MINISTRY OF NATURAL RESOURCES AND
ENVIRONMENTAL SUSTAINABILITY

BUSINESS MODEL FOR THE DEVELOPMENT OF

ION-ADSORPTION CLAY RARE EARTHS INDUSTRY IN MALAYSIA

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TABLE OF CONTENTS

3 Foreword

4 Preface

6 Introduction

8 Global and Malaysia's Demand

11 National Targets by 2030

12 The Guiding Principle for a IAC-REE Business Model

14 Upstream Sector

17 Midstream Sector

19 Downstream Sector

20 Environment, Social and Governance

21 Chain of Custody

23 Integrated Business Model

27 Recommendations

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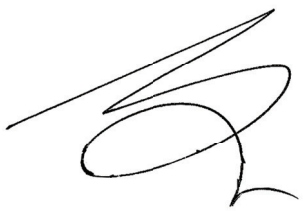
FOREWORD

Considering the forward march of the modern age, contemporary life is greatly reliant on the advancement of technology. Nevertheless, as we eagerly embrace this modern era, it is crucial to synchronize the use of advanced technology with environmental sustainability to ensure it enhances the well-being of all communities.

To sustain this equilibrium, the government has delved into the potential of a new mineral resource called Ion-Adsorption Clay Rare-Earth Elements (IAC-REE). These resources present immense possibilities for fuelling technological progress today, given their wide-ranging applications, spanning from the manufacture of high-tech gadgets like smartphones, laptops, and TVs, to military assets, and even to the production of renewable and environmentally friendly energy sources like wind turbines and solar panels, among others.

Given the nation's reserves of IAC-REE, it's imperative to ensure their efficient utilization through responsible and sustainable production practices. Following this principle, the ministry aims to align Malaysia's IAC-REE industry development with Environmental, Social, and Governance (ESG) standards to meet the objectives outlined in the Sustainable Development Goals 2030 (SDG 2030).

With the publication of this document, it is hoped that it will serve as a reference for all stakeholders interested in developing the IAC-REE industry in Malaysia.



YB TUAN NIK NAZMI BIN NIK AHMAD
Ministry of Natural Resources and Environmental Sustainability

PREFACE

In the fast-evolving high-technology industries, the need and demand for ion-adsorption clay rare earth elements (IAC-REE) and their products, are rapidly increasing, especially in the electronics, transport, energy, and defence sectors. To develop a sustainable value chain in the IAC-REE industry, it is important to develop the mining, processing and manufacturing of rare earth-based products responsibly to harvest its socioeconomic value. It is timely for the Malaysian Government to develop the IAC-REE industry on the right footing, where its activities should prioritise sustainability and well-being of the people. That's where the Environment, Sustainability, and Governance (ESG) standards come into play, guiding the industry toward a greener future.

Currently, global demand for REE is out-stripping supply, and, if net zero carbon is to be achieved by 2050. The abundance of IAC-REE resources in Malaysia give us the strength to become a global player in this industry. NRES envisions Malaysia becoming the next regional hub for rare earth-based products manufactured. Essentially, this would translate as vertical integration of a critical mineral commodity from mine to finished mass-produced products ready for end-user product fabrication. The raw materials of IAC-REE need to be mined responsibly, processed in locally established rare earth processing plants, metals and alloys plants, then go into downstream manufacturing plants for super-magnet and electric motors production.

To unlock the full economic potential of domestic IAC-REE resources towards achieving Net Zero Carbon Emissions goal by 2050, a business model for the entire rare earths ecosystem has been formulated. The study comprised the whole value chain – upstream, midstream, downstream, ESG, and the integrated business model which would serve as a guide for government agencies, both at the Federal and State levels, as well as industry players to develop respective holistic action-oriented plans.

YBHG. DATUK DR. CHING THOO A/L KIM
Secretary General
Ministry of Natural Resources and Environmental Sustainability

INTRODUCTION

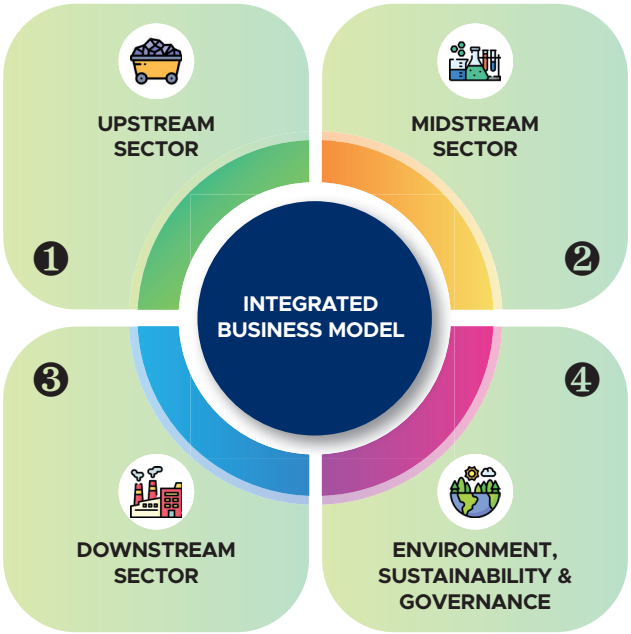
On 15th July 2022, the Ministry of Energy and Natural Resources (now known as the Ministry of Natural Resources and Environmental Sustainability, NRES) appointed the Academy of Sciences Malaysia (ASM) as its strategic partner to formulate a business model for the development of the Ion-Adsorption Clay Rare Earths (IAC-REE) industry in Malaysia.

Given that Malaysia is rich in mineral resources and rock materials, its mining and quarrying sector is one of the significant contributors to the national economic development. These minerals and rock materials are crucial components that catalyse the other sectors of the economy, including but not limited to construction, manufacturing, energy and agriculture. Over the past fifteen years, the rapid growth of the East Asian consumer economy has substantially increased the demand for miniaturised electronic devices for communications, data processing and entertainment purposes, as well as light-weight wind turbines to drive the demand for renewable wind energy. In particular, specific rare earth metals used to manufacture miniaturised high-strength super-magnets for application in automobiles and defence equipment have displayed an exponential increase of late.

Objective

The objective of the study is to formulate a Business Model for developing the IAC-REE industry in Malaysia

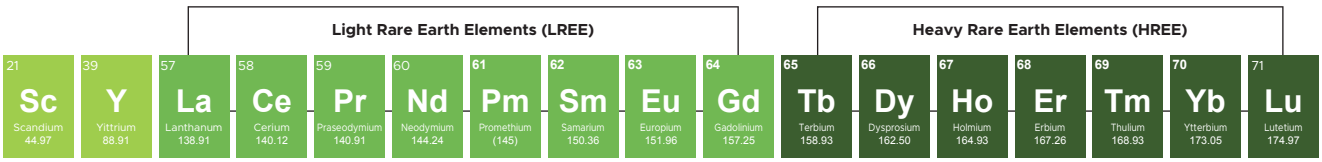
that serves as a guide for the Federal Government, State Governments, academia, industry, and civil society towards building a responsible and sustainable IAC-REE ecosystem. The Business Model covers the entire supply chain consisting of four sectors of the IAC-REE industry.



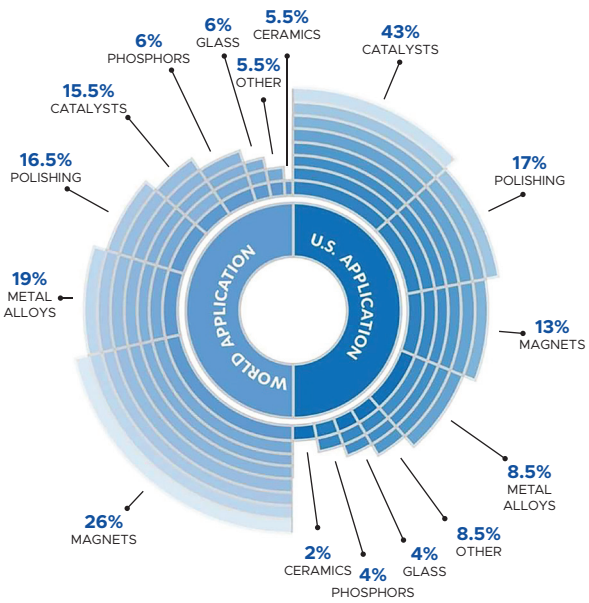
Rare Earths

Rare Earths refer to a group of 15 elements (REE) that belong to the Lanthanide series. Upon including Scandium and Yttrium, Rare Earths comprise of 17 critical elements.

Described as technology metals, Rare Earths are among the most resource-critical raw materials. Despite their highest economic importance, Rare Earths feature a high supply risk with the supply chain being currently dominated by China for the production of super-magnets used in electric vehicles (EV), wind turbines, consumer electronics, and most military hardware.



