JAWATANKUASA PILIHAN KHAS MENGENAI PROJEK LYNAS ADVANCED MATERIALS PLANT (LAMP) YANG BERTEMPAT DI KAWASAN INDUSTRI GEBENG, KUANTAN, PAHANG DARUL MAKMUR

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IKATAN DOKUMEN/BUNDLE OF DOCUMENTS (BOD)

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attention of the review team. The review team wishes to emphasize its appreciation of the good interactions and views shared with it.

Main findings

The review team provides the following independent expert opinion, recommendations and suggestions for good practice:

Compliance with international radiation standards

The review team was not able to identify any non-compliance with international radiation safety standards. However, the review team identified 10 issues for which it considered that improvements were necessary before the next licensing phases of the Lynas project. Those recommendations are listed below and discussed in more detail in the report. The review team also added an 11^{th} recommendation dealing with the manner in which recommendations 1–10 should be acted upon.

Recommendations

Where the review team considered that improvements were necessary, it made recommendations. The report presents and discusses the situations and bases for each of those recommendations separately. The following 11 important recommendations are made:

Technical recommendations

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[1] in support of such a plan. The safety case should address issues such as:

   (a) Future land use (determined in consultation with stakeholders);
   (b) The dose criterion for protection of the public;
   (c) The time frame for the assessment;
   (d) Safety functions (e.g. containment, isolation, retardation);
   (e) The methodology for identification and selection of scenarios – this must include the scenario in which the residue storage facility at the Lynas site becomes the disposal facility for the WLP solids;
   (f) Any necessary measures for active and/or passive institutional control.

   As the safety case is developed, the radiological impact assessment (RIA) for the facility as a whole should be updated accordingly.

[1] In terms of the IAEA Safety Glossary, a safety case is a collection of arguments and evidence in support of the safety of a facility or activity. This will normally include the findings of a safety assessment and a statement of the confidence in these findings.

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 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 optimization 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 purposes 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. The financial provision should be regularly monitored and managed in a transparent manner.

6. For regulating the Lynas project, the Malaysian Government should ensure that the AELB has sufficient human, financial and technical resources, competence and independence.

7. The AELB and the relevant Ministries should establish a programme for regularly and timely updating the Regulations in accordance with the most recent international standards. In particular, regulations pertinent to NORM activities relevant to the proposed rare earths processing facility should be considered to be updated.

Public communications recommendations

8. The AELB should enhance the understanding, transparency and visibility of its regulatory actions in the eyes of the public, particularly those actions related to inspection and enforcement of the proposed rare earths processing facility.

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 processes;
   (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 earths processing facility (except for security, safeguards and commercially sensitive information) and ensure that the public knows how to gain access to this information.

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10. Lynas, as the party responsible for the safety of the proposed rare earths 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.

Follow-up recommendation

11. Based on recommendations 1–10 above, the Government of Malaysia should prepare an action plan that:

    (a) Indicates how the above-mentioned recommendations are to be addressed;
    (b) Sets out the corresponding time schedule for the actions;
    (c) 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.

Good practices

The review team identified examples of good practices and made acknowledgements in recognition of good organization, arrangements or performance, which can contribute to the sharing of experience and exchange of lessons learned on an international basis.

(a) The review team took particular note of the dedication, commitment and professionalism displayed by the Malaysian Atomic Energy Licensing Board in regulating the Lynas project.

(b) The review team was encouraged by the approach shown by Lynas Malaysia Sdn Bhd towards the management of solid residues from the proposed rare earths processing plant, in that it was actively investigating safe ways of recycling and reusing such residues in order to minimize the amount of radioactive waste that would need to be disposed of. This approach is a good example of how to fulfil Principle 7 (Protection of Present and Future Generations) of the Fundamental Safety Principles (IAEA Safety Standards Series No. SF-1).

Acknowledgements

(a) The review team appreciates the request of the Malaysian Government for this review mission.
(b) The review team appreciates the Malaysian Government's commitment to improve radiation and nuclear safety in Malaysia and in the region.
(c) The review team appreciates the opportunities that were provided for meeting various groups of the public in sessions that were well organized and allowed individual views to be expressed to the review team.

Structure of the report

The structure of this report follows the typical IAEA review mission report structure. This opening chapter on introduction and main findings is followed by discussions on the relevant legal and regulatory framework, radiation protection, waste management,

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3. WASTE MANAGEMENT

Basis for the review

The IAEA Fundamental Safety Principles, Safety Fundamentals No. SF-1 state that "Radioactive waste must be managed in such a way as to avoid imposing an undue burden on future generations; that is, the generations that produce the waste have to seek and apply safe, practicable and environmentally acceptable solutions for its long term management. The generation of radioactive waste must be kept to the minimum practicable level by means of appropriate design measures and procedures, such as the recycling and reuse of material."

