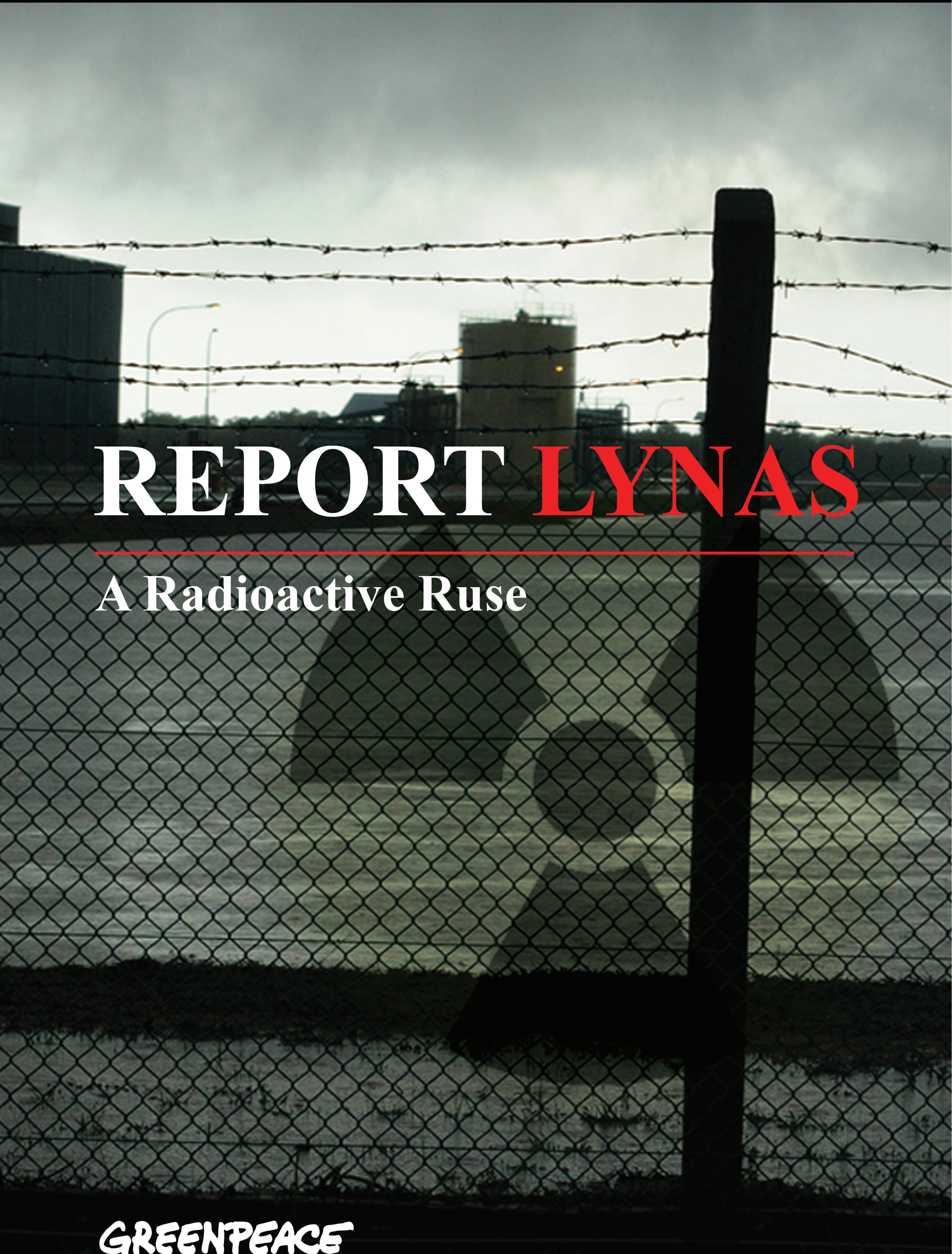


REPORT LYNAS

A Radioactive Ruse

GREENPEACE

A Radioactive Ruse

Environmental threats posed by the Lynas rare earth element processing facility in Malaysia

by Wytze van der Naald
For Greenpeace Southeast Asia

Methodology

The author compiled information on Lynas' Rare Earth Elements facility in Malaysia with the help of several individuals and groups. Astrid van de Ven assisted throughout the research for the report and for onsite research in Malaysia. Malaysians who helped with providing and reviewing information include Tan Bun Teet, Wong Tack, and Andansura Rabu, amongst others.

This research used both secondary information sources and primary sources collected in December 2012, March 2013 and January 2014.

The author conducted a thorough desk review of all available literature, which was collected from various relevant sources, including publications by research institutions, news agencies, government agencies, international agencies, NGOs, scientific literature, corporate websites, and publications by Lynas and other relevant companies.

Experts from Greenpeace Southeast Asia, Greenpeace International, Greenpeace Australia-Pacific, and Greenpeace Research Laboratories at the University of Exeter reviewed the report. Editing and design was done by Greenpeace Southeast Asia.

Acronyms

AELB	Malaysian Atomic Energy Licensing Board
EoL	End-of-life
EPR	Extended Producer Responsibility
FGD	Flue Gas Desulphurization
HDDs	Computer hard disk drives
HDPE	High-density polyethylene
HREEs	Heavy Rare Earth Elements (Terbium through Lutetium, atomic numbers 65-71, and Yttrium, atomic number 39)
IAEA	International Atomic Energy Agency
LAMP	Lynas Advanced Materials Processing plant
LREEs	Light Rare Earth Elements (Lanthanum through Gadolinium, atomic numbers 57-64, and Scandium, atomic number 21)
MOSTI	Ministry of Science, Technology and Innovation
NdFeB	A (rare-earth) neodymium magnet (alloy of neodymium, iron and boron, $Nd_2Fe_{14}B$)
NTN	National Toxics Network (an Australian NGO)
NUF	Neutralization Underflow Residue
PDF	Permanent Disposal Facility
PSC	Parliamentary Select Committee
REEs	Rare Earth Elements (Scandium (Sc, atomic number 21), Yttrium (Y, 39), Lanthanum (La, 57), Cerium (Ce, 58)), Praseodymium Pr, 59), Neodymium (Nd, 60)), Promethium (Pm, 61), Samarium (Sm, 62), Europium (Eu, 63), Gadolinium (Gd, 64), Terbium (Tb, 65), Dysprosium (Dy, 66), Holmium (Ho, 67), Erbium (Er, 68)), Thulium (Tm, 69)), Ytterbium (Yb, 70)), Lutetium (Lu, 71).
REO	Rare Earths Oxides
SMSL	Save Malaysia, Stop Lynas
TOL	Temporary Operating License
WLP	Water Leach Purification

Introduction

Lynas Corporation, Ltd. is an Australian rare earth elements mining company that built a refining and processing plant in Kuantan, on Malaysia's eastern Peninsula coast. The Lynas facility, which is set to become one of the world's largest processing plants for rare earths, poses a host of intractable environmental and social problems.

This report recommends that Malaysian authorities should suspend Lynas' temporary operating license and refuse to grant the permanent operating licence, which is due to be granted in September 2014, unless Lynas completes a thorough overhaul of its facility's construction defects to upgrade the plant to best environmental practices – and presents a safe and acceptable plan for disposing of the radioactive waste stream from this plant outside of Malaysia.

Greenpeace believes that the Malaysian authorities should close down the Lynas operation in Kuantan until environmental protection protocols and conditions that meet the highest standards are in place. The solution should not involve storing or disposing of radioactive waste in Malaysia.

The Lynas plant was not built according to best available technology. Lynas is not applying best environmental practices in Malaysia and is not working according to international standards with respect to: air emissions, water discharges, and temporary waste disposal arrangements. Furthermore, Lynas has no concrete plan for the final disposal of its waste, especially the radioactive fraction. Moreover, Lynas has not provided sufficient information for a detailed environmental impact assessment, so the full impact of the plant remains unclear.

As an Australian company, Lynas can, and should, live up to the standards set by its home country as well as to international standards. Malaysia has less stringent environmental regulations in place than many other countries, including Australia, where the company is registered and where it holds a permit under much stricter regulations.

Public information and public participation around the approval and construction of the Lynas plant have also been deficient. Documentation provided by Lynas to the regulators in order to obtain operating licences was inadequate and moreover, was typically not accessible to the public. This, in addition to concerns by local communities that their health will be affected by the operations of the mega-plant, has fuelled snowballing protests against the plant.

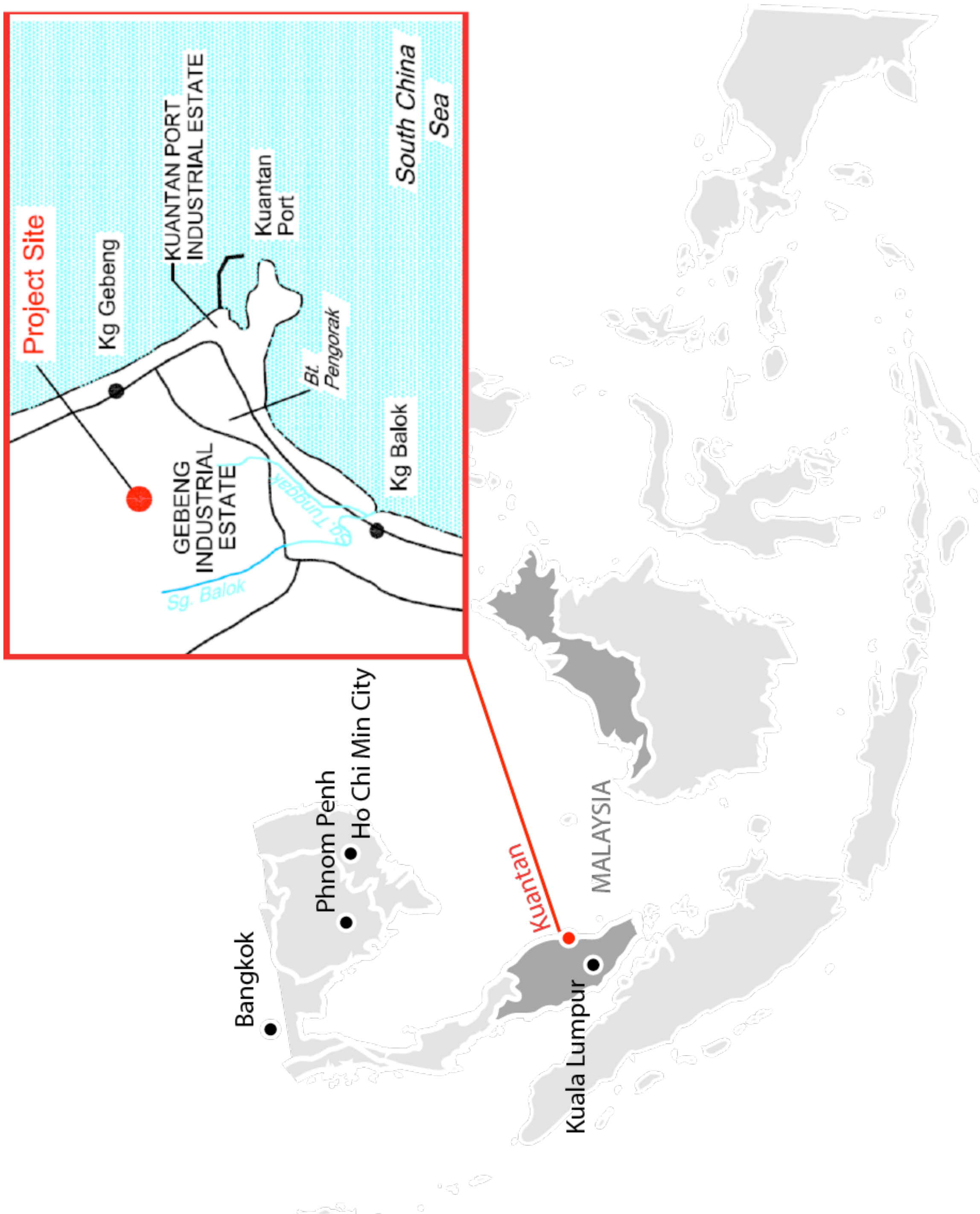
Strong public protests against the development have rocked the Kuantan and

Balok areas nearby. Demonstrations subsequently radiated outwards, as the Lynas plant became an issue of public concern throughout Malaysia. As a result, the Lynas' plant has now become highly controversial nationwide. The trigger for this widespread unrest has centred around citizens' genuine concerns about environmental and health impacts; in particular the impacts of the large volumes of radioactive and other toxic waste at stake, for which Lynas still has not put forward a safe and acceptable solution. At this point, tens of thousands of citizens have mobilized for protests and actions, and over 1 million Malaysians signed a petition demanding that Lynas leaves Malaysia.

Until acceptable solutions are found to the issues being raised by local groups and communities, closing down the Lynas plant appears to be the best option. Any attempt to resolve the current impasse must be transparent, with full public consultation and participation in further decisions, and must include a complete and detailed Environmental Impact Assessment of the facility, as well as the deployment of best available technology that meets the highest international standards. The radioactive waste stream of the plant must be dealt with safely and responsibly and must not be allowed to remain in the country.

As this report will show, Lynas oversold its proposal to the Malaysian authorities, and its commitments to deliver adequate safeguards for its operations in the country have proven hollow. The Malaysian Government has the right to close down the plant if Lynas fails to meet the conditions of its Temporary Operating License, specifically involving the final disposal of the radioactive waste.

By adopting Greenpeace's recommendations, the Malaysian government would be sending a clear signal to the rare earth elements industry and other industries that there is no room for polluting practices anywhere, whether in industrialized countries or in the developing world.


Project Site
Kg Gebeng
KUANTAN PORT
INDUSTRIAL ESTATE
Kuantan
Port
South China
Sea
Bt.
Pengorak
Kg Balok
GEBENG
INDUSTRIAL
ESTATE
Sg. Tunggak
Sg. Balok
Bangkok
Phnom Penh
Ho Chi Min City
Kuantan
MALAYSIA
Kuala Lumpur

I. Background on the Lynas processing plant for rare earths elements in Kuantan

1. Rare earth elements (REEs)

Rare earth elements (REEs) are used in a variety of products, including those from the fast-growing electronics and clean energy industries. With a global shift towards a more high-tech and greener economy, REEs are becoming part of a group of crucial components of modern industrial production and have recently become new elements of geopolitical power struggles. After an early boom in REE worldwide, a rash of environmental concerns emerged, leading to sharply increased production costs and the subsequent closure of many sites. Production then progressively concentrated in the People's Republic of China (China), which now provides 95% to 97% of REEs used worldwide. In 2006, however, China began decreasing REE exports because of increasing internal demand and escalating environmental concerns. Since 2010, China has been imposing strict export quotas on REEs. With demand increasing, prices rising, and possible shortages looming in the near future, REE production outside of China has started up again, generating an old-fashioned style "gold rush" in rare-earth-elements. However, although Russia, India, and a host of other countries have announced plans to bring new REE supplies to market, at this stage, only Molycorp in the USA and Lynas in Australia/Malaysia have significant production capacity for REEs outside of China.[1]

2. Background on Lynas Corporation

Lynas was founded in 1983 as Yilgangi Gold NL in Western Australia and took on the name Lynas in 1985. It was publicly listed in 1986 on the Australian Stock Exchange (ASX). In 2001, it sold its gold division and focused on rare earths.[2] Lynas was founded by its current chairman Nicholas Curtis, who was appointed President and Chief Executive Officer in 2001.[3] Lynas acquired a license to operate a REE processing plant in Australia through the takeover of Ashton, which had acquired a permit in 1992 to build such a processing plant in Meenaar in Australia.[4]

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[1] Bongaerts and Liu 2013.