Key Applications of Rare Earth Elements



GLASS & POLISHING
Polishing Compounds
Pigments & Coatings
UV Resistant Glass
Photo-Optical Glass
X-Ray Imaging
Nd Gd Er Ho La Ce Pr

METAL ALLOYS
NiMH Batteries
Fuel Cells
Steel
Super Alloys
Aluminum/Magnesium
Nd Gd Er Ho La Ce Pr

CERAMICS
Capacitors
Sensors
Colorants
Scinitillators
Refractories
Nd Y Eu Dy Gd La Ce Pr

CATALYSTS
Petroleum Refining
Catalytic Converter
Fuel Additives
Chemical Processing
Air Pollution Controls
Nd La Ce Pr

PHOSPHORS
Display Phosphors-
CRT, LPD, LCD
Flourescents
Medical Imaging
Lasers
Fiber Optics
Nd Eu Tb Y Er Gd Ce Pr

MAGNETICS
Computer Hard Drives
Disk Drive Motors
Anti-Lock Brakes
Automotive Parts
Frictionless Bearings
Magnetic Refrigeration
Power Generation
Microphones & Speakers
Communication Systems
MRI
Nd Tb Dy Pr

DEFENCE
Satellite Communications
Guidance Systems
Aircraft Structures
Fly-by-Wire
Smart Missiles
Nd Eu Tb Dy Y Lu Sm Pr La

Source: National Energy Technology Laboratory (NETL), "REE-CM Program," https://www.netl.doe.gov./coal/rare-earth-elements/program-overview/background

GLOBAL DEMAND FOR PRODUCTS FROM RARE EARTHS

In order to achieve the net zero target by 2050, reducing greenhouse gases emitted from the energy sector is a priority across the globe. Efforts are made to reduce CO_2 in energy usage and energy generation by promoting EV and wind turbine generators that deploy high-powered NdFeB super-magnets.

At the global scale, the demand for NdFeB super-magnets is projected to grow by 114% in 2030 and 293% in 2050 (relative to the demand recorded in 2020) (MacKenzie, 2022). The European Commission in 2022 depicted that, “Lithium and Rare Earths will soon be more important than oil and gas. Our demand for Rare Earths alone will increase fivefold by 2030.”

Seemingly, Nd, Pr, Dy, Tb, Sc, and Sm are in high demand to produce super-magnets. Hence, establishing new mines will be necessary to meet this growing demand. While China is the dominant player, Mount Weld in Western Australia, Mountain Pass in the US, and a few Southeast Asia countries have active mines. New opportunities have been noted for mining in the US, Canada, Brazil, Australia, Vietnam, Thailand, Malaysia, and Uganda, which are bound to start their production in near time.

In terms of processing, China currently supplies 87% of the world's REE, while Lynas Malaysia contributes only 11% with the potential to increase its contribution. The EU and India each account for 1% of the global supply. Since the start of Lynas in 2013 in Malaysia, Vietnam has developed the third biggest magnet manufacturing base in the world (behind China and Japan) by using all the RE products generated by Lynas in Malaysia. Malaysia has identified enormous amounts of REE in ion adsorption clay (IAC) and due to their widespread occurrence, Malaysia has the potential to set up the REE industries at a large scale.

DEMAND FOR REE BY 2030

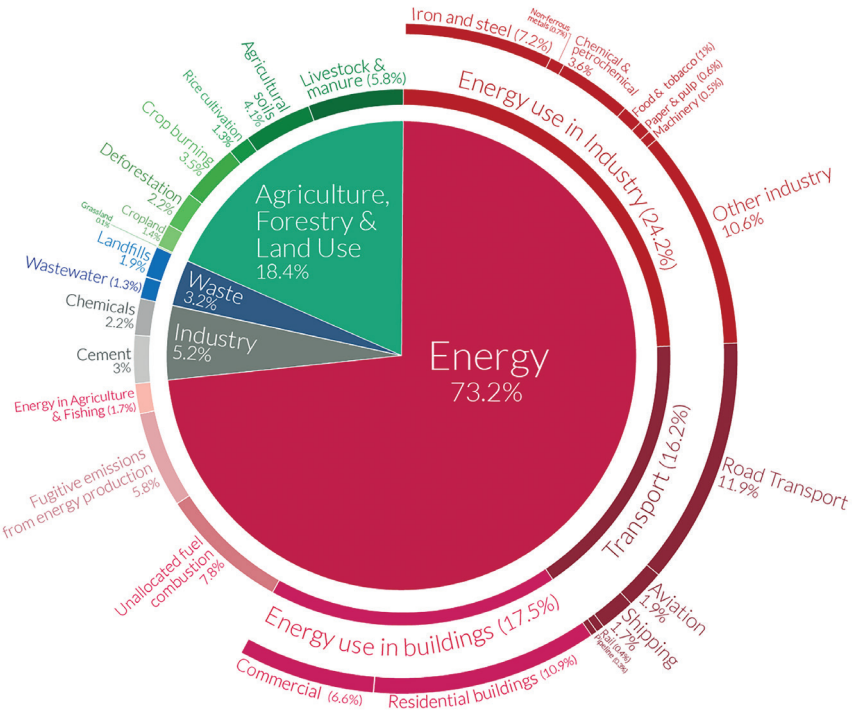
Adamas Intellengence
[August 2022]
4 Fold Increase

European Comission
[September 2022]
5 Fold Increase

MacKenzie
[June 2022]
4 Fold Increase

American RE
[October 2022]
4 Fold Increase

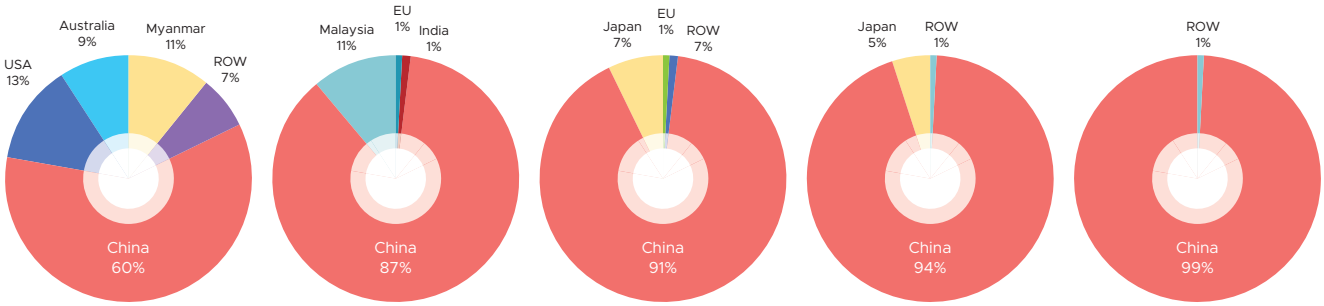
Global Greenhouse Gas Emission by Sector



Our World in Data

Source: Our World in Data, Climate Watch, the World Resources Institute (2020)
Licensed under CC-BY by the author, Hannah Ritchie (2020)

Global Rare Earth Supply Chain



ROW: Rest of the world
Source: Ionic Rare Earths (2022) Sustainably Sourcing Magnet and Heavy Rare Earths to meet Net Zero Carbon Ambitions

Malaysia's Demand for Products from Rare Earths

The government of Malaysia aspires to build an EV ecosystem towards maturity through its National Automotive Policy 2020 and Low Carbon Mobility Blueprint 2030. Through these policies, Malaysia aims to achieve 15% of EVs in its Total Industry Volume by 2030, which is equivalent to 183,000 units of EVs. Since this megatrend signifies the increasing demand for super magnets and electric motors in Malaysia, Rare Earths are indeed a critical component that is highly sought.

Permanent Magnet

Malaysia Average Trade Value
[2017–2021]

EXPORT	IMPORT
RM529.6 million	RM877.2 million

Electric Motor

Malaysia Average Trade Value
[2017–2021]

EXPORT	IMPORT
RM664.2 million	RM3.9 billion

Catalyst

Malaysia Average Trade Value
[2017–2021]

EXPORT	IMPORT
RM53 million	RM70 million

Ion Adsorption Clay-Rare Earth Elements

IAC-REE are found in deposits where Rare Earth elements occur in the elemental form in the clay and can be easily extracted by leaching with minimal environmental impact. The IAC deposits, first discovered in Southern China, are also found in Southeast Asia, South America, and Africa.

Characteristics

- IAC-REE deposits contain 300 to 3500 ppm (0.03-0.35%) Total Rare Earth Oxides (TREO)
- Shallow occurrences in soil layers and ease of extraction by leaching
- Contain high proportions of Nd, Pr, and Heavy Rare Earth Elements
- Categorised as non-radioactive because Th and U in the products and residues are significantly less than 1 Bq/g (246 ppm) 232 Th or less than 1 Bq/g (81 ppm) 238 U.

