

FUTURE DIRECTION OF MALAYSIAN RARE EARTH INDUSTRY : FROM ESTABLISHING R&D TO HUMAN CAPITAL DEVELOPMENT

5TH INTERNATIONAL WORKSHOP ON INDUSTRIAL TECHNOLOGY OF RARE METAL

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Universiti Malaysia Pahang
JULY 9, 2014



WORLD SCENARIO

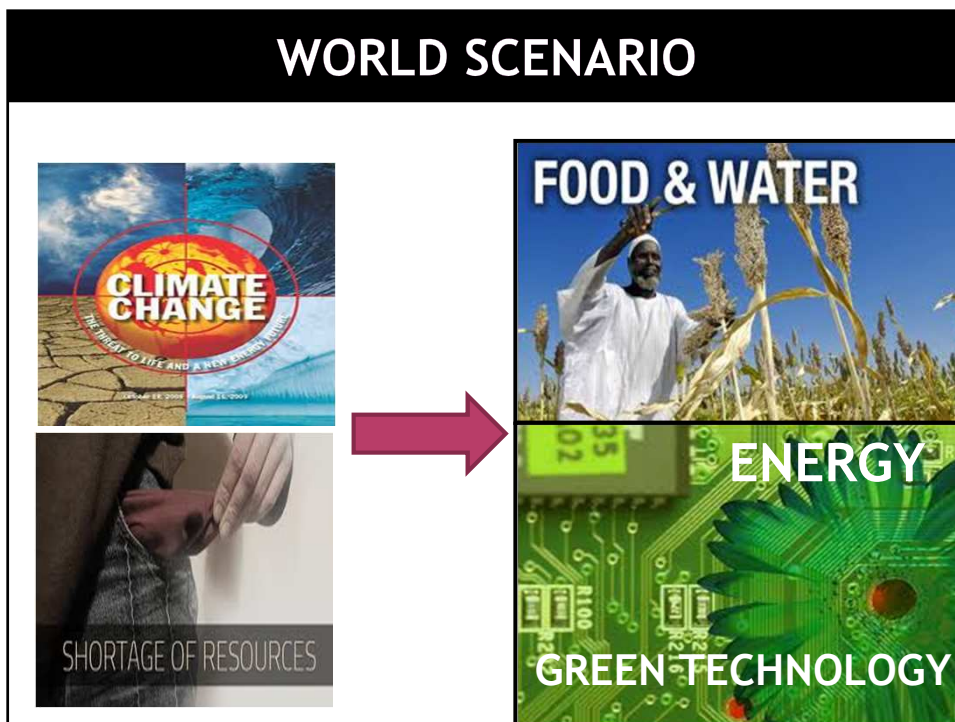
CLIMATE CHANGE
THE GREAT THREAT TO LIFE AND A NEW ENERGY SOURCE

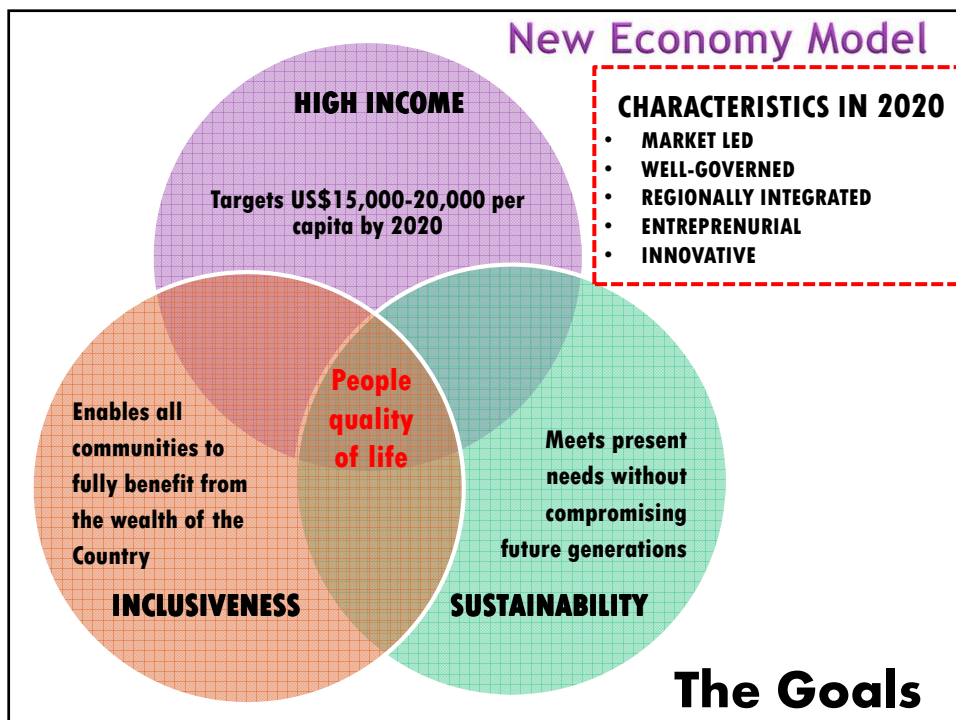
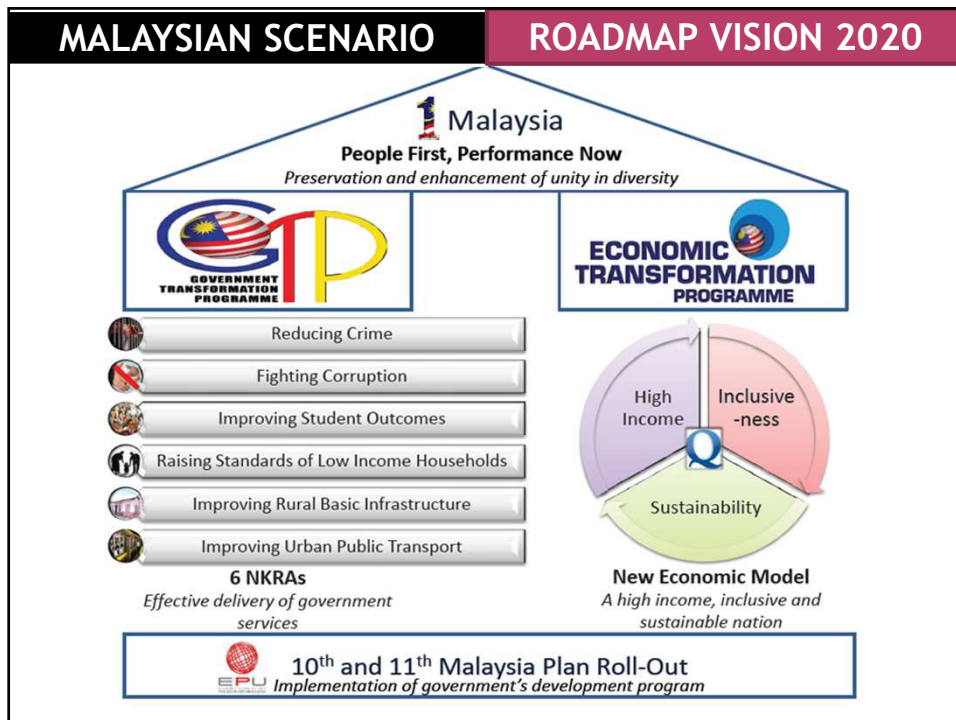
SHORTAGE OF RESOURCES

