
- Commercialisation strategy examining options to develop recycling facility processing up to 600 tpa waste magnets and swarf to produce ~ 200 tonne REO
- Capital and operating costs under review as part of due diligence
- Provide springboard to accelerated rare earth production capacity, with potential to commence operation in 2023 whilst Makuutu is being developed and ramped up and in parallel to the development of the Refinery

MIXED GRADES OF WASTE PERMANENT MAGNETS

100% RECYCLED INDIVIDUAL RARE EARTH OXIDES

HIGH SPECIFICATION PERMANENT MAGNETS FOR E-DRIVES

Looking Forward to 2022

KEY ACTIVITIES OVER NEXT 6 TO 12 MONTH THAT UNLOCK SUBSTANTIAL VALUE AT IONIC RARE EARTHS

- Drill assays from final Tranche remaining from Phase 4 infill program (next 1-2 weeks)
- Complete DD / Acquisition of Seren Technologies (Q1/Q2 2022)
- Mineral Resource Estimate update (Q2 2022)
- Feedback on ESIA in Uganda (Q2 2022)
- Phase 2 Metallurgical variability and testwork (Q2 2022)
- Finalise Makuutu Project Approvals (Q3 2022)
- Makuutu Feasibility Study (Oct 2022)
- Makuutu Mining Licence Application target submission (Oct 2022)
- Refinery Scoping Study (Q3 2022)
  - → Downstream Opportunity and how IonicRE can play a larger role in development of alternative, secure and traceable rare earth supply chains and alliances
- Ongoing Exploration Activity – RAB Phase 3 metallurgical testwork to inform exploration drilling at EL00147 and EL0257
- Magnet recycling demonstration plant(H2 2022)

ADDITIONAL SLIDES

Significant Advantages for IAC Mining/Processing vs Hardrock

Ionic Clay Rare Earth Elements Vs Hard Rock Rare Earth Elements

Significant project and cost advantages associated with ionic clay projects like Makuutu

Mining & Processing Stages	Ionic Adsorption Clay – Hosted REE	Hard Rock – Hosted REE
Mineralisation	Soft material, negligible (if any) blasting Elevated HREO/CREO product content	Hard rock: Bastnaesite and Monazite (LREO dominant); Xenotime (HREO dominant)
Mining	Low relative operating costs: Surface mining (0-20m) Minimal stripping of waste material Progressive rehabilitation of mined areas	High relative operating costs: Blasting required Could have high strip ratios
Processing Mining Site	No crushing or milling Simple process plant Potential for static or in-situ leaching with low reagent at ambient temperatures	Comminution, followed by beneficiation that often requires expensive (flotation) reagents to produce mineral concentrate
Mine Product	Mixed high-grade Rare Earths precipitate, either oxide or carbonate (+90% TREO grade) for feedstock directly into Rare Earth separation plant, low LaCe content	Mixed REE mineral concentrate (typically 20-40% TREO grade), high LaCe content, requires substantial processing before suitable for feed to rare earth separation plant
Product Payability	60-70% payability as mixed Rare Earth oxide/ carbonate	30-35% payability as a mineral concentrate
Processing - Environmental	Non-radioactive tailings Solution treatment and reagent recovery requirements (somewhat off-set by advantageous supporting infrastructure)	Tailings often radioactive (complex and costly disposal) Legacy tailing management
Processing - Refinery (Typically, not on Mining site)	Simple acid solubilisation followed by conventional REE separation Complex recycling of reagents and water Lower Capex (~$100-$200m)	High temperature mineral "cracking" using strong reagents to solubilise the refractory REE minerals Complex capital-intensive plant (~$500m-$1B) required Radionuclide issues follow REE mineral concentrates

Ionic Adsorption Clay (IAC) deposit mineralisation is highly desirable given it produces a balanced **REO basket dominant in CREO & HREO with higher value and broader appeal**

Near surface IAC mineralisation translates to **lower strip ratios** with lower cost mining methods

IAC ores require much **lower CAPEX intensity to produce refined REOs**

IACs produce **value added Mixed Rare Earth Carbonate** product from IAC deposits, **higher grade and basket value**

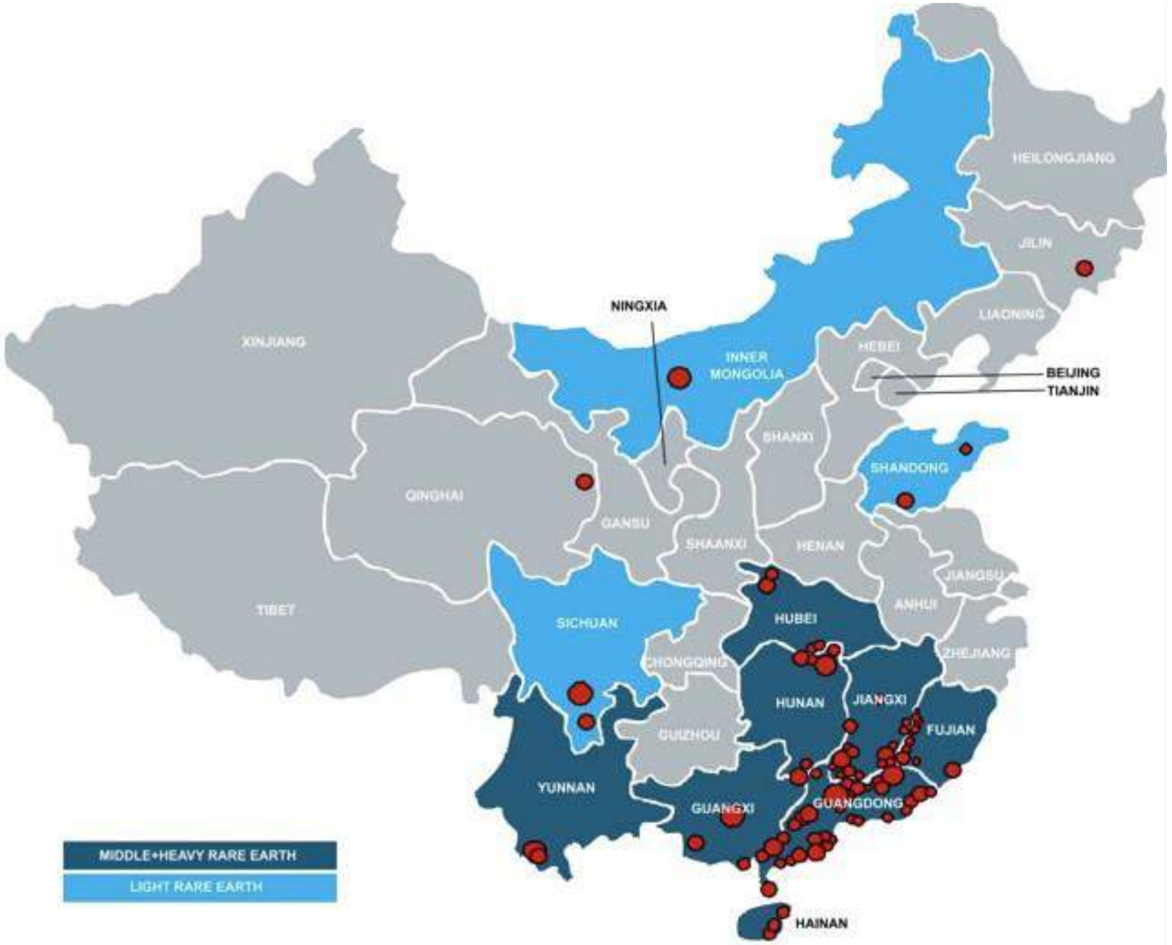
IAC product achieves **approx. double the payability**

IACs experience **none of the radionuclide issues the plague hard rock LREO Projects**

IAC separation and refining much lower CAPEX requirement

The REE Basket Problem – the Solution requires 'Balance'

IONICRE THROUGH MAKUUTU CAN DELIVER UNIQUE BALANCE TO WESTERN HREO PRODUCTION FROM 'RARE' IAC MINERALISATION



Ionic Adsorption Clay (IAC) deposit mineralisation is highly desirable given it produces a balanced **REO basket dominant in CREO & HREO with higher value and broader appeal**

Hard rock rare earth mines typically >90-95% LREE, i.e. very low in HREE content

Very few true IAC deposits (<5) identified of scale outside of southern China, Myanmar and south east Asia

Increased LREE production to facilitate oversupply, and potentially suppress LREE prices, specifically NdPr

IAC HREE mines complement hard rock LREE mines in China, providing 'balance' to REE supply quotas

IAC HREE mines typically **much lower production capacity** than hard rock LREE mines, however **much higher value product**

The rare earth solution for the future requires a balance; LREE readily sourced but HREE is truly rare