This principle is elaborated in the "Predisposal of Radioactive Waste, General Safety Requirements Part 5, No. GSR Part 5" and it is stated, for example, that "Measures to control the generation of radioactive waste, in terms of both volume and radioactivity content, have to be considered before the construction of a facility, beginning with the design phase, and throughout the lifetime of the facility, in the selection of the materials used for its construction, and in the control of the materials and the selection of the processes, equipment and procedures used throughout its operation and decommissioning. The control measures are generally applied in the following order: reduce waste generation, reuse items as originally intended, recycle materials and, finally, consider disposal as waste."

Management of solid residues[3]

The processing of the rare earths concentrate will give rise to three main solid residue streams, characterized by relatively large volumes of material and low concentrations of thorium, uranium and their decay products (see Table 1):

(i) Flue gas desulphurization (FGD) residue;
(ii) Neutralization underflow (NUF) residue;
(iii) Water leach purification (WLP) residue.

TABLE 1. CHARACTERISTICS OF SOLID RESIDUES

Residue	Radioactivity concentration (Bq/g)		Dry mass, year 1 (t)	Assumed dry density (t/m^3)	Annual volume (m^3)		Volume after 10 years (m^3)
	Th-232	U-238			Year 1–2	Year 3–10	
FGD	0.04	0.003	27 900	1.05	26 600	53 200	478 800
NUF	0.03 combined		85 300	1.05	81 300	162 600	1 463 400
WLP	6	0.2	32 000	0.70	45 800	91 600	824 400
Biosolids[a]	–	–	913	0.28	3 318	6 636	29 864
Total	–	–	146 113	–	157 018	314 036	2 796 464

[a] This is a minor residue stream in the form of a sludge from the waste water treatment plant and has no radiological significance.

[3] NORM residue means material that remains from a process and comprises or is contaminated by naturally occurring radioactive material (NORM). A NORM residue is waste if no further use is foreseen.

Each of the solid residues will be subjected to pressure filtration in readiness for storage in the residue storage facility (RSF), and is therefore expected to be in filter cake form with a moisture content of 30–40%. The residues will be transported to the residue storage cell, spread and compacted. The RSF (including the associated waste water treatment plant) covers approximately 48 ha. Construction of the storage cells is presently nearing completion.

The radionuclide concentrations in the FGD and NUF residues are expected to be very low – similar to the average values in normal rocks and soil worldwide (and in Malaysia) – but would nevertheless require to be specifically exempted from the provisions of the Atomic Energy Licensing Act in order not to be treated as radioactive waste. In the event of them being exempted, they might then fall within category of 'scheduled waste' in terms of the Environmental Quality (Scheduled Wastes) Regulations 2005, depending on their chemical composition. For practical purposes, however, the AELB and the Department of Environment (DOE) have agreed to defer any such decisions for the first one or two years of plant operation so that they can remain in storage at the RSF under the designation 'radioactive waste'.

Lynas intends to recycle and reuse the solid residues to the extent possible in order to minimize the amount of waste that eventually will have to be disposed of. This is in line with the IAEA Fundamental Safety Principles, Safety Fundamentals No. SF-1 mentioned above. A study commissioned by Lynas on management options for the solid residues (*Lynas Advanced Materials Project Preliminary Comparison of Residue Disposal Options*, Worley Parsons, January 2008) focused on the potential for reuse of the solid residues. Lynas informed the review team about the research and development activities aimed in particular at recycling and reuse of the WLP residue. The development of a 'synthetic mineral product' by adding 5% WLP to hydrated lime and using this as an additive to concrete is one of the applications being investigated. However, it is expected that at least some of the WLP will end up having to be disposed of as waste.

The detailed design of the RSF is presented in "Residue Storage Facility - Detailed Design Report" dated 11 December 2009 and takes in to consideration the geological, hydrological and meteorological characteristics of the site and the nature of the waste to be stored. The embankments for the residue storage cells and waste water treatment plant lagoons are constructed of earth fill and/or dried and compacted FGD and NUF residues. The design of these embankments has included extensive geotechnical analysis and modelling to ensure acceptable factors of safety. Seepage analysis and settlement analysis of embankments were also carried out during the design. Embankment slopes and basins incorporate leachate control measures, decant water structures, erosion protection and emergency spillways. The design process has also incorporated an analysis of failures such as ground subsidence and embankment failure.