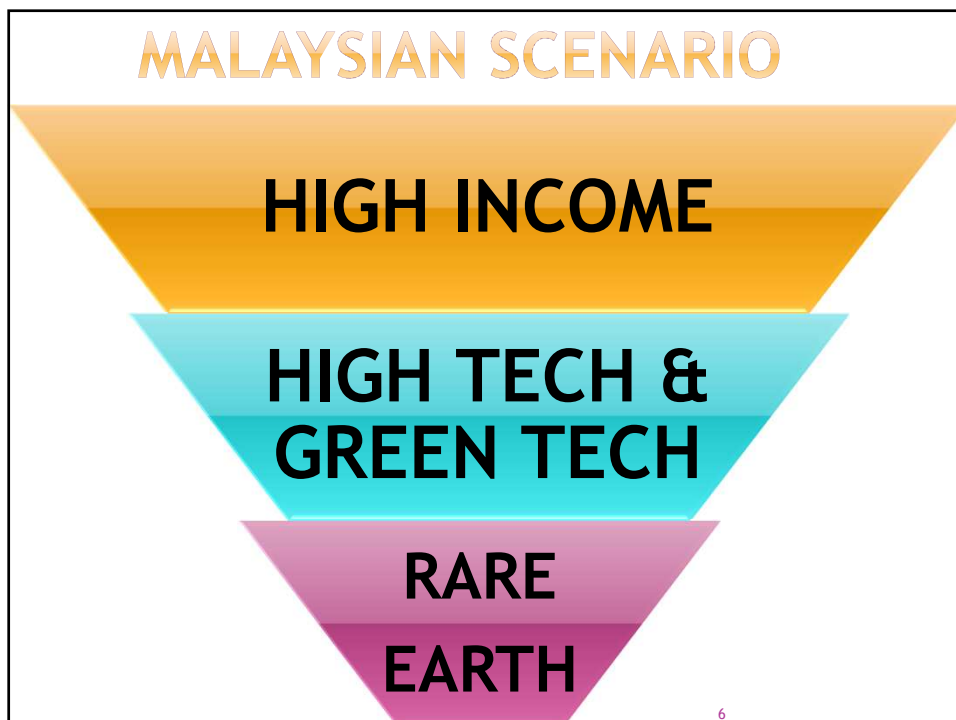
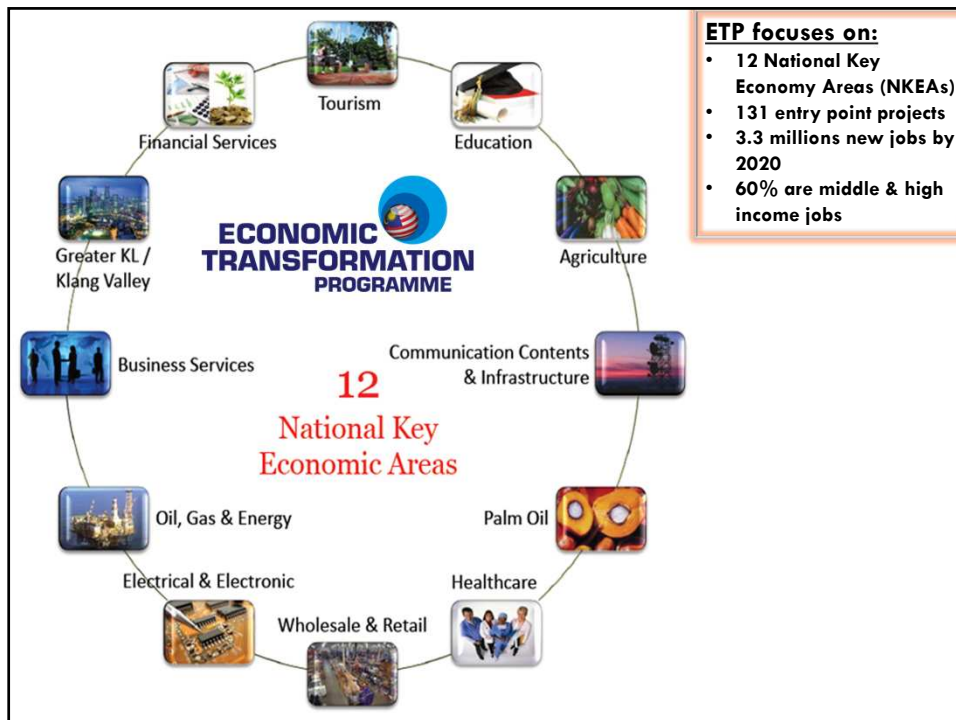
FOOD & WATER

ENERGY

GREEN TECHNOLOGY







WHY RARE EARTH?



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CHINA'S PROGRAM 863 (IN 1986)

- ◉ National High Technology Research and Development Program, namely Program 863
- ◉ the objective of the program is to “gain a foothold in the world arena; to strive to achieve breakthroughs in key technical fields that concern the national economic lifeline and national security; and to achieve ‘leap-frog’ development in key high-tech fields in which China enjoys relative advantages or should take strategic positions in order to provide high-tech support to fulfill strategic objectives in the implementation of the third step of China’s modernization process.”

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RE IN PROGRAM 863

- ◉ mainly meant to narrow the gap in technology between the developed world and China, which still lags behind in technological innovation, although progress is being made.
- ◉ focuses on biotechnology, space, information, laser, automation, energy, and new materials.
- ◉ The use of rare earth elements can be found in each one of the areas in which Program 863 focuses.

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FATHER OF CHINESE RARE EARTH CHEMISTRY



◉ Professor Xu Guangxian

- ◉ in 2009, at the age of 89, won the 5 million yuan (\$730,000) State Supreme Science and Technology Prize, China's = Nobel Prize.

Xu Guangxian
Source: China Military Report

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ABOUT RARE EARTH

ARE NOT REALLY RARE ;

WIDELY SPREAD THROUGH OUT THE
EARTH'S CRUST IN SMALL
CONCENTRATIONS;

CANNOT BE MINED ECONOMICALLY.