Makuutu Basket is Balanced, magnet +HREO Dominant, & High Value

Company		**Ionic Rare Earths**	**Aclara[1]**	**Serra Verde[2]**	**Lynas Rare Earths[3]**	**MP Materials[4]**	**Arafura Resources[5]**	**Australian Strategic Materials[6]**	**Hastings Technology Metals[7]**	**Peak Resources[8]**	**Pensana Rare Earths[9]**	**Northern Minerals[10]**	**Namibia Rare Earths[11]**	**USA Rare Earths[12]**	
Mineralisation		IAC	IAC	IAC	Monazite	Bastnasite	Monazite	Eudialyte / Bastnasite	Monazite	Bastnasite	Monazite	Xenotime	Xenotime	Rhyolite	REO Pricing
Project		Makuutu	Penco	Pela Ema	Mt Weld / LAMP	Mountain Pass	Nolans Bore	Dubbo	Yangibana	Ngualla	Longonjo	Browns Range	Lofdal	Round Top	Argus Metals
Development Stage		FS	FS	FS	Operations	Operations	DFS	DFS	DFS	FS	DFS	PFS	PFS	PFS	15-Mar-22
First Production		2024	2024	2022	Now	Now	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	US$/kg
La_2O_3	%	13.5%	11.5%	32.1%	25.5%	34.0%	19.3%	22.1%	10.0%	27.6%	23.9%	1.9%	0.5%	3.3%	$ 1.52
Ce_2O_3	%	13.5%	3.8%	4.2%	46.8%	48.8%	48.7%	36.3%	39.6%	48.2%	45.9%	4.8%	0.8%	12.2%	$ 1.58
Pr_6O_{11}	%	5.5%	2.9%	5.9%	5.3%	4.2%	5.9%	3.6%	8.0%	4.8%	4.9%	0.7%	0.1%	1.9%	$ 169.00
Nd_2O_3	%	23.2%	12.5%	19.3%	18.5%	11.7%	20.5%	14.1%	33.8%	16.5%	17.2%	3.2%	0.3%	5.1%	$ 182.50
Sm_2O_3	%	4.7%	2.6%	3.3%	2.3%	0.8%	2.3%	1.7%	3.9%	1.6%	2.5%	2.1%	0.5%	1.8%	$ 5.20
Eu_2O_3	%	0.9%	0.3%	0.2%	0.4%	0.1%	0.4%	0.0%	0.8%	0.3%	0.6%	0.4%	0.5%	0.0%	$ 31.50
Gd_2O_3	%	4.4%	3.2%	3.2%	0.1%	0.2%	1.0%	1.6%	1.8%	0.6%	1.2%	5.7%	3.5%	2.0%	$ 112.50
Tb_4O_7	%	0.6%	0.7%	0.5%	0.1%	0.0%	0.1%	0.2%	0.2%	0.0%	0.1%	1.3%	1.1%	0.6%	$ 2,340.00
Dy_2O_3	%	3.7%	5.5%	3.2%	0.1%	0.0%	0.3%	1.9%	0.5%	0.1%	0.6%	8.8%	9.1%	5.7%	$ 480.00
Ho_2O_3	%	0.7%	1.3%	0.7%	0.1%	0.0%	0.0%	0.3%	0.1%	0.0%	0.1%	1.8%	2.0%	1.5%	$ 305.00
Er_2O_3	%	2.0%	4.0%	2.0%	0.1%	0.0%	0.1%	1.1%	0.1%	0.0%	0.2%	5.3%	6.3%	6.1%	$ 69.00
Tm_2O_3	%	0.3%	0.5%	0.3%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.7%	0.9%	1.2%	$ 850.00
Yb_2O_3	%	1.3%	3.2%	1.8%	0.1%	0.0%	0.0%	0.9%	0.1%	0.0%	0.1%	4.4%	5.6%	9.4%	$ 16.30
Lu_2O_3	%	0.2%	0.5%	0.3%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.6%	0.8%	1.3%	$ 805.00
Y_2O_3	%	25.4%	47.6%	23.0%	0.4%	0.1%	1.4%	15.8%	1.1%	0.2%	2.6%	58.2%	67.9%	47.8%	$ 16.10
		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
Magnet REO	%	43%	29%	36%	26%	17%	30%	24%	48%	24%	27%	24%	17%	19%	
LREO	%	56%	31%	62%	96%	99%	94%	76%	91%	97%	92%	11%	2%	22%	
HREO	%	44%	69%	39%	4%	1%	6%	24%	9%	3%	8%	89%	98%	78%	
CREO	%	54%	67%	46%	20%	12%	23%	32%	36%	17%	21%	72%	79%	59%	
CREO+HREO	%	73%	85%	64%	28%	17%	32%	42%	50%	24%	30%	93%	99%	84%	
Product		MREC	MREC	MREC (?)	REO	Concentrate	REO	REO	MREC	Concentrate	MRES	MREC	MREC	TBA	
Basket	**REO/kg**	**$ 102.50**	**$ 97.65**	**$ 89.12**	**$ 48.59**	**$ 30.08**	**$ 53.65**	**$ 54.44**	**$ 85.74**	**$ 41.82**	**$ 49.57**	**$ 117.25**	**$ 111.88**	**$ 96.30**	

Note. Rounding Applied to nearest 0.1%.

[1] Aclara IPO Prospectus, Sept 2021 [2] Serra Verde Project, November 2015 [3] Lynas Rare Earths website. [4] MP Materials 31 Dec 2014. [5] Arafura Resources – Nolans DFS Delivers Robust Project Economics, 7 February 2019. [6] ASM Information Memorandum Demerger Booklet, June 2020. [7] Yangibana Project – Begin the Future December 2019. [8] Project Update, Ngualla Rare Earth Project, October 2017. [9] Pensana - Longonjo PFS 15 November 2019. [10] Browns Range Project Definitive Feasibility Study, February 2015. [10] Namibia Rare Earths Inc. Q2 2015 Management Discussion and Analysis, 31 May 2016. [11] USARE_NI43-101 PEA_2019-16AUG REV A.

Investment in Uganda – The Pearl of Africa

MAJOR INTERNATIONAL INVESTMENT INTO UGANDA IS UNDERWAY

- Ugandan law allows for 100% foreign-owned businesses, and foreign businesses are allowed to partner with Ugandans without restrictions.
- The US$10B Lake Albert Oil Project (Total (56.67%), CNOOC (28.33%) and UNOC (15%)) development encompasses Tilenga (operated by Total) and Kingfisher (operated by CNOOC) upstream oil projects in Uganda, delivering a combined production of 230,000 barrels per day, and the construction of the East African Crude Oil Pipeline (EACOP) transporting from the oilfields in Uganda 1440km to the port of Tanga in Tanzania.
- Uganda is rich in natural resources. Foreign Direct Investment (FDI) mainly goes to the coffee and mining sectors. Kenya, Germany and Belgium are the country's main investors.
- Good support from government agencies including the Directorate of Geological Survey and Mines (DGSM)
- Transparent Mining Cadastral system implemented in Uganda for tenement management
- Ugandan Mining Act 2003 outlines royalties for base metals at 5% and Corporate Tax Rate = 30%
- Asset depreciation given Project is > 50km from Kampala is 50% initial depreciation allowance, and 100% of the assets in a 3-year period.

Foreign Direct Investment[1]	2017	2018	2019
FDI Inward Flow (million US$)	803	1,055	1,266
FDI Stock (million US$)	11,996	13,051	14,317
Number of Greenfield Investments	8	17	29
Value of Greenfield Investments (million US$)	290	366	960

[1] Source: UNCTAD - Latest available data.

Makuutu and Critical Raw Materials 2020

MAKUUTU BASKET CONTAINS HIGH RANKED CRMs IDENTIFIED IN 2020 EU STUDY REQUIRED TO ACHIEVE CARBON NEUTRALITY

Secure and sustainable supply of both primary and secondary raw materials, specifically of critical raw materials (CRM)

Targeting key technologies and strategic sectors as renewable energy, e-mobility, digital, space and defence is one of the **pre-requisites to achieve climate neutrality**

European Commission report identified Global **competition for resources will become fierce in the coming decade**

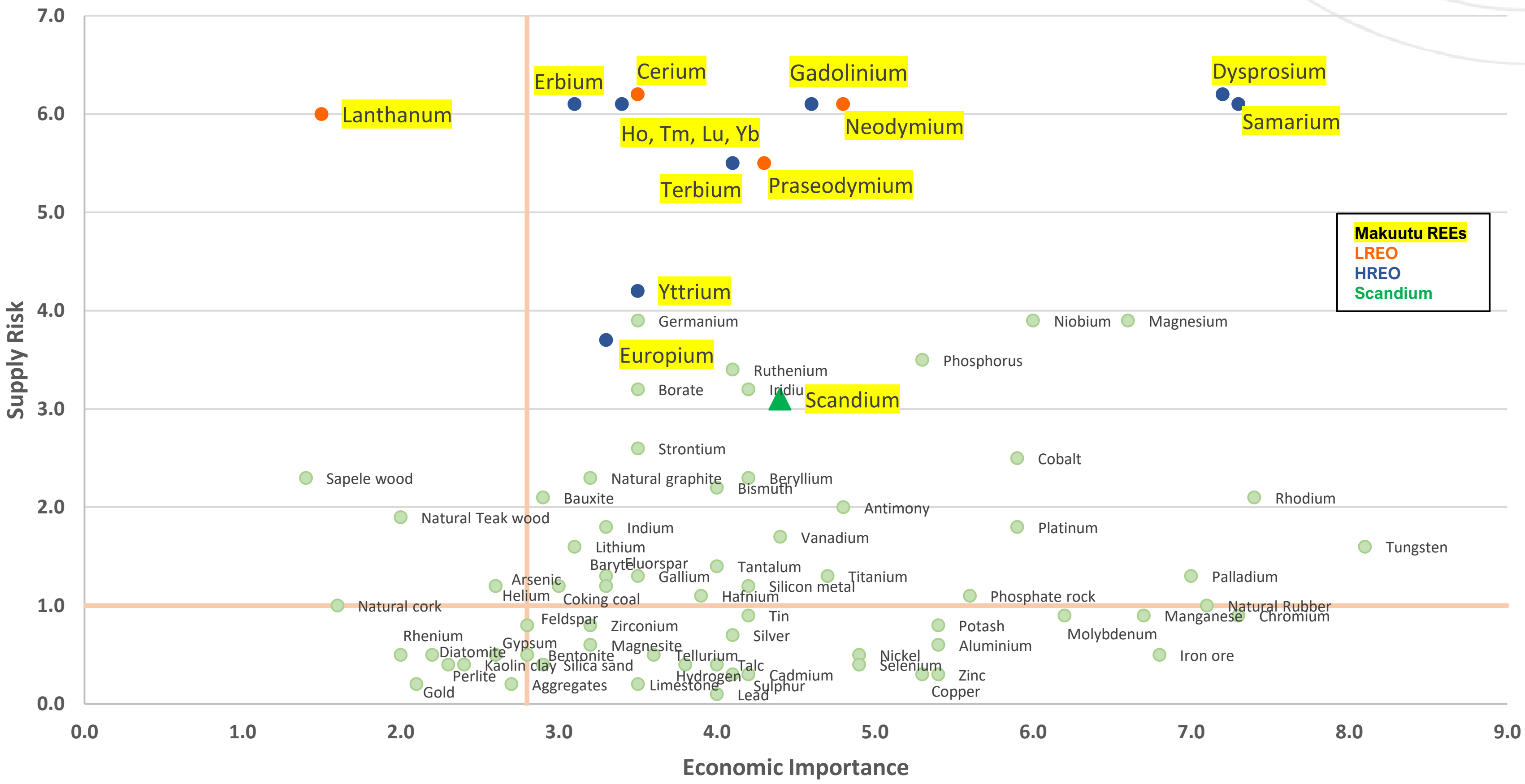
Dependence of critical raw materials may soon replace today's dependence on oil

