

# **Developing an emerging magnet and heavy rare earth supply chain**

European Raw Material Alliance

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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](http://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](http://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**



## 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

**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



# 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 (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



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

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



# 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 (NDP III)

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 – Update planned for late 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

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

Scoping Study<sup>1</sup> completed in April 2021 defined a **very robust base case** with highly attractive 11-year Base Case economic parameters

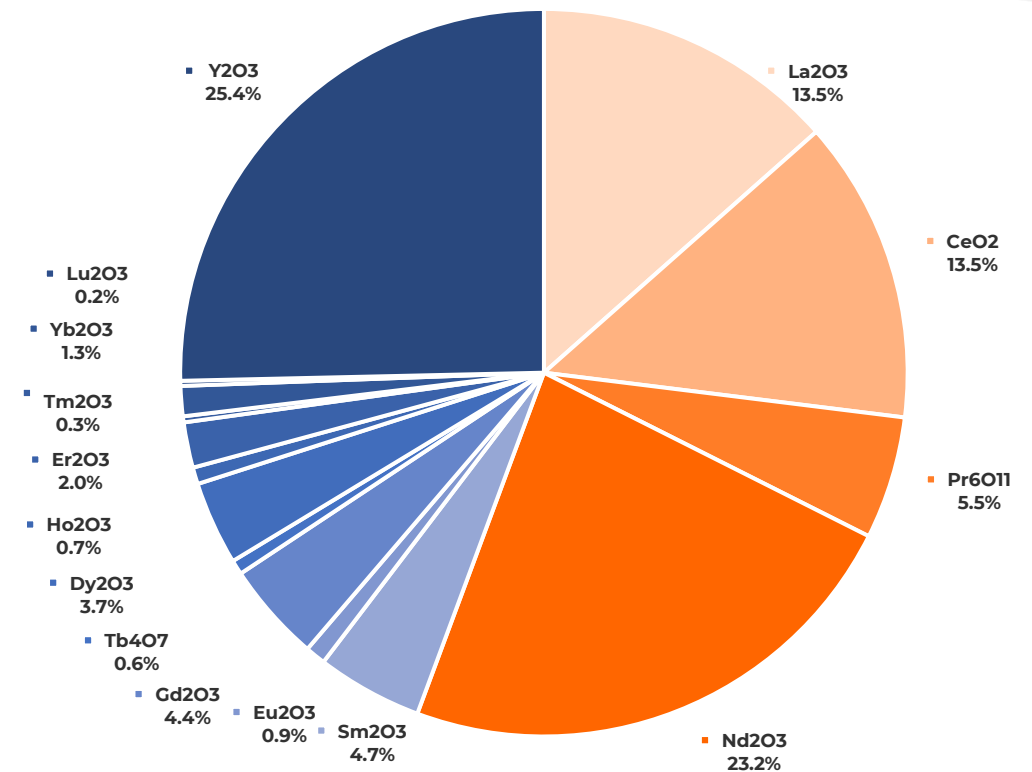
- Post-tax long term free cash flow **US\$766 million** over 11 years
- EBITDA of **US\$1.28 billion**
- Post-tax Net Present Value (8) of **US\$321 million**
- Internal Rate of Return of **38%**
- Pre-production CAPEX requirement of **US\$89 million**
- Expansion CAPEX of \$212 million funded by Project 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)**

315 Mt Mineral Resource Estimate<sup>2</sup> with **significant exploration upside** confirmed with mineralisation stretching across 37 km trend – **MRE Update planned for Q2 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  $\text{Sc}_2\text{O}_3$ , potential annual production from 25 to ~100 tonnes per annum