Rare Earth Elements

Rare Earth Elements consist of a group of fifteen elements known as the Lanthanides. The lanthanides are located in block 5d of the [periodic table](#) from lanthanum to lutetium

Rare Earth Elements																Y 39
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Lanthanum (La)	
57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	Cerium (Ce)	
Lanthanides															Praseodymium (Pr)	
															Neodymium (Nd)	
															Samarium (Sm)	
															Europium (Eu)	
															Gadolinium (Gd)	
															Terbium (Tb)	
															Dysprosium (Dy)	
															Holmium (Ho)	
															Erbium (Er)	
															Thulium (Th)	
															Ytterbium (Yb)	
															Lutetium (Lu)	
															Yttrium (Y)	

Rare Earths cannot be substituted in many applications

RARE EARTHS: LANTHANIDES PLUS YITTRIUM – UNIQUE PROPERTIES

Rare Earth Elements

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
57	58	59	60	61	62	63	64	65	66	67	68	69	70	71

Lanthanides

- **Chemical**
 - Unique electron configuration
- **Catalytic**
 - Oxygen storage and release
- **Magnetic**
 - High magnetic anisotropy and large magnetic moment
- **Optical**
 - Fluorescence, high refractive index
- **Electrical**
 - High conductivity
- **Metallurgical**
 - Efficient hydrogen storage in rare earths alloys

LIGHT RARE EARTH AND USAGES

Z	ELEMENT	SYMBOL	USE
21	Scandium	Sc	Aerospace framework, high-intensity street lamps, high performance equipment
39	Yttrium	Y	TV sets, cancer treatment drugs , enhances strength of alloys
57	Lanthanum	La	Camera lenses, battery-electrodes, hydrogen storage
58	Cerium	Ce	Catalytic converters, colored glass, steel production
59	Praseodymium	Pr	Super-strong magnets, welding goggles, lasers
60	Neodymium	Nd	Extremely strong permanent magnets, microphones, electric motors of hybrid automobiles , laser
61	Promethium	Pm	Not usually found in Nature
62	Samarium	Sm	Cancer treatment, nuclear reactor control rods, X-ray lasers

Ref :Namibia rare earths inc.

HEAVY RARE EARTH AND USAGES

63	Europium	Eu	Color TV screens, fluorescent glass, genetic screening tests
64	Gadolinium	Gd	Shielding in nuclear reactors, nuclear marine propulsion, increases durability of alloys
65	Terbium	Tb	TV sets, fuel cells, sonar systems
66	Dysprosium	Dy	Commercial lighting, hard disk devices, transducers
67	Holmium	Ho	Lasers, glass coloring, High-strength magnets
68	Erbium	Er	Glass colorant, signal amplification for fiber optic cables, metallurgical uses
69	Thulium	Tm	High efficiency lasers, portable x-ray machines, high temperature superconductor
70	Ytterbium	Yb	Improves stainless steel, lasers, ground monitoring devices
71	Lutetium	Lu	Refining petroleum, LED light bulbs, integrated circuit manufacturing

Rare Earths underpin new materials technology required to sustain the needs of today's society

Energy efficiency through lower consumption



- Compact Fluorescent Lights
- Hybrid vehicle
- Weight reduction in cars

Environmental protection through lower emissions

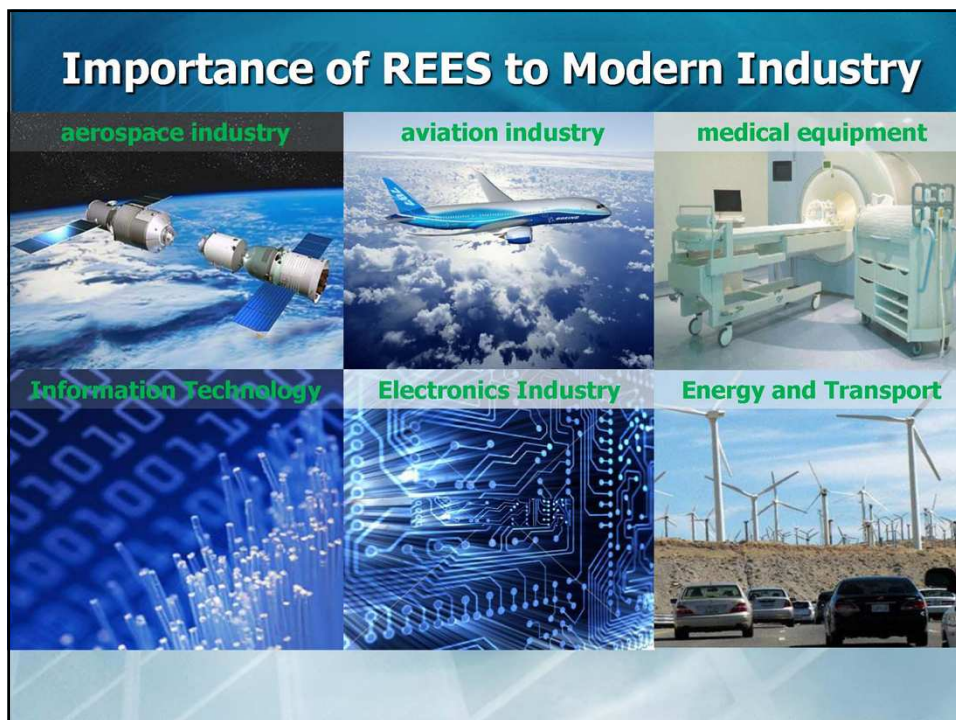


- Wind turbine
- Auto catalytic converter
- Diesel additives

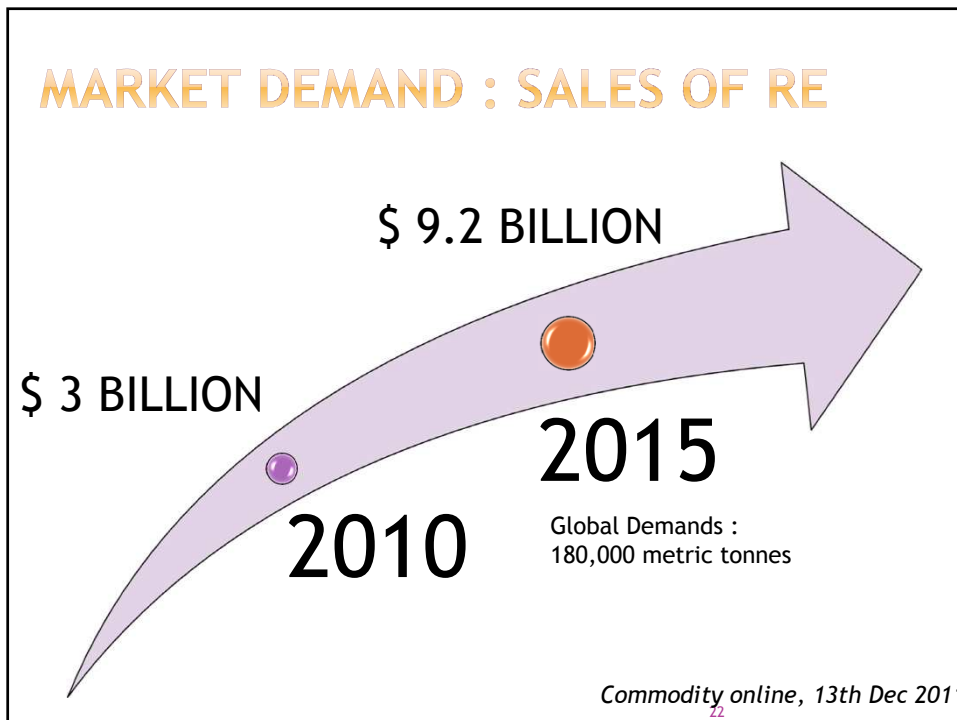
Smaller yet more powerful digital technology