Makuutu has all the REO requirements in appreciable quantities

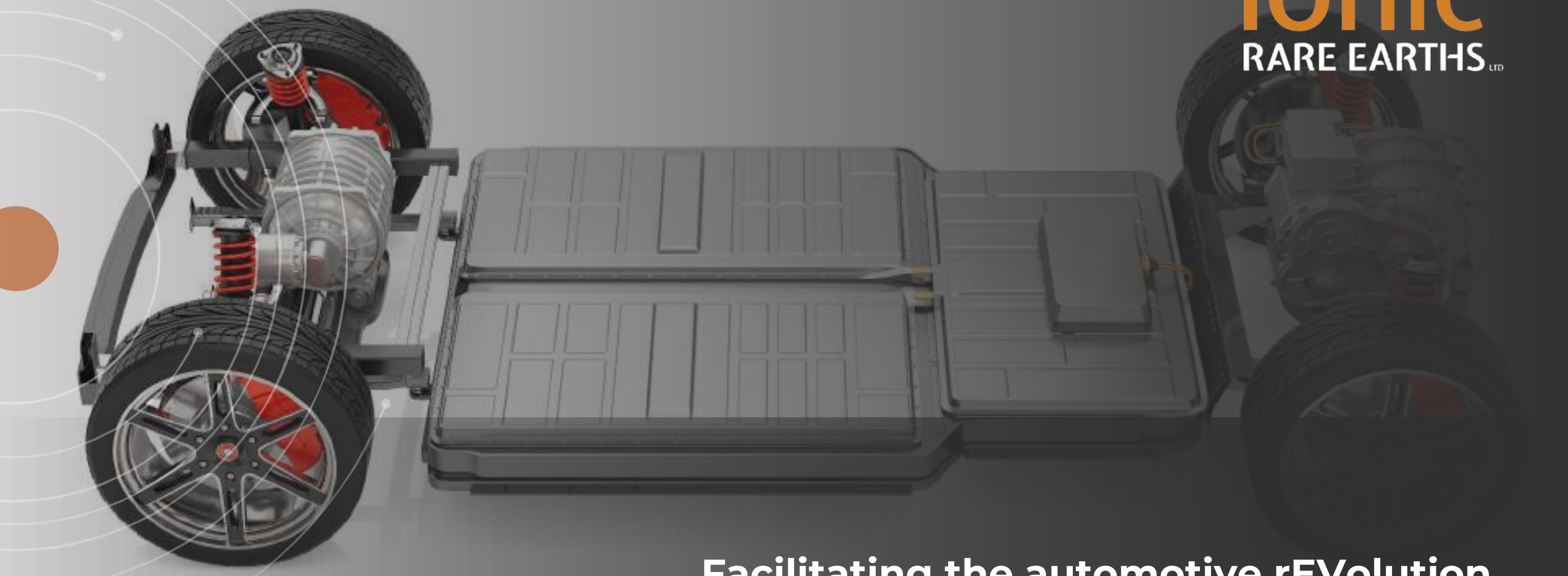
Scandium potential at Makuutu to **facilitate light weighting transportation**

Long term stable supply is not a given – will **require investment further up the supply chain**

Economic Importance vs Supply Risk results for 2020 criticality assessment[1]



[1] European Commission, Study on the EU's list of Critical Raw Materials – Final Report, 2020.



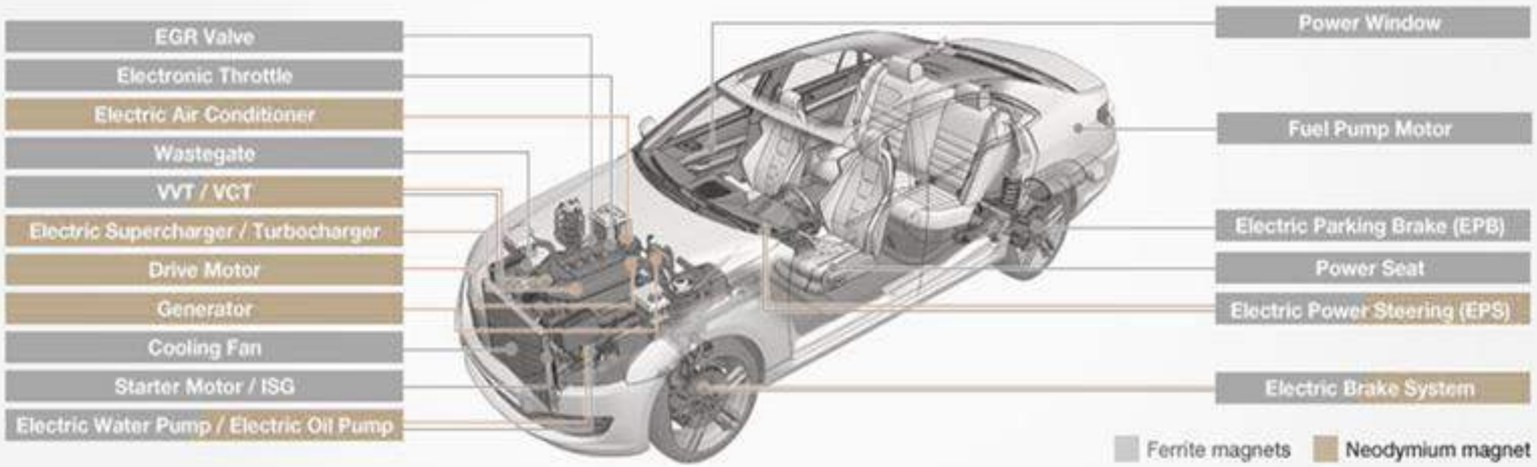
Facilitating the automotive rEVolution

43% Magnet REOs required for Permanent Magnet drives for EVs

Electric Vehicles – Driven by NdPr (and DyTb)

Nd, Pr, Dy & Tb EXPECTED TO BE IN DEFICIT BY 2027

- Worldwide EV demand driving insatiable appetite for NdPr, but DyTb largely overlooked
- NdFeB permanent magnets (PM) are essential for producing light, compact and high efficiency traction motors. Approx. 28-32% of the NdFeB magnet is magnet NdPr, with DyTb used as a minor additive (~4-8%) to improve magnet performance at high temperatures[1]
- Global governments mandate change with ICE to be banned in several countries from 2025, with significant changes expected in Europe where demand driven by government incentives will see it overtake China by 2030 as largest market for EVs
- Global EV sales in 2020 ~ 3.1 million, with global EVs sales expected to hit ~11 million in 2025, and ~23 million by 2030[2]



Proposed Internal Combustion Engine (ICE) Bans	
Year	**Country**
2025	Norway
2030	Denmark, Iceland, Ireland, Netherlands, Slovenia, Sweden, UK
2040	France, Spain
2050	Japan

[1] Pavel, et al., Role of substitution in mitigating the supply pressure of rare earths in electric road transport applications, 2017; Roskill, Rare Earths: Outlook to 2030, January 2021;
[2] Argus Analytics, March 2021;

Facilitating Offshore Wind Capability

IonicRE basket producing all the Nd, Pr, Dy and Tb required for offshore wind turbines

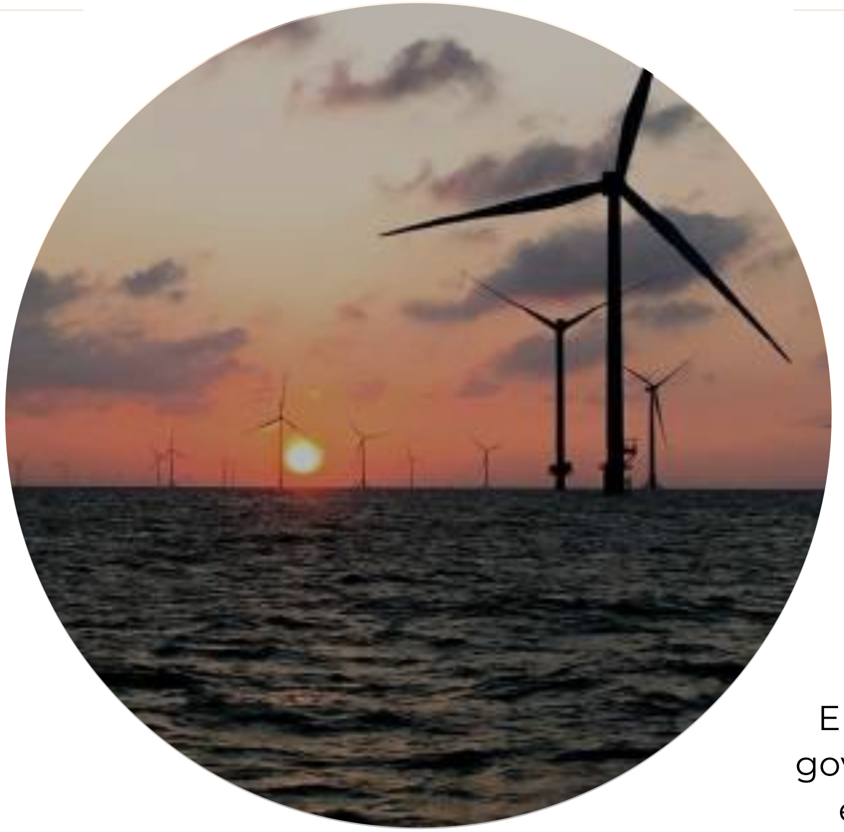
Land Constrained – Go Offshore

COUNTRIES ADOPT OFFSHORE WIND TURBINES TO REACH CO_2 TARGETS

Current world offshore wind turbine capacity is 36 GW

Argus[1] estimates an additional 235 GW of installed offshore wind turbine capacity to be added by 2030 → 25% CAGR for the remainder of the decade

In its 2019 World Energy Outlook, the International Energy Agency (IEA) Sustainable Development Scenario has up to 570GW of offshore wind in 2040. If achieved, the world would be on track to reach about 1TW in 2050[2].



The International Renewable Energy Agency (IRENA) also has a 1TW ambition by 2050.