Cerium Oxide (High Surface Area) | Bastnasite Concentrated | Neodymium Oxide | Lanthanum Carbonate

The Current Status in Malaysia

Malaysia has discovered massive amounts of REE in IAC, also referred to as Ion-Adsorption ClayRare Earth Elements (IAC-REE). The Rare Earth Carbonate (REC) products typically found in the Malaysian IAC-REE mine contain 42% of Rare Earth magnetic metals (Pr, Nd, Sm, Tb, and Dy) in comparison to 27% of Rare Earth magnetic metals of the mineral type of REE deposits (Duncan mine, Lynas). The first pilot project in Kenering, Perak, was audited towards the end of 2022 to ensure that the in-situ leaching of REE did not adversely affect the environment. Other states in Malaysia are also ready to extract REE from IAC-REE found in their respective states once the SOP is released for implementation. In doing so, Malaysia will be able to establish a full REE supply chain from upstream to downstream by encouraging local investors and Foreign Direct Investments.

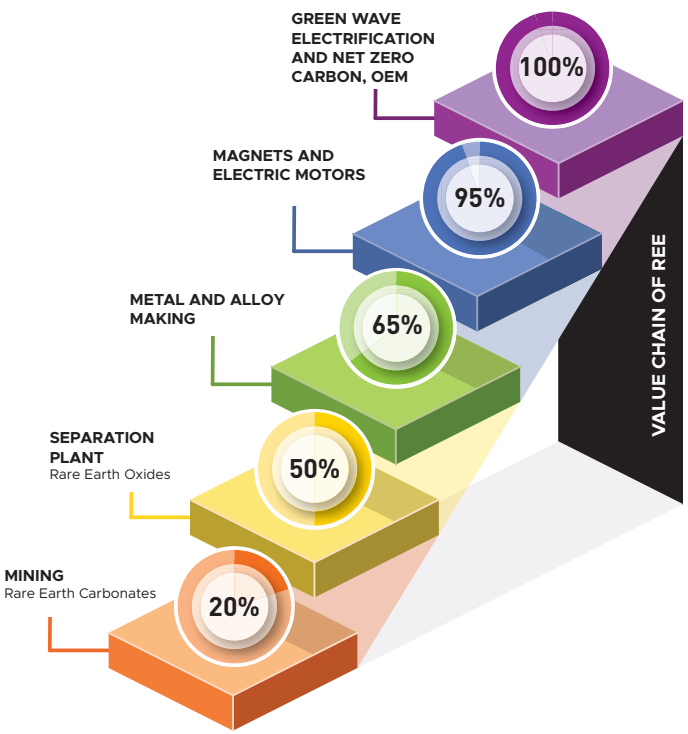
NATIONAL TARGETS BY 2030

Based on the global and local REE demands of super-magnets, national targets by 2030 are set for Malaysia towards becoming a regional player in the IAC-REE supply chain.

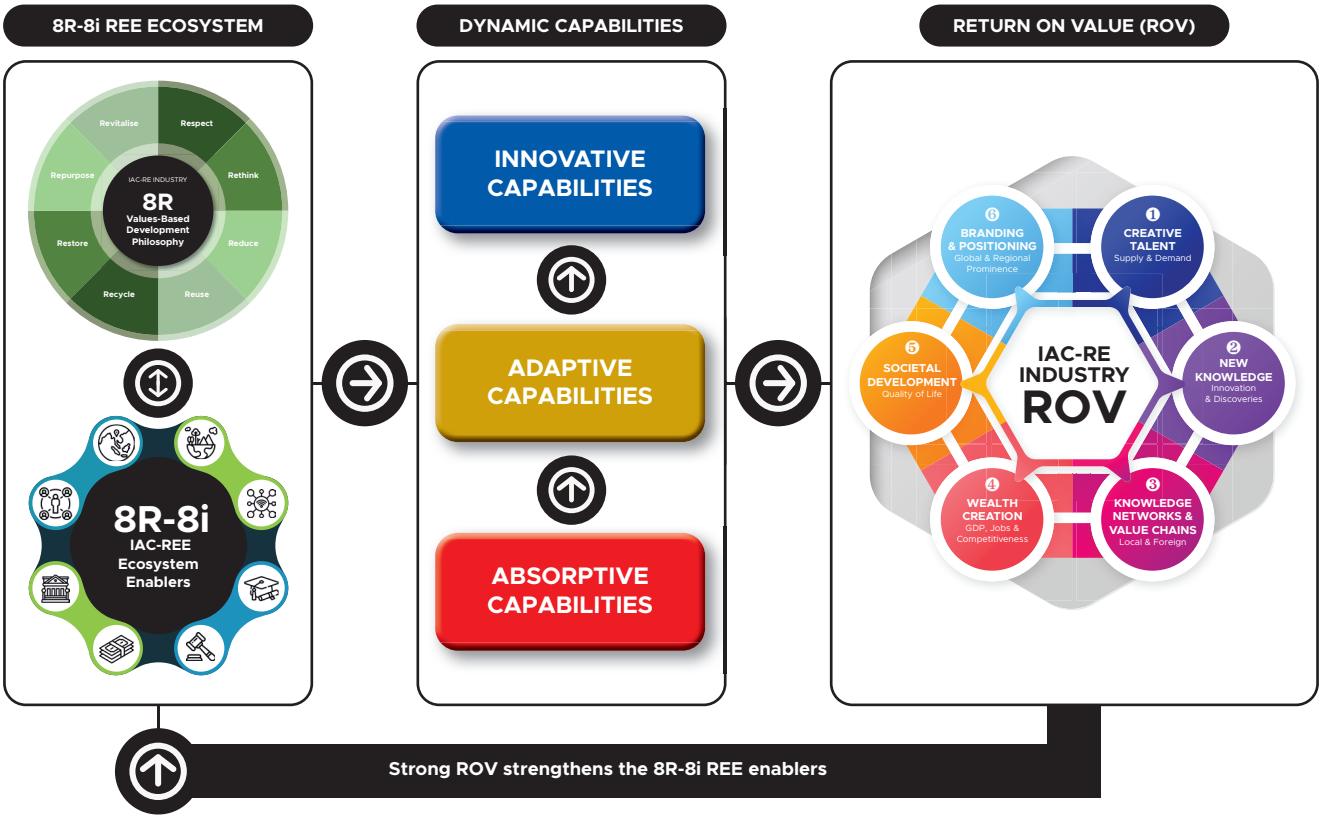
UPSTREAM	MIDSTREAM	DOWNSTREAM
30,000 tonne per year TREO	**10,000** tonner per year Nd/Pr	**35,000** tonne per year NdFeB super-magnets

Vertical Integration Value Chain: Mine to Magnet

The value of IAC-REE can only be maximised with the establishment of a full supply chain from Upstream (Mining), Midstream (REE Separation, Purification, and Manufacturing of Metals/Alloys) to Downstream (Super-Magnets and Electric Motors Manufacturing). A vertical Integration of the IAC-REE ecosystem that envisions "Mine to Magnet" is proposed. With the relatively higher amount of Rare Earth magnet metals, it is prudent for Malaysia to develop its own REE separation plant to separate and purify the Rare Earth magnet metals for subsequent downstream super-magnets and electric motors manufacturing, which is in line with the “Mines-to-Magnets/ Electric Motors” concept.



THE GUIDING PRINCIPLES FOR A COMPREHENSIVE REE BUSINESS MODEL



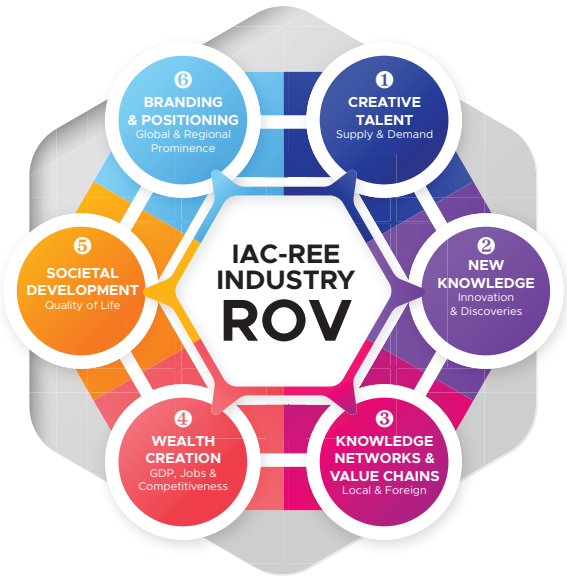
Adapted from Nair, Ahmed, and Vaithilingam (2022)

A Business Model was developed based on the ecosystem approach. It started with identifying the drawbacks and strengths of the current ecosystem by deploying the 8i ecosystem analysis that consists of the eight enablers: Institution, Interaction, Integrity, Infrastructure, Infostructure, Intellectual Capital, Incentives, and Internationalisation. The 8i ecosystem enablers, coupled with the 8R Values-Based Development Philosophy, yield a responsible and sustainable ecosystem that enhances the Dynamic Capability of the industry. Dynamic Capability refers to knowledge and talent development. It starts with Absorptive Capability, moving into Adaptive Capability, and finally achieving Innovative Capability. An industry with Innovative Capability has the ability to create high-value services and products.