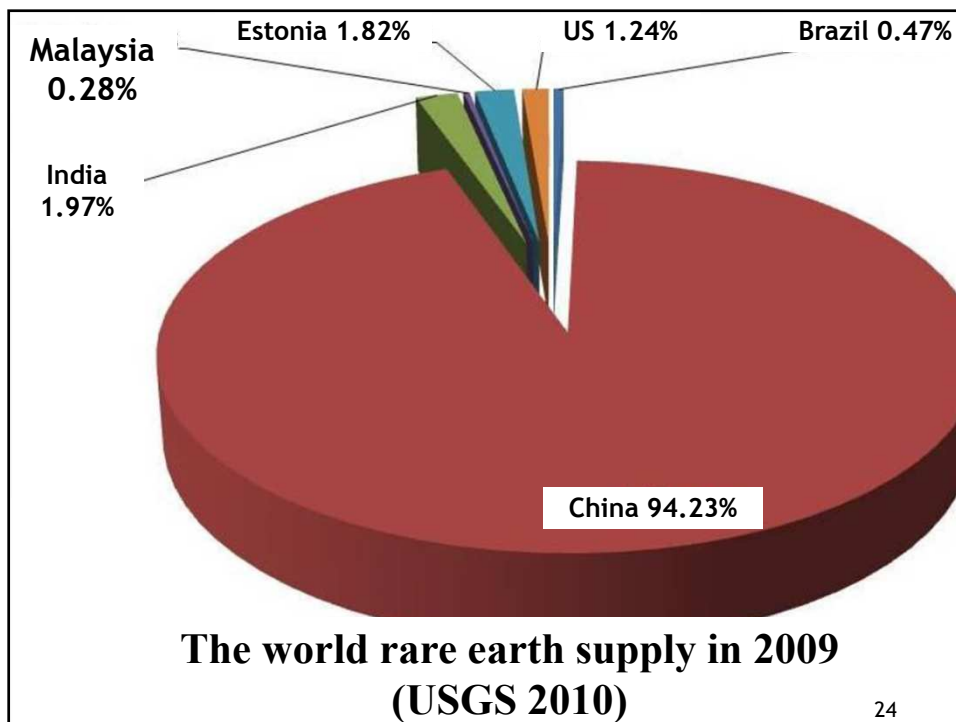
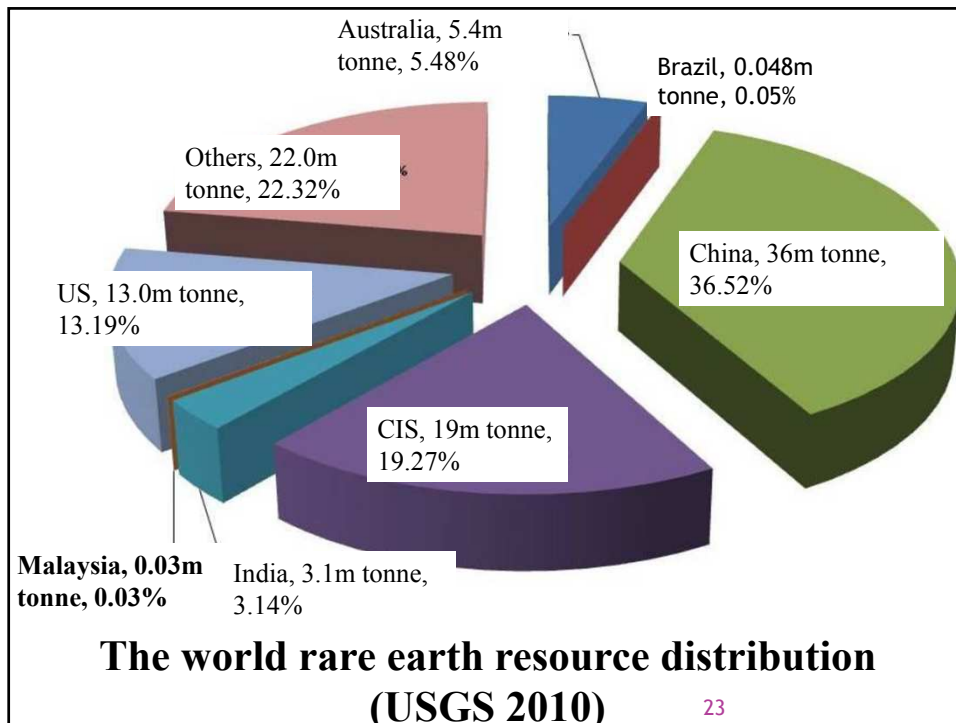


- Flat panel displays
- Disk drives
- Digital cameras



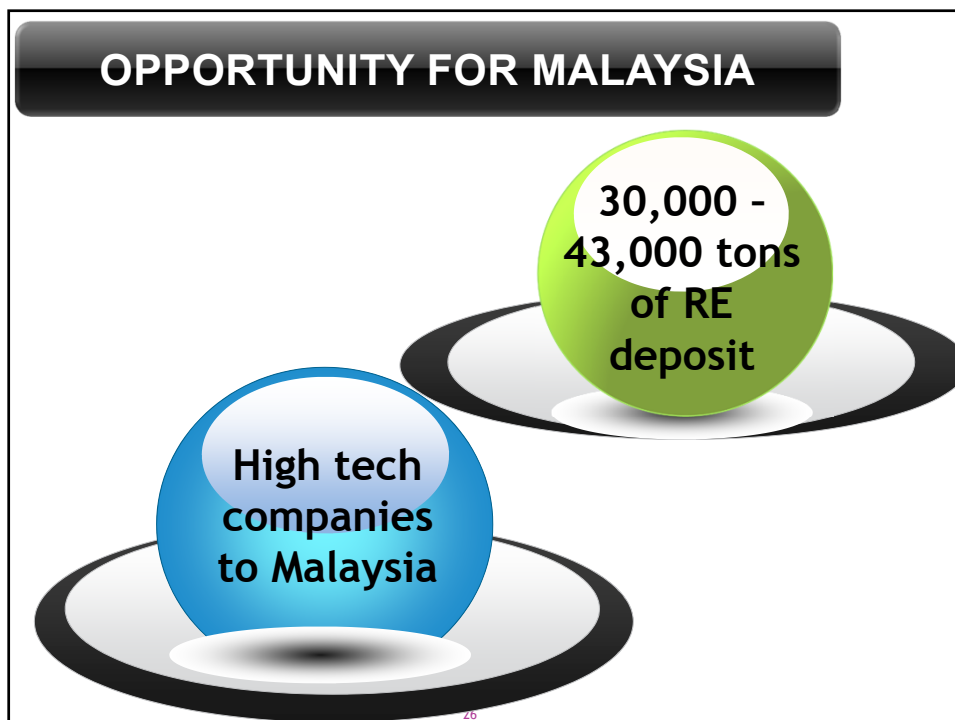






World Mine Production and Reserves (2012 Estimates)		
Country	Production (Metric Ton)	Reserves (Metric Ton)
United States	7,000	13,000,000
Australia	4,000	1,600,000
Brazil	300	36,000
China	95,000	55,000,000
India	2,800	3,100,000
Malaysia	350	30,000
Other countries	not available	41,000,000
World total (rounded)	110,000	110,000,000