## MAKUUTU BASKET HIGH VALUE CREO / HREO PRODUCT



# 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**

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)**

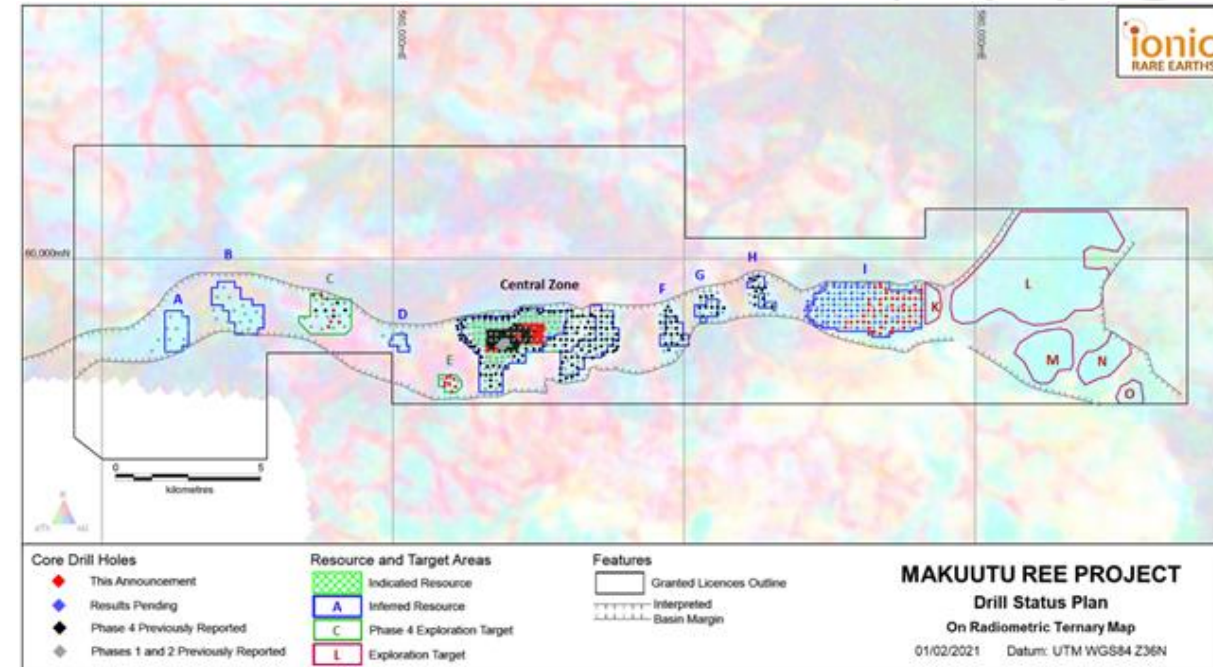
279 drill holes (4,754 metres) completed between October 2019 and October 2020 defining **JORC MRE<sup>1</sup> of 315 Mt @ 650 ppm** Total Rare Earths Oxide (TREO), at a cut-off grade of 200 ppm TREO-CeO<sub>2</sub>

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 <sub>2</sub> (ppm)	LREO (ppm)	HREO (ppm)	CREO (ppm)	Sc <sub>2</sub> O <sub>3</sub> (ppm)
Indicated	Clay	66	820	570	590	230	300	30
Inferred	Clay	248	610	410	450	160	210	30
<b>Total Resource</b>	<b>Clay</b>	<b>315</b>	<b>650</b>	<b>440</b>	<b>480</b>	<b>170</b>	<b>230</b>	<b>30</b>