A strong ecosystem exerts a positive 'knock-on' impact on Return on Value (ROV) to the industry and economy. Investments towards strengthening the 8R-8i ecosystem enablers can effectively underpin the development of Dynamic Capabilities and ROV. The objective here is to create horizontal and vertical ROV within and across the IAC-REE sectors, which can generate high-income jobs, knowledge creation, wealth generation, and societal development while moving up the global value chain. In many advanced markets, upon recording higher ROV, accumulated wealth is reinvested into the 8R-8i ecosystem to create a virtuous and sustainable innovation cycle. On the contrary, the setbacks observed in the enablers can result in firms operating at the lower end of the value chain. Over time, operating at the status quo will lead the industry to lose its competitive advantage over other dominant players in the global market.

Return on Value (ROV)

The Business Model is aimed at creating a virtuous cycle that leads to both Return on Investment (ROI), and more importantly, Return on Value (ROV) in light of the national economic development.



Adapted from Nair, Ahmed, and Vaithilingam (2022)

1. **Strong supply of creative world-class talent** to lead the development of new knowledge in the IAC-REE industry.
2. **Yield new knowledge that attracts FDIs and initiates vibrant industry-led knowledge networ**ks in the IAC-REE industry both locally and internationally.
3. **Vibrant knowledge networks** that generate knowledge-driven industries and clusters spawn the next-generation economic sectors in the REE industry (to increase the economic wealth of the country).
4. **Create high-income jobs**, besides increasing contribution to revenue streams and GDP. The wealth effect increases the adoption of STI and knowledge in IAC-REE systems for the Rakyat to enjoy an enhanced quality of life.
5. **Cross-sectoral spillover impacts of IAC-REE applications** (i.e., medical and healthcare, renewable energy, and transportation) to create an advanced domestic market for high-value technologies and services.
6. **Increase in domestic and foreign investments** to intensify the creation of next-generation creative talent, new knowledge, and market potential in the industry (reinforcing ecosystem development).

UPSTREAM SECTOR

Based on a reconnaissance study carried out by the Jabatan Mineral dan Geosains Malaysia (JMG), funded under 11MP, 16.2 million tonnes of TREE (or 18.9 million tonnes of TREO) were delineated as Inferred Resources.

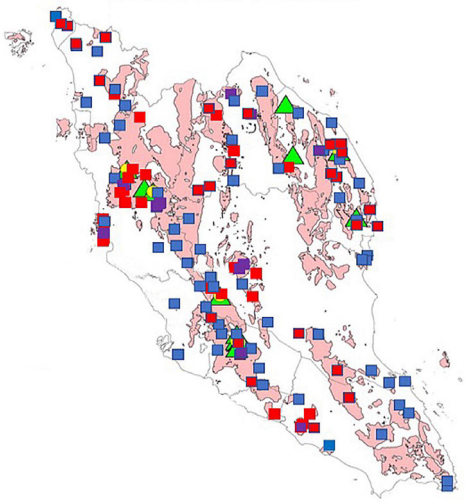
REE Potential in Malaysia

Reconnaissance Study RMKe-11

- REE > 300-500 ppm
- REE > 500-1000 ppm
- REE > 1000 ppm

Collaboration survey with ASM 2014

- Total HREE > 100 ppm
- Total HREE > 50 ppm
- Granite



REE Potential Study, Scandium and Thorium Sabah & Sarawak

- REE, Scandium & Thorium
- REE > 300 ppm
- Sc > 100 ppm
- REE > 500 ppm
- Soil Sample

Source: JMG

The top five States with high potential for the discovery of enormous REE deposits are Terengganu, Kelantan, Perak, Kedah, and Pahang.

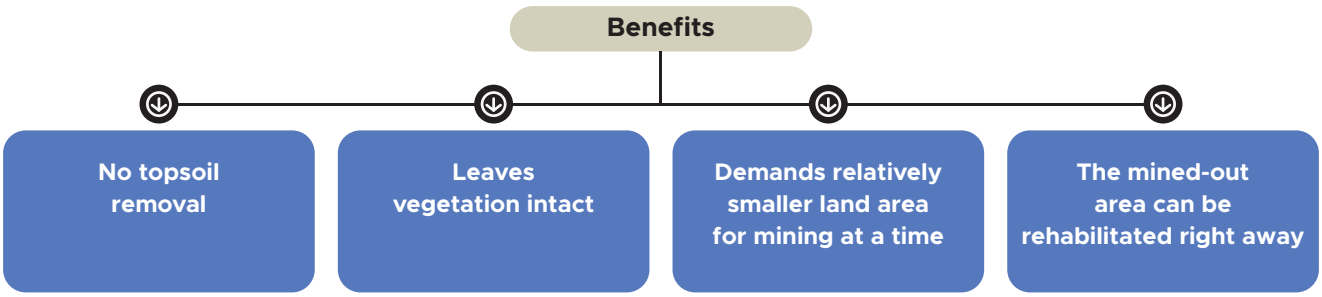
State	Potential Area (km^2)	Inferred Resource (tonnes)	
		TREE*	TREO*
Terengganu	5,750	7,187,500	8,373,438
Kelantan	2,050	2,562,500	2,985,313
Perak	1,350	1,687,500	1,965,938
Kedah	1,005	1,256,250	1,463,531
Pahang	1,000	1,250,000	1,456,250
Selangor	600	750,000	873,750
Negeri Sembilan	550	687,500	800,938
Johor	450	562,500	655,313
Sarawak	100	125,000	145,625
Melaka	100	125,000	145,625
Total	**12,955**	**16,193,750**	**18,865,721**

* TREE converted to TREO by multiplying by a factor of 1.165

Source: JMG

In-Situ Leaching (ISL)

ISL mining is the most suitable mining method currently deployed for extracting IAC-REE. The REE is extracted via an ion exchange process by injecting a lixiviant into the ground. This method exerts a lower environmental impact than the conventional mining method.



Strategies and Recommendations

Minerals left in the ground have no intrinsic value. It is only when the mineral resources are mined and processed into useful products that they benefit a country and its people. The success of the Upstream Sector relies on the support provided by the government, industry, and civil society.

- **JMG to continue follow-up reconnaissance surveys** to firm up the measured resources in order to reduce exploration risk for the industry players
- **Industry players to apply the latest exploration and mining techniques** that are environment-friendly
- **20% of local mine production should be reserved at market price for the local Midstream Sector** for Research, Development, Innovation, Commercialisation & Economy (RDICE) purposes
- **The REC Central Buying House should be set up as a GLC** to store REC before Midstream Plants are ready and operational.

Business Model for the Upstream Sector of the IAC-REE Industry

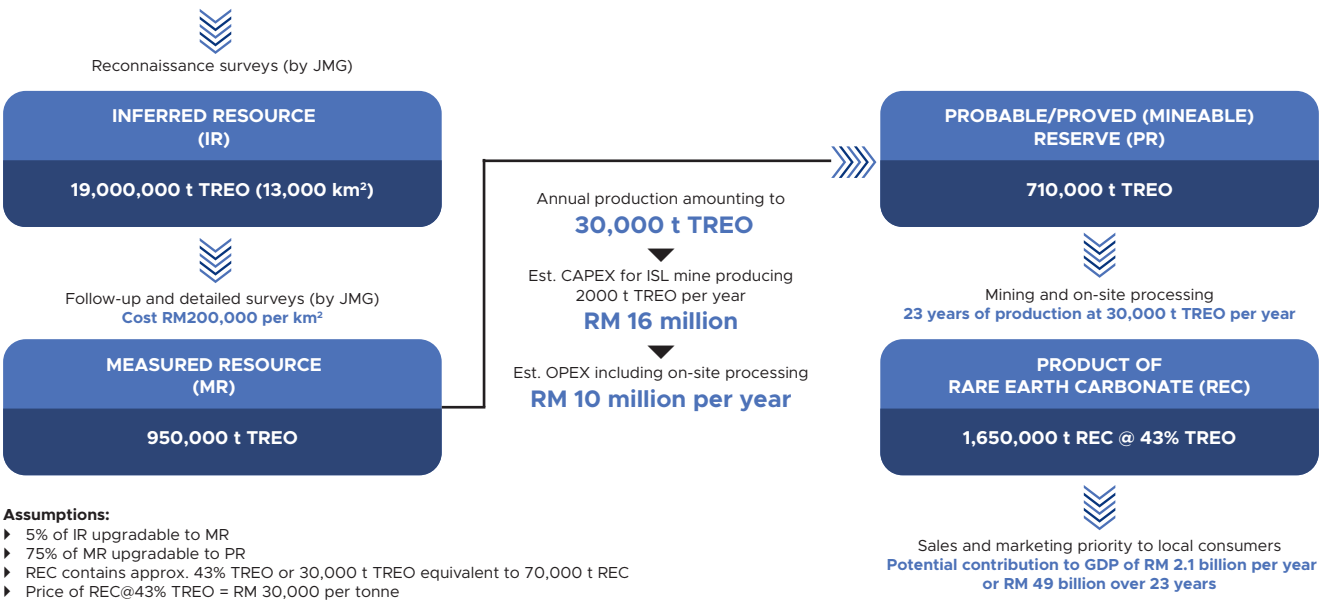


Figure 4.8: Business model for the upstream sector of the IAC-REE industry (value creation process)

MIDSTREAM SECTOR

Strategies and Recommendations

❶ SET UP A LARGE CAPACITY REPP

An effective and large-capacity RE Processing Plant (REPP) in Malaysia can boost the REO/HREE output. The REPP should have excess capacities over and above the local upstream IAC-REE mining productions to process REC from the region.