[2] Lynas 2002

[3] Lynas 2002. At the time of his appointment, Curtis was also Chairman of Sino Mining Ltd, an Australian gold mining company with operations in China. Prior to that, he was President of Sino Mining International Ltd and before that he was an Executive Director of Macquarie Bank Ltd. (Macquarie Group Ltd. is an Australian finance company. The company is seen as a high earning company with high margins and profits, and the rewards for its executives and shareholders are known as the "Macquarie Model." See e.g. Business Spectator 1-5-2009)

[4] Free Malaysia Today 9-9-2011, EPA 1992, EPA 1998

INSET BOX: Lynas subsidiaries [5]

- Lynas Malaysia Sdn Bdh, developing advanced material processing plant;
- Lynas Services Pty Ltd, providing corporate services;
- Mount Weld Holdings Pty Ltd, which is a holding company;
- Mount Weld Mining Pty Ltd, developing mining and operation of concentration plant;
- Lynas Africa Holdings Pty Ltd, a holding company
- Lynas Africa Ltd, which is engaged in mineral exploration

3. The Lynas rare earth elements processing plant: history and operations

Lynas already held a permit for processing in Australia but, looking for cost-cutting alternatives, planned to move its processing to China – a country that boasted low capital and operating cost, as well as high skills within the REE industry, and existing separation capacity. [6] Moreover, China consumes 50% of global REE demand. [7] To finance the project Lynas raised A$75 million (A$ refers to Australian dollars) through the issue of convertible notes and shares. [8] The idea to move production to China was abandoned in 2006 because of possible export control and taxation by the Chinese government.[9] When China imposed new export taxes and VAT, Lynas decided to move to Malaysia instead, where it was exempted from taxes for a significant period of time. Lynas reached an agreement with the Malaysian government in 2006 to build a processing plant there. [10]

In 2007, Lynas finalised an agreement with the Malaysian government to build a processing plant in Kemaman in Terangganu province. According to the company, the plant in Kemaman would bring significant tax advantages, a 10 year tax free holiday and a 27% revenue advantage compared to China, where it would have had to pay 17% VAT and a 10% export tariff. [11] Lynas assured shareholders and financiers that it could fast-track separation production in

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[5] Google Finance 2014, Lynas Corporation Limited (ASX:LYC), http://www.google.com/finance?cid=675181 (accessed 20-Aug-2014)

[6] Lynas Gold NL acquired the Mount Weld deposit in 1999 from Ashton Mining Ltd, in a transaction completed in 2002. After Curtis took over Lynas Gold, the Gold operations were sold and Lynas was reformed into a company with its only goal being to mine and process the Mount Weld rare earths deposit and market it. Based on its access to Chinese processing capacity at that time, Curtis held out to investors and shareholders that Lynas did not need to incur "the large capital cost usually associated with building separation plants, thus leveraging a greater return on our own capital outlays." Nicholas Curtis in Lynas 2002. "The time for Mt Weld has now come. Finally, through this access to Chinese processing capacity, the high-quality Mt Weld ore body has become economic." Ibid.

[7] In 2006 Lynas obtained a site to built a processing plant in Shandong in China, with annual production of 10.500 tonnes; and was granted the environmental and project approvals, as well as business licenses. Lynas expected to start production in China in the first quarter of 2008 with a total investment of A$76,6 Million and a first positive cash flow in 2008. Lynas 2006a

[8] Lynas 2006b

[9] Lynas 2007a

[10] According to the Preliminary Environmental Impact Assessment report commissioned by Lynas, a third potential option (besides Malaysia and China) was Abu Dhabi in the United Arab Emirates but that was not attractive to the company because 'the procedures were not transparent.' See, Environ 2008

[11] Lynas 2007a

Malaysia of approximately 5,000 tpa Rare Earths Oxide equivalent (REO) and produce an additional 5,000 t/a REO at ‘a strategic partner’s’ plant. It was also expecting to expand the Malaysian capacity shortly after commencement of production to 10,500 t/a in 2008 and 20,000 t/a in 2010. Due to these changes, Lynas expected its capital costs to increase ‘significantly,’ though no new cost estimates were given except for an extra A$ 26 million for a mining contractor for the Mount Weld operation.[12] Although the permit for the Kemaman site was denied, Lynas moved on to another part of Malaysia – the industrial site Gebeng near Kuantan. Thus, as a key part of its positioning in global markets, Lynas started production of Rare Earth Elements at its processing plant in Malaysia in November 2012.

Lynas’ plant is located at the Gebeng industrial site, approximately 15 km north of Kuantan on the east coast of Peninsular Malaysia. The plant, also called LAMP (Lynas Advanced Materials Processing plant), is located in a peat swamp area with heavy rainfall, which increases the risks of spills and leaching. There are several smaller villages close by but the nearest village is Balok, where inhabitants live off of fishing and farming. The number of people that could be affected by LAMP is considerable and includes residents from the nearby villages and from Kuantan, which is the capital of Pahang state and its metropolitan area has a population of more than half a million[13] LAMP is near the Balok River, only about 3km to the east of the refinery. Lynas discharges its waste water – 330 m3/h[14] to 500 m3/h[15] – into the Balok River,[16] which runs through a mangrove forest into the South China Sea and near the Turtle Sanctuary located at Cherating, Pahang, on Chendor Beach (Pantai Chendor).[17] A 2006 study showed that the Balok river and Mangrove forest in this discharge area is a very rich and important ecosystem, but also very vulnerable to changes in the environment.[18]

Before being processed in Malaysia, the ore for LAMP starts its journey in Australia. Ore from Lynas’ Mount Weld mine is concentrated at the Lynas concentration plant in Laverton in Western Australia, located near the Mt Weld deposit. Floatation techniques are used to produce a rare earths concentrate at a target grade of 40% Rare Earths Oxide equivalent (REO).[19] The concentrate is then placed in two-ton bulker bags, loaded into sea containers at site and trucked to the Western Australian Port of Fremantle for transport by container ships to Singapore; and from there by sea freighter to the port of Kuantan in

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[12] Lynas 2007a
[13] Phua and Velu 2012
[14] Oekoinstitut 2013a (Also note that IAEA 2011 estimates the discharge rate at average 213 m3/h.)
[15] Environ 2008 (part 2 of 2 page 5-26)
[16] The Balok Mangrove area is a national forest reserve according to the MPA World Database on Marine Protected Areas, see http://www.mpatlas.org/mpa/sites/5899/
[17] Pahang-delights (website), http://www.pahang-delights.com/pahang-turtle-sanctuary.html See also: The Star 10-4-2009, “Turtle-watching season in Kuantan, Malaysia begins.”
[18] Rozainah and Mohamad 2006,
[19] Lynas 2010

Pahang, Malaysia. From there it is a 5km trip by road to the Lynas Advanced Materials Plant (LAMP) processing plant. [20]

The plant processes the concentrate in two main stages: (1) cracking and separation and (2) product finishing. In the first stage, the concentrate is roasted with sulphuric acid in a rotary kiln at high temperature to produce an acid solution, which is then washed with water and other chemicals to produce a rare earth sulphate solution. In the second stage of the process, the solution is subject to a number of solvent extraction systems to produce the REE solutions that undergo further separation and purification into marketable REE products in the product finishing stage. [21]

The Kuantan operation is projected to produce a large amount of contaminated and hazardous waste in Malaysia, amounting to around 300,000 tons per year d.w. (dry weight) relative to the input of 65.000 t/y d.w. rare earth concentrate from Mount Weld and the output of 22.500 t/y Rare Earth Oxides.[22] This means the output amount of solid waste is over 4 times the input amount of concentrate processed and over 13 times the amount of Rare Earth Oxide output by weight.

At least 21.3% of LAMP's waste (64,000 t/y d.w.)[23] consists of low-level radioactive waste (the Water Leach Purification or WLP fraction[24]) that could add significantly to the radiological exposure of the local communities and the environment, depending upon how the waste is handled and disposed of.

4. The International Atomic Energy Agency review of the Lynas facility

Following local communities' protests against the Kuantan facility from March 2011 onwards, the Malaysian government approached the International Atomic Energy Agency (IAEA) in May 2011 with a request to organize an independent review of the plant. The IAEA review was published in June 2011,[25] making a range of recommendations for improvements in the Kuantan facility and criticizing Lynas on a number of issues which is outlined below. .

The IAEA review was limited in scope and related only to the construction licence and documentation associated with this licence, which was made available to the review panel for consideration. It is important to further note that the panel made its site visit when the plant's construction was only already

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[20] Lynas 2010
[21] Environ 2008
[2222] Lynas 2011 Radioactive Waste Management Plan
[23] Lynas 2011
[24] The WLP fraction must be considered low level radioactive waste by the IAEA (2011). According to the IAEA, the FGD and NUF waste streams may be declared non-radioactive for the purpose of regulation and that the AELB should develop criteria that would allow such an exemption to be granted.
[25] IAEA 2011


AIR EMISSION QUALITY
DET. RESULTS STANDARD
SO2 0.00 500 mg/m³
SO3 100.34 200 mg/m³
HF 0.00 200 mg/m³
DUST -77.12 400 mg/m³

approximately 40% complete.[26]

In Malaysia, an industrial facility like the Lynas plant requires:
- a licence for a site,
- a construction licence,
- a pre-operation licence,
- an operation licence, and
- a decommissioning licence.

According to the IAEA, the review was not intended to address licensing phases subsequent to construction. According to the review report, Lynas must make updated documentation available to the Malaysian Atomic Energy Licensing Board (AELB) for the next licensing phase. Therefore, the IAEA recommended in its review report that the Government of Malaysia should invite the IAEA to conduct a follow-up mission to review the fulfilment of its original recommendations in line with other IAEA review missions. [27]

The IAEA also recommended that the radioactive waste (the Water Leach Purification or WLP-fraction) generated should be stored in a permanent disposal facility and that AELB should develop criteria to determine if the Neutralization Underflow Residue and Flue Gas Desulphurization (NUF and FGD) waste fractions must be stored in such a facility or can be disposed off in another way.

While the IAEA concluded that its review team was not able to identify non-compliance with international radiation safety standards, it pointed out significant omissions in the plans that Lynas submitted to the Malaysian government.

The agency also identified 11 recommendations for improvements to the Malaysian Government before the next licensing steps should be taken. Recommendations included the following:[28]

> #1: "The AELB should require Lynas to submit, before the start of operations, a plan setting out its intended approach to the long term waste management, in particular management of the water leach purification (WLP) solids after closure of the plant, together with a safety case in support of such a plan..."
>
> #2: "The AELB should require Lynas to submit, before the start of operations, a plan for managing the waste from the decommissioning and dismantling of the plant at the end of its life. The RIA and decommissioning plan should be updated

[26] IAEA 2011
[27] IAEA 2011
[28] IAEA 2011

accordingly."

#3: "The AELB should require that the results of exposure monitoring and environmental monitoring once the plant is in operation be used to obtain more reliable assessments of doses to workers and members of the public, and the RIA updated accordingly. The AELB should also require that dose reduction measures be implemented where appropriate in accordance with the international principle of optimisation of radiation protection."

#4: "The AELB should develop criteria that will allow the flue gas desulphurization (FGD) and neutralization underflow (NUF) residues to be declared non-radioactive for the purpose of regulation, so that they can be removed from the site and, if necessary in terms of environmental regulation, controlled as scheduled waste."

#5: "The AELB should implement a mechanism for establishing a fund for covering the cost of the long-term management of waste including decommissioning and remediation."The AELB should require Lynas to make the necessary financial provision and that the financial provision should be regularly monitored and be managed in a transparent manner."

#9: "The AELB should intensify its activities regarding public information and public involvement. In particular, it should:

(a) Develop and make available easily understandable information on radiation safety and on the various steps in the licensing and decision making process;

(b) Inform and involve interested and affected parties of the regulatory requirements for the proposed rare earths processing facility and the programme for review, inspection and enforcement;

(c) Make available, on a routine basis, all information related to the radiation safety of the proposed rare earth processing facility (except for security, safeguards and commercially sensitive information) and ensures that the public knows how to gain access to information."

#10: "Lynas, as the party responsible for the safety of the proposed rare earth processing facility, should be urged to intensify its communication with interested and affected parties in order to demonstrate how it will ensure the radiological safety of the public and the environment." [29]

To help ensure that the Malaysian Government carry out its commitment to act on the recommendations, a prescriptive 11th recommendation was made.

#11: "(Based on recommendations 1-10 above,) the Government of Malaysia should prepare an action plan that:

[29] IAEA 2011

- Indicates how the above-mentioned recommendations are to be addressed;
- Sets out the corresponding time schedule for the actions;
- Is geared to the possibility of an IAEA-organized follow-up mission, which will review the fulfilment of recommendations 1-10 above in, say, one to two years' time, in line with other IAEA review missions."

Despite its robust findings and important analysis and recommendations, the IAEA failed to address further problems with the Lynas plant. Several critics pointed out deficiencies in the IAEA report, including Hong[30] and Oekoinstitut[31] (representing or commissioned by local civil society groups opposed to the plant), who noted that the IAEA failed to specify:

- relevant regulations,
- safety standards,
- disposal procedures,
- limits that Lynas should adhere to,
- the critical monitoring sites and details of the exposure monitor system, and
- regulatory limits and the mitigation measures to be taken when these limits are exceeded.

Hong[32] points out that the IAEA report focuses only on sources of gamma radiation in the waste. Alpha and beta radiation were not mentioned anywhere in the report, despite these being important components of the two major decay chains of radioelements present in the waste. Hong[33] also pointed out that as a result, the possible pathways for inhalation or ingestion of these pollutants and the risks of internal radiation were not considered in the review. These pathways can pose substantial risks to internal organs as a result of inhalation/ingestion of airborne thorium/uranium-containing particles.

Given that the IAEA review did not fully address the concerns of local communities concerning radioactivity; and because the company had not addressed other potential contamination issues from the plant, the protests continued.

5. Suspension of the Lynas Temporary Operating License (TOL)

Despite the IAEA recommendations and a number of unresolved concerns, including the requirement of a waste management plan, on February 1st 2012, the Malaysian Atomic Energy Licensing Board approved a 2-year Temporary Operating License (TOL) for the Lynas plant. When the AELB approved the TOL, it added some requirements to be met by the company. Among these were

[30] Hong 2011
[31] Oekoinstitut 2013
[32] Hong 2011
[33] Hong 2011

requirements for:
- a financial guarantee,
- appointment of a third party assessor, and
- putting in place a monitoring system.[34]

The additional requirements imposed by the AELB effectively suspended the approved TOL until these requirements were met.

In a Joint Ministerial Statement, Malaysian authorities added five other conditions to the TOL and required that Lynas *"submit a letter of undertaking that it will accept a return of any residue generated by its factory in Gebeng to its original source,"*[35] *i.e.* the Mount Weld site in Australia. The five extra conditions for the TOL in the joint ministerial statement were designed to help guarantee public health and safety:

i. Lynas is required to submit to AELB details of the plans and location of a proposed permanent disposal facility that will manage the residue, if any, generated by the factory;
ii. This submission must be made within ten months from the date the TOL is issued;
iii. This requirement must be complied with regardless of any alternative proposal Lynas may make for the management or disposal of the factory residue (e.g. recycling, conversion into products that can be sold, etc.);
iv. Lynas must agree to provide a USD 50 million security deposit to the Government;
v. The AELB has the right to appoint an independent expert assessor to evaluate Lynas' compliance with the safety and good practices requirements." [36]

On the 23rd of February 2012, Lynas gave a full undertaking in response to these conditions and its CEO Nick Curtis agreed to, "*If necessary, remove from Malaysia all waste generated at the LAMP in Gebeng."* [37] However, the company viewed the extra conditions and requirements negatively, given that the plant was nearing completion. Moreover, the Australian government subsequently announced that it would not accept any radioactive waste from Lynas. This prompted the CEO of the Malaysian operation to deny that Lynas had agreed with the Malaysian authorities to ship back the waste to Australia.[38] The ensuing dispute between Lynas and the Malaysian authorities was widely reported in the media. The AELB then made its own media statements to the effect that Lynas would have to send to Australia only the residue, which could not be turned into commercial products, or if a location for a permanent disposal facility (PDF) in

[34] AELB 2012a, AELB 2012b
[35] Joint Ministerial Statement 22-02-2012
[36] Joint Ministerial Statement 22-02-2012
[37] Lynas 2012
[38] International Business Times 22-2-2012


EFFLUENT QUALITY
DET. RESULTS STANDARD
pH 9.95 5.5-9.0
BOD5 45.02 50 mg/L
COD 35.00 200 mg/L
TSS 7.00 100 mg/L
Fe 0.67 5 mg/L
Mn 0.02 1 mg/L
19-Jan-2014 16:07:52

Malaysia could not be determined or approved. [39]

On March 17 2012, the federal government (the Barisan Nasional ruling coalition) proposed a Parliamentary Select Committee (PSC) to investigate and make recommendations on the Lynas development. Both the political opposition coalition parties and the civil society groups concerned refused to participate in the PSC and claimed that it was simply an attempt by the federal government to quash concerns attached to the project. [40]

In a related development, in June 2012, the Ministry of Science, Technology and Innovation (MOSTI) responded to an appeal by Save Malaysia, Stop Lynas (SMSL) against the TOL. The ministry added two new conditions to the TOL, requiring Lynas to submit a plan to immobilise radioactive elements in its waste, and to come up with an emergency response plan on dust control. [41]

The protesting civil society groups' concerns, however, were not alleviated by these new terms and conditions. The fact remained that the temporary licence was issued, allowing the production of radioactive waste and its disposal in open ponds, without a permanent solution for the waste having been determined.