# Makuutu Timeline to Production

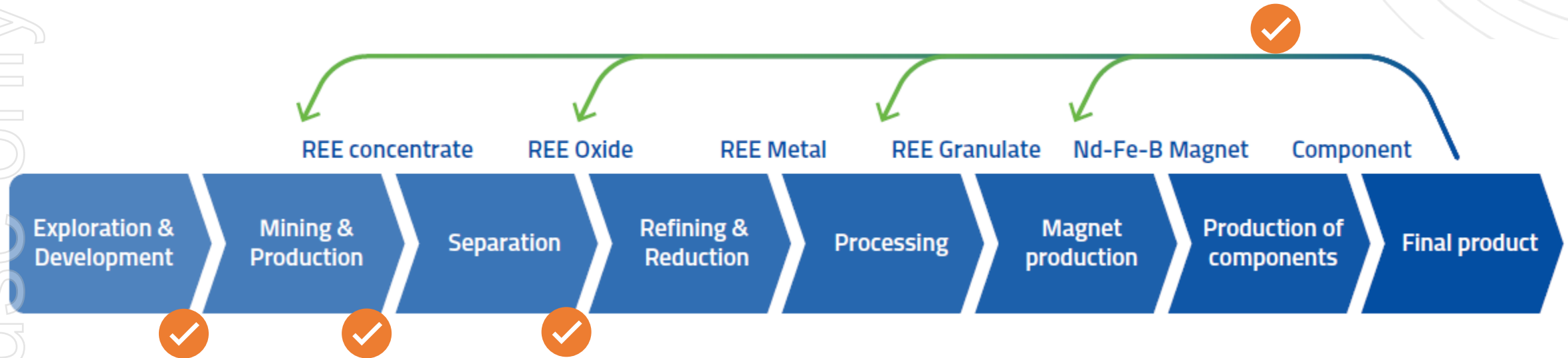
## ACCELERATING MAKUUTU TOWARDS PLANNED PRODUCTION IN 2024

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

# China Dominates Global REE Separation & Refining Capacity

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

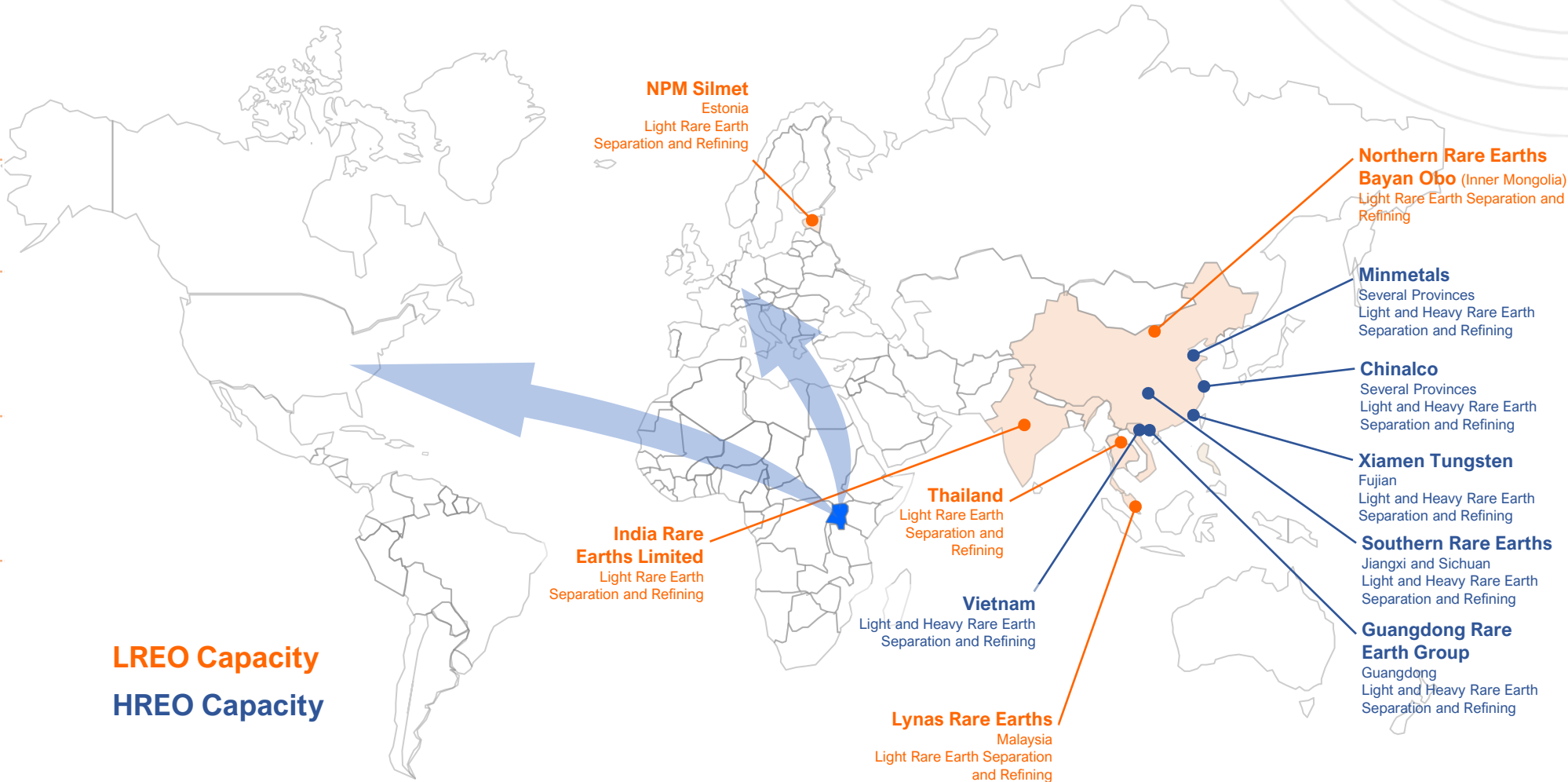
Global HREO separation and refining capacity operated and controlled by China<sup>1</sup>