Under normal operating conditions, stormwater from the FGD and NUF cells is to be processed through the waste water treatment plant, while WLP stormwater is diverted (recycled) back to the leaching process. Stormwater management also takes into consideration the very unlikely reoccurrence of some very high rainfall events recorded in the past.

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Discharges to the environment

All liquid waste streams arising from the plant operation are expected to be treated and discharged into the drainage system at an average rate of 213 m^3/h via a dedicated pipeline into a nearby river (Sg. Balok), provided that authorized discharge limits are met.

Gaseous waste generated from the processing of the rare earths concentrate will be passed through a scrubbing system for the removal of particulates, sulphur dioxide and sulphur trioxide, and will be discharged from a stack at a height of 34 m. The amount of gaseous waste discharged is estimated to be 35 000 m^3/h.

Disposal of solid waste

The IAEA "Fundamental Safety Principles, Safety Fundamentals No. SF-1" state that "Radioactive waste must be managed in such a way as to avoid imposing an undue burden on future generations; that is, the generations that produce the waste have to seek and apply safe, practicable and environmentally acceptable solutions for its long term management." The intention of Lynas to recycle and reuse the solid residues to the extent possible is in accordance with these principles.

Lynas intends to temporarily store the WLP residue on site at the RSF. Any of this residue that cannot be recycled and reused will eventually have to be disposed of in a disposal facility. The study on management options for the solid residues (*Lynas Advanced Materials Project Preliminary Comparison of Residue Disposal Options*, Worley Parsons, January 2008) discusses the disposal of the solid residues as waste, in the event that the option of recycling and reuse proves not to be feasible. However, no specific management option to be used as a design basis for a waste management site was selected. Post-closure development options of the waste site were discussed, and the data needed to address such potential uses were outlined. However, the time scale that the waste management area needs to function and the possibility of future events that could affect the integrity of the waste management site (e.g. flooding, erosion) were not addressed.

Findings

Regarding waste management, the review team was not able to identify any non-compliance with international radiation safety standards. However, the review team has identified issues concerning the management of solid residues and disposal of waste where it considers that improvements are necessary before the next licensing phases of the Lynas project.

Management of solid residues

The review team considers that the segregation, characterization and storage of the various solid waste streams have been adequately addressed at this licensing phase. In revising the project documentation before the start of operations, Lynas should present more details of the planned programme for radioactivity monitoring in the RSF and surrounding environment. The review team welcomes the efforts on the part of Lynas to investigate suitable, safe ways of recycling and reusing the solid residues, since this will contribute to the minimization of waste that would need to be disposed of in the future, in line with the IAEA Fundamental Safety Principles.

Although the decision to store the flue gas desulphurization (FGD) and neutralization underflow (NUF) residues on site for the first year or two of operation has practical advantages, the review team considers it important for criteria to be in place for these residues to be declared non-radioactive (that is, exempted from the provisions of the Atomic Energy Licensing Act). This would enable them to be removed from the site and disposed of either as normal industrial waste or as scheduled waste, depending on their chemical characteristics. The AELB should develop criteria that would allow such an exemption to be granted.

Discharges

The review team considers that the information provided on gaseous and liquid discharges is adequate and acceptable for the current licensing stage of the project. However, Lynas should elaborate on the monitoring programme for both types of discharge before the plant is put into operation.

Disposal of solid waste

Although the site for a disposal facility is currently not identified, Lynas need to demonstrate that the disposal of solid waste can be carried out in a safe manner over the long term. The review team was informed by Lynas that the RSF will be designed to meet stringent requirements such that, if necessary, it could become a permanent disposal facility. The review team considers it appropriate that Lynas assess this option even if the waste will be relocated to another site, since it will help to build confidence that disposal can be carried out safely.

In the documentation made available to the review team, disposal of the WLP is discussed in the Conceptual Decommissioning Plan (which is an update of the Lynas Waste Management Plan dated 17 January 2008). The RIA presents some results of calculations of the long term consequences should the WLP remain in the RSF (up to approximately 1500 years after the termination of operations). For a variety of reasons, these calculations are not considered sufficient for the next licensing phases. The review team recommends that for the next licensing phases, the AELB requests Lynas to develop a formal safety case based on the IAEA's recently published safety requirements on "Disposal of Radioactive Waste, Specific Safety Requirements No. SSR-5". These requirements specify important components that must be addressed, such as:

(a) *Future land use.* Assessments of the radiological consequences should consider different scenarios concerning possible land uses and evolution of the site and facility over time. It is a good practice to consult stakeholders on issues such as possible land uses and the review team recommends that this be done.
(b) *The time frame for the assessment.* This addresses the question of how far into the future the radiological consequences are to be assessed. In line with international radiation safety standards, an appropriate time frame should be proposed by Lynas and reviewed and approved by the AELB.