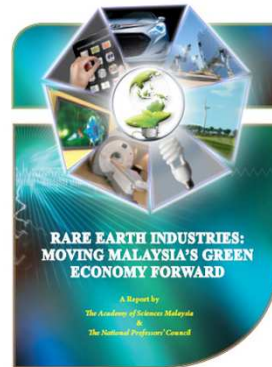
Ref :Hobart King, Geology.com





PERSPECTIVES FROM

**ACADEMY SCIENCES OF
MALAYSIA (ASM)
&
MALAYSIAN PROFESSORS
COUNCIL (MPN)**



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RECOMMENDED STRATEGIES

Enhance the environment, safety and health aspects

Undertake a national exercise to map the potential rare earths deposits

Incentivise the upstream mining and extraction of rare earths

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RECOMMENDED STRATEGIES

Incentivise investments in the downstream manufacturing of rare-earth based products

Build the key competence in human capital for the entire value chain of the rare earths business

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RECOMMENDED STRATEGIES

Strengthen the legal and regulatory framework to enable the effective functioning of the rare earths business

Undertake coordinated, comprehensive and continual public awareness program & community engagement

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MALAYSIAN RARE EARTH BLUEPRINT

Initiated
by
Academy
Sciences of
Malaysia

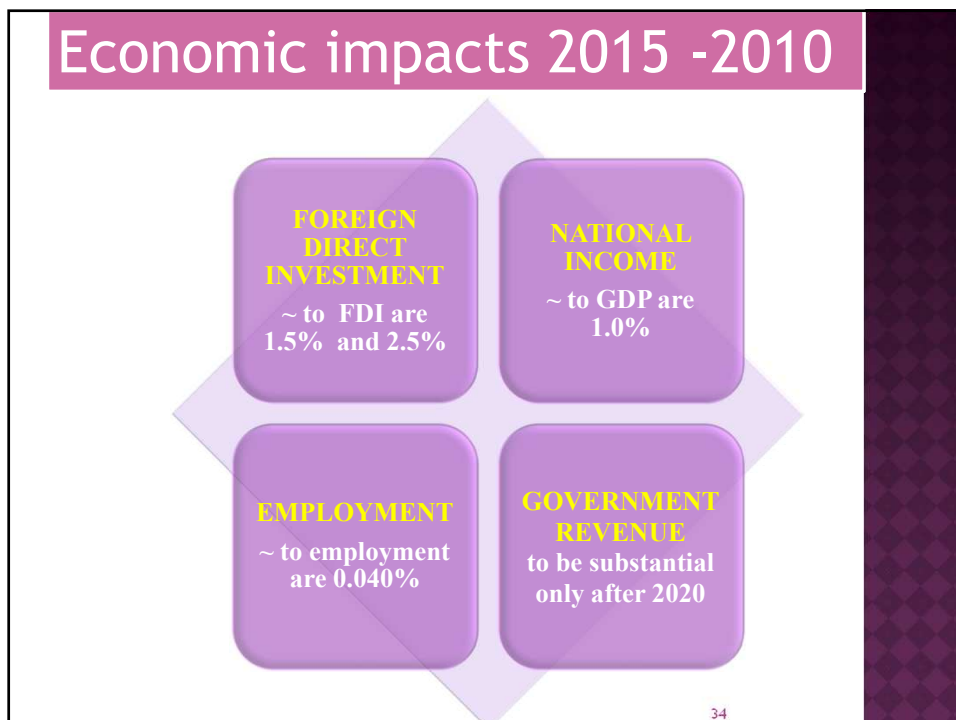
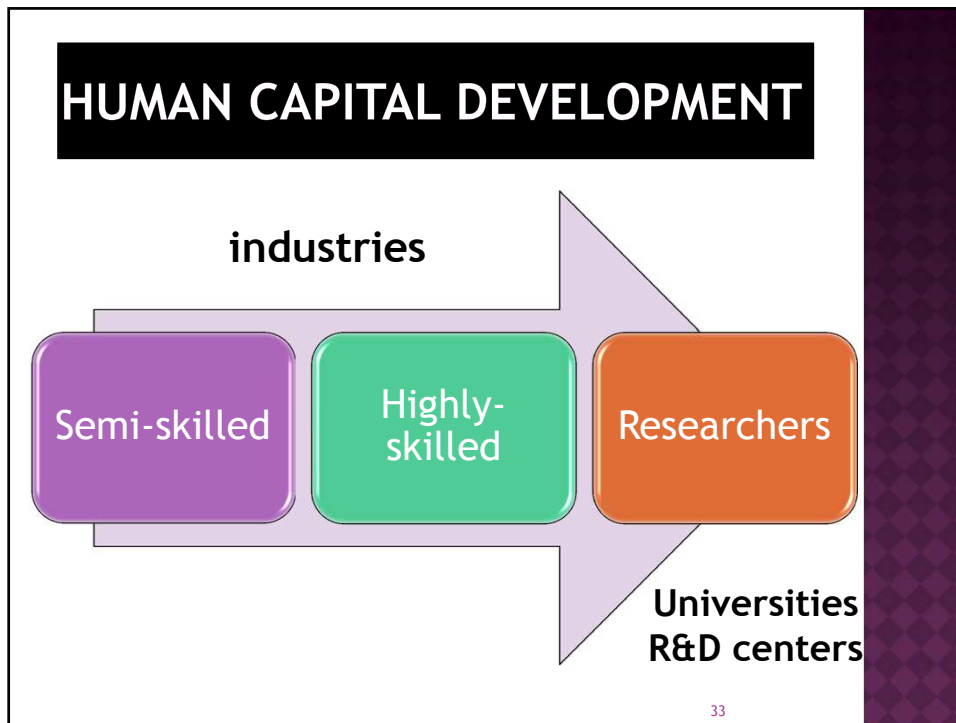
main objective : to provide the necessary information for the policy makers or investors to make an informed decision on establishing industries in mining, in processing or in downstream industries using rare earths metals