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



# 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

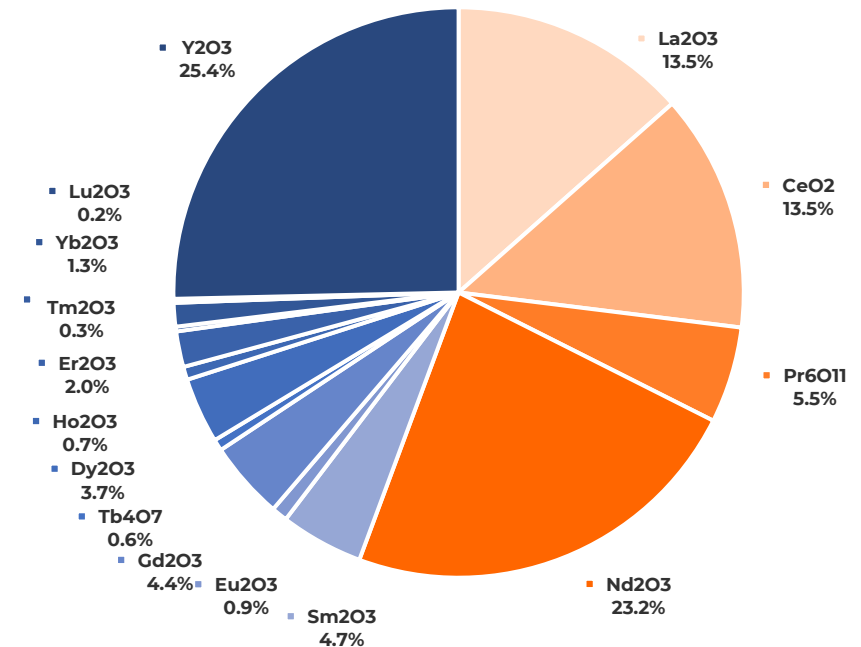
### Exploring opportunities to value add beyond REOs

- MREC product typically has payability ~ 70% (~ US\$67/kg)
- Refined REO payability increased to 100% (~US\$96/kg)
- Value added **metals and alloys** creates significant step change in revenue potential from (~US\$131/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 1-FEB-2022 US\$/kg
La <sub>2</sub> O <sub>3</sub>	%	13.5%	\$ 1.52
CeO <sub>2</sub>	%	13.5%	\$ 1.58
Pr <sub>6</sub> O <sub>11</sub>	%	5.5%	\$ 151.00
Nd <sub>2</sub> O <sub>3</sub>	%	23.2%	\$ 170.00
Sm <sub>2</sub> O <sub>3</sub>	%	4.7%	\$ 5.20
Eu <sub>2</sub> O <sub>3</sub>	%	0.9%	\$ 32.00
Gd <sub>2</sub> O <sub>3</sub>	%	4.4%	\$ 98.00
Tb <sub>4</sub> O <sub>7</sub>	%	0.6%	\$ 2,150.00
Dy <sub>2</sub> O <sub>3</sub>	%	3.7%	\$ 482.00
Ho <sub>2</sub> O <sub>3</sub>	%	0.7%	\$ 265.00
Er <sub>2</sub> O <sub>3</sub>	%	2.0%	\$ 68.00
Tm <sub>2</sub> O <sub>3</sub>	%	0.3%	\$ 850.00
Yb <sub>2</sub> O <sub>3</sub>	%	1.3%	\$ 16.30
Lu <sub>2</sub> O <sub>3</sub>	%	0.2%	\$ 850.00
Y <sub>2</sub> O <sub>3</sub>	%	25.4%	\$ 14.90
Sum Total		100%	
Magnet REO	%	43%	
LREO	%	56%	
HREO	%	44%	
CREO	%	54%	
Basket Value	US\$/kg		\$ 96.35

### MAKUUTU BASKET CONTENT HIGH VALUE CREO / HREO PRODUCT



Note. Rounding Applied to nearest 0.1%.