(c) *Description of the various safety functions of the disposal facility.* Examples include the containment and isolation of the waste and the capability to delay (retard) the migration of radionuclides.

(d) *The methodology for identification and selection of scenarios.* The range of scenarios considered should include the scenario in which the RSF at the rare earths processing site becomes the disposal facility for the WLP solids.

(e) *Any necessary measures for active and/or passive institutional control.* Institutional controls are put in place to prevent intrusion into the facility and to confirm that the disposal system is performing as expected by means of monitoring and surveillance. Internationally it is not unusual to plan for institutional controls to be in place over time periods of the order of 300 years. In line with international radiation safety standards, any necessary measures for institutional control should be proposed by Lynas and reviewed and approved by the AELB.

(f) *The dose criterion for protection of the public.* The "Disposal of Radioactive Waste, Specific Safety Requirements No. SSR-5" recommends using a dose constraint of 0.3 mSv per year or a risk constraint of the order of 10^{-5} per year[4]. The RIA mentions that the AELB has used a constraint of 0.3 mSv per year in the past. This is consistent with international standards.

Another important component of the safety case is the management of uncertainties. There are always some remaining uncertainties related to factors such as the detailed characteristics of the waste, the evolution over time of the disposal facility and the environment. The safety case should discuss how uncertainties are to be managed.

When designing the disposal facility and developing the safety case, a graded approach has to be adopted, depending on the hazard potential of the waste and the complexity of the site and disposal facility design. The WLP contains relatively low concentrations of naturally occurring radionuclides and thus the hazards are equally low. It can therefore be assumed that the development of the safety case will be straightforward and that it can rely on established methodologies and assessment tools. The safety assessment is discussed in more detail in Section 6.

The review team recommends that the AELB require Lynas to submit a plan setting out its intended approach to the long term management of the WLP residues after closure of the plant, together with a safety case in support of such a plan. The RIA for the entire facility should be updated to account for the conclusions of the safety case.

Recommendations

- 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 purposes of regulation, so that they can be removed from the site and, if necessary in terms of environmental regulation, controlled as scheduled waste.

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[4] Risk due to the disposal facility is to be understood as the probability of fatal cancer or serious hereditary effects.

- 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. The safety case should address issues such as:

(a) Future land use (determined in consultation with stakeholders);
(b) The dose criterion for protection of the public;
(c) The time frame for the assessment;
(d) Safety functions (e.g. containment, isolation, retardation);
(e) The methodology for identification and selection of scenarios – this must include the scenario in which the residue storage facility at the Lynas site becomes the disposal facility for the WLP solids;
(f) Any necessary measures for active and/or passive institutional control.

As the safety case is developed, the RIA for the facility as a whole should be updated accordingly.

CAP-SAM Written Submission to MOSTI /AELB: Review of the Lynas documents "Radioactive Waste Management Plan" and "Safety Case for Radioactive Wastes Disposal"

Date: 20 January 2012

Introduction

The Lynas Radioactive Waste Management Plan (RWMP) poses more questions about the professionalism, competence and ethics of the entire review and compliance process. The inclusion of controversial provisions inter alia on the reuse and recycling of radioactive wastes; the arbitrary classification of radioactive wastes which radically differs from the latest International Atomic Energy Agency (IAEA) classification of radioactive wastes; the glaring and shocking omission of the Decommissioning and Cessation plans; and the non-identification of the Permanent Disposal Facility and its casual dismissal by Lynas even as it prepares to commence operations, renders the RWMP inherently flawed, makes the public review process meaningless and invalidates the RWMP as an expert document.

Our comments are, *inter alia*:

1. The Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011 or P.U.(A) 274

Unknown to the public, this newly minted Regulations which was gazetted on 16 August 2011 and quietly put up on the Malaysian AELB's website to coincide with the release of Lynas' RWMP, has created new provisions which allow the reuse and recycling of radioactive materials. For example:

'Part VI REUSE AND RECYCLE OF RADIOACTIVE MATERIAL.

Reuse and Recycle

9. The licensee shall, before declaring radioactive material including a sealed source as radioactive waste, consider whether he or any other person can make use of or recycle the radioactive material.'

The regulations are very general and actually give a licensee carte blanche to manage the radioactive wastes upon approval from AELB. It appears that this piece of legislation has been specifically crafted to meet Lynas' needs and propitiously timed to allow Lynas to apply for the temporary operating licence (TOL) thus facilitating Lynas to circumvent the problem of the storage of radioactive wastes which until today it has failed to provide a credible solution.