❷ MALAYSIA TO DEVELOP ITS OWN MINING AND SEPARATION CHEMICALS

Efficient lixiviant and extractant chemicals are to be developed locally to avoid supply disruption.

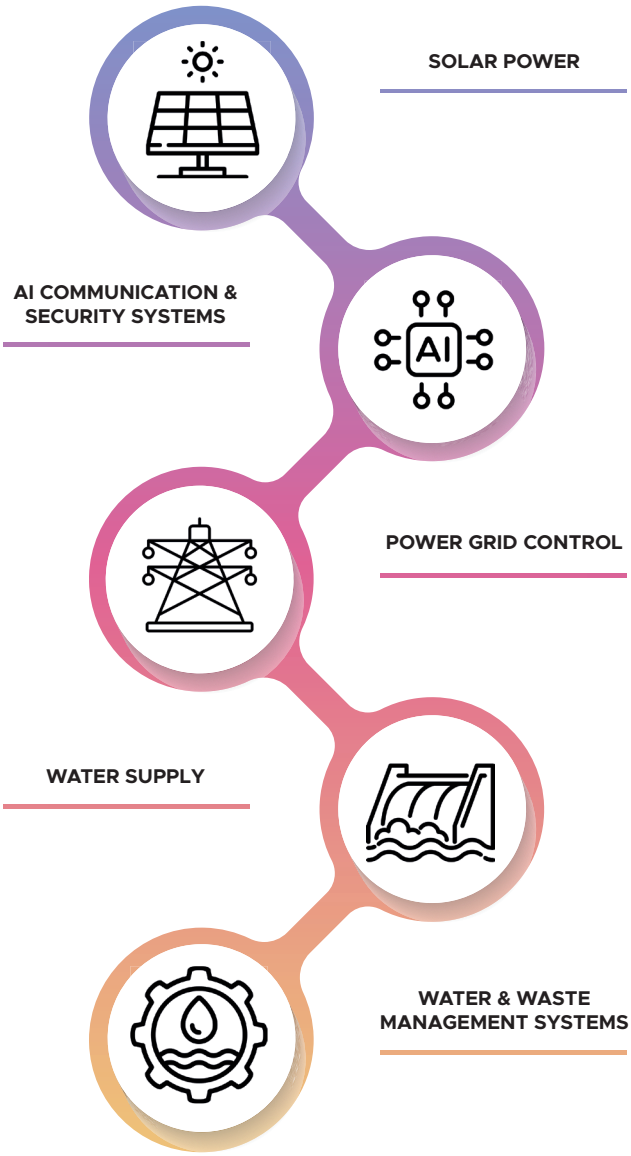
❸ SET UP A REC CENTRAL BUYING HOUSE

A central buying house to build up a stock of critical high-tech commodities that will put Malaysia in a strong position in the super-magnets supply chain. The stocks are separated into purified REO by the REPP.

❹ ESTABLISH AN INTEGRATED MRTP

The REE separation plants require high capital outlay and intricate chemical processes

- The Malaysian REE Technology Park (MRTP) is a strategic option to bring together financial resources and talent for the Midstream industry.
- MRTP houses infrastructures for midstream and downstream processes in proximity for a seamless supply chain and to gain logistic advantage.
- MRTP should incorporate State-of-the-Art and environment-friendly technologies, such as:



Key Strategies

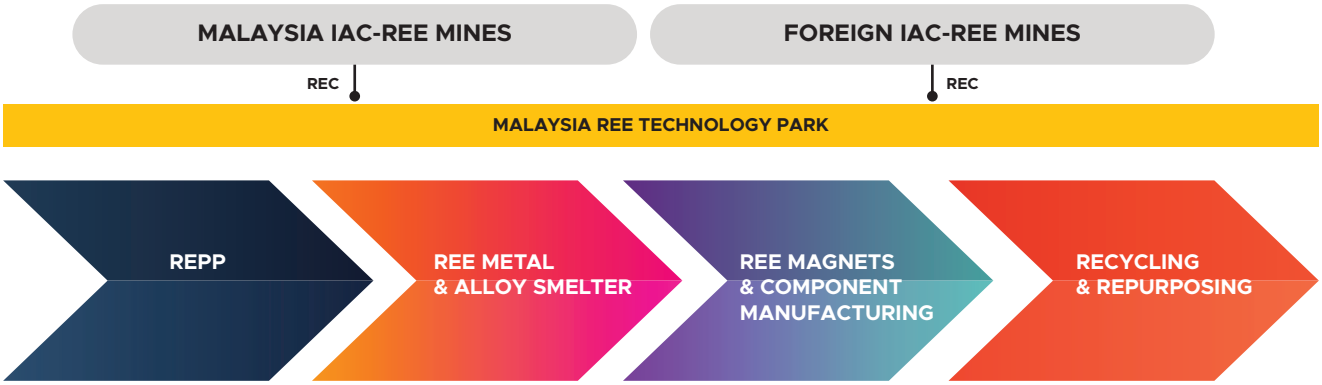
❶ **All REC products from all IAC-REE mines in Malaysia** are encouraged to be sold at market price to the MRTP for separation and purification

❷ **The purified REO may be supplied** for metal and alloy refining, and subsequently, for the magnets, components, and module

❸ **MRTP should include R&D facilities** to generate local technologies

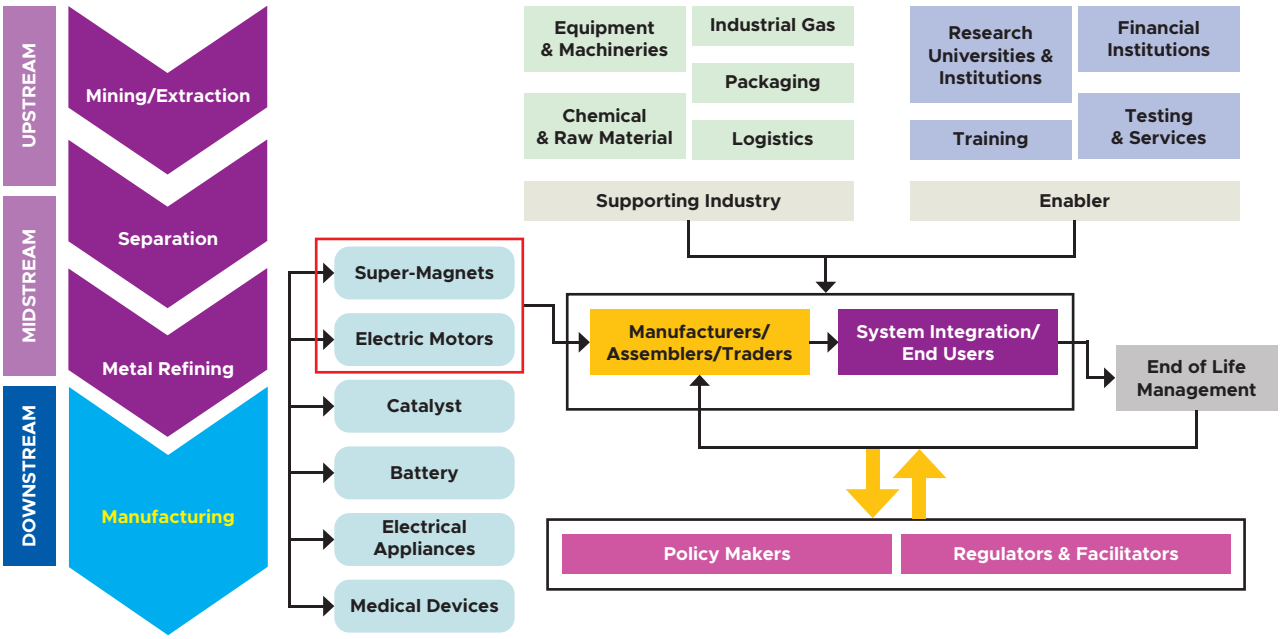
❹ **MRTP should be a collective investment** by the Federal Government, State Governments, Domestic Direct Investment (DDI), and Foreign direct investments (FDI)

The target annual processing capacity of the REPP is 70,000 tonnes of REC (equivalent to 30,000 tonnes of TREO).