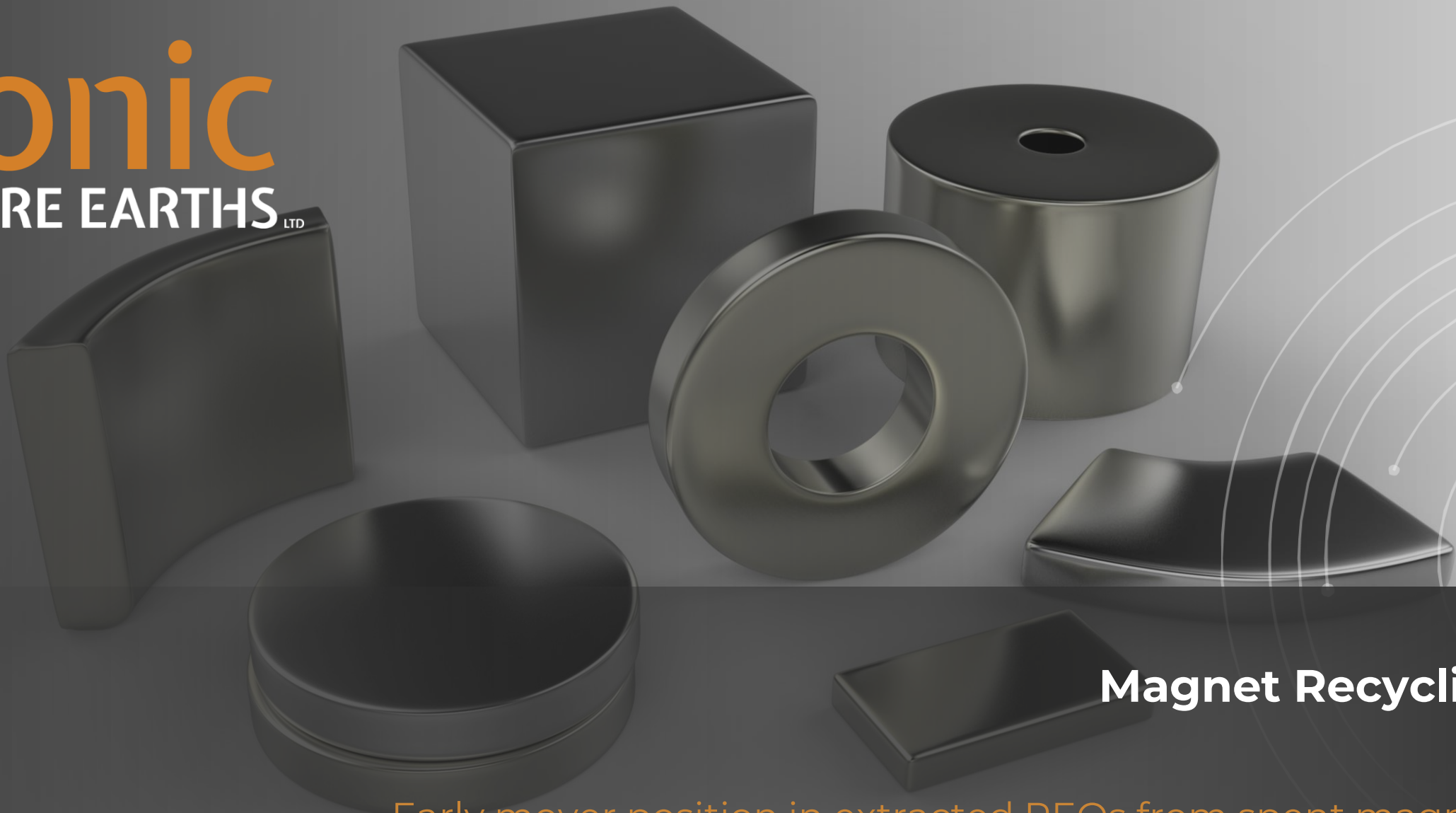


# Standalone Refinery to unlock value of balanced basket REOs

## 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 <sup>1</sup> (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