In the end, on 5 September 2012 the AELB lifted its suspension and issued the TOL, which freed the way for Lynas to start production. In a joint press statement the AELB and MOSTI [42] confirmed that *"the issue of removal of residue being non-binding for Lynas does not arise. It is legally binding and AELB will enforce it."*[43] The press statement also confirmed that Lynas had to accept all 7 conditions previously imposed on the company; and that the 2-year TOL issued on 5 September 2012 would expire on 2 September 2014.[44]

Lynas responded by providing an assurance that all residue material would be converted into saleable co-products and exported from Malaysia if not approved for use in Malaysia. [45] This still does not resolve the questions about what will happen to the wastes produced.

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[39] Malaysian Insider 28-6-2012
[40] New York Times 19-4-2012
[41] The Malaysian Insider 15-6-2012
[42] AELB 2012
[43] AELB 2012
[44] Joint press statement 8-9-2012, joint press statement the AELB and Ministry of Science, Technology and Innovation ("*All the requirements and conditions imposed on Lynas throughout the above decision processes still apply to Lynas, including the additional two (2), instituted by the Hon. Minister of Science, Technology and Innovation under sub-section 32(5) of the Atomic Energy Licensing Act (Act 304). The management and removal of residue is an integral part of the TOL conditions and agreements, and is permanently documented in the licence document issued to Lynas on 5 September 2012, effective for 2 years from 3 September 2012 to 2 September 2014."*)
[45] Reuters 11-12-2012

6. Project costs have been rising and share prices are down

Project costs have been steadily rising due to escalating construction and ramping up costs
Taken together, these increasing costs effectively negate some of the benefits that the project garnered when it was granted "strategic pioneer status" by the Malaysian government with a 12-year tax-free period, 3-year training grant, and no stamp duty on the land purchase.[46]

The first anti Lynas protest in Malaysia started in 2007 in Terengganu State. In 2007, after consultation with stakeholders including NGOs and local communities, the Terengganu State Government reneged on its decision to sell land for the proposed construction site, and decided to reject the project.[47] Lynas had already started to prepare the site for construction of the processing plant. The federal Malaysian Government then offered Lynas a site in the State of Pahang, at the Gebeng industrial area near Kuantan. Lynas started to clear the land for the construction of its rare earth processing plant in Gebeng in 2008.[48] By 2008 the total costs for the Lynas Advanced Material Plant were estimated to have increased to A$ 415 Million[49] and production was expected to start in the 3rd quarter of 2009, which meant a delay of one and a half years as compared to earlier announcements by the company.[50]

In 2009 the estimated project costs were increased again at A$ 492 Million with an additional A$ 120 Million for working capital and production ramp up costs. Moreover, start of production was again delayed by a year and nine months and was then expected to start in the first half 2011.[51] (The additional costs Lynas faced came at a time when its African operations in Malawi also encountered difficulties.[52]) In May 2011 the concentration plant in Western Australia was commissioned and the first phase of the Malaysian plant with an annual capacity of 11.000 tonnes was declared ready in May 2012, a year later than planned, and expanded to 22.000 tons in 2013. Total cost estimates also raised significantly again in 2012 to A$ 641 Million.[53] In November 2012 Lynas got a temporary licence for the processing plant in Malaysia and in February 2013, five years later than planned and at a much higher cost, Lynas produced its first Rare Earths products for customers. By 2013 the total investment reported by

[46] Lynas 2008a
[47] SAM 2011
[48] Lynas 2008a (In 2008 Lynas also started expanding its activities with the acquisition of the Kangankunde Carbonatite rare earth deposit in Malawi, Africa and planned to start exploiting it by utilizing the concentration plant and the separation plant capacity in Malaysia.)
[49] Lynas 2008a
[50] Lynas 2008b
[51] Lynas 2009d, Lynas 2009e
[52] The acquisition of the Kangankunde deposit in Malawi was completed in 2011 for US$ 4 Million (+VAT), (Lynas 2011a) but a dispute about the ownership arose in the Malawi courts (The Age 14-11-2011). Lynas is trying to reclaim ownership and as a result has not made any further capital investment and has put the project on hold pending the outcome of the case. (Lynas 2013)
[53] Lynas 2012a

Lynas stood in excess of A$1 billion in Malaysia and A$300 million at the Mount Weld site.[54] For a total REE market value of $US 4 to $US 6 billion, these facilities' costs may prove to be prohibitively high.[55]

Meanwhile, production has been lower than expected – and by extension, profits too. By 30 June 2013 the company had produced only 144 tonnes and shipped 117 tonnes on a Rare Earth Oxide (REO) equivalent basis.[56] Production in the 3rd quarter (July-September) was 253 tonnes REO equivalent products and shipments were 218 tonnes REO equivalent products.[57] Production continued at a reduced volume of 741 tonnes in the last quarter of 2013 and a total of 409 tonnes were shipped.[58] Performance has thus fallen short of the company's original projections: Lynas was expecting to supply more than 25% of the world REE market for some 20 years when it took the commercial decision to focus solely on rare earth elements in 2001.[59] Nicholas Curtis himself stated, *"Initial production and sales volumes are smaller than we would have liked."*[60] From the initial announcement to shareholders in 2002 that it had access to Chinese processing capacity, Lynas has taken more than a decade to generate its first end product. The high (and ever increasing) investments involved, the long delays to the project and the low revenues generated have caused the company to suffer from financial problems at several points in time.

In late 2008, for example Lynas experienced severe cash flow problems[61] and in 2009 it had to put the Mount Weld project and construction in Malaysia on hold because a US$ 95 million convertible loan fell through.[62] Lynas then tried to negotiate a deal with the state-owned China Non-Ferrous Metal Mining (Group) Co. by offering a 52% majority stake designed to generate A$ 252 million to allow investment for Lynas to continue its projects in both Australia and Malaysia.[63] This would have given China a majority interest in Lynas. The proposal, however, was blocked by Australia's Foreign Investment Review Board on the basis of concerns that it would threaten supply to non-Chinese buyers and undermine Australia's position and reputation as a reliable trading

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[54] Lynas 2013
[55] Packey 2013
[56] Lynas 2013
[57] Lynas 2013b
[58] Business Spectator 31-1-2014
[59] Lynas 2002
[60] Nicholas Curtis in Lynas 2013
[61] Lynas 2008c
[62] Lynas 2009a
[63] Lynas 2009b, Lynas 2009c. Former Lynas top-man Harry Wang was involved in this deal together with Lynas CEO Nick Curtis. See, Sydney Morning Herald 16-4-2011 According to the same article, Harry Wang and Nick Curtis were also working together in 2011 trying to sell the Crown metal deposit, a part of the Lynas Mount Weld deposit. Curtis was then not only CEO of Lynas, but he and Wang were also directors on the Forge board and principals of Riverstone Advisory. Riverstone is better known as Sino Resources where both were working at the time when they took over Lynas. Under its changed name it is the corporate adviser to Forge. Apparently, the idea was to sell the Crown deposit for only A$ 24 Million although it was said to be worth A$ 50 Million. Curtis would accrue a A$ 26 Million bonus at Forge for this deal. In the end this deal did not happen because of angry Lynas shareholders questioning this deal.

partner.[64]

On 24 January 2012, Lynas raised US$225 capital with a convertible bonds issue through the US-based investment firm Mt Kellett Capital Management. The funding for the Convertible Bonds was received early in the year and the proceeds have been used to fund construction and commissioning of Phase 1 of the LAMP in Malaysia and for day to day operational expenses.[65] The extended delays to the Malaysia project and the $225 million convertible bonds issue caused the Lynas shares to drop to a 2 year low and the Lynas CEO Curtis had to face angry shareholders again at the AGM in November 2012.[66] Revenues from sales in 2013 were only $0.9 million and the overall loss from operating activities increased by $38.3 million, or by 43%, to $128.4 million for the year ended June 30, 2013, compared to $90.1 million for the year ended June 30, 2012.[67]

As a result of on-going controversy, cash-flow problems, production lagging continuously behind schedule and the unstable price of rare earth elements, Lynas' financial situation is seen as weak in the market. Share prices are low. According to financial analysts, Lynas' uncertain financial situation is likely to persist for some time to come.[68]

II. Environmental threats posed by Lynas

Worldwide, the extraction and processing of rare earth elements has significant environmental risks in its potential for spread of radioactive material and toxic chemicals, and the acidification of watersheds.[69] The risks of a disaster in Kuantan are real. Indeed, there is a precedent in Malaysia for environmental and health problems arising from an unsafe REE facility: namely the Mitsubishi Chemical joint venture company called Asian Rare Earth (ARE) in Bukit Merah in Malaysia, which became notorious for its pollution and harmful impacts on neighbouring communities. Although Mitsubishi paid 100 million dollars towards a cleanup, still today, 32 years after production stopped, ARE's radioactive waste remains a deadly legacy. At present, in the particular case of Lynas, a number of environmental threats have been identified that must be addressed: problematic treatment and disposal of solid waste tailings that will include large amounts of radioactive waste; production of pollutants including radioactive substances and heavy metals; potentially unsafe storage of waste in open ponds; the risk that Kuantan's regular floods and storms may damage the waste

[64] Sydney Morning Herald 15-2-2011
[65] Lynas 2013
[66] Malaysiakini 20-11-2012, Sydney Morning Herald 20-11-2012
[67] Lynas 2013
[68] Australian Network News 9-12-2013
[69] Coil et al 2013


LONG TERM STORAGE FACILITY
DECOMMISSIONING AND DISPOSAL PROJECT
THIS PROJECT IS CONTROLLED
AND SUPERVISED BY THE
ATOMIC ENERGY LICENSING BOARD (AELB)
MOSTI
AELB
RARE EARTH SDN. BHD.
WITHOUT LTI
WITHOUT LTI
20
SECURITY

storage systems; potential contamination of surrounding groundwater resources; and the problem of fugitive dust from the tailings. In around 20 years time Lynas will have produced over 6 million tons of waste. Lynas is thus potentially building up a waste stockpile of millions of tons of radioactive waste and, moreover, is imposing the long-term management burden of this waste upon Malaysia. The bottom line is that the Lynas facility in Kuantan is endangering people and ecosystems.

1. **General environmental risks and problems with REEs**

Mining in the natural environment is the primary means of REE acquisition; and such mining typically results in over 90% of excess and unused materials being left over, which need to be disposed of. This excess material, often contaminated with toxic waste, is associated with various environmental impacts. [70]

Major environmental risks in mining and processing REE are associated with the treatment and disposal of tailings. The tailings typically contain high-surface-area particles, wastewater, and process chemicals. Typical pollutants are the ore-associated metals (e.g. aluminium, arsenic, barium, beryllium, cadmium, copper, lead, manganese, zinc); radionuclides (e.g. thorium and uranium); radon; fluorides; sulphates; and trace organics. [71]

Rare earth impoundment areas are often exposed to weathering and have the potential to contaminate the air, soil, surface, and groundwater. Fugitive dust from the tailings impoundments can contaminate the air and surrounding soil. Surface water run-off from rainfall or dam over-topping can contaminate surrounding soil and surface water-bodies. Additionally, if adequate groundwater protection measures are not utilized (e.g., impoundment liners), the potential exists to contaminate surrounding groundwater resources. A worst-case scenario is dam failure due to poor construction or from a catastrophic event, resulting in serious long-term environmental damage. [72] A dam failure as happened in Hungary in 2010, involving the red mud from an aluminium oxide factory led to significant emissions of thorium, uranium, heavy metals, acids and fluorides. [73]

Historic evidence from similar production sites teaches us that there are many environmental problems and concerns attached to REE production. It is precisely for that reason that most production sites have been closed down in the past. Environmental concerns are the main reason why most countries, with the exception of China, have stopped producing REEs. One of the major

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[70] USEPA 2012
[71] USEPA 2012
[72] USEPA 2012
[73] Oekoinstitut 2011

problems leading to the closure of the Mountain Pass mine in 1998 in the USA, for example, was a series of radioactive waste-water spills from the mine facility. A total of around 600,000 gallons (approximately 20.000 metric tons) of thorium-contaminated water spilled into and around Ivanpah Dry Lake.[74]
Even China is now cleaning up its existing production sites. In order to protect the rare earth resources, the Chinese government has implemented a comprehensive series of regulations and standards from 2009 onwards, including enforcing stricter environmental standards and developing clean rare earth production technologies and processes.[75] The main mining operation in China is the Bayun Obo mine near Baotou in Inner Mongolia[76] with a second, less consolidated operation located in Sichuan with lower value resources and underground mining as opposed to open pit mining.[77] The third REE producing region in China is based on mining 'ionic clay' deposits in Jiangxi, Guangdong, Hu'nan and Fujian provinces, where most of the "heavy" Rare Earths are produced.[78] China's Baotou mine has significant problems with water and air pollution. The tailings, containing radioactive substances, fluorides, sulphides, acids and heavy metals are stockpiled in a large and growing impoundment. In 2010, the impoundment covered eleven square kilometres and drainage water could easily penetrate into groundwater and flow into the Yellow River. An ecological disaster could occur if the highly toxic water and sludge were to flood the surrounding area.[79]

Environmental conditions and the health of the inhabitants of the villages around Baotou (Mongolia) are reported to be dramatic: pollution of drinking water sources has occurred and there is a risk of polluting the water of the Yellow River with radioactive materials. Amongst the general population, increases in cases of cancer, in respiratory diseases and dental loss are reported.[80] Some sources have estimated that, every year, the mines around Baotou produce about ten million tonnes of highly acid and radioactive wastewater; most of these waters are released into the environment without any treatment.[81]

The Southern China REE clay deposits do not contain any significant quantities of radioactive elements, but these deposits require extraction techniques that use large amounts of acids and other chemicals, mixed directly with the ore at the mine site. One estimate from China concluded that for each ton of rare earth brought to the surface, 200 square meters of vegetation and 300 square meters of soil were sterilized by acid treatment.[82] Although a more advanced in-situ

[74] Bongaerts and Liu 2013, The Atlantic 1-5-2009
[75] Bongaerts and Liu 2013
[76] This is controlled by a large State-Owned Enterprise (SOE), Baotou Iron and Steel, and produces approximately 55kt Rare Earths Oxide (REO) per annum
[77] Sichuan has an estimated capacity of up to 20kt REO. See, e.g. Lynas 2011
[78] Europium, terbium, dysprosium and yttrium are the key heavy Rare Earths in demand today. Accurate production figures are unavailable but it is estimated at approximately 40kt REO. See, e.g. Lynas 2011
[79] Bongaerts and Liu 2013
[80] Schuler et al., 2011 cited from: Massari and Ruberti, 2013
[81] Folger, 2011
[82] Coil et al. 2013

leaching method has now been widely adopted, large quantities of ammonium nitrogen, and of heavy metals and other pollutants are being produced, resulting in the destruction of vegetation and severe pollution of surface water, ground water and farmland. Light rare earth mines usually contain many other associated metals. Large quantities of toxic and hazardous gases, wastewater with high concentration of ammonium nitrogen and radioactive residues are generated during the processes of smelting and separation. In some places, mining of rare earth ores has resulted in landslides, clogged rivers, environmental pollution emergencies, and major accidents and disasters, causing great damage to people's safety to their health, and to the wider environment. [83]

In 2004, researchers Tong and co-workers analysed rare earth elements present in human head hair as a biomarker of human REE exposure. Data were collected on REEs exposure levels in children aged from 11-15 years and living in areas in southern China where ion-adsorptive type light REEs (LREEs) exploitation was taking place. Sixty head hair samples were analysed by ICP-MS for 16 REEs. The distribution pattern of REEs in scalp hair from the mining area was very similar to that of REEs from the mine itself and present in the atmosphere in the surrounding area. The authors concluded that scalp hair REE content may indicate not only quantitatively but also qualitatively (distribution pattern) the absorption of REEs from environmental exposure into the human body. The study concluded that children living in this mining area should be regarded as a high-risk group with respect to REEs (especially LREEs) exposure, and their health status should be examined from a REEs health risk assessment perspective.[84]

China is not the only place where the environment may be at risk because of REEs. A recent study by Kulaksiz and Bau [85] has shown that the Rhine River in Europe carries high concentrations of lanthanum (La) from a production plant for fluid catalytic cracking catalysts (at Rhine river km 447.4). This effluent is characterized by extremely high dissolved total REE and La concentrations of up to 52 mg/kg and 49 mg/kg, respectively. According to the authors, these La concentrations are well above those at which eco-toxicological effects have been observed. The study results suggest that almost 1.5t of anthropogenic dissolved La is exported via the Rhine River into the North Sea per year. This reveals that the growing industrial use of REE can result in their release into the environment, and highlights the urgent need to determine the natural background concentrations in terrestrial surface waters [86] and more widely in the environment.