MRTP as the regional hub for REE supplier

DOWNSTREAM SECTOR



Strategies and Recommendations

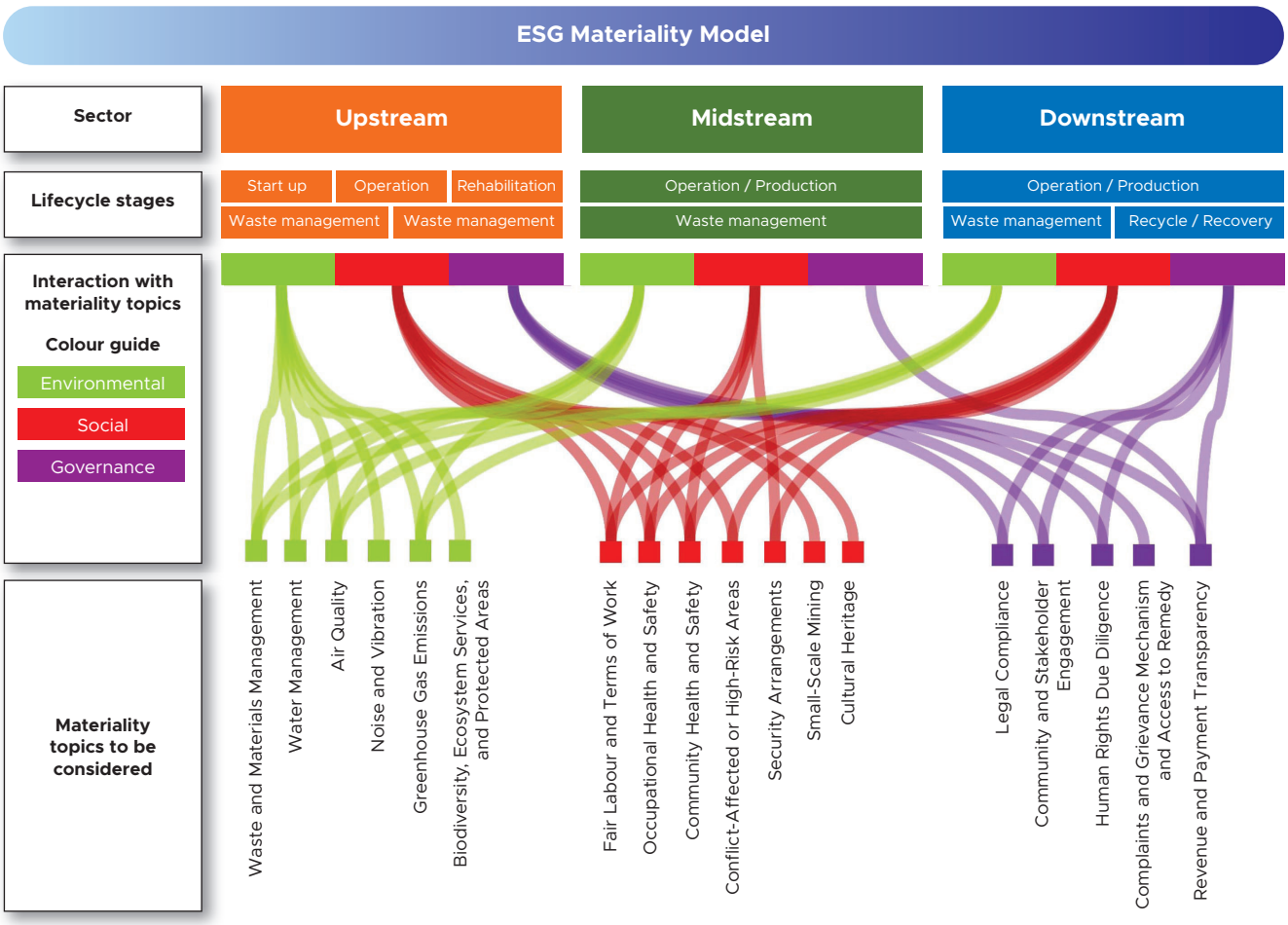
Hybrid Approach

Government

- **Clear and transparent business-friendly policy** needs to be established with attractive incentives
- **Attract FDIs** to develop local downstream industries as enduring as the E&E sector
- **The establishment of MRTP** should be coupled with the creation of a free trade zone to promote industry symbiosis
- **Set a quota** to secure raw materials for REPP and finished products
- **Introduce fiscal assistance** for the adoption and application of local content in product development
- **Midstream players** should be supported with a reasonable period of operating license to amplify business connections to downstream
- **Introduce favourable export tax** for global competitiveness

Industry

- **Downstream activities** with the highest demand are super magnets and electric motors
- **Supporting industries** will emerge, including equipment and machinery, chemicals & raw materials, logistics, financial institutions, testing and services, as well as research universities and institutions
- **Strategic partnership** facilitates the transfer of technologies between JV partners
- **Surplus products** can be exported as semi-finished goods
- **Strategise talent development** through technology knowledge transfer with assistance from industry and government via government strategic procurement of offset programs



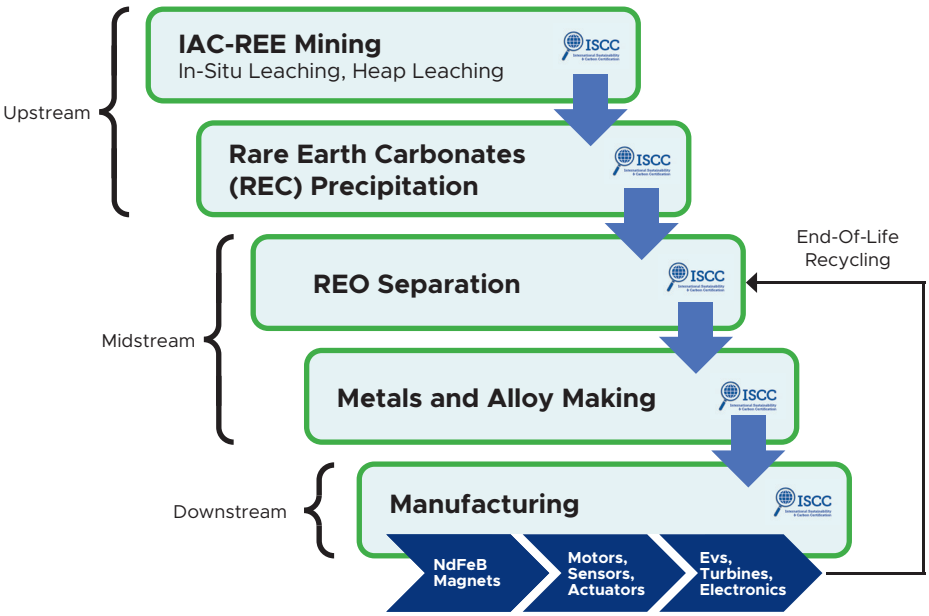
The overall business model approach undertaken by this project enhances the contribution of the RE Industry to the socio-economic development of Malaysia, backed by a projected increase in ROV without jeopardising sustainability requirements. The materiality model was developed for companies within the entire mineral extractive and processing supply chain to make the right choices in striking a balance of benefits to the planet, people, and profit.

Governments play a crucial role in enhancing sustainability and transparency in several ways. This includes setting the requirements of sustainability reporting (or ESG disclosures), suggesting collaborative initiatives to voluntary sustainability initiatives (VSI) in policies, and enhancing the use of Environmental Impact Assessments (EIA) to pinpoint key areas in the reporting.

CHAIN OF CUSTODY

A radio frequency identification (RFID) tracking system may be set for the entire supply chain. Relevant information may be shared online in real-time with the authorities, including the state authorities. This diminishes potential product leakages/ thefts/under declaration for royalty payments.

Information should be readable while in transit and at the discharge destination at the REPP. The information will be used by the REPP to input the corresponding quantity and purity of REO in REC, calculate the market value, and determine the corresponding royalties to the States. Similar RFID coding may be incorporated in the downstream products to complete product tracing. In addition, R&D on emerging technology, such as blockchain, is encouraged to be applied in the traceability tracking system.