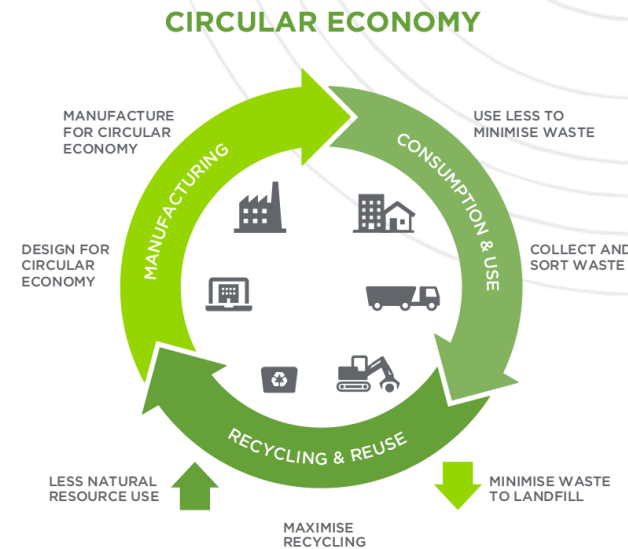
## Magnet Recycling

Early mover position in extracted REOs from spent magnets

# 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 100% recycled rare earth to produce oxides at purity of 99.99%
- 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



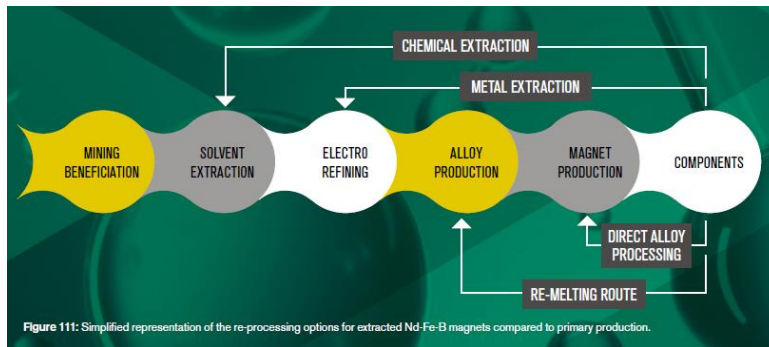
# NdFeB Magnet Recycling – low cost, modular plan

## 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 99.99%+ 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

# Magnet Recycling – a lower risk, responsive REO supply source

## MAGNET RECYCLING CAN ACHIEVE REO PRODUCTION WITH SIGNIFICANTLY REDUCED ENVIRONMENTAL BURDEN

- A secondary economy for magnets significantly **reduces the environmental burden** compared to the primary sources
- Secondary materials can be sourced from a much wider array of companies and countries, which **reduces the risk of supply shortages** when the supply chain is narrow
- The **material that is extracted will only contain the magnet REEs in demand**, unlike a primary ore, where all 17 rare earth elements are mixed together and need separating
- A recycled source of materials **will not contain radioactivity**, a problem with some primary hard rock REE resources
- **Lower capital and faster to market**