[83] China Internet Information Center 2012
[84] Tong et al. 2004
[85] Kulaksiz and Bau 2011
[86] Kulaksiz and Bau 2011

2. Malaysia's painful history of a polluting REE facility: the case of Bukit Merah

Radiation concerns, coupled with the low cost of Chinese competition, caused the closure of all rare earth refineries in Japan and prompted Mitsubishi to move its Asia Rare Earth (ARE) refining operation to Malaysia, where old tin mines had left behind thousands of tons of semi processed slag that was rich in rare earths and could be used as ore. [87] In 1979, Mitsubishi Chemical set up a joint venture company called Asian Rare Earth (ARE) in Bukit Merah in Malaysia. As with Lynas, the company was given a special tax-free 'pioneer industry' status. ARE extracted rare earth from monazite, produced as by-product from tin mining in the area. [88] Furuoka and Lo have made an extensive analysis of the Bukit Merah case, and the deleterious health impacts of ARE on communities nearby.[89] According to their study, ARE had not carried out an environmental impact assessment and operated without either a permanent or temporary disposal site for the waste.

In February 1985, eight residents of Bukit Merah filed a complaint against ARE at the High Court of Ipoh, alleging that exposure to ARE's radioactive materials and waste were harmful to their health. An injunction was obtained in November 1985 ordering ARE to cease its operation. Pending the construction of a waste disposal/storage building, the ARE factory was shut down for 2 years through the decision of the Ipoh High Court. In February 1987, the authorities granted ARE a licence and the company resumed operations even though the legal injunction was still in place. [90]

During the period over which the plant operated, various health studies were conducted. These are well described in a publication of the Consumers Association of Penang. [91] According to this publication, health impacts became evident shortly after the ARE operation commenced. About 14% of the Bukit Merah mothers in the period 1982-1986 experienced unexplained miscarriages or perinatal and neonatal deaths. Reported perinatal deaths in 1982 were about three times the national average. In 1987-1988 children in Bukit Merah were blood tested. On average they were found to have lowered blood counts and appeared to be more susceptible to infections. Seven cases of leukaemia were reported after 1987, meaning that the leukaemia rate was 35 times above the

[87] New York Times 8-3-2011
[88] Furuoka and Lo 2005
[89] Furuoka and Lo 2005. and most of the following overview is derived from their publication. The Bukit Merah plant used the caustic soda method and produced tricalcium phosphate as a by-product from the process. When operating at full capacity, ARE production per annum was 4200 tons of light rare earth, 550 tons of heavy rare earths and 4400 tons of tricalcium phosphate. The rare earth products typically contained 50-55% total rare earths and they were exported to a Mitsubishi purification plant in Japan for further separation and purification (Meor Yussoff and Latifah 2002).
[90] Furuoka and Lo 2005
[91] CAP 1993

usual incidence reported in Peninsular Malaysia. [92]

Due to mounting public pressure in Japan, ARE was forced to close its operation in Bukit Merah once again but on 23 December 1993, the Supreme Court of Malaysia ruled to allow ARE to reopen the factory because the court considered its operation as lawful and in compliance with regulations. It was also deemed that neither established facts nor scientific rationale had been produced to support the claims that the alleged health injuries of Bukit Merah residents were related to the operation of ARE. [93]

In January 1994, however, ARE decided to cease its operations. The factory was having difficulties in obtaining monazite locally because of a decline in tin ore mining activities; and was facing competition from rare earth producers in places such as China and it was deemed neither viable nor profitable to continue the business in Malaysia.[94]

Affected residents did not receive any compensation after the shutdown. ARE claimed that there had been no conclusive evidence to show the cause of the alleged deterioration of Bukit Merah residents' health. The Malaysian Government and Mitsubishi could both afford to remain unresponsive to public concerns because they took the position that there was no conclusive scientific evidence to support a causal link between the health impacts observed and documented by local communities and the radioactive pollution from the ARE plant. This position fails to recognise that it is in general, extremely difficult to conclusively link human health impacts to pollution and industrial activity. This is particularly true where systematic population health studies and epidemiological analyses have not been carried out as part of the Impact Assessment process.

Mitsubishi, the main operator of the plant, paid 100 million dollars towards a cleanup and the construction of a permanent disposal facility to store the radioactive waste. [95] Even today, 32 years after production stopped, the radioactive waste remains a deadly legacy whose impacts extend far into the future.

Malaysia is again confronted with a radioactive and toxic waste problem created by a foreign company, Lynas. Until acceptable solutions are found to the radioactive waste problem of LAMP, Malaysia should learn the lessons from the Bukit Merah experience, and deny the company's Permanent Operating License.

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[92] CAP 1993
[93] Furuoka and Lo 2005
[94] Furuoka and Lo 2005
[95] New York Times 8-3-2011

3. Specific environmental threats posed by the Lynas plant in Malaysia

The Lynas plant in Kuantan could endanger human health as well as damaging vulnerable and important ecosystems, potentially including a mangrove forest,[96] a turtle sanctuary, and peat swamps.

Lynas is expected to use large amounts of chemicals, including sulphuric acid, hydrochloric acid, magnesium oxide, kerosene and proprietary solvents like trichloroethylene in its refining process.[97]

However, the most significant source of concern is the solid waste tailings, which will include large amounts of radioactive waste. For the time being, this highly problematic waste stream is being planned to be stored in open ponds. Lynas' plant at the Gebeng industrial site is located in a peat swamp near Kuantan, and also with periodic flooding due to heavy annual rainfall. Since production started, the area has suffered twice from flooding, with the most recent and serious flood occurring in December 2013. According to the AELB, this flooding caused no contamination from Lynas,[98] but community activists fear that future, more extreme flooding, or extreme weather events could trigger contamination from the REE facility's open ponds.

In 2012 the National Toxics Network, an Australian NGO, reviewed the available information and concluded that it is very likely that the LAMP plant will have significant atmospheric, terrestrial and water-borne emissions of toxic chemicals and radionuclides including uranium and thorium.[99] The study concluded that it is likely that the radioactive waste will contaminate groundwater within months of deposition due to the local environmental conditions and technical limitations of the containment cells. The high rainfall and low evaporation create, according to the study, elevated risks for the radioactive tailings waste and increase the risk of environmental contamination.[100]

The study also concluded that contamination of the Balok River and the receiving marine environment are highly likely given the poor wastewater discharge limits set by Malaysian authorities, which are not at par with international best practices for wastewater discharge. The study also criticized Lynas, because radionuclide contamination of waterways and aquatic biota was only poorly addressed in the Preliminary Environmental Impact Assessment

[96] For a study on the local mangroves around the river, see: M. Z. Rozainah, M. R. Mohamad, "Mangrove Forest Species Composition and Density in Balok River, Pahang, Malaysia." The study's abstract states that "Sixteen mangrove species from 10 families, including four associate species, were recorded in 4 study plots along the riverbanks of Balok river, Kuantan and Pahang… Highest species diversity was recorded in the order of plots located on downstream to the river mouth .., based on the Shannon-Weiner Diversity Index."
[97] National Toxics Network 2012 [hereinafter NTN 2012]
[98] The Malay Mail Online 7-12-2014
[99] NTN 2012
[100] NTN 2012

conducted for Lynas by Enviro Research Services. [101]

The NTN study raised concerns that atmospheric contamination by acid gases will occur if the flue gas pollution scrubbers are not maintained in pristine condition or are incapacitated by power outages. Additionally it can be expected that emissions of SOx, HF and NOx will exceed international guidelines if the scrubbers deteriorate in efficiency over time. [102]

On the subject of waste storage, another study by Oekoinstitut[103] concludes that the design of the storage facilities is not state-of-the-art with respect to leakage prevention. A state-of-the-art design would, for example use 2.5 mm High-density polyethylene (HDPE) and at least two 25 cm layers of clay instead of 1 mm HDPE and only a single 30 cm layer of clay – as specified by Lynas for the project. Accordingly, the inappropriate layout chosen by Lynas could result in leakage of radioactive and toxic constituents to the near groundwater even under normal operating conditions. As the layers underneath the facility are not qualified as barriers and do not guarantee the enclosure of those constituents, the spreading of the constituents is not substantially reduced or delayed. The author of Oekoinstitut's report questions whether this inappropriate design is compatible with the minimization requirement established in the Malaysian regulation for the control of radioactive waste and its storage.

The study also concludes that storage for the waste from the Water Leach Purification (WLP) process stage with the highest radionuclide and toxic content is not designed to store the wastes produced before a safe external permanent disposal facility has been established, due to its limited capacity.

Oekoinstitut,[104] an institution which also conducted a study on the Lynas facility in Kuantan and its flaws, reviewed the potential to re-use the waste as construction or building material. The Oekoinstitut report points out that release of Lynas' wastes from regulatory control and to the public domain has to primarily consider the adverse health consequences: if the radiological dose/risk of such release exceeds internationally accepted protection levels, the waste cannot be released and has to be disposed of in any case. Based on their calculations on Lynas waste data the Oekoinstitut authors conclude:

- The WLP waste with the highest radioactive content would exceed by a factor of more than 1,000 internationally accepted protection levels for the release of radioactive materials from regulatory control (Beyond Regulatory Concern, BRC level).
- Even if diluted 1:1 with gypsum the WLP waste is 200-fold above those internationally accepted levels.

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[101] Environ 2008
[102] NTN 2012
[103] Oekoinstitut 2013
[104] Oekoinstitut (2013a, b)

- Even if diluted 1:100 with gypsum (technically unrealistic) the doses would still exceed BRC level.
- Even the less contaminated wastes Flue Gas Desulphurization and Neutralization Underflow Residue (FGD and NUF) are above that level and require 1:4 & 1:9 mixing respectively before they can be released (assuming that the material properties meet the necessary requirements and their toxic by-product content does not give rise to any non-radiological environmental concern).

The authors conclude that that the roughly 1.2 million tons of WLP waste likely to be produced have to be disposed of in a Permanent Disposal Facility (PDF), that isolates the radiologic and toxic content over virtually unlimited future time frames. Any hopes that this waste can be re-used in the public domain are, according to the author, scientifically and technically nonsensical and, with respect to the risks posed, irresponsible. The study points out that operation of a facility that generates those wastes should only be allowed, whether temporarily or permanently, if the Permanent Disposal Facility is available, otherwise another dangerous legacy is created and the burden of responsibility for these wastes is unacceptably shifted to future generations.

Based on the above findings, Oekoinstitut [105] noted that the International Atomic Energy Agency review, [106] Lynas (in its Radioactive Waste Management Plan, or RWMP) [107] and the regulators at AELB and MOSTI did not recognize, mention, or take into consideration the relevant dose criteria. This failing and the resulting issue that these agencies do not set this as a prime condition for any waste reuse scenario is seen as highly irresponsible.

Problems in the Kuantan facility's cracking and leaching units have meant that production has only been a fraction of what was expected. In 2011, the New York Times featured a report, which revealed cost-cutting practices at the plant as well as construction and design flaws. Anonymous engineers speaking to the New York Times 'felt a professional duty to voice their safety concerns'. These centred on structural cracks, air pockets and leaks in many of the concrete shells for the 70 containment tanks.[108] The New York Times also reported internal memos indicating that the refinery's concrete foundations were built without a thin layer of plastic needed to prevent the concrete pilings from drawing moisture from the reclaimed swampland underneath and associated problems. A contractor engaged for securing and securing the linings of the containment tanks, Akzo-Nobel, pulled out due to quality concerns. [109]

[105] Oekoinstitut (2013b)
[106] IAEA 2011
[107] Lynas 2011 Radioactive Waste Management Plan
[108] New York Times 29-6-2011, New York Times 31-1-2012
[109] New York Times 29-6-2011, New York Times 31-1-2012

4. Problems with Lynas' plan for radioactive waste disposal, storage, recycling

The volume of waste will be considerable

The Lynas operation in Malaysia is projected to produce extremely large volumes of waste, estimated at around 300.000t/y d.w. (dry weight) relative to the input of 65.000 t/y d.w. rare earth concentrate from Mount Weld and the output of 22.500 t/y Rare Earth Oxides as final product. This means the output amount of solid waste is over 4 times the input amount of concentrate and over 13 times the amount of Rare Earth Oxide output. With a projected production period of 20 years[110] this leaves Malaysia with a toxic waste legacy of over 6.000.000 tons.

Thorium

Monazite ore used by Lynas as a raw material contains the radioactive element thorium and traces of uranium. Thorium-232 concentration in the concentrate is between 0,13-0,16% and uranium-238 is 0,0021-0,0029%. Based on this, the activity concentration is estimated 6 Bq/g, which is below the threshold of 10 Bq/g, meaning that no specific radioactive transport measures are needed in connection with international transport. [111]

The expected activity of thorium-232 is 6 Bq/g in both the Lynas feedstock rare earths concentrate and in the water leach purification (WLP) residue. The average dose that will be received by workers is estimated at 2 mSv/y with some workers receiving an average of 10 mSv/y, which means the Lynas plant needs to be licensed by the AELB and requires a radiation protection programme to protect workers and members of the public.[112]
The expected annual dry volume of waste is around 314.000 m3/y at full production, with a lower production in the first 1-3 years. Of this, 91.600 m3/y is made up of the WLP fraction with an expected activity of Thorium-232 of 6 Bq/g and Uranium-238 of 0,2 Bq/g. The rest of the waste consists of flue-gas desulphurization (FGD) residue and neutralization underflow (NUF) residue that have concentrations of 0,03-0,04 Bq/g. A minor fraction (6.600 m3/y) is sludge from the wastewater treatment plant and is expected to be of no radiological significance. [113]

According to Lynas[114] the tot annual waste amount is approximately 300.000 tonnes (dry weight). A significant part - 64,000t/y d.w. (21.3%) - of the Lynas

[111] IAEA 2011
[112] IAEA 2011
[113] IAEA 2011
[114] Lynas 2011

facility's waste consists of low-level radioactive waste with an expected Th-232 activity 5.91 Bq/g and a U-238 concentration of 0.23 Bq/g. The expected total activity of this waste fraction, taking all thorium decay products into account is 62.29 Bq/g, or an order of magnitude higher than the sum of the Th-232 and U-238 concentration. It should be noted that these values are those provided by Lynas and are based on calculation rather than empirical measurement. Actual concentrations measured on site are not (yet) available.

The average worldwide background concentration of thorium-232 in soil is around 0.7 pCi/g[115] which is equivalent to 0,0259 Bq/g. A study by Lee and co-workers[116] found gross alpha activity concentrations ranging from 0,015 to 9,634 Bq/g with a mean value of 1,558±0,121 Bq/g from the different soil types found in the Kinta District, Perak, Malaysia. Background radiation levels attributable to thorium-232 and uranium-238 in the natural environment around Pahang are around of 0.08 +- 0.05 Bq/g and 0.07 +- 0.04 Bq/g respectively, as given by Environ 2011[117]. This means that the Thorium concentration of nearly a quarter of the Lynas waste (The WLP fraction) has the potential to add significantly to the radiological exposure of the local communities and the environment. The amount of waste generated incrementally every year from the Lynas production plant can be expected to contribute significantly to background exposures of workers and the general population in the region. Other waste fractions can be expected to further add to the radiological exposure.