Compared to the IAEA General Safety Guide, the new Malaysian P.U. (A) 274 regulations do not clearly set limits or standards for exemption of radioactive wastes based on radiation exposure that is allowed for individuals.

According to the IAEA GSG-1 (General Safety Guide-1, pp8-9) on the category Exempt Waste (EW), ***'The primary radiological basis for establishing values of activity concentration for the exemption of bulk amounts of material and for clearance is that the effective doses to individuals should be of the order of 10 µSv or less in a year. To take account of the occurrence of low probability events leading to higher radiation exposures, an additional criterion was used, namely, the effective doses due to such low probability events should not exceed 1 mSv in a year. …'***

This is in sharp contrast to Lynas' own Radiological Impact Assessment (RIA) report which states: 'The highest possible doses to be received by workers resulting from operation of the plant for the first 10 years are below 13mSv per year' (RIA, p71). It further states 'that there will be a period of about 1500 years from now when members of the public may get doses as high as 6.23 mSv/y from the residue' (RIA, p68).

The RIA concludes that the 'estimated individual annual doses for the driver, loader and all workers working in the process areas of the plant are between 3.04 x 10^{-2} mSv/y to 12.68 mSv/y' with workers 'depositing the WLP residue' will receive radiation doses of 4.34 mSv/y (RIA, p63).

Please note that the upper limits of exposure mentioned in the Lynas RIA report itself is much higher than the allowable limit set by the IAEA for the wastes to be categorised as Exempt Wastes (or Cleared Wastes, under the P.U.(A)274).

We now have a situation where AELB has arbitrarily set its own safety standards for radiation exposure, which is not according to the international standard. The AELB standards will be used to exempt and clear Lynas' radioactive wastes for reuse and recycle. This would endanger public health.

2. Lynas labels its radioactive wastes as 'residue'

Page 1 of the Executive Summary of Lynas' RWMP states:
'While this document is termed as a Radioactive Waste Management Plan, Lynas considers the process waste generated from the LAMP operation to be "residues" as these waste streams can be reprocessed and commercialized in a variety of applications. The term "waste" is not preferred at this stage as it denotes an end product or material suitable only for disposal after all avenues for reuse and reprocess have been exhausted. This assumption is consistent with the Atomic Energy Licensing (Radioactive Waste Management) Regulations, 2011 which requires reuse and recycle options to be fully explored before any radioactive material is declared as radioactive waste meant for disposal.'

Since the regulations P.U.(A) 274 allow radioactive wastes to be used and recycled, Lynas is taking advantage of this clause to declare that its radioactive wastes are harmless and safe. This enables Lynas to submit its RWMP plan as it can now claim to have fulfill AELB's requirements.

However, not all Lynas' LAMP wastes can be reprocessed and commercialised. As stated in the RWMP report itself, all is still at the research stage with potential of not being successful, and appear only on the 'drawing board'.

The controversial P.U.(A) 274 regulations cannot be used to render radioactive wastes as non-radioactive.

Lynas' Radioactive Waste Management Plan (RWMP) emphasis towards reuse and recycling of the radioactive wastes is based on this flawed assumption of the wastes being suitable for reprocessing and commercial use as per the P.U.(A)274 provision for reuse and recycling. This reveals Lynas' cavalier attitude towards public health and environmental safety.

More disturbing is the fact that the imported Lathanides concentrates itself already contain a total radiation activity of 61 Bq/g, and has Thorium (ThO) content of 1600 ppm and Uranium (U_3O_8) content of 29 ppm, as reported in the Lynas EIA itself (EIA, pp2-6).

Moreover, the final disposal material i.e. the Flue Gas Desulfurisation Residue (FGD), the Neutralisation Underflow Residue (NUF) and the Water Leach Purification residue (WLP) also **contain** Uranium and Thorium. These are ultrahazardous materials. Lynas is duty bound to demonstrate satisfactorily how it will manage and dispose of these radioactive substances before it generates the wastes.

The new P.U.(A) 274 regulations legitimises what Lynas is doing and AELB is a party to this.

3. Comparison of IAEA and AELB radioactive wastes classification schemes

According to the IAEA General Safety Guideline (GSG-1), the latest IAEA radioactive wastes classification has six categories. However, under the Malaysian AELB's P.U.(A)274 Regulations 2011, its radioactive wastes classification has only five categories. The missing one category in the Malaysian AELB regulation is a very crucial category.

Under the IAEA classification scheme, the Lynas' WLP (Water Leach Purification) wastes would fall under the LLW (Low Level Waste) or VLLW (Very Low Level Wastes) categories. Both LLW and VLLW would require a regulatory control of disposal, including a specified engineered disposal area.