RFID information for Upstream

- Origin of the product
- Mining tenement locations
- ESG compliant mining methods
- Estimated quantity
- Quality of the product batch

RFID information for Midstream

- Chemical constituents
- Purity
- Weight of purified REO products
- Incorporating information about raw material source

RFID information for Downstream

- Incorporating information of the manufactured products
- Quality of the product batch

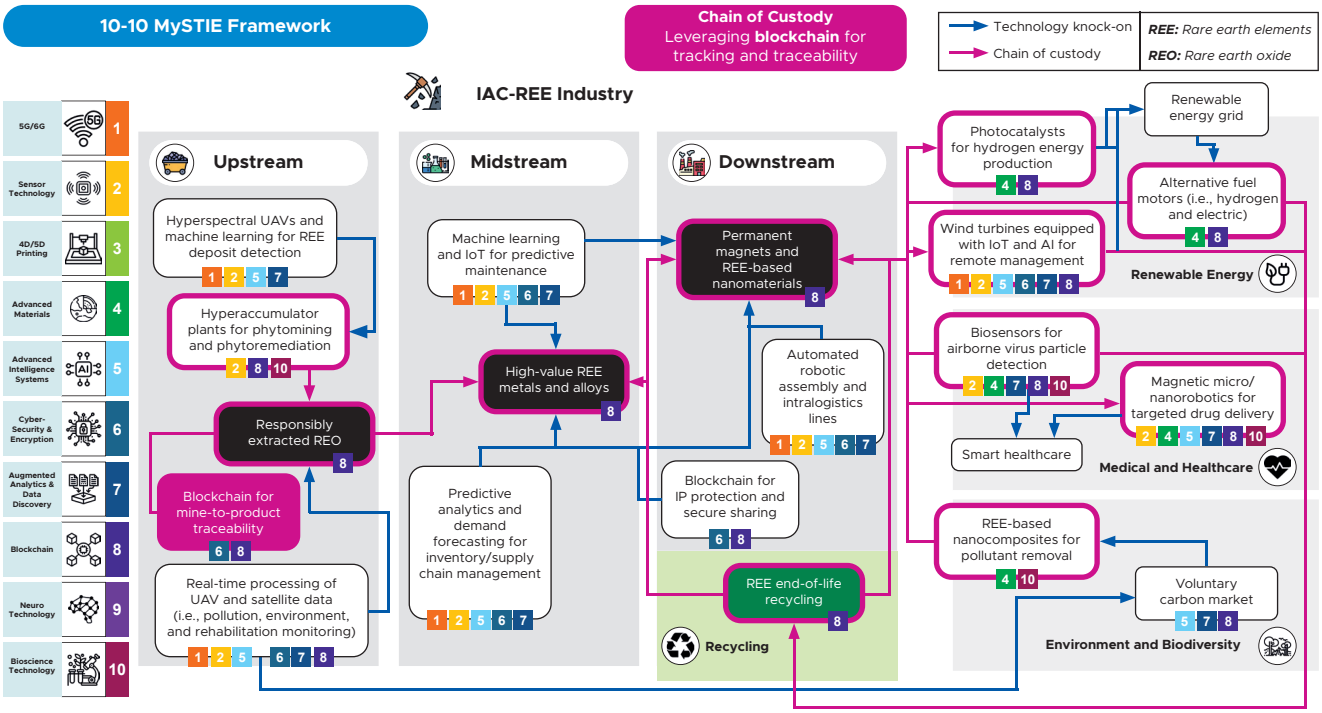
Related ISO Standards

- International Sustainability in Carbon Certification (ISCC)
- International Tin Supply Chain Initiatives (ITSCI)

Strengthen R&D in All IAC-REE Sectors

The 10-10 MySTIE framework was adopted for its holistic approach that blankets several key technologies required for the industry, especially blockchain, to support traceability and accountability systems. Some existing funding mechanisms have incorporated the 10-10 MySTIE, such as the MOHE Grants and MOSTI's Malaysia Grand Challenges. In making RDICE investment to all relevant 10-10 technologies (e.g., blockchain technology), it is crucial to ensure that some auxiliary technologies can perform optimally.

Dynamic Sustainable IAC-REE Economy

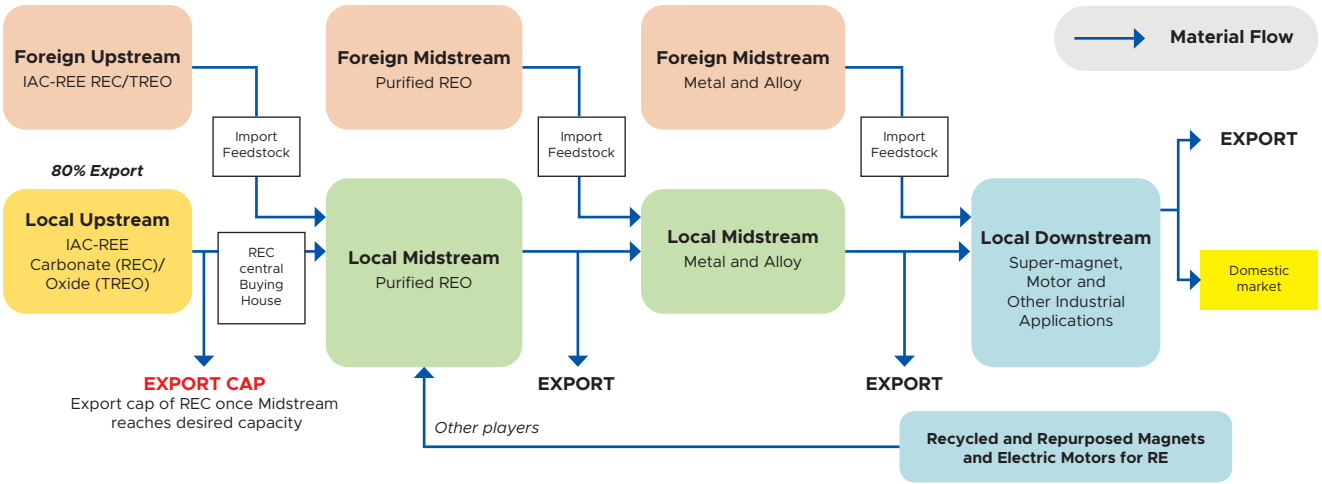


Note: Analytics by Sunway Institute for Global Strategy and Competitiveness

INTEGRATED BUSINESS MODEL

Short-Term – Fast-Track Establishment of Full-Scale Production by 2025

- Ensure supply security for process and technology development and test produce
- Build capacity for Economy of Scale



UPSTREAM

1. The export of REC cakes should be limited
2. Policy should ensure the security of supply to local REPP
3. At least 20% is reserved for local Midstream R&D
4. The REC must be legal and traceable

MIDSTREAM

1. Undertake full scale processing of legal and certified REC cakes within 36 months
2. Manufacture RE metals and alloys for downstream sectors
3. REPP is allowed to source REC from external sources that are legal and certified

DOWNSTREAM

Manufacturing of super- magnets and electric motors for both domestic and foreign markets by prioritising local market