Pillai describes the potential significance of internal radiation exposure due to thorium and its decay-products.[118] He notes that in chemical processing of rare earths the radioactive equilibrium of the thorium decay chain is broken at the acid extraction stage and that, thereafter, the build-up and decay of specific isotopes follows separate routes through the production process. As a result of breaking the equilibrium, therefore, the concentration levels may change significantly at different stages of the process. The activity at each specific stage has to be taken into account in radioactivity monitoring. The external and internal exposures typically contribute equally to the total radiation exposure in a monazite processing plant.[119]

[115] CAP 1993
[116] Lee et al. 2013
[117] Environ 2011
[118] Pillai 2008
[119] Pillai 2008

The WLP fraction of the waste and IAEA recommendations

Table 4 Waste fraction Lynas

Waste Fraction	Annual Amount (t/y d.w.)	Th-232 Bq/g	W-238 Bq/g	Tot radio-activity Bq/g
FDG	58920	0,0239	0,0204	0,47
NUF	177820	0,0490	0,0040	0,52
WLP	64000	5,91	0,23	62,29

Source: Lynas 2011

The radio logically significant materials in the waste will be subject to weathering under current management plans. Winds may spread dusts and waste particles off site. They may be mobilised by spillages, malfunctioning of the plant or from overflow during heavy rainfall. Ground and surface water pollution could result. Ultimately it is possible that the radioactive substances entering the environment may enter the food chain. Because of the potential for significant impacts on the environment and human health, the IAEA recommended that the most radioactive fraction of the waste (the WLP-fraction) should be stored in a permanent disposal facility. It also requested further measurements of the actual radioactive contamination of the other waste fractions in order to determine if these require storage in a secure facility or could be disposed of in another way. [120]

Lynas' plan to deal with its waste and its response to the IAEA recommendations

In response to the IAEA recommendations, Lynas produced a Waste Management Plan in 2011, which includes a Radioactive Waste Management Plan [121] listing the following radioactive waste streams generated and their respective total activity concentration (total Th-232 and U-238 decay chains), [122] This follows the Radiological Impact Assessment that Lynas had commissioned from Nuklear Malaysia in 2010. [123]

- Flue Gas Desulphurization residue (FGD) arising from waste gas scrubber system (0.47 Bq/g)
- Neutralization underflow residue (NUF) arising from the High Density Sludge system, which is part of the pre-treatment system for the liquid waste streams arising from the Cracking and Separation Plant (0.52 Bq/g);
- Water Leach Purification residue (WLP) resulting from the leaching and purification of the Water-soluble lanthanide components from the calcined, cracked concentrate in the Cracking and Separation Unit (62.29Bq/g).

[120] IAEA 2011
[121] Lynas 2011
[122] Lynas 2011
[123] Nuklear Malaysia 2010

Each of the solid waste residues will be subjected to pressure filtration before storage in separate cells in the residue storage facility. All wastewater from the plant is expected to be treated and discharged via a pipeline into the Balok river (213 m3/h). The same is the case with storm water from the FGD and NUF cells, while storm water from the WLP cells will be diverted back to the leaching process. Process off-gases go through a scrubbing system for the removal of particulates, sulphur dioxide and sulphur trioxide and are discharged via a 34 m stack to atmosphere (35,000 m3/h). [124]

The problem of WLP radiation levels

A 2012 study by the National Toxics Network (NTN) [125] points out that at the concentration at the Lynas plant in Kuantan, the WLP radiation levels are two orders of magnitude higher than existing background radiation levels attributable to thorium-232 and uranium-238 in the natural environment around Pahang. This background is generally around 0.08 +- 0.05 Bq/g and 0.07 +- 0.04 Bq/g respectively for these natural radionuclides These background levels were cited in Lynas' Radiological Impact Assessment study (RIA). [126] The NTN study[127] also points out that the radioactivity in the RIA for both the Mt Weld concentrate and the WLP residue was quoted at 61 Bq/g, being the radioactivity of the entire decay chain of the thorium and uranium and which, therefore, includes radio logically significant decay products such as radium and radon. According to the NTN study, each of these decay products should be assessed for environmental and human health risk in their own right given their different exposure pathways. Significantly, no such assessment, or modelling of impacts, was done by Lynas or by its consultants. NTN also raise question in their study as to why the NUF and FDG waste streams were excluded from the radiological risk assessment on the basis that the levels in the waste are the same as natural background levels in soil at Pahang. Given the figures quoted in Nuklear Malaysia's report, which indicate that that the FGD/NUF waste is two orders of magnitudes higher than background levels, NTN [128] consider that these wastes should have been included in the modelling.

The problem of particulate matter size

NTN also criticized the assumptions inherent in Nuklear Malaysia's modelling of the radioactive exposure of the public and workers from tailings and emissions. Nuklear Malaysia assumes that dust particles from the concentrate and tailings will be of the size PM 5 (particulate matter of a size 5 microns and greater) for all their dust assessment. According to NTN in 2012, similar processes for the extraction of aluminium hydroxide in Western Australia can result in tailings that

[124] IAEA 2011
[125] NTN 2012
[126] Nuklear Malaysia 2010
[127] NTN 2012
[128] NTN 2012


25.12.2012 10:34

have a high proportion (up to 50%) of PM2.5 particles If the PM 2.5 fraction also contains alpha emitting radioactive particles they can become embedded in the lining of the lungs and cause serious diseases, including cancer. [129]

The problem of scale enrichment

Oekoinstitut [130] points out that in a facility like that operated by Lynas, the effect of enrichment of scale on surfaces is a well-known phenomenon. Scale enrichment occurs in uranium ore milling, in phosphate production and in the oil and gas industry. On certain surfaces such as those of pipes, valves, filter cloths, etc. certain elements of the decay chain (such as radium) become selectively enriched. These "concretions" build up an insoluble, firmly adhering layer (e.g. of radium sulphate) and accumulate over time. The rate of accumulation depends on the separation efficiency. This can range from very low to very high, and largely unpredictable. Once "trapped" in the concretion, the nuclide specific decay chain of the separated element starts to build up and the gamma dose rate rises. In their review, Oekoinstitut points out that this not only has consequences for the radiological monitoring and exposure of workers, but also for the handling and waste storage commitment that arises from dealing with these enriched scales. [131]

For permanent storage of radioactive waste, a long time horizon is needed

Permanent storage of radioactive wastes should be carried out according to IAEA guidelines. These include institutional controls of the disposal site, over a long period into the future. Internationally a specified period of 300 years is not uncommon[132]. According to IAEA, the FGD and NUL residues may not need to be treated as radioactive waste and the Malaysian Atomic Energy Licensing Board (AELB) may be able to exempt them as such in the future. The rationale for any such exemption by the AELB needs to be established on the basis of empirical measurement. For the next 1-2 years, however, these wastes will be stored in an on-site storage facility. [133]

Lynas plans to move the waste from temporary to permanent storage – but will not disclose the location

According to the current Waste Management Plan, initial on-site storage capacity for 1,5 years of waste production is planned. According to Lynas, this corresponds to a volume amounting to 127,000 m3 of waste. An additional 3.5-year storage capacity is planned in phase 2 amounting to a volume of 1,508,000 m3 of waste. According to Lynas' Waste Management Plan, as the designed storage capacity is reached, it is intended that the waste will be transported to a

[129] NTN 2012
[130] Oekoinstitut 2013
[131] Oekoinstitut 2013
[132] IAEA 2011
[133] IAEA 2011

permanent disposal site. According to Lynas, this location will also be the site where waste from the plant will be stored after closure of the plant at the end of its projected 20 year lifetime [134] and will also accommodate the radioactive waste arising from the future decommissioning of the plant itself. [135] According to media reports, Lynas submitted details and a proposed location for the permanent disposal site in July 2013 to the AELB, but Lynas has so far refused to publicly disclose the location of that disposal site. [136] Lynas' possible planned use of a final disposal site within Malaysia would directly contradict the Malaysian government's demand that no waste should remain in Malaysia. [137]

Difficulty of recycling REE waste

Lynas has been aware of its waste problem from the beginning of the project, but the formulation of a robust waste management plan has been delayed, and the company has asserted that it will be possible to recycle the waste. Thus far, however, this has not been happening. Indeed, it is highly unlikely that Lynas will be able to recycle all of its waste because of the natural radionuclides present in it and their long half-lives. For example, the half-life of Thorium is some 14 billion years.

According to Lynas, the company will 'commercialize' the FDG and NUF wastes in gypsum for plaster board, cement manufacture and road base formulation as well as in Magnesium fertilizer and this will free up storage capacity for 17 years production of WLP. Lynas also claims that it is developing techniques to 'commercialize' the WLP waste and hopes that in this way it will be able to meet the AELB requirement that no waste be stored permanently in Malaysia. [138]

Based on current experience, it is likely that Lynas' proposals for recycling will prove unfeasible and unrealistic. According to the NTN 2012 study, [139] similar approaches using similar waste elsewhere have, thus far, been unsuccessful. The Lynas tailings have similar qualities to red mud tailings from alumina production in Western Australia, but with higher concentrations of radioactive uranium and thorium and of their decay products. The alumina producer has been trying for decades to find a way to make use of its red mud in construction products or as an agricultural "soil amendment." Tests by the Western Australian Department of Health found that the bricks made using red mud resulted in houses too radioactive for human habitation and as a result, no houses were ever permitted to be made using the wastes. The government gave permission for limited trials applying red mud to farmland in the Peel Harvey district, but has never given final permission for red mud to be used as soil

[134] Lynas 2011
[135] Lynas 2011a
[136] Australia Network News 9-10-2013
[137] Joint Ministerial Statement 22-02-2012
[138] Lynas 2011
[139] NTN 2012

amendment. Controversy broke out over the trial after farmers refused to accept any more of the material as evidence started to emerge concerning the toxic compounds it contained and after livestock kept on the farms began to experience unusual sicknesses and deaths.[140] In this regard, it should be emphasized that the Lynas waste, especially the WLP fraction, has a significantly higher radioactive concentration then the red mud used in the above trial. The concentration of 6.2 Bq/g is well above the cut off level used by the IAEA of 1 Bq/g for uranium and thorium series radionuclides, below which it is usually unnecessary to regulate material. It should be stressed that there is not a scientifically assessed safety level and there is no internationally accepted standard below which it is safe to use radioactive wastes in construction materials or as fertilizer.[141]

Even so, Lynas seems intent on producing synthetic gypsum and aggregate co-products on site, doing market trials and trying to obtain necessary regulatory approvals for the export of these products. Lynas also says it has applied for approval from the AELB to use the waste as an aggregate co-product in a road base trial including plans to build a road at LAMP that will be tested and monitored by independent experts over a period of 12 months to demonstrate the performance of the material. The Company has applied to the AELB to approve the release of synthetic gypsum co-products.[142]

Overall, it would be highly unlikely that safe and beneficial recycling options for the WLP waste could be found due to the levels of radioactivity present in the material. Similarly, it is highly questionable whether the less contaminated waste fractions could also be recycled, or put to beneficial use.

Dumping the waste Malawi is not a good option

As part of its business plan Lynas also intended to start mining in Malawi where they have purchased a mine. The REEs from Africa are also intended for processing in Malaysia.[143] This, in turn, would generate a potential requirement for storage of any additional radioactive wastes in Malaysia. Alternatively, it would be plausible for the company to seek an arrangement with the Malawian government to dispose of radioactive waste in its mine there. Neither option seems to be particularly attractive in environmental terms. The ownership of the Malawi mine is disputed[144], however, and further development/ production from this mine was on hold[145] at the time of this writing.

[140] NTN 2012
[141] IAEA 2008
[142] Lynas 2013
[143] Lynas 2008a
[144] The Age 14-11-2011
[145] Lynas 2013

III. Other problems with the Lynas facility in Kuantan

There are other problems with the Lynas plant beyond waste disposal issues or the straightforward environmental risks that the facility poses to human health and to neighbouring ecosystems. These additional objections can be categorised under four major headings, which describe principles that are central and integral to the concept of sustainability and which should underpin and inform any industrial development which takes place. They are elaborated below and include violations of the “Right to Know” principle, the “Precautionary Principle,” and the “Polluter Pays” principle, as well as a failure to develop pollution registries or related clean production policies.

1. Violations of the “Right to Know” and lack of transparency

Neither Lynas nor the national authorities provided information about planned activities, potential pollution, and other risks involved, which might specifically affect nearby residents. Local communities were not consulted at any stage during the planning process and had to fight in the courts and protest on the streets to get access to basic information about the Lynas plant.

Public consultation and participation is a key 'enabler' in Malaysia (and elsewhere) for implementing truly green and sustainable development.[146] In the international arena, Malaysia often tries to project itself as a leading exponent of sustainable development[147], articulating the voices and position of the developing world on development issues. The level of public protests inside the country on the Lynas issue indicates that it has become imperative for the government to walk the talk. The authorities must begin to implement a truly green and sustainable national agenda, in keeping with Malaysia’s leadership role at the ASEAN and international levels. This would also mean ensuring that public and social acceptability becomes a feature of permit issuance processes, especially for environmentally critical projects and ventures (see also Annex 4 ‘Malaysia and Sustainable Development’ for more information and background materials).

2. Authorizing the Kuantan facility violates the “Precautionary Principle”

The authorities’ irresponsible authorization of the Kuantan Lynas facility without appropriate safeguards violates “the precautionary principle” for several reasons. First, the Malaysian authorities are guilty of ignoring the lessons learned from problems with the Bukit Merah REE facility. Second, it is possible

[146] Victor and Agamuthu, see also Annex 4 ‘Malaysia and ustainable Development’ in this report
[147] Hezri and Hasan 2006


KUANTAN
MALAYSIA STOP LYNAS
SAVE MALAYSIA


SAVE MALAYSIA
STOP LYNAS

that without adequate safeguards, the Lynas will pollute its surroundings in ways that may be irreversible, and with serious impacts on human health and the environment. Third, Lynas is generating radioactive waste without a proper management and containment solution for its production waste.

Main ways that authorizing the Kuantan facility violates the "Precautionary Principle"

The opposition to Lynas construction of a new facility stems from Malaysians' awareness of problems over two decades ago with toxic and radio-active waste from the ARE rare earth production facility in Bukit Merah, run by the Japanese company Mitsubishi Chemical (engaged in a $100 million clean-up since the facility closed in 1992).[148] Malaysians are also learning from the extreme environmental challenges that have plagued China's rare earths processing plants. Based on past experience, citizens now expect their authorities to take precautionary action and not allow a company to again create and dump radioactive waste in Malaysia.

Starting operations without a proper solution for the waste that its plant will generate, is the antithesis of a precautionary approach. Lynas is potentially building up a waste stockpile of millions of tons of radioactive waste and, moreover, is imposing the long-term management burden of this waste upon Malaysia. The proposed permanent facility for the disposal of low-level radioactive waste will need a monitoring programme extended over a minimum period of 300 years.[149] In around 20 years time Lynas will have produced over 6 million tons of waste, at least 21% of which (over 1 million tons) would be radio-active.[150]

Precautionary principle:

The Precautionary principle was identified as one of the guiding principles for sustainable development at the Earth Summit in Rio de Janeiro in 1992, which the Malaysian government has also endorsed.

International environmental policy-making has embraced the precautionary principle since the 1980s**.** One of the primary foundations of the precautionary principle, and globally accepted definitions, is enshrined in Principle #15 of the Rio Declaration: [151]

"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

[148] The New York Times 8-3-2011
[149] IAEA 2011
[150] See chapter 4 of this report for detailed information
[151] UNEP 1992

The precautionary principle aims at ensuring a higher level of environmental protection through preventative decision-making and rapid response in the face of possible danger to human, animal or plant health, or a convincing need to protect the environment. In particular, where scientific data do not permit a complete evaluation of the risk, governments and industry should take action to prevent harm if there is enough reason for concern, even in the absence of conclusive evidence.

Hence, on top of its failure to perform adequate consultation with various stakeholders on the Lynas project, the Malaysian government has also failed in its task of critically reviewing environmental and hazard information about the plant's process that would have allowed it to mandate environmental requirements and bring the plant up to international standards and prevent Lynas from imposing its radio-active waste on Malaysia.