Unlike the IAEA radioactive wastes classification, AELB's five categories in its wastes classification do not include a 'very low level waste' (VLLW) category. In the First Schedule of the P.U.(A) 274, there are three categories of Low Level Wastes but <u>no</u> category of VLLW. If AELB has subsumed the VLLW into its Cleared Wastes category,

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it does not need to regulate the WLP residues. Lynas will attempt to fit its WLP wastes into the Cleared Waste category, going by its expressed intention to reprocess and commercialise the 'residues'.

It would appear that using AELB's radioactive wastes classification, the WLP would presumably fall under the Cleared Waste (Exempted) category allowing it to be used and recycled, and, 'scattered everywhere' as according to AELB DG Raja Datuk Abdul Aziz Raja Adnan.

As discussed earlier, under the IAEA GSG-1 guideline, any wastes to be categorised as Exempted Wastes (EW) has a very low limit allowed for individual exposure in mSv/year. However, the AELB P.U.(A)274 is not clear on its Cleared Waste category and on what basis the cut off points are made.

Despite reassurances from Lynas' safety advisor Professor Ismail Bahari (former UKM radiology professor) that 'it can dilute the WLP to below 1Bq/g to be used as a base in road building', the volume of radioactive wastes generated makes it physically impossible to do so. Professor Ismail says that 'if you mix the WLP with 10 times the amount in the soil, it is already at ground level (radiation)'. Please note that the Lynas EIA (pp5-53) estimates that 145,200 tons of wastes will be generated annually i.e.

- The WLP (Water Leach Purification) residue from the Cracking and Separation plant (32,000 tonnes per year at 62 Bq/g)
- The FGD (Flue gas desulphurization) residue from the waste scrubber system (27,000 tonnes per year at 0.47 Bq/g)
- The NUF (Neutralization Underflow) residue from the HDS treatment system (85,300 tonnes per year at 0.25 Bq/g).

Over a 10-year period of the plant's operation the total volume of wastes will amount to 2,766,600 cubic meters (EIA, Table 5.51, pp5-54). Over a 20-year period, presumably double the amount. It is inconceivable that there will be enough soil and technology available to 'dilute' the wastes and remove its radiation level to natural ground level radiation. This is especially crucial as Lynas plans to store the wastes onsite in the Residue Storage Facility (RSF).

Moreover, WLP wastes contain 5.91 Bq/g of Th-232 and 0.23 Bq/g of U-238. Th-232 has a half-life of 14 billion years and the LAMP is projected to generate 1,248,000 tonnes of WLP over a 20 year operating life, as stated in the RWMP report itself (RWMP, Document 2, pp 52-56).

AELB needs to explain which IAEA standards it has used for the radioactive wastes classification. It would appear that earlier categories from IAEA's 1994 classification were used despite the fact that IAEA has since improved its safety classification.

AELB needs to explain the scientific and technical basis of the various cut-off points for its Cleared Wastes category. More importantly AELB must use the internationally accepted standards for exemption e.g. based on IAEA GSG-1 (which limits individual effective exposure to less than 10uSv and should not exceed 1mSv in a year) or even better. Or have a look at how UK did theirs. Instead of using internationally accepted standards, is AELB arbitrarily concocting its own? AELB needs to come clear on this.

4. RWMP did NOT include Decommissioning and Cessation

According to the Lynas document under review, '***the Management of Radioactive Residue generated from decommissioning activities of the LAMP upon cessation of operations after 20 years are not within the Scope of this RWMP but presented in a separate document entitled "Decommissioning Plan (ENVIRON 2011b)".***'

The above statement i.e. that the decommissioning and cessation is not within the scope of a comprehensive radioactive waste management plan flies in the face of international standards. The IAEA's GSG-1 Fundamental Safety Principles (Fig. 1) list out seven General Safety Requirements, of which Part 6 is on 'Decommissioning and Termination of Activities'.

According to IAEA, the 'Safety Requirements establishes the requirements that must be met to ensure the protection of people and the environment, both now and in the future'. Thus 'Decommissioning and Termination of Activities' must be part and parcel of a national regulatory framework and the government is responsible to ensure that this is fulfilled. This is in line with international good practices reflecting best practices to achieve high levels of safety.

Why is the report 'Decommissioning Plan for the Advanced Materials Plant, Gebeng Industrial Estate, Kuantan.' by the consultancy firm for Lynas i.e. ENVIRON (2011) not included? After a 20-year operation period, the amount of wastes would be considerable and this will affect any decision now whether to permit Lynas to begin its operation. This makes the Decommissioning and Cessation plan imperative. Again Lynas has not complied with full information and public disclosure. Moreover, for Lynas to state that decommissioning activities of the LAMP is not within the scope of the RWMP is totally unacceptable.