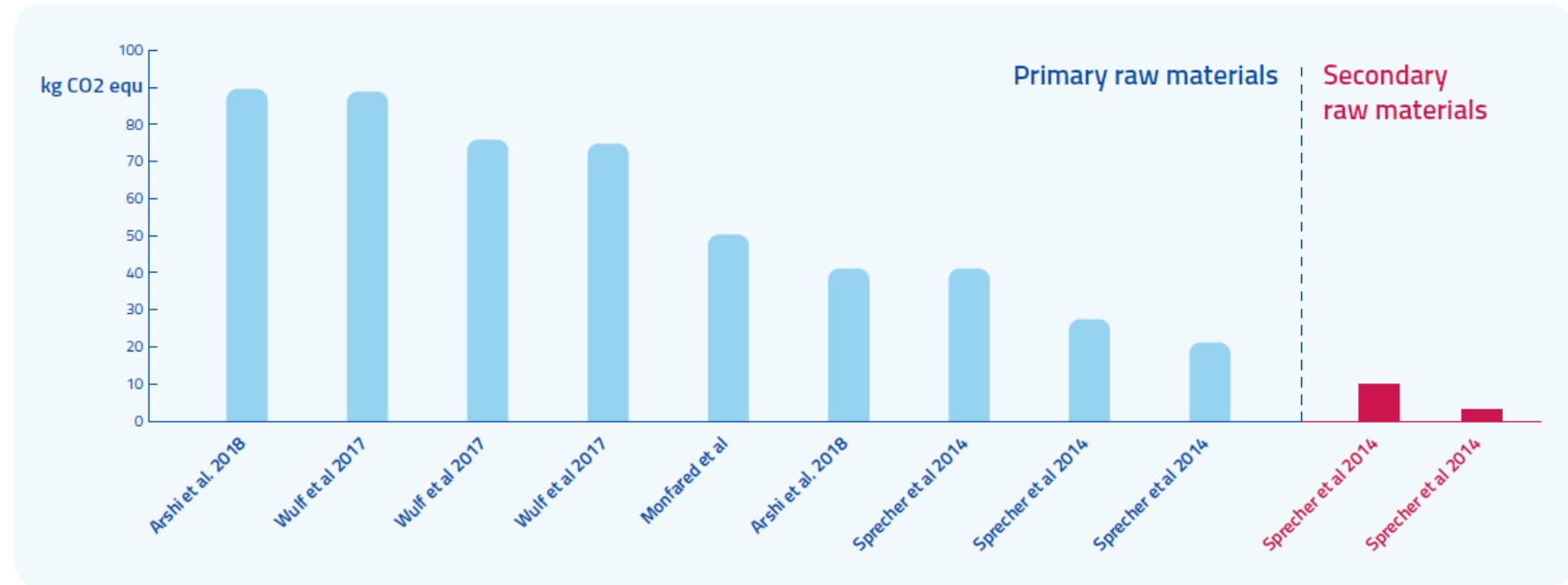


Fig. 6: Global Warming Potential of 1 kg Nd-Fe-B (kg CO2 equ.) according to various LCA reports. The scores vary greatly depending on the raw materials, the processing routes, and the LCA methodology used. There is a lack of a standardised LCA approach to rare earths. For direct quantitative comparison of processing routes, only consider each data of the same publication to ensure comparability. The authors of each report are shown beneath the individual data columns.

**MAGNET RECYCLING ENABLES THE CIRCULAR ECONOMY FOR RARE EARTHS THAT WILL INCREASE IN TIME TO REPRESENT 20% + OF THE REO SUPPLY CHAIN**

## DELIVERING MAGNET & HEAVY REO SUPPLY CHAIN TO CREATE NEW INDUSTRY AND JV'S

- 
- REE**
- MAGNETS**  
 Nd, Pr, Sm (Tb, Dy)  
 Motors and generators, HD Drives,  
 Microphones and Speakers,  
 MRI, Defence applications,  
 Magnetic refrigeration
- METAL ALLOYS**  
 La, Ce, Pr, Nd, Y  
 NiMH batteries,  
 Superalloys,  
 Al - Mg alloys, Steel
- PHOSPHORS**  
 Eu, Y, Tb, Nd, Er, Gd  
 (Ce, Pr)  
 LED, Laser, Flat Panel  
 Display, Fluorescent  
 lamps, Xray imag-  
 ing, Optical  
 sensors,  
 Fibre  
 Optics
- CATALYST & CHEMICAL PROCESS**  
 La, Ce, (Pr, Nd)  
 Petroleum Refining,  
 Automotive Catalysts,  
 Diesel Additive, Water  
 treatment
- CERAMICS & GLASS**  
 Ce, La, Pr, Nd, Gd, Er, Ho  
 Polishing media, UV  
 resistant glass, Thermal  
 glass, Capacitors, Sensors,  
 Colorants, Refractories,  
 Fuel Cells, Super-  
 conductors
- OTHER**  
 Fertilizer, Pigments,  
 Nuclear, Medical Tracers
- metallic state**
- oxidized state**

# IonicRE Value Proposition

## MAKUUTU'S STRATEGIC IMPORTANCE WILL INCREASE LONG TERM

- Long-life, low-CAPEX, high-value basket asset
- Planned operations in 2024
- Exposure to 43% magnet REOs & 44% heavy REO basket

## THROUGH ACQUISITION OF SEREN TECHNOLOGIES, IONICRE NOW ON PATH TO VERTICAL INTEGRATED RARE EARTH COMPANY

- Addition of REE separation and refining capacity has increased internal capability to deliver refinery solution for new supply chains into western markets
- Technology applicable to both mineral concentrates, intermediate products (MREC) and magnet recycling

## MAGNET RECYCLING

- Potential for near term supply of magnet REOs sourced from environmentally favourable magnet recycling
- Will play a growing role in future REO supply chain, up to 25% 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**





**Ionic Rare Earths Limited**

Level 1, 34 Colin Street  
West Perth WA 6005 Australia

[www.ionicre.com.au](http://www.ionicre.com.au)  
[admin@ionicre.com.au](mailto:admin@ionicre.com.au)

**T** +61 8 9481 2555  
**F** +61 8 9485 1290