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MALAYSIAN RARE EARTH BLUEPRINT

Supply and demand	Mapping of resources	Upstream, midstream & downstream sector
Human capital	Economic & social impacts	Establishing local industries

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IMPACT ON TECHNOLOGY DEVELOPMENT AND ADVANCEMENT

Mining industry;

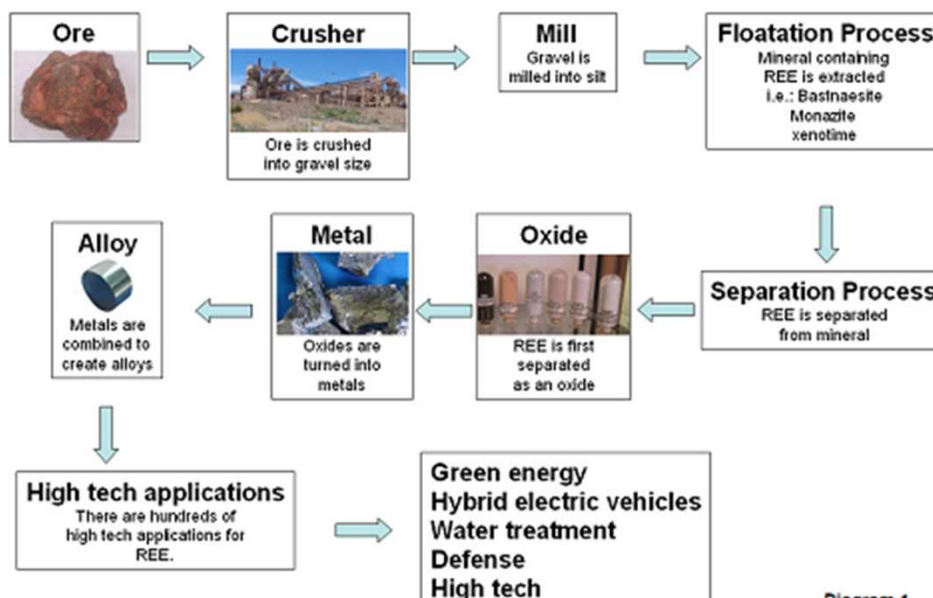
Processing - *midstream (separation and refining);*

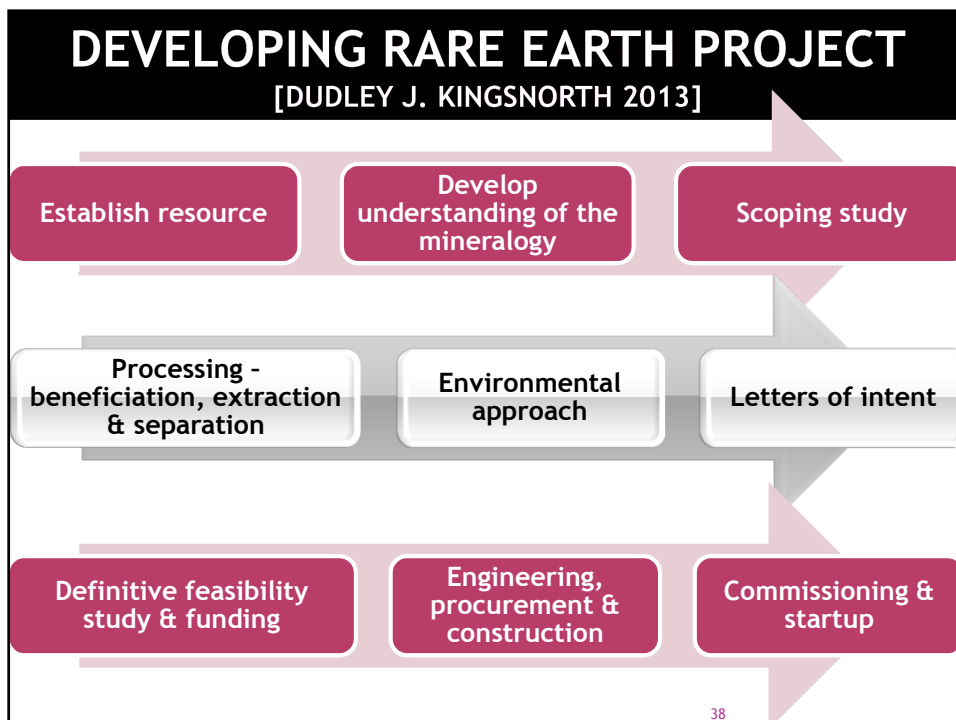
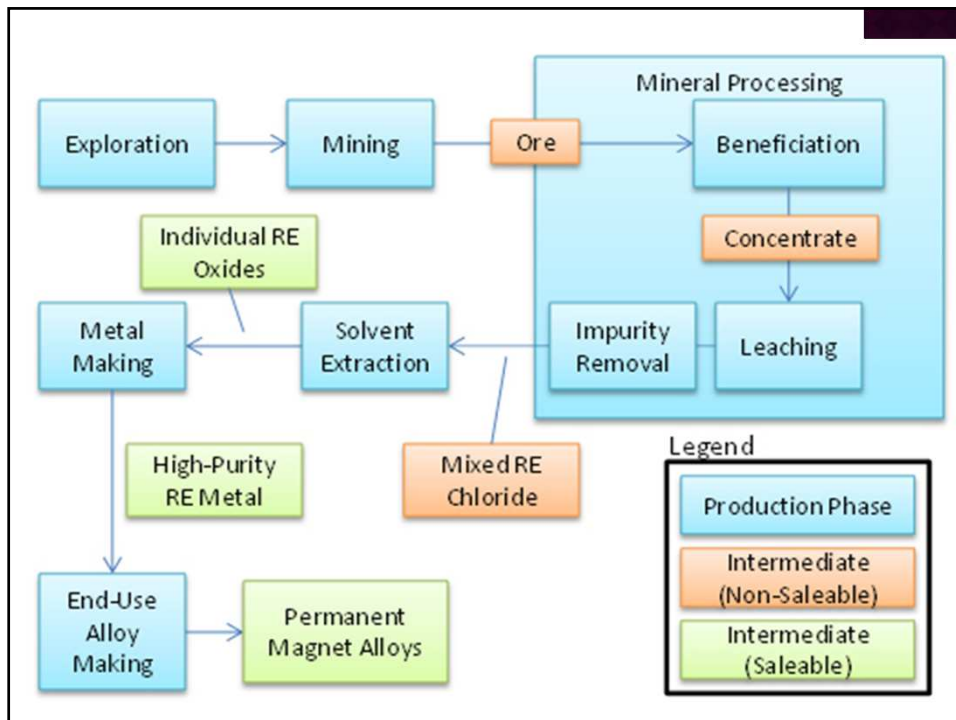
Downstream Application - *Catalyst, Magnet, Automotive;*

Safety, Health and Environment.