Thus, the public review process of an **incomplete** RWMP is totally meaningless.

5. Permanent Disposal Facility (PDF) not indentified

According to the Lynas RWMP document under current public review, ***'….. upon plant closure after 20 years, any remaining residue within the RSF will be transported off site to a permanent disposal facility (PDF) for long term storage. At the time of report preparation (December 2011), the proposed site for the PDF had not been identified'.***

This was publicly affirmed by Lynas managing director Datuk Mashal Ahmad when he said that a PDF will be needed in a 'worst case scenario' where it is unable to reprocess the waste into a commercial product. According to him 'we have 17 years before we even need to identify where is the PDF … we are working on commercial applications … Once we find all this, we can even **forget** about a RSF (Residue Storage Facility)'.

He said the PDF only came about during the IAEA expert review of the Lynas project in June2011. 'Why did the PDF come about? It is because the IAEA said 'very good but tell us the worst case scenario. That is why this topic came about. Not because Lynas doesn't know what to do', he added.

Note that the storage capacity for the RSF is for five years only (RWMP, p5); whereas Datuk Mashal says the RSF is only for 1.5 years of operation 'because of the high level of confidence in finding the solution'. Given the huge volumes of wastes that will be generated, the need of a PDF is absolutely fundamental. This is all the more crucial when the RSF caters for a storage capacity of only one and a half years to five years. What are the concrete plans for storage of the radioactive wastes when the RSF reaches full capacity? What is going to happen to the wastes after 20 years when Lynas folds up?

Note that the final wastes product as mentioned earlier contains ultrahazardous thorium, uranium, etc. The sheer volume of these radioactive materials built up over time adds on to the background level of radiation. This will increase the concentration and radiotoxicity levels.

Note that the wastes in the Bukit Merah rare earth plant 20 years ago is still being cleared up at the cost of over RM300 million with lives lost and children maimed. Being the largest rare earths processing plant in the world, Lynas' capacity to generate wastes is said to be ten times as much as the Bukit Merah plant in Perak.

Using IAEA yardstick for comparison, Lynas compares this PDF wastes with that of a natural uranium ore body and wastes from a uranium mill. Malaysia does not have uranium outcrops or uranium mills. Having these ultrahazardous wastes amounts to adding a foreign hazard to the environment. Please note that WLP wastes contain 5.91 Bq/g of Th-232 and 0.23 Bq/g of U-238. Th-232 has a half-life of 14 billion years and the LAMP is projected to generate 1,248,000 tonnes of WLP over a 20 year operating life, as stated in the RWMP report itself (RWMP, Document 2, pp52-56).

The RWMP foresees the possibility that the FGD and NUF radioactive wastes will be exempted from regulation by the AELB and be treated as classified scheduled wastes under the purview of the Environmental Quality Act 1974 (EQA 1974) and its subsidiary regulations which will be enforced by the Department of Environment (DOE), Ministry of Natural Resources and Environment. However, DOE list of Scheduled Wastes Schedule 1 of the Environmental Quality (Schedule Waste) Regulations, 2005 deals specifically with heavy metals wastes from batteries; from iron and steel factories; from metal processing e.g. zinc and copper; oily sludge; tar residues from oil refinery and petrochemical plants; acid wastes; clinical wastes and pharmaceutical wastes; wastes containing dioxins or furans; contamination of soil and debris from cleaning up chemical, oil, mineral spills; wastes from the production of pesticides, biocides; and other chemicals. The DOE scheduled wastes list has no category for the kind of wastes that Lynas is producing i.e. radioactive wastes containing Uranium and Thorium.

For public safety purposes, it is crucial that the onsite and offsite wastes disposal areas be known. What happens if there is no suitable site to be found later to hold the massive amounts of radioactive wastes, especially the WLP wastes? Risk management requires anticipating the unexpected which can have major repercussions. Planning for such 'black swan events' is in line with the Precautionary Principle.

6. Confusion between Baseline data for Malaysia vs. for Gebeng

According to the baseline background readings as published in year 2000 by UNSCEAR, Malaysia's 'baseline level' is 0.051 uSv/j or uSv/hour (AELB Data monitoring document, AELB website). The location/s of the UNSCEAR baseline reading is not mentioned, presumably the data was not specifically measured in the Gebeng area.

It is highly important to note that the UNSCEAR baseline background data for Malaysia is NOT the baseline background reading for Gebeng.