3. The government has yet to develop pollution registries and related clean production policies

The Malaysian government has also failed to request and to critically review information regarding environmental hazards – or adequately regulate environmental hazards with appropriate laws.[152]

Moreover, the government is still lagging behind the development of so-called pollution registries (e.g. toxics use and release inventories.) anchored on the twin principles of public right to know and clean production. Monitoring and controlling pollution from existing industrial facilities represents a heavy burden on the part of regulatory authorities. The absence of reliable pollution registries, in countries like Malaysia, only serves to exacerbate a situation, where authorities do not possess the wherewithal and capacity to check industrial facilities for emissions of concern. Establishing a system to collect and disseminate data on pollutants and environmental releases from industrial facilities would help empower both government and local communities living around polluting facilities. An independent, transparent and reliable pollutant register would also give the public an important tool to pressure companies to remove hazardous substances from their production processes.

Currently, Malaysian environmental regulations do exist but there is little real effort to implement and enforce all of them comprehensive and meticulously (see also Annex 4 of this report for more information on environmental laws and disclosure of information in Malaysia). Setting up a Toxics Release Inventory (TRI), for example would include a national database identifying facilities, chemicals manufactured and used at those facilities, and the annual accidental and routine releases of these toxic substances.[153] In so doing, it could also help to change the relationship between the Malaysian government, industry, and citizens – expanding the public's right to know and empowering communities to be partners in sustainable development. The current system of disclosure of

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[152] See Hezri and Hasan 2006 for a good overview of Malaysian environmental laws and regulations, and Ahmad and Mohamad 2013 for analysis of disclosure of information in Malaysia. See also Annex 4 to this report.
[153] United States Environmental Protection Agency 1997.

information in Malaysia is not adequate and lacks credibility.[154]

4. The situation in Kuantan violates the "Polluter pays principle"

A principle, which has been established also for environmental matters and public goods over the past decades, is the "polluter pays" principle, which requires any damage or adverse effects to be prevented, reduced or compensated for by those who initially cause such damage or adverse effects.

The situation in Kuantan violates the "Polluter pays principle" which is crucial in cases of hazardous and radioactive waste management. Indeed, the lack of taxation indicates rather the opposite. The company has been granted a 12-year tax holiday by the Malaysian government and the local communities cannot see the justification for this, given that the company is effectively externalising its environmental costs upon their communities, which will bear the brunt of any pollution and health impacts. This does not reflect a "polluter pays principle" but a "polluter profits principle" and is unacceptable.

A full and coherent liability scheme, which puts the burden of proof on the polluters and follows the polluter pays principle, must be established. In case contamination occurs, the polluting industry must be held strictly liable. Fault-based liability should be established to guarantee that measures to prevent contamination are applied. Numerous other countries have already enshrined the polluter-pays principle in law and policy, and most notably, the Supreme Court of Canada unanimously upheld the polluter-pays principle. In a 2003 decision, the Court stated that the polluter-pays principle 'has become firmly entrenched in environmental law in Canada.' The Court explained the principle as follows: 'To encourage sustainable development, that principle assigns polluters the responsibility for remedying contamination for which they are responsible and imposes on them the direct and immediate costs of pollution. At the same time, polluters are asked to pay more attention to the need to protect ecosystems in the course of their economic activities.' [155] Malaysia could lead the way in promoting the polluter-pays principle in ASEAN.

5. Contrary to expectations, Lynas is not generating downstream high-tech industries

Perhaps lured by the prospect of greater investments, the Malaysian government has, unfortunately allowed itself to be misled by Lynas' claims that

[154] Ahmad and Mohamad 2013, see also Annex 4

[155] Ferrara and Mesquita 2003, "Supreme Court of Canada Upholds a Minister's Application of the Polluter- Pays Principle", Stacey Ferrara and Jennifer Mesquita, Gowling Lafleur Henderson LLP, October 2003. Cited in: Greenpeace 2011, "Comments on the Environmental Assessment Review: Guidelines for Ontario Power Generation's Darlington Refurbishment and Life-Extension Project," Prepared by: Shawn-Patrick Stensil. August 2011. http://www.nuclearsafety.gc.ca/eng/pdfs/japan-earthquake/cmd/Ser-9-GP-Darlington-Refurb.pdf ; (website accessed 30-Jun-14) .

its operation will attract high-tech downstream industries to Malaysia.[156] It appears that so far Lynas has not been able to attract any additional business to Malaysia. An intent signed in 2011 for a joint venture with Siemens to start production of magnets in Malaysia has not been finalized. It is even questionable if this will ever be finalized because of the on-going controversy over Lynas in Malaysia.[157] It is also possible that other green high tech industries that use rare earth products, such as wind-energy and electric cars, will be wary of direct association with Lynas because of its failure to meet the high environmental standards that such industries require. Moreover, the company's end products are destined for export markets in Japan, China and Europe.[158]

6. Lynas is guilty of applying double standards

The evidence indicates that Lynas is guilty of applying double standards by working to lower environmental standards in Malaysia than would be allowable in Australia, or indeed, in many other parts of the world.

The absence of a (radioactive) waste management, decommissioning and site rehabilitation plan for Malaysia contrasts with the practices in Australia. Indeed, the provisions of the permit that Ashton acquired for Australia are much stricter than those of the Malaysian operation[159] (see Table below). This provides additional evidence that the Malaysian operation failed to apply best environmental practices. The Ashton permit application for processing in Meenaar in Australia included a requirement for the submission of a rehabilitation and decommissioning plan for the sites in compliance with the guidelines of the Commonwealth of Australia's Code of Practice on the Management of Radioactive Wastes from the Mining and Milling of Radioactive Ores 1982.[160] The Environmental Protection Authority furthermore, required submission of the details of Environmental Management Systems and Programmes from Asthon.[161] The omission of such plans for the Malaysian operation makes it clear that Lynas intended to operate to lower standards than it would have been possible in Australia, despite statements to the contrary by Lynas executive Nicholas Curtis: *"We will continue to strive to make a positive contribution to Sustainable Development through applying best practices to all our operations. Significant operational steps have been undertaken to ensure we remain true to this commitment."*[162]

This conclusion is also consistent with findings from the Australian based NGO NTN on reviewing the potential waste streams:[163]

[156] See Environ 2008
[157] Siemens 7-7-2011, Malaysian Insider 26-3-2012
[158] Lynas 2013 and other corporate Lynas documents
[159] Free Malaysia Today 9-11-2011
[160] EPA 1992
[161] EPA 1992, EPA 1998
[162] Lynas 2010
[163] NTN 2012

- Malaysian regulators permit SOx, NOx and PM 10 levels that are much higher than WHO guidelines:
- Lynas should have provided detailed air modelling for atmospheric emissions of each major chemical pollutant. That would have been a pre-requisite for an EPA assessment in Australia.
- Malaysian water pollution standards do not include key pollutants from the processing of rare earth such as uranium and thorium, solvents such as trichloroethylene, total petroleum hydrocarbons or fluorides and their discharges may remain unregulated.
- The impacts on the Balok River system of this pollutant loading are unknown as the baseline studies of the river ecosystem, contamination levels and cumulative impacts from other industries has not been presented in the EIA documents by Lynas as would be expected in other jurisdictions such as Australia, the US or Europe.
- No Social Impact Analysis (SIA) was carried out for the community in Balok and the greater Kuantan area, when SIA was a requirement if Lynas was to build its refinery plant at Meenaar in WA.

In addition Oekoinstitut[164] adds the following observations:

- The filtering equipment used by Lynas to reduce gaseous emissions from its cracking stage is not consistent with the current state-of-the-art technology or best available technology in Europe, neither for the removal of acidic gases nor of particulate matter from the off-gas of the plant.
- The EIA was incomplete and had serious flaws (does not provide information on the by-product content of the ore concentrate, no leachate studies were done, no mass balance calculations are presented for other toxic constituents of the ore, etc.).
- The wastewater flows into a 3 km long open discharge channel, easily accessible to humans and to animals.
- The storage facilities are not state-of-the-art with respect to leakage prevention. A state-of-the-art design would use 2.5 mm HDPE and at least two 25 cm layers of clay instead of 1 mm HDPE and only a single 30 cm layer of clay.

The standards to which Lynas operates in Malaysia are also much less stringent than the standards under which the upgraded Molycorp plant in California resumed its production in 2012. Molycorp reuses the process water by pressing it out of the tailings and does not, therefore, need tailing ponds.[165]

Table 5: Double standards under the Australian proposal compared to LAMP in

[164] Oekoinstitut 2013
[165] Rare Earths Investing News 8-10-2012

Malaysia.[166]

Australia	Malaysia
Bury the waste at Mt Weld where it came from. No accumulation of waste at the refinery, the waste is to be shipped to the burial site immediately they are produced.	No permanent waste disposal plan. Temporarily dump on-site.
Distance between Mt Weld and the refinery site at Meenaar is 880 km apart by road.	Raw materials transported 1000 km by land and more than 4000 km by sea to Gebeng.
Nearest population centre is 35 km away, with only 1,500 inhabitants.	700,000 people living within 35 km.
Waste diluted to 2.3 Bq/g.	Waste not diluted, radioactivity nearly 3 times higher at 6.1 Bq/g.
Impermeable ponds, progressively buried upon filling	Temporarily cover the waste using an "unspecified" method.
Located in the desert away from the aquifer. Annual rainfall 234 mm.	On reclaimed swampland. Underground water just 0.95-3.5 m below surface. Annual rainfall 2,860 mm, area prone to flooding.
Total containment policy. All waste water evaporated and all leftover residues returned to Mt Weld.	500 tonnes/hour of wastewater discharged to the South China Sea.

IV. Growing Public opposition against the facility

The on-going protests and subsequent mobilization of tens of thousands of citizens has been a unique chapter in Malaysian history.[167] Although Lynas was granted permission to build the plant by the current government, the project may very well be derailed as a result of the massive groundswell of resistance to the REE facility in Kuantan that has so far culminated in more than one million signatures for a petition demanding Lynas leave Malaysia. The crisis has caught not only the attention of the Malaysian public, but also that of political parties. [168] The *status quo*, under which Lynas has no robust solution for the waste it generates, raises the possibility that the Malaysian government may wish to shut down the plant altogether. This is not an unthinkable scenario: the political opposition in Malaysia has already announced that they want to do precisely this if they come to power amid a growing national public opposition towards the company. The magnitude of the anti-Lynas movement is unprecedented in Malaysia and demonstrates very clearly that polluting industries may face growing scrutiny and oversight in Malaysia in the future. [169]

1. Civil society protests and resistance

[166] Table retrieved from: Nuclear free planet 21-3-2012
[167] New York Times 18-6-2012
[168] Rare Earths Investing News 15-10-2012
[169] New York Times 18-6-2012

When Lynas decided to move production to Gebeng near Kuantan in 2008 residents in the Balok area were alerted by the Malaysian NGO Consumer Association Penang (CAP) that had been involved in the stakeholder consultation in Terengganu, were Lynas first tried to build their plant but where the plans had been rejected by the State authorities. The residents in the Balok area were alerted about the potential generation of radioactive waste and asked Lynas to take back the waste to Australia but the company refused and said it wanted to find a solution for the waste in Malaysia. [170]

After the Fukushima disaster and following the publication of a New York Times article about the planned Lynas facility in Kuantan,[171] the plans started to attract increasing public scrutiny and more and more people joined the anti Lynas protests. Much of the concern was focused on radioactive waste and the lack of a plan to ensure that this waste would not impact upon the local environment and upon human health.

Concerned residents began to organise themselves and in March 2011 the Save Malaysia, Stop Lynas (SMSL) group was formed. [172] The first march of concerned citizens was held on March 30, 2011 when a hundred residents went to the House of Parliament in Kuala Lumpur to present a petition calling for the complete revocation of the Lynas project. In May 2011, two hundred people participated in a ‘Stop Lynas Solidarity Walk’ to the Australian Embassy in order to submit a memorandum to the High Commissioner asking for the project to be stopped. [173]

As the anti-Lynas movement became bigger, more groups joined the campaign, employing different but complementary tactics and approaches. On September 24, 2011 a new anti-Lynas coalition group, the Stop Lynas Coalition, was formed from the 20 or so NGO’s and other civil society groups that were supporting the anti-Lynas position. [174] In February 2012 a green movement group, called Himpunan Hijau, was formed. By then the anti-Lynas movement had grown impressively.
To give an idea of the diversity and growing strength of the anti-Lynas campaign, consider the following: [175]

- On 9th October 2011 a mass protect action with around 6,000 people took place near Taman Gelora in Kuantan
- On February 26, 2012 around 15.000 people gathered at the Kuantan Municipal Council to protest against Lynas.
- On June 24, 2012, around 1000 people joined a protest at the entrance of

[170] Andansura Rabu 2014 (personal communication)
[171] New York Times (8-3-2011)
[172] SMSL blogspot
[173] Tan Bun Teet 2014 (personal communication)
[174] Wikipedia 2014, Entry on Fuziah Salleh
[175] Wikipedia 2014, Entry on Fuziah Salleh


No Lynas On Malaysian Soil !
STOP LYNAS !
Himpunan Hijau
Pilihan Di Tangan Kita !
STOP LYNAS !
Lynas GET OUT NOW !
STOP LYNAS !
祸国殃民
莱纳斯稀土厂
撤 ! 滚
STOP LYNAS !
SAVE MALAYSIA
STOP LYNAS!
SELAMATKAN MALAYSIA, HENTIKAN LYNAS
SAVE MALAYSIA STOP LYNAS!
拯救马来西亚, 中止莱纳斯
மலேசியாவை பாதுகாப்போம்!
லைனாஸ் தடை செய்வோம்!


Pilihan Di Tangan Kita !
STOP LYNAS !
Himpunan Hijau
Lynas GET OUT NOW !
No Lynas On Malaysian Soil !
STOP LYNAS !
Himpunan Hijau
莱纳斯稀土厂
STOP LYNAS !
Himpunan Hijau

the Gebeng Industrial Zone;

- On July 14, 2012 some 26.000 people in 19 cities and towns across Malaysia joined in a ‘National Day of Stop Lynas Action”.
- On 25 November 2012, 70 people started a protest walk from Kuantan to Kuala Lumpur and on November 25 some 20.000 people joined the march when it arrived in Kuala Lumpur itself.
- In October 2013 over 1 million people have signed a petition to stop Lynas, in only 60 days[176].
- On 22 June 2014, 15 Malaysian citizens and one foreign citizen were arrested during what they say was a 1,000-strong protest to blockade the entrance of the Lynas rare earths processing plant in Gebeng, Kuantan, in a new effort to have it shut down.[177]

The resistance to Lynas has become a national phenomenon of historic proportions.

2. Legal actions

Civil society activists and affected residents near the Lynas facility have not stopped at protests, petitions, and other actions on the ground. They have also engaged in a variety of creative legal actions, to block or slow the Lynas facility. The Stop Lynas Coalition (SLC) appealed on February 17, 2012 against Lynas' Temporary Operating License at the High Court in Kuala Lumpur. On March 30, 2012 the Court ordered the AELB to reveal details of the TOL[178] and as a result, local communities and civil society groups were given access to the information. The Kuala Lumpur High Court decided to hold a hearing on April 4, 2012 with submissions from both the Malaysian government and Lynas to the objections of residents. However, on April 12, 2012 the appeal was rejected because it was judged that residents still had the option of an appeal to the Minister and that, therefore, it would be premature for the court to rule on the issue. [179]

In parallel with the court appeal, SMSL had appealed against the TOL to the Ministry of Science, Technology and Innovation (MOSTI) in June 2012, but the Minister did not uphold the appeal. SMSL then appealed against the MOSTI rejection at the High Court in Kuantan though this process was pre-empted when the AELB decided to lift its suspension and issue the TOL on September

[176] The Sunday Daily 29-9-2013, 1,000,000 sign anti-Lynas petition Dorothy Cheng by Posted on 29 September 2013 - 12:08pm http://www.thesundaily.my/news/841994, website accessed 22-8-2014

[177] theguardian.com 23-6 2014, Malaysian police detain Australian environmental activist in custody, Agence France Presse, http://www.theguardian.com/world/2014/jun/23/malaysian-police-detain-australian-environmental-activist-in-custody (website accessed 22-Aug-2014)

[178] The Star online, 20-3-2012 (Updated: Saturday May 25, 2013) Court orders AELB to explain Lynas TOL details by m. mageswari, http://www.thestar.com.my/News/Nation/2012/03/20/Court-orders-AELB-to-explain-Lynas-TOL-details/ (website accessed 22-Aug-2014)

[179] New York Times 19-4-2012

5th. The TOL was again suspended on September 12 by the High Court in Kuantan, pending the review of the appeal made by SMSL. The Court Suspension was finally lifted on November 8, 2012, paving the way for Lynas to start production. [180]

Both SLC and SMSL have subsequently issued appeals against the rejections of the High Courts in Kuala Lumpur and Kuantan and at the Court of Appeals in Putrajaya. But these were unsuccessful for a variety of reasons including lack of legal standing, late filing, etc. The Federal Court in April 2013 decided not to allow residents of Kuantan and SMSL to appeal for a further suspension of the TOL pending a hearing of their judicial reviews at the High Court in Kuantan.