US DOE announced in March 2021 plan to develop 30GW of offshore wind turbine by 2030. Further, Achieving this target also will unlock a pathway to 110 GW by 2050.

Ambitious target announced in December 2020, Ocean Renewable Energy Action Coalition (OREAC) calling on governments to up their offshore renewable energy ambition to achieve the coalition's vision of 1,400 GW of offshore wind by 2050.

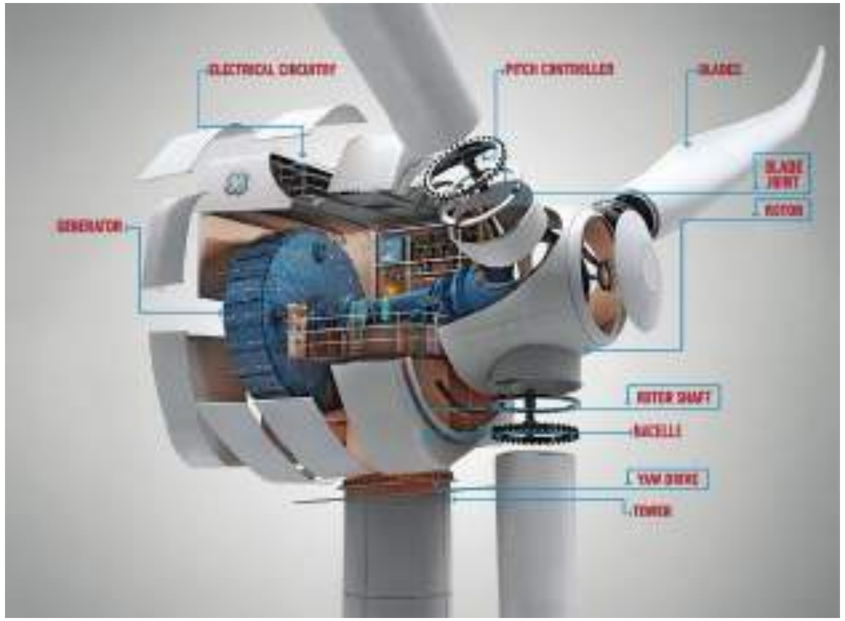
1 Argus analytics, October 2021; 2 Ocean Renewable Energy Action Coalition, The Power of our Ocean, December 2020;

No DyTb – No Offshore Wind Turbine Capacity

THE BASICS – HOW MUCH REO IS REQUIRED PER MW OF OFFSHORE TURBINE CAPACITY?

Rare-earth elements and boron (B) are essential for turbine designs that employ permanent magnets (NdFeB). The HREOs Dy_2O_3, Tb_4O_7 and in some cases Ho_2O_3, can be substituted to improve the operability of the NdFeB magnets. Adding these HREOs helps the high temperature direct drive turbines maintain their magnetic characteristics[1]. Substitution is not an option.

Most direct-drive turbines, but also to different extents certain technical designs with gearboxes, are equipped with permanent magnet generators, which contain NdPr and smaller quantities of DyTb. On average, a permanent magnet contains 28.5% NdPr, 4.4% DyTb, 1% B and 66% Fe and weighs up to 4 tonnes for a 6MW offshore direct drive wind turbine[2].



HALIDE* 150-MV OFFSHORE WINE TURBINE

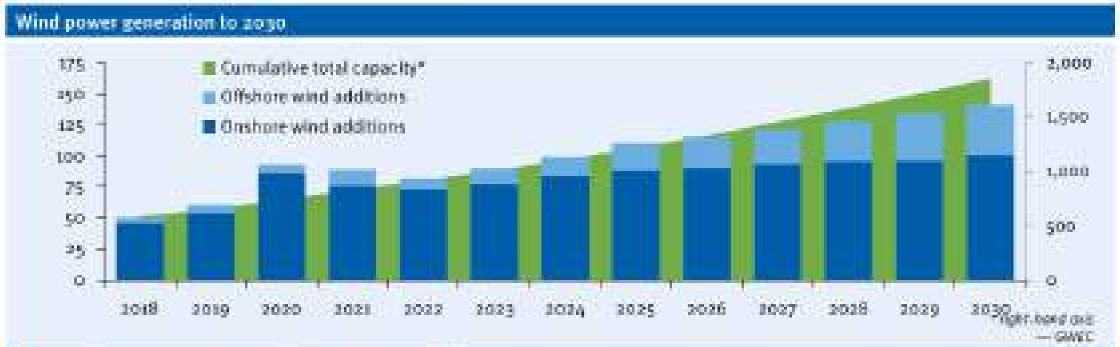
- Each 6 MW of offshore direct drive wind turbine capacity requires ~ 1,700 kg magnet REOs;
  - ~210 kg/MW Nd_2O_3 x 6 MW = 1,260 kg Nd_2O_3
  - ~42 kg/MW Pr_6O_{11} x 6 MW = 254 kg Pr_6O_{11}
  - ~20 kg/MW Dy_2O_3 x 6 MW = 117 kg Dy_2O_3
  - ~8 kg/MW Tb_4O_7 x 6 MW = 49 kg Tb_4O_7
- HaliadeX 13 MW offshore direct drive wind turbines now under development

1 Roskill, Rare Earths: Outlook to 2030, January 2021; 2 European Commission, Raw materials demand for wind and solar PV technologies in the transition towards a de-carbonised energy system, 2020; 3 Li et al., One Earth 3, Critical Rare-Earth Elements Mismatch Global Wind Power Ambitions, 2020; Haliade 150-6MW turbine by GE Renewable Energy @GErenewables;

Makuutu & Offshore Wind Turbine Capacity

MAGNET REO – SUPPLY FAILING DEMAND → 'ESCAPE VELOCITY' BY 2027

- Forecast offshore capacity increase by 235 GW by 2030[1,2] (25% CAGR)
- 2020 global offshore wind turbine capacity of 35.7 GW
- 2020 added capacity of 6.07 GW with 2021 installations increasing to 12.7 GW (**+110% of 2020 added capacity**)
- **By 2025 the crunch will come**, with forecast supply of magnet REOs is forecast to be below demand
- By 2027 heavy magnet REOs Dy_2O_3 and Tb_4O_7 significantly in deficit
- By 2030 demand of magnet REOs forecast to exceed supply by 40%
- Beyond 2030 however the rate of growth on offshore wind turbine appears to **exceed the capability to supply magnet REEs**
- Projections of future wind turbine installation growth beyond 2030 to 2050 have highlighted the inadequacy of existing REO supply chains, with an estimated 11-to-26-fold expansion of current magnet REO supply required to meet global wind turbine targets[2].
- **Makuutu magnet REO production ramped up from 2024 to supply an estimated 17 GW of offshore wind turbine capacity by 2030, 11-year LOM estimated to enable 35 GW of capacity, LOM potential 90+ GW of capacity with scale to grow substantially**



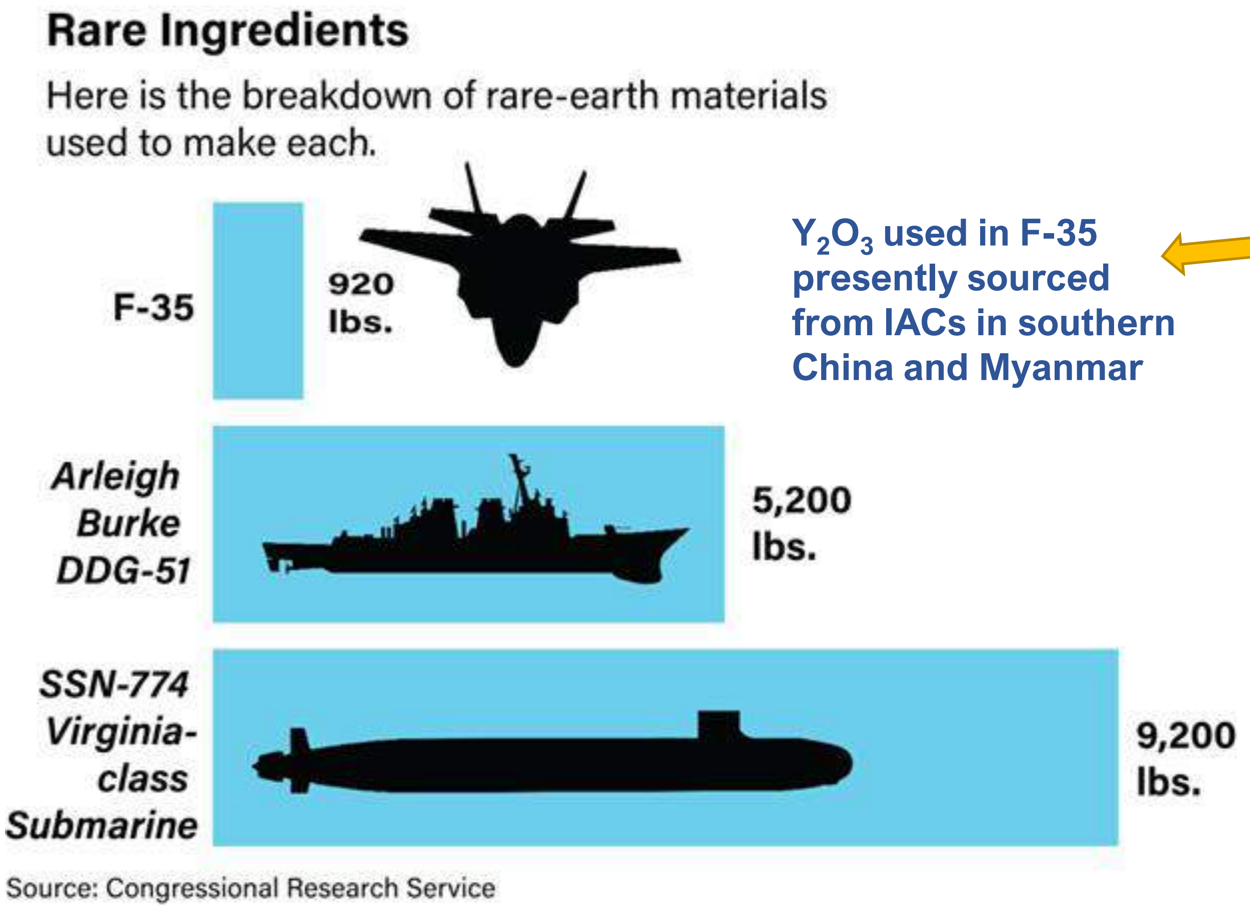
1 Argus Analytics October 2021. 2 Li et al., One Earth 3, Critical Rare-Earth Elements Mismatch Global Wind Power Ambitions, 2020. 2 Excludes US DOE plan to add 30 GW by 2030