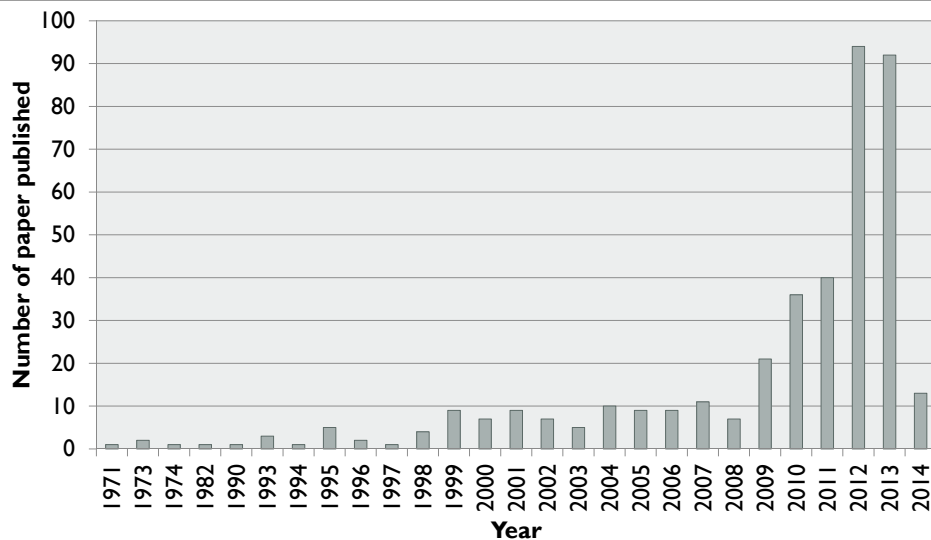
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RARE EARTH PROCESS & SUPPLY CHAIN





- ◉ 401 paper published since 1971 from various local universities; USM, UKM, UM, UTM, UPM and etc



RESEARCH WORK BASED ON PAPERS PUBLISHED IN MALAYSIA

FUNDAMENTAL [231]

- Characterization
- Spectroscopy
- Luminescence prop
- Superconducting prop
- Thermal studies
- Elastic prop
- Optical prop

APPLICATIONS [153]

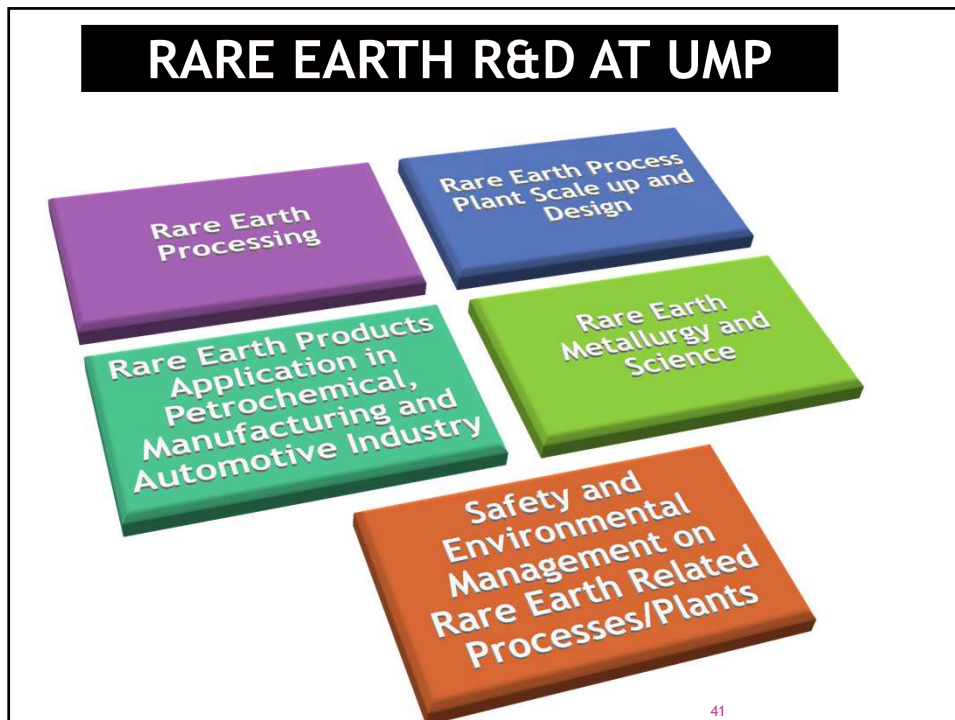
- Laser
- Sensor
- Catalyst
- Solid fuel cell
- Biomedical
- OLED

TECHNOLOGY [6]

- Separation and extraction

ENVIROMENTAL [11]

- Distributions



EXAMPLE RESEARCH PROJECTS

- 1) FUNDAMENTAL STUDIES IN RARE EARTH CHEMISTRY FOR DESIGN AND OPERATION PURPOSES;
- 2) ALTERNATIVE SEPARATION METHODS AND TECHNIQUES IN RARE EARTH PROCESSING PLANT;
- 3) FLEXIBLE, MODULAR DESIGN AND OPERATION OF RARE EARTH PROCESSING PILOT PLANT;
- 4) OPTIMIZATION IN THE SEPARATION OF RARE EARTH ELEMENTS VIA OPTIMAL SEQUENCE;
- 5) PROCESS SIMULATION OF RARE EARTH PROCESSES;
- 6) DATA MONITORING AND ANALYSIS OF AEROSOL MONITORING SYSTEM [AMS];
- 7) APPLICATION OF RARE EARTH IN VARIOUS INDUSTRIES;
- 8) RECYCLING OF RARE EARTH METALS FROM VARIOUS SOURCES.

SEPARATION SEQUENCE

L. Wenli et al./Analytica Chimica Acta 417 (2000) 111–118

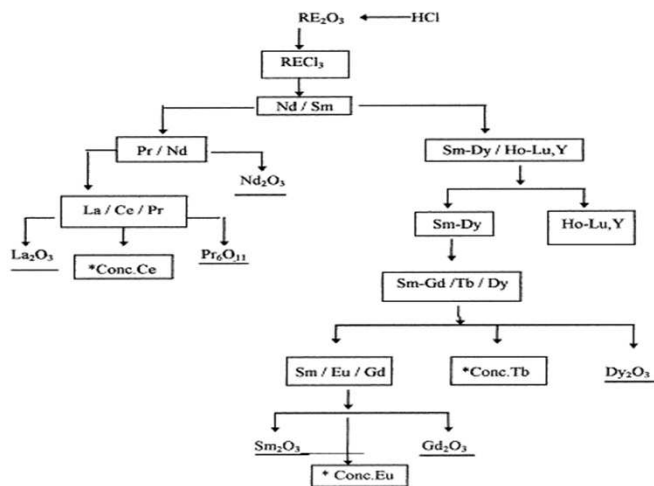


Fig. 2. General schema of HEH(EHP) extraction flow-sheet for Baiyunebo Bastnaesite rare earth separation.