The filing of the aforementioned court cases appears to have been a direct response to the failure of the company to provide plans for the management of its (radioactive) waste. While these actions were not able to prevent Lynas from eventually starting production on November 30, 2012, they delayed the start of production by about six months, considering that Lynas had originally commissioned the plant to begin operating in May 2012. These legal manoeuvres also provided civil society groups with the means to secure access to information that Lynas and the government had either refused, or neglected to put into the public domain. For example on October 10th, 2012, in a hearing at the Kuantan High Court Lynas' lawyers revealed that the company had been issued the ore import and the waste disposal licence, which had not at that stage been announced openly by the Atomic Energy Licensing Board (AELB). [181]

Onerous conditions were imposed to restrict the circulation of some documents. For instance the Radio-active Waste Management Plan commissioned by Lynas in response to the IAEA review was released under severe restrictions. Individuals were allowed to read the documents for only a maximum of one hour and copying or photographing them was not allowed. The submission was initially only open for one week. After strenuous protests this period was extended and people managed to hand-copy the 300-page document word for word.[182] This was certainly counter to the spirit of what the IAEA had intended with its recommendation to improve communication between stakeholders. The AELB in response to the media made the statement that these documents officially belonged to Lynas and *'are therefore subject to their legal rights over the protection of commercial information and intellectual property.'* [183]

Following the theme of restricted access to documents, The Preliminary Environmental Impact Assessment conducted to fulfil obligations to the Department of Environment (a part of the Ministry of Natural Resources and

[180] Malaysiakini 20-11-2012
[181] SMSL press release 12-10-2012
[182] Tan Bun Teet 2012 (personal communication)
[183] AELB 2012c

Environment) was not made available to the public until April 2011, despite having been commissioned by Lynas in 2008, and the same with the Radiological Impact Assessment.[184]

Lynas Corporation Ltd and Lynas Malaysia Sdn Bhd also started a legal action and sued SMSL (and its directors Tan Bun Teet and Lim Sow Teow) at the Malaysian High Court in April and May 2012 for defamation.[185] The Malaysian High Court decided against granting Lynas the defamation injunction in July 2012, and indeed, the High Court ordered Lynas to pay RM5,000 in costs.[186]After SMSL used this defamation suit to apply to the court to obtain documents from Lynas, Lynas dropped the case for no further reason in July 2013.[187]

[184] Jin Hou Soo 2014, personal communication
[185] Free Malaysia Today 1-5-2012 .
[186] Free Malaysia Today 26-7-2012.
[187] Tan Bun Teet 2014 (personal communication)

GREENPEACE Recommendations

To Lynas Corporation, Ltd:

- Close the Lynas Advanced Materials Plant (LAMP) in Kuantan, Malaysia, until reliable and transparent environmental protection protocol and conditions are put in place and an acceptable solution is found for the management of the plant's radioactive waste, and its disposal outside of Malaysia.
- Ensure Lynas Corporation conducts all operations, including those outside of Australia, according to the highest possible standards, and at a minimum to standards and regulations, which would apply under Australian law.

To the Malaysian Government:

- Deny Lynas Corporation a permanent operating license to ensure the health and well-being of its people and to protect the environment, until the company institutes reliable and internationally recognised best practice environmental protection protocols and conditions that are acceptable for all stakeholders for its operations in Kuantan, and comes up with an acceptable solution for the management and disposal of its radioactive waste outside Malaysia.
- Demonstrate leadership in the field of green development and protect the environment of Malaysia by implementing sustainable development guidelines that protect Malaysian environmental and public health interests. To this end the government can adopt guiding principles and regulations which would begin to effectively implement the following, when considering environmentally critical projects and investments and as part of (strategic) environmental assessments:
  - (i) The precautionary principle;
  - (ii) The polluter pays principle;
  - (iii) Public and community acceptance as a requirement of the EIA and related permit approval processes; and
  - (iv) Pollution registries that require disclosure of environmental information from companies, as well as enactment and implementation of "public right to know" policies.

To the Australian Commonwealth Government:

Monitor and implement mechanisms to promote the international application of stringent domestic environmental standards, especially for Australian businesses with operations overseas.

To the Government of Japan:

Discontinue all investment for LAMP as a part owner of Japan Oil, Gas and Metal National Corporation (JOGMEC) and as the most important financier of Lynas in Malaysia via the Japanese consortium Sojitz, in order to prevent a repetition of the radioactive waste legacy scandal at Bukit Merah.

To BASF SE, Siemens AG, and other 'downstream' companies consuming Lynas' REE:

Refuse to enter into supply contracts with Lynas as long as the company is not compliant with best environmental practices, and continues to evade responsibility for dealing with its plant's radioactive waste management and disposal problems.

Annex 1: Rare-Earth Elements

Rare Earth elements (REEs) include the Lanthanides, which are a group of 15 metallic elements atomic numbers 57 through 71, as well as Yttrium (atomic number 39) and Scandium (atomic number 21). Rare Earth elements are actually not rare. On the contrary, they are moderately abundant in the earth's crust, and some are even more abundant than copper, lead, gold, and platinum. Most REEs are not concentrated enough to make them easily exploitable economically.[188] The U.S. Geological Survey estimates the global reserves of the sum of all rare earth oxides that could be economically extracted in future to stand at some 99,000,000 tons. [189]

Rare Earth elements are very stable elements with numerous desirable properties and are increasingly used in a variety of high technology products. Mature applications, including fluid petroleum cracking catalysts, petrol catalysts and glass production, consumed about 60 % of the total REE produced (within these mature market segments, lanthanum and cerium constitute about 80 % of REE used.)[190] The remaining 40% of REE consumed in the world goes towards high-growth new technologies and products, such as the phosphors in colour television and flat panel displays (cell phones, portable DVDs, and laptops), fluorescent lamps, permanent magnets,[191] rechargeable batteries for hybrid and electric vehicles such as nickel-metal hydride batteries, hard disc drives, wind turbine generators, and numerous medical devices (in terms of value of the rare-earth market, it breaks down to 38% for magnets, 32% for lamp phosphors and 13% for metal alloys[192]). In these new market segments, dysprosium, neodymium, and praseodymium account for about 85 % of the rare earth elements used. [193] There are also important military applications for REE, such as jet fighter engines components, missile guidance systems, antimissile defence, and space-based satellites and communication systems.[194]

Lanthanides are often segregated into two groups: light rare earth elements (LREEs) – lanthanum through europium (atomic numbers 57-63) and the heavier rare earth elements (HREEs) –gadolinium through lutetium (atomic numbers 64-71). Yttrium is typically classified as a heavy element. [195] Promethium (atomic number 61) is not generally found in nature.

[188] CRC 2012a
[189] Oekoinstitut 2011
[190] Goonan 2011
[191] Permanent magnets containing neodymium, gadolinium, dysprosium and terbium are used in numerous electrical and electronic components and in the latest design of wind turbine generators. About 75% of permanent magnet production is concentrated in China. See, CRS 2012a
[192] Binnemans et al. 2013
[193] Goonan 2011
[194] CRC 2012a. See also, I am gold corporation, April 2012, Rare Earth Elements 101.
[195] CRC 2012a

According to the USA Congressional Research Centre [196] world demand for REEs will possibly grow from 136,100 tons in 2010 to reach 185.000-210.000 tons by 2015. The non-China annual output would, accordingly, need to be between 45,000 to 70,000 tons to meet global demand for REEs. The lighter elements such as lanthanum, cerium, praseodymium, and neodymium are more abundant and concentrated and usually make up about 80%-99% of a total deposit. The heavier elements – gadolinium through lutetium and yttrium – are scarcer but more desirable. [197]

Table 1. Rare Earth Elements (Lanthanides): Selected End Uses

Light Rare Earths	Major End Use	Heavy Rare Earth	Major End Use
Lanthanum	hybrid engines, metal alloys	Terbium phosphors,	permanent magnets
Cerium	auto catalyst, petroleum	Dysprosium	permanent magnets,
hybrid engines			
	refining, metal alloys		
Praseodymium	magnets	Erbium	phosphors
Neodymium	auto catalyst, petroleum	Yttrium	red color, fluorescent
lamps,			
	refining, hard drives in		ceramics, metal alloy
agent			
	laptops, headphones, hybrid engines		
Samarium	magnets	Holmium	glass coloring, lasers
Europium	red color for television	Thulium	medical x-ray units
	and computer screens		
		Lutetium	catalysts in petroleum refining
		Ytterbium	lasers, steel alloys
		Gadolinium	magnets

Source: DOI, U.S. Geological Survey, Circular 930-N. (from CRC 2012a) [198]

The CRC [199] expects that new mine production may be able to make up the difference for some lighter elements (there may be an excess supply of the lighter elements such as cerium, lanthanum, and praseodymium), it expects likely shortfalls of other light rare earths (LREEs) and several of the heavier rare earth elements (HREEs), such as, dysprosium, terbium, neodymium, europium and erbium. Areas considered to be attractive for REE mine development because of the more desirable HREE content in the ores include Strange Lake and Thor Lake in Canada; Karonga, Burundi; and Wigu Hill in Southern Tanzania. [200]

Most REEs worldwide are located in deposits of the minerals bastnaesite and

[196] CRC 2012a
[197] CRC 2012a
[198] CRC 2012a
[199] CRC 2012a
[200] CRC 2012a

monazite. Bastnaesite occurs as a primary mineral and over 90% of the world's economically recoverable rare earth elements are found in bastnaesite deposits. Bastnaesite deposits in the United States and China account for the largest concentrations of REEs. [201] Monazite is found in primary deposits of other ores (e.g. from tin mining) and typically recovered as a by-product and in the monazite deposits of Australia, South Africa, China, Brazil, Malaysia, and India account. Concerns over radioactive hazards associated with monazite (because it contains thorium) have nearly eliminated it as an REE source in the United States and there are high costs associated with disposal of wastes containing thorium.[202]

The REE market itself is relatively small in global terms at around $US 4 to 6 billion per annum. However, the commercial and military markets that REE feed into are orders of magnitude larger. Despite their relatively high unit cost, REEs are used in small amounts and thus have little impact on the overall cost of most final goods, with the exception of magnet and phosphor producers.[203]

Table: REE production and major applications at the Lynas site in Kuantan[204]

PHASE 1 — 11,000t

REO CAPACITY VOLUMES (tpa)		Major Applications
Ce	2,600	Autocat, Chemical Catalysis
La	1,350	FCC, NiMH batteries
Ce / La	4,000	Polishing, NiMH batteries
Nd / Pr	2,700	Magnet, NiMH batteries
SEG + Heavy Rare Earths	480	Lighting, Magnets

PHASE 2 — ADDITIONAL 11,000t REO CAPACITY. Phase 2 will provide additional finishing flexibility, with capacity to produce up to the following approximate volumes:

Ce	2,600	Autocat, Chemical Catalysis, UV cut
La	1,350	FCC, NiMH batteries
Ce/ La and Ce/ La / Pr	4,000	Polishing, NiMH batteries
Nd/ Pr, Nd and Pr	2,700	Magnets, NiMH batteries, Autocat
SEG + Heavy Rare Earth	480	Lighting, Magnets

201 CRC 2012a
202 CRC 2012
203 Packey 2013
204 Lynas 2013

Annex 2: Key end-users for Lynas' REE production: Sojitz, Siemens, BASF

Japan is the most important market for Lynas' REE. In 2011 Lynas signed an agreement with the Japanese consortium Sojitz to supply 30% of the Japanese market over the next 10 years, until 2021. The New York Times reported[205] that according to its contract with Sojitz, Lynas had to commit to shipping 3,000 tons of products to Japan in 2012 and increasing these shipments to over 9,000 tons a year by early 2013. In return, Sojitz has provided a US$250 million loan and equity to Lynas and may acquire a direct stake in the mine at some point in the future.[206] The deal between Sojitz and Lynas has financial support from the Japanese government-backed Japan Oil, Gas, and Metal National Corp. (JOGMEC). This sum was allocated for the construction of additional capacity at the plant from 11.000 tons to 22.000 tons a year.[207] Because production is still behind schedule and revenues from production remained low in 2013, Lynas was not able to meet the requirements of the Sojitz agreement. On 13 September 2013 the terms and conditions of the Sojitz loan were adapted by Sojitz to allow extra time for Lynas to gear up its production, but according to the new conditions, Lynas has to pay back the US$225 million loan by 31 March 2016, that started with a first payback of 10 million on 19 January 2014.[208] The previous repayment schedule was of 5 equal six monthly instalments of US$45 million from 31 March 2015 to 31 March 2017.[209] This means that as a result of not meeting the requirements of the original agreement with Sojitz, the start and end-date of the repayment schedule have been moved a full year forward in time, which is likely to put extra financial pressure on Lynas.

Lynas signed a letter of intent in 2011 with German firm Siemens to form a joint venture for the production of magnets.[210] A final agreement for the joint venture was expected to be signed in 2012 but Siemens backed out, which may indicate that Siemens is concerned about the controversy attached to Lynas operations in Malaysia.[211]

In September 2011 Lynas also signed a long-term supply agreement with BASF Corporation, headquartered in Germany. Under terms of the agreement, Lynas would supply BASF with a pre-determined annual volume of lanthanum for the production of BASF's fluid catalytic cracking (FCC) refinery catalysts and certain chemical catalyst products. Additional contract details remain confidential.[212]

[205] New York Times 24-11-2010
[206] The New York Times 24-11-2010
[207] Sojitz press release 30-3-2011
[208] Lynas 2014, 1st Q 2014 financial report
[209] Lynas 2013
[210] Siemens 7-7-2011
[211] Malaysian Insider 26-3-2012, Theantdaily 14-11-2013
[212] BASF 2011

Annex 3: China, the main REE producer in the world

With a global shift towards a more high-tech and greener economy, REEs are becoming part of a group of crucial components of modern industrial production and have recently become new elements of geopolitical power. [213] The major importers of rare earth compounds in 2008 were Europe, USA and Japan with a total of 78,000 tons, around 90% of which were imported from China – indeed, China provides 95 to 97% of REEs used worldwide, which gives China considerable leverage over the market. [214]

In 2006, China began decreasing exports of rare earths because of increasing internal demand and environmental concerns. This generated uncertainty of supply among key industries worldwide including the automotive and electronics industries and caused significant price increases throughout 2009 up to and including the first three quarters of 2011. As a result, some companies with a critical dependency upon these elements have chosen to relocate to China to assure a cheaper and more reliable supply of rare earths. [215] In September 2010 China also suspended rare earth exports to Japan after a maritime dispute near the contested Senkaku/Diaoyu islands. In response to this and to China's domination and effective control of the REE supply, Japan and South Korea have both attempted to reduce their reliance on, and vulnerability to, Chinese rare earth supplies. Seabed exploration and mining is being explored, in some cases in disputed territories, which might ultimately contribute to further geopolitical tensions and instability in the East Asian region. [216] Since 2010, China has imposed strict export quotas on REEs. The United States, Japan and the European Union have complained to the World Trade Organization about Beijing's efforts to control the sector, claiming that China is trying to use its dominance over supplies to drive up prices and gain a competitive advantage. However, China has repeatedly stated that it no longer wants to pay the environmental costs of supplying the vast bulk of the world's rare earths. In 2013 China restricted its exports to 93.800 tons of rare earths. [217]

Price for REEs in recent years has been very volatile. After China announced its REEs export quota in 2010, prices went up dramatically and in 2011 they were nearly 11 times higher than in 2009. But in September 2011 prices dropped sharply again, because of a reduction of demand. Reacting to the price peak of 2011, many companies had reduced their usage of REEs or switched to alternative materials. [218] Unstable supply and fluctuating prices make recycling and substitution a viable option in the longer term. Effective recycling, recovery, and reuse of spent consumer and industrial products could also reduce the

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[213] Ting and Seaman 2013
[214] Oekoinstitut 2011
[215] CRS 2012b
[216] Ting and Seaman 2013
[217] Reuters 6-9-2013
[218] Bongaerts and Liu 2013

need to develop new mining areas.[219] In Japan and the EU there are many new initiatives on recycling and substitute technologies for rare earth metals.