Facilitating Defence Capability

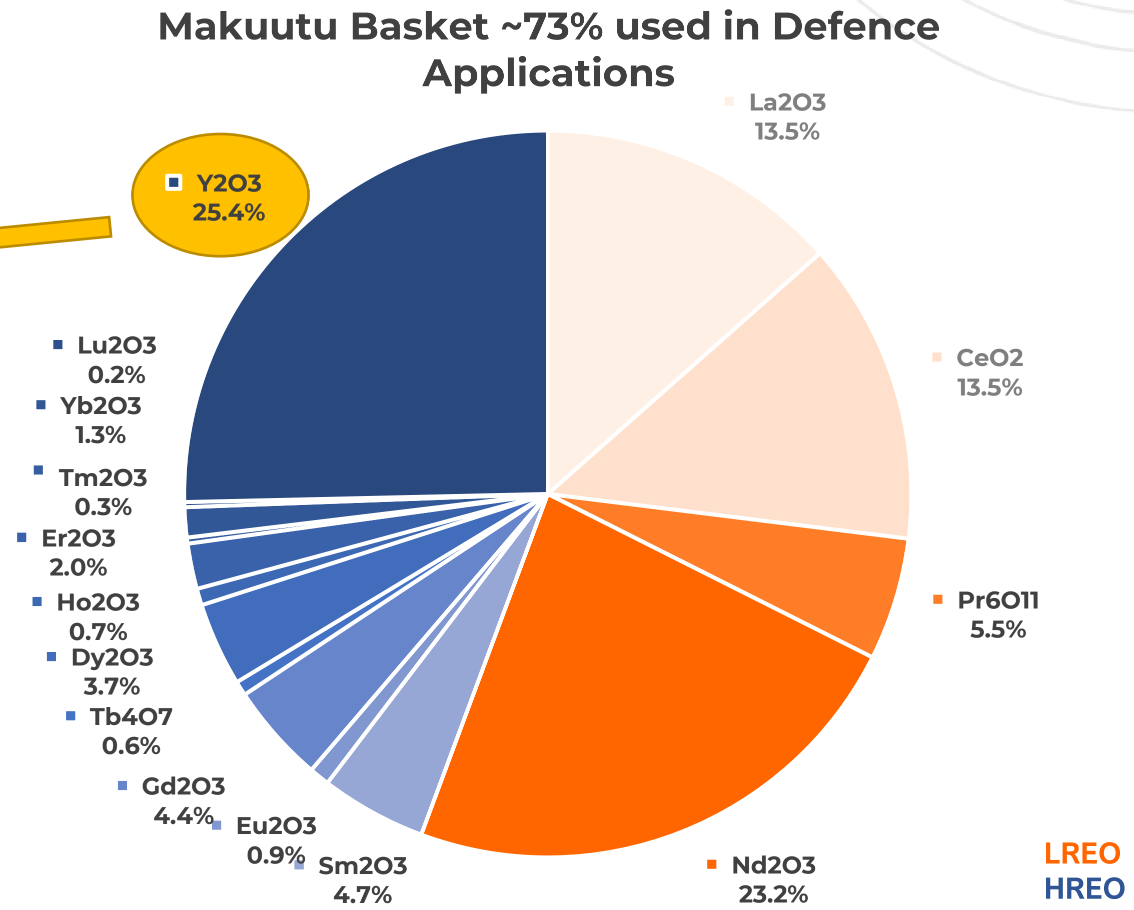
IonicRE basket – Heavy Rare Earth Strategic Appeal for Defence Applications

HREO & CREO crucial in Defence Applications

DEFENCE HREO SUPPLY CHAIN – PROVIDING SECURE SOURCE OPTION



Y_2O_3 used in F-35 presently sourced from IACs in southern China and Myanmar



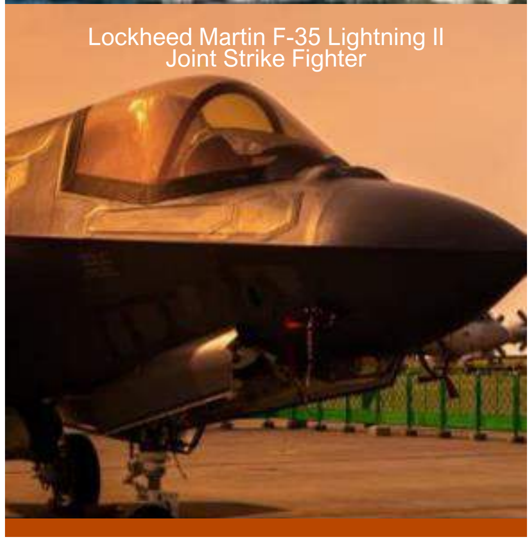
HREO & CREO crucial in Defence Applications

DEFENCE HREO SUPPLY CHAIN – MAKUUTU POTENTIALLY SUPPLIES IT ALL

- Numerous HREO & CREO materials are used in defence applications in the engines, disk drive motors, radar of the aircraft, fin actuators in missile guidance and control systems, control devices in tanks, missile systems, command and control centres; lasers, interrogators, underwater mines, countermeasures; satellite communications, radar, and sonar on submarines and surface ships; optical equipment and speakers, components in anti-missile defense systems, satellites and night vision devices among others.
- REE metals used in F-35 fighter (417kg); Virginia-class submarine (4,170kg); and Arleigh-Burke guided missile destroyer (2,360kg).
- Terfonal-D is a rare earth alloy made of Tb, Fe and Dy that is used in high-power sonar on ships and submarines.
- Stealth helicopters also use Terfenol-D speakers in their noise cancellation technology blades and NdFeB magnets.

PRODUCT / APPLICATION	RARE EARTH ELEMENT (REE)	USAGE
F-35 Lightning II joint strike fighter	Y	Jet engine
ATHENA laser weapon system	Er, Yb, Nd	Optical fibres in fibre laser module
Tomahawk missile	Combination of Nd, Pr, Dy, Tb, Sm	Fin actuators in missile guidance and control systems, GPS, sensors
Joint Direct Attack Munition (JDAM) guided bombs	Combination of Nd, Pr, Dy, Tb, Sm	Fin actuators in missile guidance and control systems, GPS, sensors
AN/ALQ-184 Electronic Attack Pod	Y	Electronic jamming devices, storage batteries
Zumwalt-class destroyer	Nd, Pr, Dy, Tb, Sm	Electric motors
HUMVEE military truck	Y, Eu, Tb	Humvee-mounted Laser Avenger
F-16, F-15, F-22	Er, Sm	Jet engine, Electric systems- permanent magnets
M1A2 Abrams tank	Sm, Eu, Nd, Tb, Y	Navigation system, Laser-equipped computer main gun sight
Stinger MANPAD	Combination of Nd, Pr, Dy, Tb, Sm	Fin actuators in missile guidance and control systems, GPS, sensors
Precision-guided munitions	Combination of Nd, Pr, Dy, Tb, Sm	Fins attached to fuselage, special magnets
PATRIOT missile air defence system	Gd, Sm, Y	Radio frequency circulators
MQ-9, MQ-1 Predator drones	Y, Tb	Laser Weapon System


US Navy Virginia Class Submarine


Lockheed Martin F-35 Lightning II Joint Strike Fighter

HREO & CREO – IonicRE Production Delivers Every Need

Figure 1. Rare Earth Elements in Guidance and Control Systems

Source: Compiled from presentations by the Rare Earth Industry and Technology Association, the United States Magnet Manufacturing Association, and David Pressault, "Global Rare Earth Element Review," Defense National Stockpile Center, Spring 2010.

✓ La ✓ Sm ✓ Tb
✓ Pr ✓ Eu ✓ Lu
✓ Nd ✓ Dy ✓ Y

Figure 2. Rare Earth Elements in Defense Electronic Warfare

Source: Compiled from presentations by the Rare Earth Industry and Technology Association, the United States Magnet Manufacturing Association, and David Pressault, "Global Rare Earth Element Review," Defense National Stockpile Center, spring 2010.

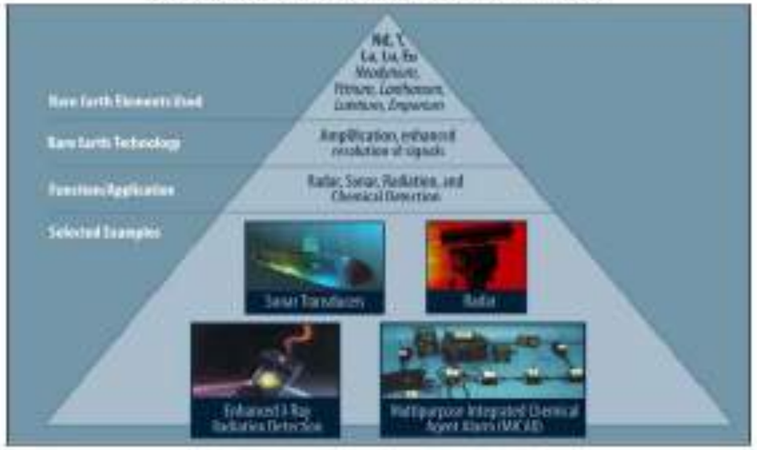
Figure 3. Rare Earth Elements in Targeting and Weapon Systems

Source: Compiled from presentations by the Rare Earth Industry and Technology Association, the United States Magnet Manufacturing Association, and David Pressault, "Global Rare Earth Element Review," Defense National Stockpile Center, spring 2010.

Figure 4. Rare Earth Elements in Electric Motors

Source: Compiled from presentations by the Rare Earth Industry and Technology Association, the United States Magnet Manufacturing Association, and David Pressault, "Global Rare Earth Element Review," Defense National Stockpile Center, spring 2010.