SIMULATION VIA MATLAB

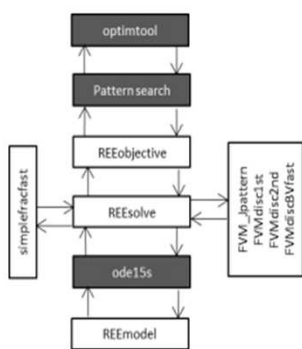


Figure 1. Structure of the code. *REEobjective* calculates the value of the objective function while *REEsolve* and *simplefracfast* calculate the amount of product with the 99% purity requirement. *REEmodel* contains system of differential equations. Auxiliary functions perform the Finite Volume Method 2-point backward discretization of the first derivative and 3-point central of the second derivative.

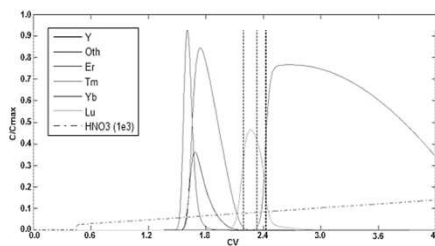


Figure 2 Retrieved fractions of the annual benefits optimum operation point. Eluent is scaled down 1000 times. Ytterbium and Thulium are successfully retrieved at a 99% purity.

Table 3 Different yield requirements for the operation points of the production costs optimization

point	Ho	Er	Tm	Yb
○	-	-	-	0.85
◆	-	-	0.85	0.85
▲	0.50	-	0.85	0.85
■	0.50	0.50	0.85	0.85
□	-	-	0.50	0.85
+	-	-	-	0.50
×	-	-	0.85	-
●	0.85	-	-	-

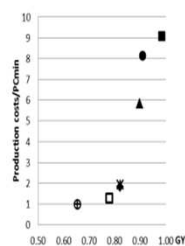
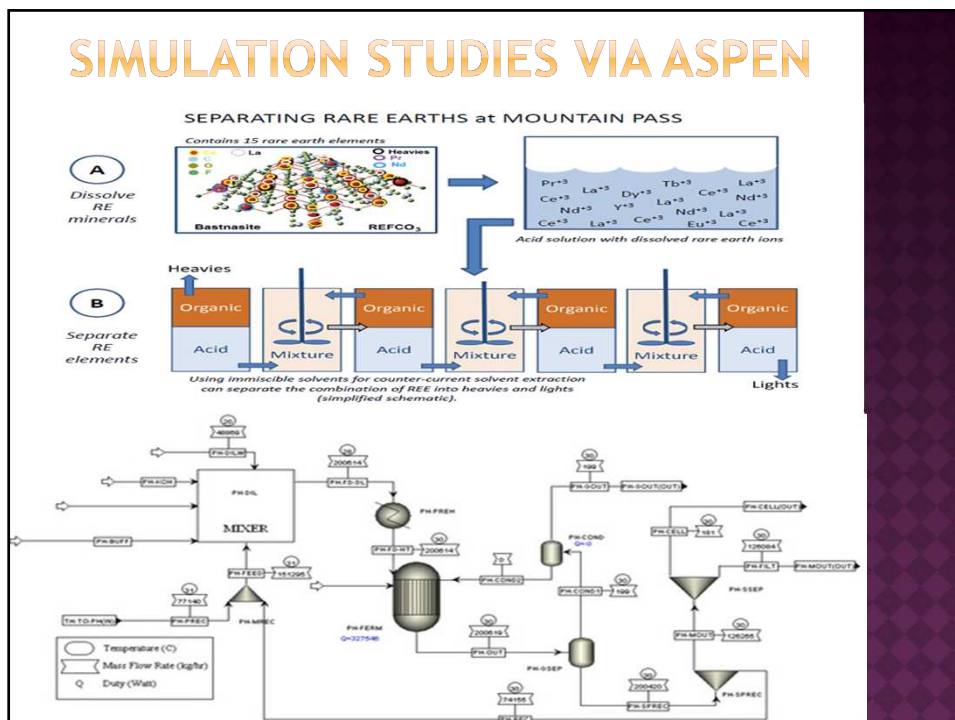


Figure 3 Normalized production costs vs global yield for the different operation points. Legend in Table 3.

SIMULATION STUDIES VIA ASPEN



DEVELOPING PILOT PLANT

SCOPES AND OBJECTIVES - set the boundary limit;

DESIGN PHILOSOPHY - modular, flexible, specific application, fixed etc.

THE PROCESS - based on the above 2 aspects;

UNIT OPERATION - techniques and methods;

FLOWRATES - size

OPERATION PHILOSOPHY

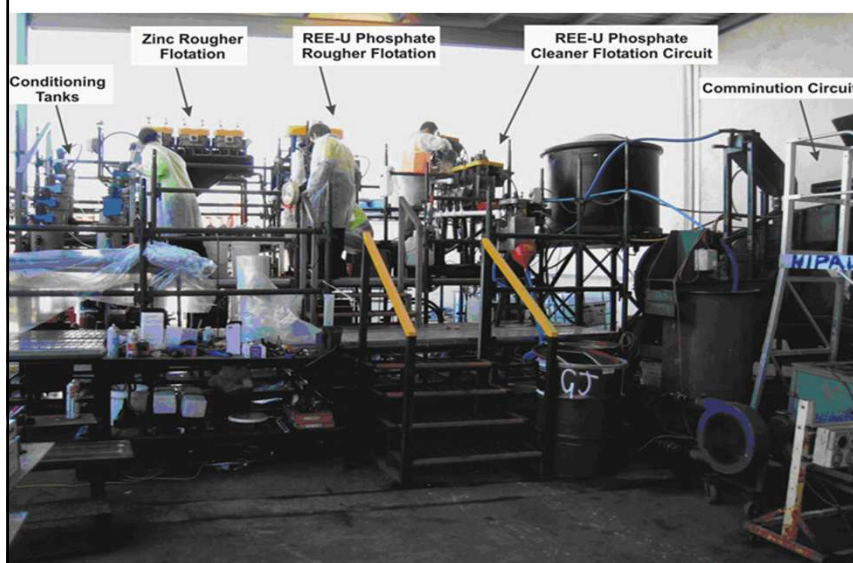
SUPPORTING RESOURCES

LOCATION

PILOT PLANT : QUEST RARE MINERALS ONTARIO CANADA



**KVANEFJELD REE-URANIUM
BENEFICIATION CIRCUIT PILOT PLANT**



DATA MONITORING & ANALYSIS



NATIONAL & INTERNATIONAL COLLABORATION

KARLSRUHE
INSTITUTE
TECHNOLOGY,
GERMANY

PEKING UNIVERSITY,
CHINA

UMP

MALAYSIAN LOCAL
UNIVERSITIES : UKM;
UTP; UTAR; and
UTEM.

UNIVERSITY OF
QUEENSLAND,
AUSTRALIA

THANK YOU

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