Because of the increasing demand, rising prices and possibility of shortages looming, not only did recycling and substitution spread, but also REE production outside of China started up again. Russia is currently starting REE production from existing ore stockpiles for domestic use. TriArkMining plans to extract about 40,000 tonnes of rare earths from monazite concentrate stored in warehouses in Russia over the course of seven or eight years starting from 2015.[220] Indian Government owned Indian Rare Earths Ltd is starting up a 5,000 metric ton production unit in the eastern state of Odisha near Gopalpur. Japan's Toyota Tshusho Corp., a part of the Toyota Group, will buy half of Indian Rare Earths production from the monazite ore, which is part of a government-to-government agreement.[221] Beyond Russia and India, it appears that the rare-earth "bubble" has generated an old-fashioned style "gold rush," as miners in ore-rich countries like Australia, Kazakhstan, Mongolia, and Afghanistan have announced plans to bring new supplies to market.[222] In 2010 and 2011 a total of 381 REE exploration projects were started.[223]

However, it is expected that not all these projects will be developed because there are many environmental risks and economic and technological challenges involved in REE mining and production. According to a US EPA study, the process of exploration, development, and construction typically required before mining can begin may take 7-10 years.[224] Currently only Molycorp in the USA and Lynas in Australia/Malaysia are in a position to start up significant production of REEs outside of China.[225] Aside from Lynas, Molycorp is the only other major REE producer of interest outside of China. Molycorp was one of the largest global suppliers in the 1990s but had to close down in 2002 due to environmental issues and high production costs that could not compete with the cheaper Chinese production costs. In 2008 Molycorp invested 1 billion USD in order to resume production at the Mountain Pass mine in California. The Molycorp operation has been upgraded to meet the high environmental and safety standards required by Californian law.[226] In order to pass all the environmental and safety requirements under Californian and USA laws, Molycorp has stricter environmental management measures in place then Lynas. Based on past experience, Molycorp implemented improved efficient mining and processing technology that still allows the company to produce but at lower prices.[227] Thus, in the end, Molycorp managed to restart production in the USA

[219] USEPA 2012
[220] Reuters 10-9-2013
[221] Bloomberg 30-10-2013
[222] Fortune 12-12-2011
[223] Bongaerts and Liu 2013
[224] USEPA 2012
[225] Bongaerts and Liu 2013
[226] CRS 2012a
[227] Fortune 2011

at a much faster pace, lower production costs and under much stricter environmental standards than Lynas. Molycorp finalized the commissioning of production capacity of 19,500 tons at the end of 2013[228] and will ultimately upscale to a total of 40,000 tons per year[229] (To realize this, the company will need to invest a further US$ 895 million and expect this will increase its global market share of REEs to around 30%[230]). Molycorp has designed a RE-oxide separation process that uses fewer reagents and recycles the wastewater, thus doing without a disposal lagoon. According to their calculations, this complex but effective process separates out the individual elements while making them the lowest-cost operator. Molycorp anticipates production costs at around $2.77/kg versus an estimated $5.58/kg in China and a potentially much higher operational cost at Lynas in Malaysia. Molycorp engineers suggest that they will use one-half the amount of ore to get the same amount of usable end product. In addition, they will use fewer reagents, use “full loop” recycling, and will have no evaporation ponds.[231] Molycorp learned their lessons from the past and internalized the environmental costs, while Lynas is externalizing the environmental costs on local communities, which is now backfiring on the company. Living up to high environmental standards as Molycorp does, would make good business sense and enrich Lynas. Even with the much stricter environmental requirements in Australia it would have been a better choice for Lynas to build its processing plant in Australia and internalize the environmental costs, as Molycorp did.

[228] Molycorp press release 19-12-2013
[229] USEPA 2012
[230] Rare Earths Investing News 8-10-2012
[231] CRS 2012a

Annex 4: Malaysia and Sustainable Development

The World Commission on Environment and Development (WCED) defines 'sustainable development' as *'development that meets present needs without compromising the ability of future generations to meet their own needs'.* According to the WCED sustainable development is process of change in which the utilization of resources, the direction of investments, and the orientation of technological development and institutional change are made consistent with present, as well as future, needs. Sustainability also requires that the responsibility for the impact of decisions be shared and calls for a greater public participation in decision-making.[232]

Malaysia was a pioneer in the 1970s in establishing a framework for environmental governance and took a leading role in developing the sustainable development agenda in the 1990s.[233] According to Hezri and Hasan, several factors determined Malaysia's leadership role. Economic success had earned Malaysia the respect and confidence of the developing world, and as a leader of the Group of 77, Malaysia began to be acknowledged as spokesperson of the South. In 1989 Malaysia began to champion the position of the South at international meetings. Malaysia, as Chair of G-77, drafted the Langkawi Declaration on Environment and Development, which incorporates concepts of equitable sharing of responsibilities and benefits, and defines the ability of developing countries to respond to environmental challenges. In 1993 Malaysia was appointed as the founding Chair of the United Nations Commission of Sustainable Development (CSD).[234]

However, according to Hezri and Hasan, policy statements were not backed by credible institutional reform in Malaysia, and national implementation of the sustainable development agenda remained poor. Although integration of environmental policy can be observed in policies such as the National Spatial Policy, the National Mineral Policy, the Third National Agriculture Policy, and the Fuel Diversification Policy (including the promotion of cleaner production in industrial manufacturing), these changes stayed mostly on paper. Environmental objectives were incorporated into the structures of non-environmental agencies and organizations, but these initiatives were mainly expressions of policy formulation.[235] Although the Malaysian Third Outline Perspective Plan (2001–2010) maintains that the nation will pursue 'environmentally sustainable development to reinforce long-term growth,' economic growth is still the overarching objective in Malaysia.[236] as in many other countries. Malaysia's limited performance against the principles of sustainability can be explained by its weak institutional capacity to tackle policy contents. Available sustainability

[232] WCED 1987
[233] Hezri and Hasan 2006
[234] Hezri and Hasan 2006
[235] Hezri and Hasan 2006
[236] Hezri and Hasan 2006

choices might often be perceived as overly costly alternatives to the status quo. Many of the principles of sustainable development – subsidiarity, community empowerment, policy integration – require difficult political and economic reforms, to become a reality.[237]

According to Sania[238] the government has acknowledged that reforms are needed, and that implementation is lagging behind. Sania attributes the government's lackadaisical attitude to reform for sustainable development to a number of reasons: the government's strong focus on a very broad concept of national security, which combines public order, racial and religious harmony, economic strength, social welfare, political stability, and strong government; and the fear of economic recession.[239]

The lack in implementation of sustainable development is also evidenced in the Malaysian policy to attract industries, according to Ang.[240] Research suggests that degradation of the environment precedes economic growth in Malaysia, according to Ang, and an increase in pollution level is not surprising given the focus on heavy industry. Ang points out that this pattern of development is consistent with the experiences of many developing countries.

An analysis of economic growth and CO2-emissions (as an indicator of pollution) in Malaysia by Saboori et al.[241] shows that in the short term the increase in industrial activity does lead to increase in pollution but not to an increase in Gross Domestic Product. This analysis also indicates that emission reduction policies and more investment in pollution abatement would not hurt economic growth and could be a feasible policy tool for Malaysia to achieve its sustainable development in the long run.[242]

This suggestion that the focus can shift away from direct benefits towards environmental sustainability in Malaysia is consistent with findings from a recent study by Victor and Agamuthu of Malaysian Environmental and Solid Waste management (SWM) policies.[243] The authors concluded that public participation and capacity building are important strategic environmental policy enablers for long term sustainable development. In fact the study concluded that public participation and capacity building may be the most critical in developing projects and more important than perceived barriers and benefits and other drivers including environmental knowledge and attitude.[244] This is consistent with the conclusion of the IAEA from their Lynas review that there was a lack of

[237] Hezri and Hasan 2006
[238] Sani 2013
[239] Sani 2013
[240] Ang 2008
[241] Saboori et al. 2012
[242] Saboori et al. 2012
[243] Victor and Agamuthu 2013
[244] Victor and Agamuthu 2013

public participation in the process. [245] The 2013 study of Victor and Agamuthu[246] also concluded that environmental considerations in Malaysia are usually integrated only during the environmental impact assessments (EIA) such as with the landfills or incinerators. However at that stage a large portion of the decision making process had been completed including the justification for the need of a project, its location and the technologies to be adopted. The authors conclude that this often leads to sub-optimal options for decision makers in integrating environmental considerations at the project levels, which in turn may lead to public dissatisfaction and non-optimal environmental management measures.[247] An example they refer to is a 0.5 billion USD incinerator project initiated in 2001, which was revoked by the government in 2007 in response to public protest and residents' lawsuit against the project. [248] The challenges of integrating environmental concerns/ objectives/issues in the SWM study, according to the authors, was mainly due to existing top-down policy formulation and the project based EIA centric environmental management framework. This policy formulation process has often been perceived as highly bureaucratic, lacking public participation with minimal cross-sectoral horizontal environmental policy integration, [249] as opposed to a strategic environmental assessment approach, which comprises the preparation of an environmental report and the carrying out of public participation and consultations. [250]

According to Furuoka and Lo[251] Malaysia's drive for industrialization and the country's pursuit of development programs, combined with flaws in its environmental laws, its various tax incentives, cheap labour, and relative political stability, make it an attractive destination for foreign investors. These authors acknowledge the importance of foreign investments for a developing country because new factories and plants give job opportunities and provide venues for the transfer of technology and knowledge. Based on the Bukit Merah case, however, and comparisons with pollution cases in Japan, e.g. in Minimata, they conclude that it is no less important to find a balance between economic development and preservation of the environment to ensure that the health of people, arguably a country's most valuable resource, is not jeopardized. [252] They also concluded that, unlike Japan, no 'structural change' in the relationship between the state and civil society has taken place in Malaysia. The state and civil society remain unequal partners in negotiations; this obstructs the formation of an acceptable strategy for both sides that could resolve pollution issues. [253] It would appear in the case of Kuantan, where citizens have only very limited access to information needed to come to an informed position on the impacts of

[245] IAEA 2011
[246] Victor and Agamuthu 2013
[247] Sutton, 1999 cited in: Victor and Agamuthu 2013
[248] Loong et al., 2007 cited in: Victor and Agamuthu 2013
[249] Victor and Agamuthu 2013
[250] Hezri and Hasan, 2006
[251] Furuoka and Lo 2005
[252] Furuoka and Lo 2005
[253] Furuoka and Lo 2005

the development project in their area, that history is repeating itself.

Annex 5: REE recycling and substitution

The absence of economical and operational primary deposits on their territory means that many countries and companies will have to invest in recycling of pre-consumer and of post-consumer End-of-Life products with REE content. Recycling of REEs also has the advantage that there are no thorium issues and that the composition of the obtained REE concentrate is less complex. [254] For instance, Solvay Group has opened two rare earth metals recycling plants in France to recover the metals from end-of-life products, such as light bulbs, batteries and magnets. These light bulbs are rich in six different REEs, including lanthanum, cerium, terbium, yttrium, europium and gadolinium.

Although many initiatives on recycling started, commercial recycling of REEs is still extremely low, less than 1%. [255] Bottlenecks in REE recycling are the collection methods, the REE price volatility, non-optimal product designs for recycling, and the long lifetime of products. For instance, magnets used in wind turbines, large electric motors and generators in hybrid and electric cars will be in service for long periods of time and are not currently available in large quantities in scrap. [256] A comprehensive, economically viable strategy still needs to be developed to realize large-scale REE collection and recycling. [257]

Table: Examples of some main reported recycling activities [258]

REE application	Major used REEs	Company/researcher	Recycling activities
Magnets disk	Nd, Dy	Hitachi,	Magnet from air condition, hard and compressors (Hitachi, 2010)
		Zang et al.	Rare earth from Nd magnet scraps
Batteries	Nd,	Honda, Toyota	Batteries from Hybrid car (Honda, 2012)
		Umicoreand Rhodia	Nickel Metal Hydride (NiMH)
Batteries			
		TU Bergakademie Freiberg	
Rare earth metal from the slag of the pyro-metallurgical treatment of used Ni-MH batteries			
Lighting	Ce, La, Y, Gd, Tb, EU	OSRAM	Yttrium and europium from discharge lamps
Resende and Morais Yttrium and europium from TV tubes an computer monitors			
Other electronics		Kosaka Smelting	Neodymium and Dysprosium

254 Binnemans et al 2013
255 UNEP 2011
256 Binnemans et al 2013
257 De Boer and Lammertsma 2013
258 Bongaerts and Liu 2013

Beyond recycling, many companies have the option of substitution of REEs. There is a lot of interest in inventing motors that can do without REE magnets. Inverto, a research and development company based in Ghent, Belgium, have a so-called reluctance motor running in a car. At Newcastle University, in Britain, researchers are working with several companies to produce reluctance motors for both cars and lorries. The Tokyo University of Science has experimented with a reluctance motor in a Mazda sports car.[259] Auto manufacturer Ford recently stated that its nickel-metal-hydride batteries will soon be replaced with lithium-ion alternatives in a move that could see the company cut 500,000 pounds of REEs from its manufacturing process annually.[260]

Annex 6: Relevant laws

- International law
  - Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, 1989. (Malaysia became a party in 1993)
  - Convention on Fishing and Conservation of Living Resources of the High Seas, 1958. (Malaysia became a party in 1960)
  - United Nations Convention on the Law of the Sea, 1982. (Malaysia became a party in 1996)
  - Convention on Wetlands of International Importance, especially as Waterfowl Habitat (Ramsar Convention), 1971. (Malaysia became a party in 1995)
- Malaysian law
  - Atomic Energy Licensing Act (Act 304) 1984
  - Environmental Quality Act of 1974; and subsidiary legislation as at 14th August, 2007
  - Environmental Quality (Clean Air) Regulations 1978 – P.U. (A) 280/78
  - Environmental Quality (Sewage and Industrial Effluents) Regulations 1979
  - Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987
  - Environmental Quality (Scheduled Wastes) Regulations 1989
  - Environmental Quality (Scheduled Wastes Treatment and Disposal Facilities) Order 1989
  - Environmental Quality (Scheduled Wastes Treatment and Disposal Facilities) Regulations 1989.
  - Environmental Quality (Water Pollution Control) Regulations 1998
  - Radiation Protection (Licensing) Regulations 1986
  - Radiation Protection (Transport) Regulations 1989

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[259] Economist 2012
[260] Rare Earths Investing News 8-10-2012

- Radiation Protection (Basic Safety Standards) Regulations 2010
- Guidelines on Radiological Monitoring for Oil and Gas Facilities Operators Associated with Technologically Enhanced Nationally Occurring Radioactive Materials (NORM) September 1996
- Occupational Safety and Health Industry Code of Practice for Road Transport Activities (OIR)

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" Greenpeace is active in many part of Asia. Our work in the region has included stopping hazardous waste imports, opposing radioactive shipments, campaigning against forest destruction, halting the spread of GMOs, stopping dirty and polluting technologies like waste incinerators and coal power plants, promoting renewable energy, and advancing sustainable solutions to key environmental problems. We made a commitment to develop a presence in Asia in late 80s and early 90s, and first established an office in Japan (1989) and then China (1997). Initial investigations were also initiated in SEA, focusing primarily on Indonesia and Philippines. After many years of investigations and establishing campaign presence in key countries, Greenpeace succeeded in opening an office in the region. Greenpeace Southeast Asia was formally established on March 1, 2000. Greenpeace now has hundreds of thousands of members in Indonesia, Thailand, and the Philippines (globally Greenpeace has 2.8 million supporters worldwide); and offices in Bangkok, Jakarta, and Manila. Each office is governed by a board, which appoints a representative called a trustee. In each office, trustees meet once a year to agree on the long-term strategy of the organisation, to make necessary changes to governance structure, to set a ceiling on spending, and to elect the Board of four members and a chairperson. Often working with other local groups, Greenpeace has run successful campaigns in the Philippines, Thailand, Malaysia, and Indonesia. Through its campaigns, Greenpeace aims to protect the region from further ecological ruin and serve as beacon of awareness and action for environmental protection and sustainable development. "

www.greenpeace.org/seasia/

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