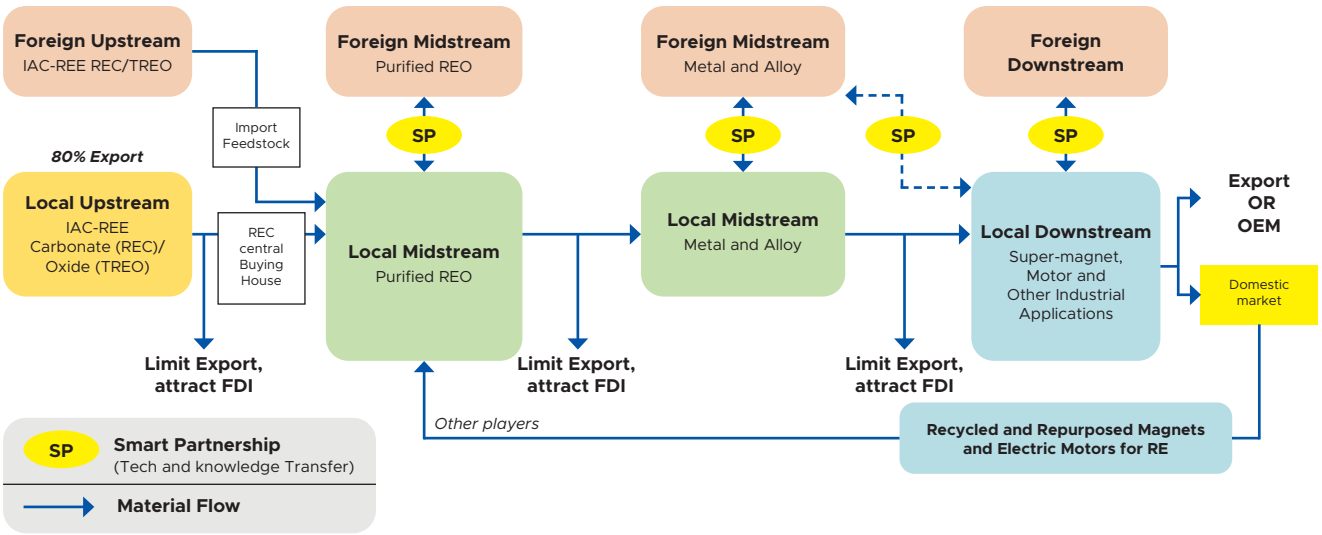
RECYCLING & REPURPOSING

Develop recycling and repurposing facilities for magnets and electric motors

MRTP

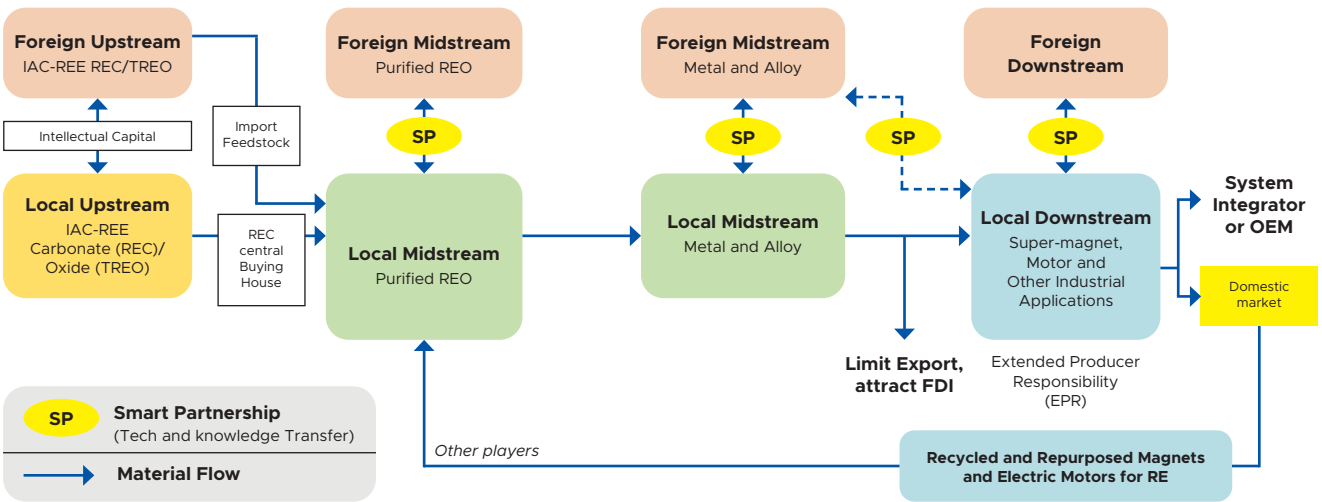
Mid-Term (2023–2030) – A Regional Player of the REE Industry by 2030

- Responsible and Sustainable Practices throughout supply chain
- Fully Functional Centralised Technology Park towards achieving Circular Economy



Long-Term (2031–2050) – Building a Sustainable, Net-Zero Supply Chain by 2050

- Operating at a higher end of the global value chain and aligned to the Net-Zero World (Decarbonised Economy by 2050)
  - IAC-REE Ecosystem Services
  - IAC-REE Process Manufacturing
  - Development of new products using IAC-REE materials



REE Industry Contribution By 2030

		INVESTMENTS	REVENUE	JOB EMPLOYMENT
UPSTREAM SECTOR	Exploration & Mining by 2030	Exploration: **RM200k / km²** CAPEX: **RM20 million / mine** OPEX : **RM12 million / mine**	**RM2.1 billion p.a.**	**3,000**
MIDSTREAM SECTOR	**TREO Separation by 2030**	CAPEX: **RM1.76 billion**	**RM7.26 billion p.a.**	**1,000**
	NdPr Alloy Manufacturing by 2030	CAPEX: **RM378.4 million**	**RM4.15 billion p.a.**	**300**
DOWNSTREAM SECTOR	**Super-Magnet Production by 2030**	**RM3.5 billion**	**RM8.27 billion p.a.**	**10,500**
	Electric Motor Production by 2030	**RM3 billion**	**RM5.46 billion p.a.**	**10,000**

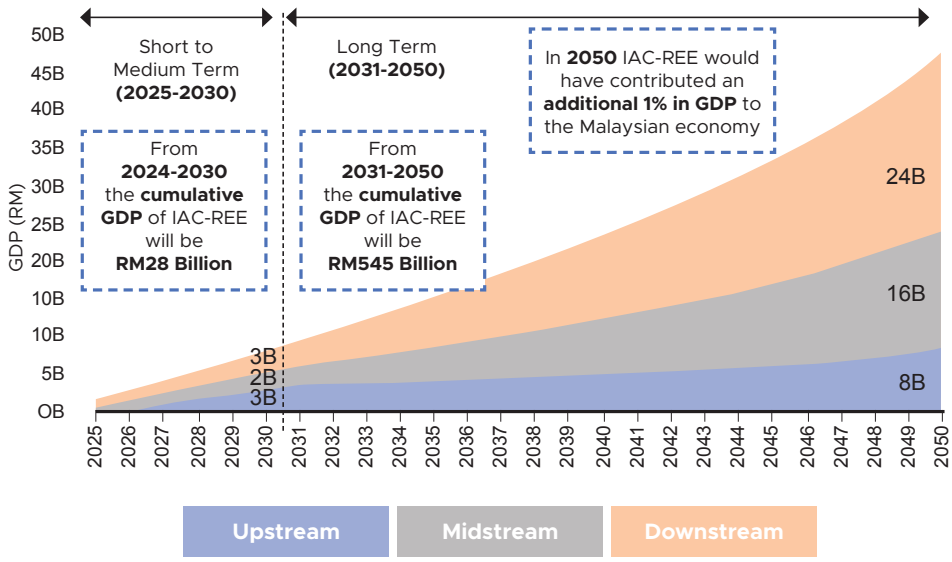
Source: ASM Task Force Analytics, 2023, UMW Sime Darby, 2024

*p.a.= per annum

REE Industry: GDP Contribution

By 2030, the industry would have the potential to generate 24,800 jobs and contribute RM8 billion to the national GDP in 2030, with a cumulative GDP value of RM28 billion from 2025 to 2030. It is envisaged that with the establishment of the REE ecosystem, it can contribute close to RM48 billion to GDP in 2050. The sustained development of the ecosystem between 2025 and 2050 is expected to contribute approximately RM573 billion to the Malaysian economy.

IAC-REE GDP Contribution Estimates (2025-2050)



Note: Analytics by Sunway Institute for Global Strategy and Competitiveness

The IAC-REE industry is critical towards the STIE sovereignty nation because it has the potential to underpin the national green circular economy and boost sustainable economic growth. A business model that champions planetary health and environmental goals is bound to generate a vibrant and dynamic local REE value chain with a significantly positive spillover impact across all economic sectors and stakeholders. These impacts entail the creation of high-income and high-skilled jobs, green industries, and environmental services, while simultaneously strengthening the position of Malaysia as a global producer of sustainable REE products and services.

RECOMMENDATIONS

1 Strengthen Institutional Governance

- Strengthen Institutional Governance to ensure the development of seamless integration of the IAC-REE (upstream, midstream, and downstream) ecosystems
- Establish a Committee for the Development of the Rare Earths Industry (ComDREI) to monitor and assess the progress of the IAC-REE industry, while outlining measures to overcome challenges
- NRES to be the lead ministry for the formulation and management of incentives in exploring and mining of critical technology minerals
- Establish a cross-ministerial One-Stop Centre that stores the latest REE information

2 Sustainable economic and financial resources

- Provide sustainable economic and financial resources to develop an integrated IAC-REE business value chain by devising a comprehensive incentive system to support a technology- and knowledge-driven IAC-REE sector, nurture creative talent, and strengthen the domestic IAC-REE supply chain

3 Fast-tracking the building of REE supply chain

- Set up an MRTP inclusive of REPP, a metals and alloys manufacturing plant, and a super-magnets and electric motors manufacturing plant, as well as a reprocessing and repurposing plant to recycle used super-magnets and electric motors
- Set up a REC central buying house

4 Effective collaboration and communication

- Conduct government-to-government (G-to-G) negotiations to perform the necessary technology and knowledge transfer
- Federal ministries and agencies as well as state governments in any collaboration/agreement made with foreign investors, should add a condition for local talent development and technology transfer
- Introduce Science, Technology, Innovation and Economy (STIE)-driven solutions to foster strong collaborative partnerships among all stakeholders in the IAC-REE ecosystem. This ensures a robust chain of custody anchored on the 10-10MySTIE, as outlined in 12MP
- NRES and other relevant ministries at both the federal and state levels should jointly develop a strong communication, education, and public awareness (CEPA) programme

5 Build homegrown technology and talent

- The Mineral Research Centre (PPM), under JMG, to be designated as the REE R&D national focal point to coordinate REE R&D and to be equipped with sustainable regular research grants and funding
- Collaboration between universities and Technical and Vocational Education and Training (TVET) with industry to offer upskilling courses through micro-credential or stackable modular units
- Ministry of Higher Education (MOHE) to initiate cooperation between faculties in universities to establish RE-related courses in geology, mining, metallurgy, mineral processing, and chemical engineering in order to produce talents knowledgeable about REE resources