Figure 5. Rare Earth Elements and Communication



Source: Compiled from presentations by the Rare Earth Industry and Technology Association, the United States Magnet Manufacturing Association, and David Pressault, "Global Rare Earth Element Review," Defense National Stockpile Center, spring 2010.

Rare Earth Elements in National Defense: Background, Oversight Issues, and Options for Congress, 23 December 2013 (https://sgp.fas.org/crs/natsec/R41744.pdf)

Heavy Rare Earth Dominant

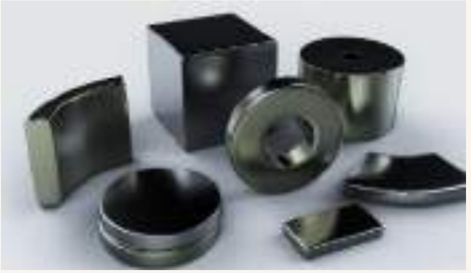
IonicRE basket – 44% Heavy Rare Earths deployed in high end applications

Key HREO Applications without Substitute – New Supply Required

HREO USED IN HIGH END FOR NICHE APPLICATIONS – NO SUBSTITUTION FOR REOS IN SPECIFIC APPLICATIONS

MRI Machine

PET Scan



NdFeB and SmCo permanent magnets

Erbium is a key input into enabling 5G technology

- IAC mines in southern China and Myanmar produce approximately 95% of the worlds production of HREO
- Export Control Ban implemented by China on 1 December 2020 now focused on prioritising Chinese consumption and strategic stockpiling
- High-value niche medical applications such as
    - Magnetic Resonance Imaging (MRI) machines using Gd;
    - Positron Emission Tomography (PET) imaging using Lu;
    - X-rays, Solid-state lasers, optical isolators and microwave equipment using Er, Ho, Tm, Yb, Y;

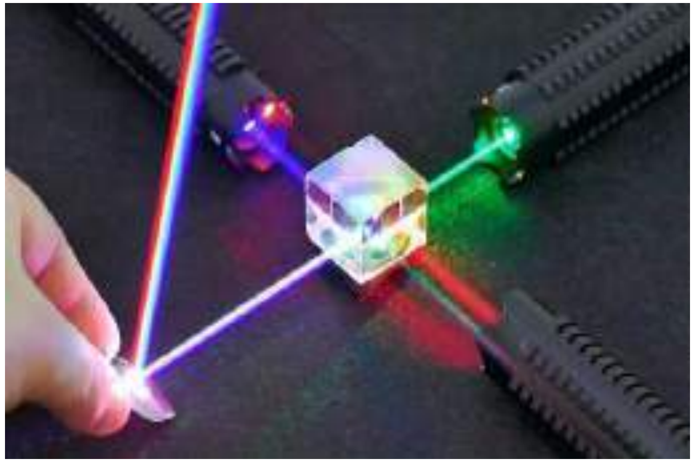
- Critical applications REE are essential for electronic devices as permanent magnets (PM) in speakers, computer components, global positioning systems (GPS), sonar, defence systems and lasers – will start to see this flow through to consumer item availability and cost
- Er is a key input into enabling 5G technology – Erbium doped fibre amplifiers (EDFA) are used to compensate the loss of an optical fibre in long-distance optical communication and can amplify multiple optical signals simultaneously. No Erbium, No 5G.
- Nuclear power plant use Sm-Co permanent magnets, and Dy & Er in neutron-absorbing control rods.

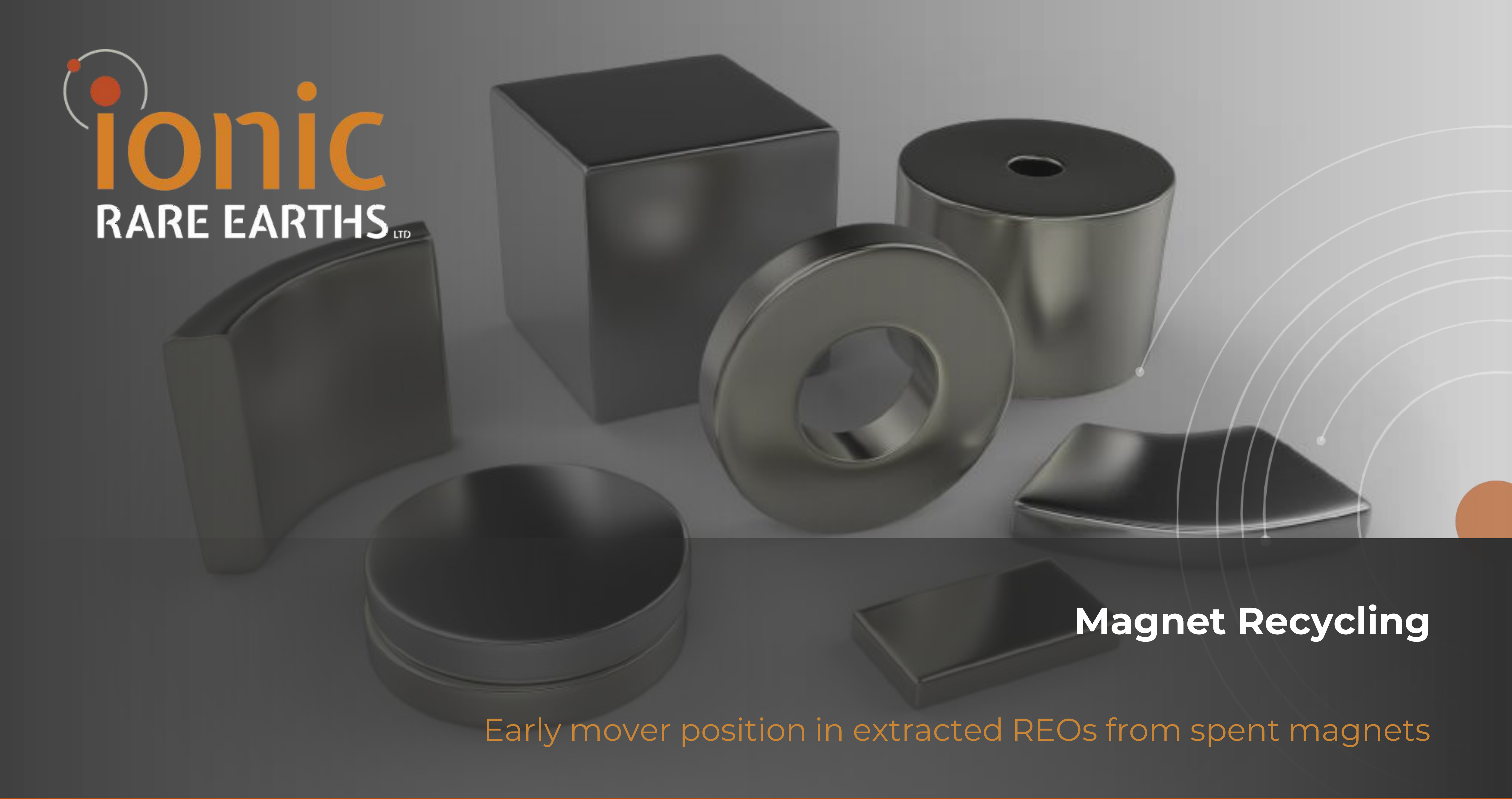
Key HREO Applications – Fibre Laser outlook to 2030

GLOBAL FIBRE LASER MARKET VALUE ESTIMATED TO REACH US$8.42 BILLION BY 2030 (CAGR 14.5%)

- Global fiber laser market value estimated to be US$2.23 Billion in 2020
- Optical fibers used in the fiber laser are doped with rare earth metals such as Yb, Er, Nd, Tb and Eu.
- Fibre lasers are optically pumped devices mostly used with laser diodes (uses REE) amplify the produced light. Fiber lasers has a large surface-to-volume ratio (heat dissipation is relatively easy). Laser is comparatively smaller and lighter in weight than traditional lasers
- Widely used in number of industrial manufacturing processes: marking, metal cutting and welding of automotive and aircraft components. Technological advancements, rapid improvement in infrastructure coupled with research and development in this field have contributed to the growth of the market.
- Automotive industry (growing demand of EVs) vital for the growth of fibre laser market.
- Growing demand for compact, cost-effective lasers along with widespread adoption of fibre lasers into numerous new industries are also anticipated to propel the market growth.







RARE EARTHS LTD

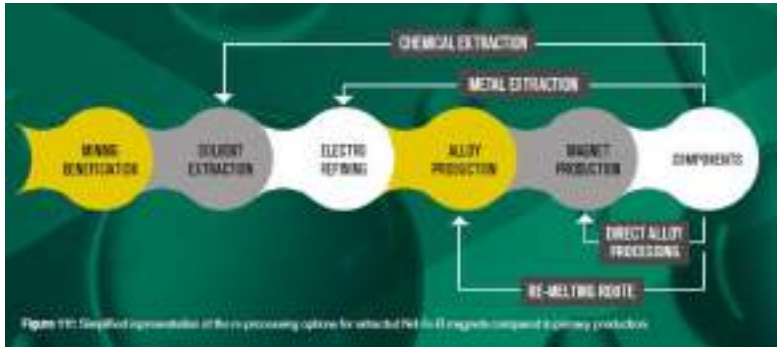
Magnet Recycling

Early mover position in extracted REOs from spent magnets

NdFeB Magnet Recycling – low cost, modular plan

FIRST MOVER CAPABILITY FOR DOWNSTREAM MAGNET RECYCLING TO SEPARATED 99.99%+ MAGNET RARE EARTH OXIDES

- Seren Technologies patented process uses **chemical extraction** to extract the magnet REE from the spent magnets to **enable recycling back to the refined 99.9%+ REO quality**
- **Unique technology that has significant advantages over existing technologies** which are unable to separate the individual REOs
- Recycled REO can then be used to make higher quality magnets with greater proportions of heavy rare earths Dy and Tb for high-cost applications such as offshore wind turbines
- Low capital and modular production of **Nd, Pr, Dy and Tb oxides**



FULL THIRD PARTY TECHNO-ECONOMIC FEASIBILITY STUDY COMPLETED

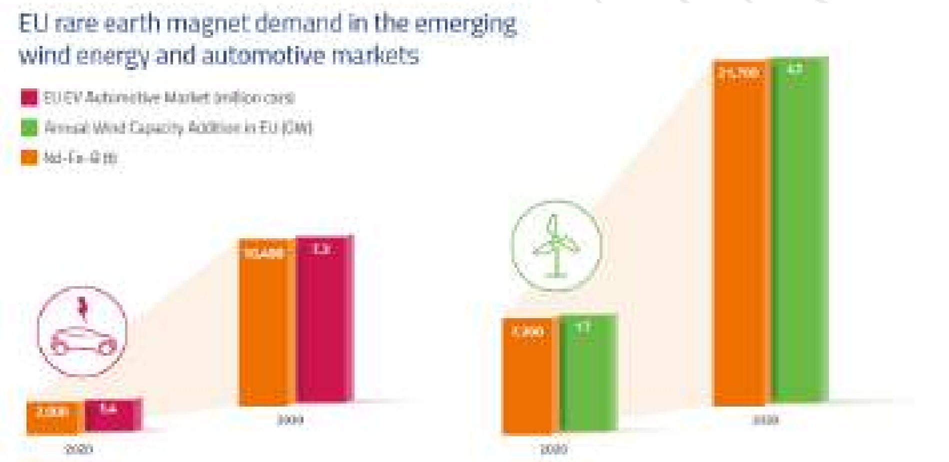
RARE EARTH MAGNETS

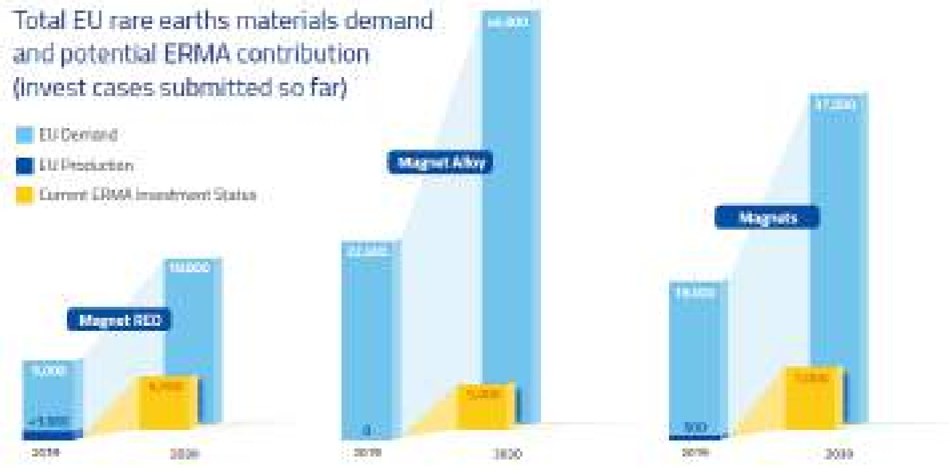
100% RECYCLED RARE EARTH OXIDES

REE Demand – Magnet Recycling to help fill the void

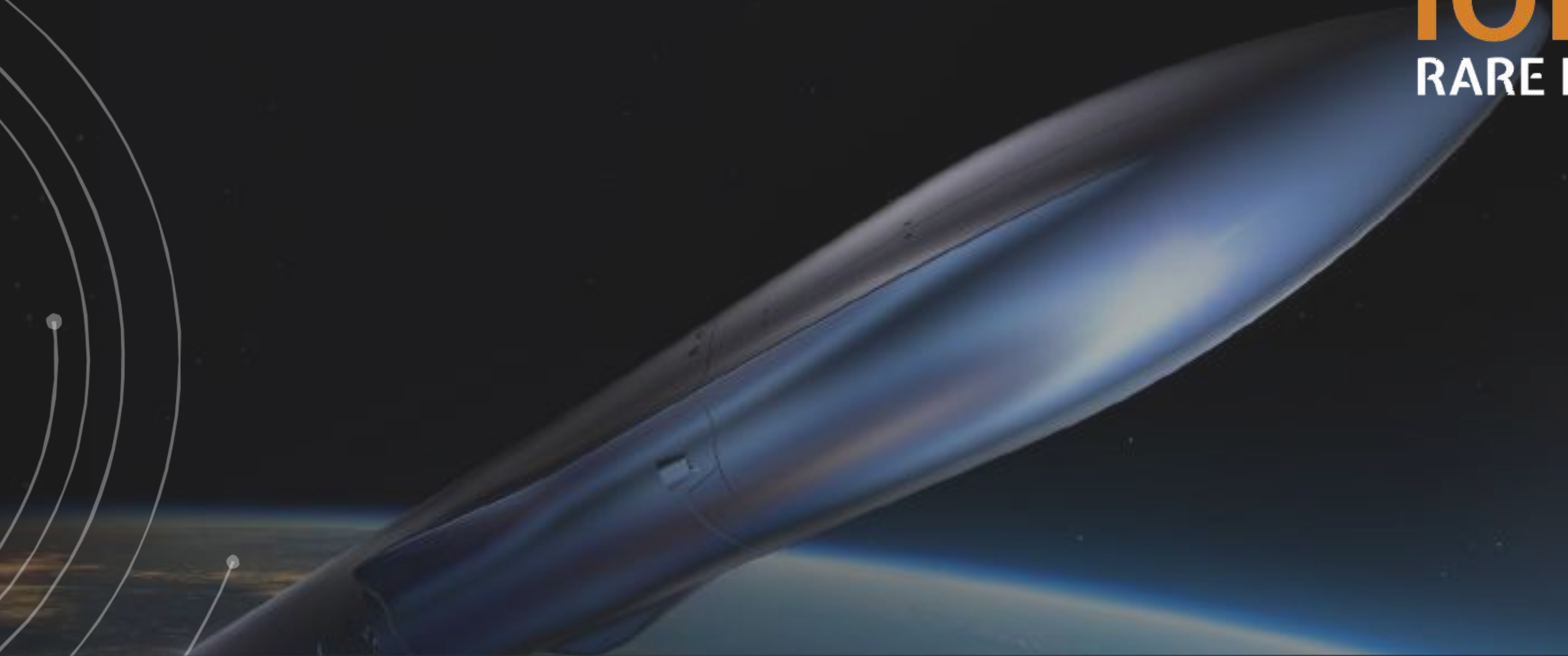
LAG IN INVESTMENT OF PRIMARY RARE EARTH EXTRACTION & POTENTIAL FOR NEAR TERM MAGNET RECYCLING

- Lack of historical investment will result in near term demand far exceeding supply
- Installation of **primary extraction (i.e. mining) of rare earths from new or existing mining projects (by-product) is significant**, with estimations up to 8-15 years
- Significant time advantage with low-cost modular Ionic Adsorption Clay (IAC) capacity also producing a more balanced basket of magnet REEs required magnet production
- New primary REO production will lag demand creating an **opportunity for secondary sources (i.e. magnet recycling) to help fill the void**
- **> 100,000 tonnes of rare earth permanent magnets** are consumed each year in renewable energy, machine tools, robotics, loudspeakers, water pumps, mobility, and ICT
- 16,000 tonnes of rare earth permanent magnets are exported from China to Europe each year, **representing approximately 98% of the EU market**
- **< 1% recovery of rare earth permanent magnet scrap in Europe**, which represents a large **potential resource at a low carbon footprint**
- Similar opportunity exists in **Nth America and Asia** to deploy low cost, REE recovery from waste and spent permanent magnets
- As magnet production increases, so to does longer term opportunity for magnet recycling, which could make up **20-25% of REO supply chain by 2030**





Rare Earth Magnets and Motors: A European Call for Action A report by the Rare Earth Magnets and Motors Cluster of the European Raw Materials Alliances, 2021.
Securing Technology-Critical Materials for Britain, 2021. https://news.metal.com/newscontent/101678717/Dismantling-of-Motor-Scrap-Will-Become-A-New-Growth-Engine-amid-Slow-Increase-in-Ore-Supply/



Scandium Upside

IonicRE basket – Scandium to unlock new industries and 'Blue Sky'

Makuutu is one of the largest global Scandium resources... and growing

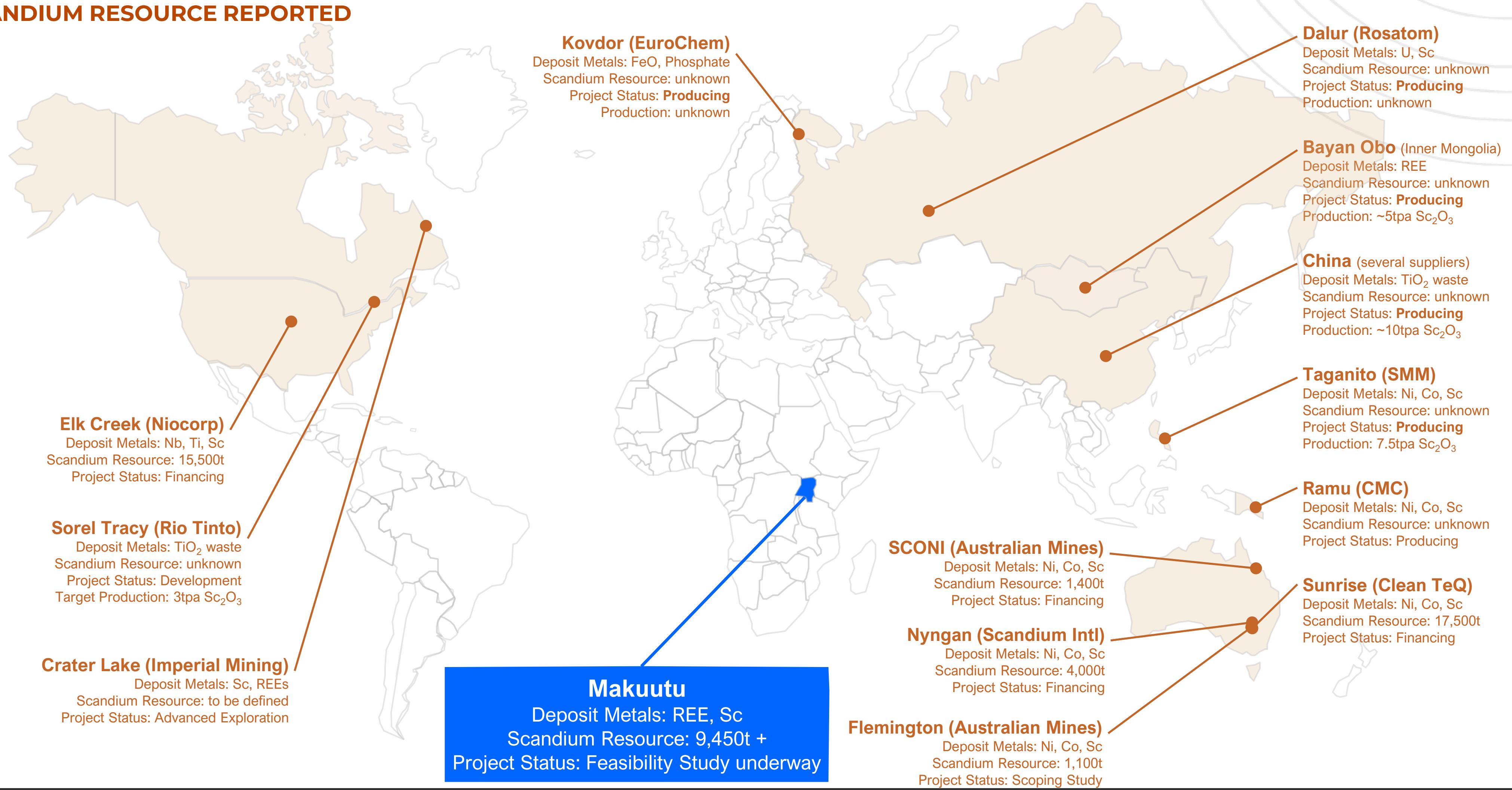
3RD LARGEST GLOBAL SCANDIUM RESOURCE REPORTED

Key to the success of the scandium industry is a diverse and reliable supply chain

While historically the scandium market has been dominated by Chinese supply, there are companies producing scandium or actively developing scandium supply

The Makuutu Rare Earths Project's scandium endowment and time to market make it a key future global player in the scandium market

Scandium market expected to grow very quickly once stable supply is demonstrated



Applications with Aluminium in Light-weighting Transportation

The need for light-weighting solutions has dramatically increased the adoption of aluminium alloys in transportation. Stricter efficiency standards, the advent of the electric vehicle and the emergence of new sectors are accelerating uptake, generating new opportunities for aluminium alloys, like Al-Sc alloys, to strengthen its position as a key material for the future

AUTOMOTIVE

Aluminium content in vehicles has been steadily increasing, driven by stricter efficiency and emissions requirements

Aluminium is displacing high-strength steel (HSS), a lower cost and heavier competitor, in several components

The electric vehicle (EV) revolution is dramatically accelerating aluminium's market share through new parts (e.g. battery boxes) and the need to increase vehicle range. EVs have 35-50% more aluminium than internal combustion engine vehicles[1]

AEROSPACE

Aluminium is well-established in aerospace, with most airplanes constructed of aluminium alloys. While carbon fibre materials are lighter, they are more expensive, have a higher maintenance cost and require costly metals (such as titanium) to be used in concert. More advanced aluminium alloys can provide comparable low-cost alternative to composites

The next aerospace aluminium alloys will be strong and weldable, removing the need for rivets, providing enormous weight saving.

SPACE

While historically niche sub-sector of aerospace, the commercial space industry represents a fast-growing sector where aluminium has a long, deep-rooted history

Rockets use a range of aluminium alloys in propellant tanks, providing a strong, lightweight material which can operate over large temperature ranges

Advanced aluminium alloys, combined with 3D printing, provide the space industry a unique opportunity to mass produce reusable rockets and satellites

MARINE

Due to its high strength and high corrosion resistance, aluminium alloys are a growing material of choice for shipbuilding

'Marine grade' aluminium is 100 times less prone to corrosion than its steel counterpart[2]

'Marine-grade' aluminium alloys are both strong and weldable, which mean large sections of ships can be constructed with no joints or bolts, which reduce corrosion and the risk of water ingress

RAIL

Like aerospace, aluminium has had a long history with rail, widely used in both freight and passenger cars

Aluminium provides ~30-35% weight reduction over steel and does not corrode, leading to a much longer service life

High-speed trains realise the greatest benefit from aluminium, which require low weight and high-strength to minimise friction loss

[1] Aluminium Content in European Passenger Cars, Ducker Frontier presentation prepared for European Aluminium, Oct 2019, range depending on vehicle category
[2] Aluminium in Transport, www.aluminiumleader.com/application/transport

Scandium Market Potential

SIGNIFICANT POTENTIAL FOR SCANDIUM MARET TO GROW RAPIDLY IN GLOBAL TRANSPORT SECTORS

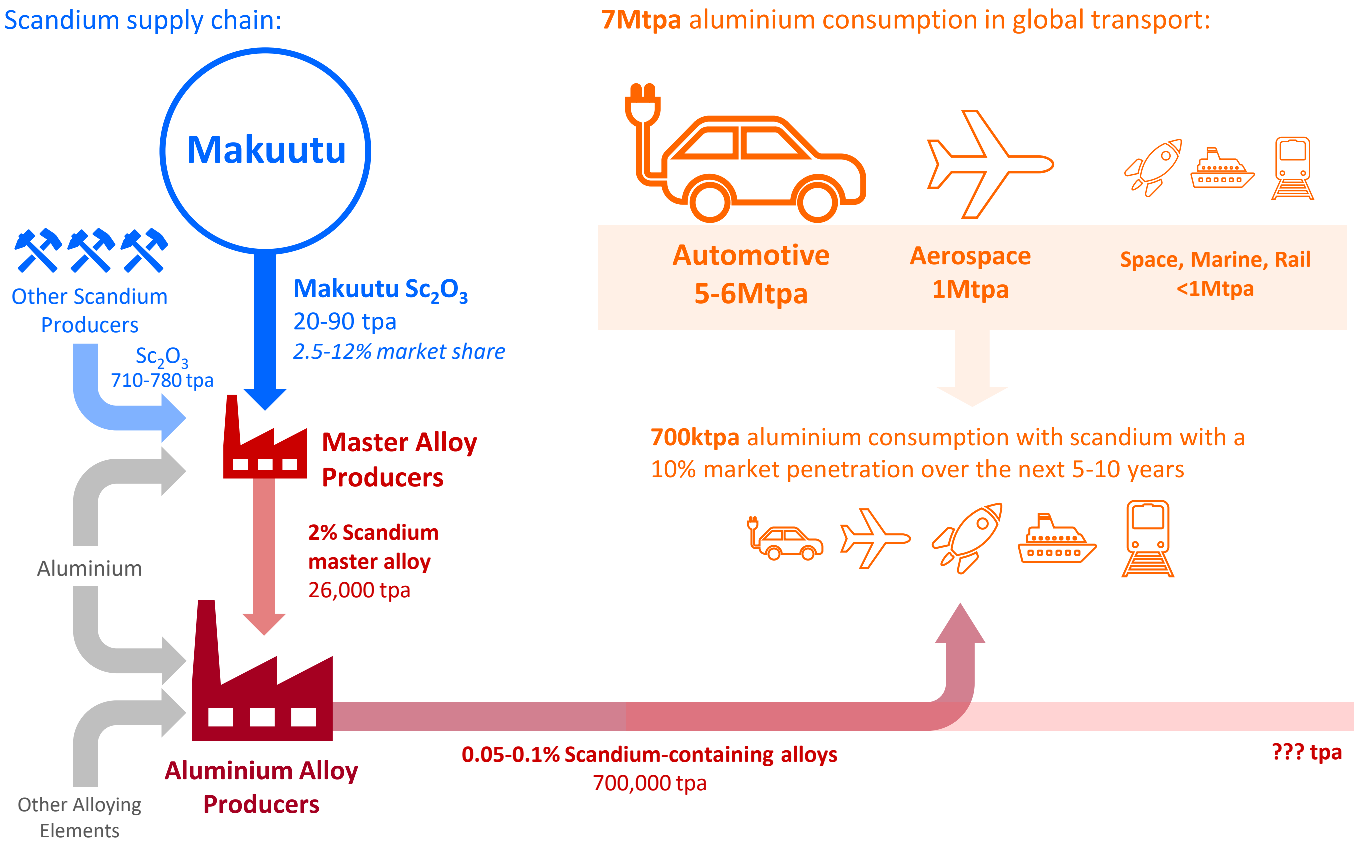
While the current scandium (Sc) market is 15-20 tonnes per annum scandium oxide (Sc_2O_3), the global transportation industry has the potential to turn scandium into a billion-dollar market

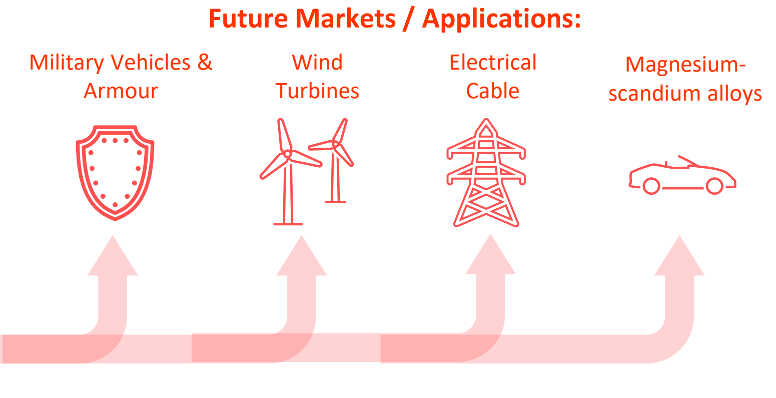
Contestable Scandium Market

The adoption of scandium will be heavily dependent on its price-point. As the market grows, the scandium price will decrease as economies of scale for production can occur. This will allow aluminium-scandium to be used in an increasing number of applications.

While the initial price of scandium could be US$1,000/kg Sc_2O_3 at low tonnages, this will likely drop to ~US$700/kg with increased volumes

Scandium Market Value	Makuutu Scandium
• Avg Sc content: 0.075% • Required Scandium: 525tpa (800tpa Sc_2O_3) • Sc price range: US$700-1,000/kg Sc_2O_3 • Market: US$560-800M p.a.	20-90+ tpa Sc_2O_3 (2.5-12% total market share) US$20-63M+ p.a. Revenue





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