The AELB cited the UNSCEAR (2000) readings and compared the Malaysian baseline readings to other countries and found the Malaysian value to be slightly higher (albeit with a correction announced by AELB due to its mistake in value conversion in an earlier report):

Malaysia= 0.051 μSv/j or **μSv/hour**
Thailand = 0.043 μSv/j
China = 0.035 μSv/j
Filipina/ Indonesia =0.031 μSv/j

In the AELB report, in its conclusion section, it cited UNSCEAR (2000) readings in a different unit:

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Malaysia iaitu 0.45 mSv/thn or **mSv/year**
Thailand (0.38 mSv/thn)
China (0.31 mSv/thn)
Filipina/Indonesia (0.27 mSv/thn)

However, in 2011 when the AELB (Atomic Energy Licensing Board) conducted measurements for a short 4-month period (August – November 2011) for the Gebeng Industrial area and Kuantan, AELB claims that its readings (e.g. August – November is ca. 0.2 uSv/hour) is four times higher than the UNSCEAR (2000) 'background radiation' in Malaysia which is 0.051 uSv/hour.

Note that AELB's mistake in basic conversion of units casts a huge doubt on its technical competency. Moreover, AELB did not provide technical specifications of the instruments it used for measuring the readings. It is basic requirement in basic scientific reporting (even in university students' reports) to indicate basic technical specifications of instruments used.

What is even more perturbing is that AELB baseline monitoring report fails to cite other sources of baseline readings specifically done for Gebeng area. For example, the Malaysian Nuclear Agency (MNA) already made baseline readings specifically at the Lynas area in 2008.

Scientifically, this MNA data (February – December 2008) is to be considered the baseline data for the Lynas and Gebeng area - if there are no earlier readings done for the area. However, before the other existing industries began operating at Gebeng, it is logical to assume that even earlier readings were made for their legally-required EIAs and RIAs at Gebeng.

When AELB already admitted to making mistakes in its conversion units earlier, perhaps it has done another similar mistake here? In addition, the fact that AELB did not cite earlier background radiation measurements (e.g. MNA values measured in 2008) specific for Lynas/Gebeng area already cast doubts on AELB's technical scientific competency.

If AELB claims that the background radiation reading is already high in Gebeng, it is the more reason not to increase radiation here. This supports the argument that radiation levels should not be increased by activities such as Lynas that will generate massive amounts of radioactive wastes and radioactive toxicity.

7. AELB has no legal provision for public review?

In a public reply to CAP and SAM, on 18 January MOSTI/AELB admits that the Atomic Energy Licensing Act (Act 304) does not provide the legal provision for public consultation or display in such situation. It further states that the application documents for the temporary operating licence (TOL) for Lynas' are copyrighted documents that **legally** belong to Lynas. This reveals that AELB in effect has no power to fulfill fundamental safety issues and safeguard public health and safety. This is utterly shocking, a regulatory agency that is supposed to look after public health and other important obligations have no legal provisions for public information and review process. AELB also cannot ensure compliance, due diligence and international best practices in carrying out its functions.

On 17 January, AELB announced that the public viewing will be extended until 24 January. After realising that the extension period will be public holidays in view of the Chinese New Year holidays and all offices and workplaces will be closed, AELB announced on MOSTI website that the extension period will be until 26 January. This latest extension notice did not appear in the printed media or online. The entire public relations exercise reflects an ad hoc approach, poor planning, non transparent, non independent, capricious behaviour which is clearly unreasonable and unprofessional.

This being the case, AELB has failed to adhere to international standards and practices in carrying out its duties. It has no capacity and competency to regulate Lynas.

Conclusion

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Despite the time-constraint due to the extraordinarily limited duration of the public review duration, CAP-SAM analyses as listed above demonstrates that the Lynas Radioactive Waste Management Plan (RWMP) and Safety Case for Radioactive Wastes Disposal are totally inadequate and not up to an acceptable international standard. The RWMP is inherently flawed, makes the public review process meaningless and invalidates the RWMP as an expert document. The AELB's competency to regulate such activities also is questionable.

In conclusion, Lynas should not be given a temporary operation licence or otherwise.

Attached: **Appendix 1 - AELB not adhering to IAEA recommendations on Lynas**

Malaysia not adhering to international recommendations on Lynas

The manner in which AELB and Lynas Corporation are conducting public disclosure makes a mockery of international best practices, safety standards and the various International Atomic Energy Agency (IAEA) recommendations which the government and Lynas had pledged they will honour.

Public Information and disclosure

Among the other IAEA recommendations relevant to public disclosure are:

Lynas should 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.
AELB should intensify its activities regarding public information and public involvement.

These recommendations are an implicit acknowledgment by the IAEA that Lynas and AELB have all along operated in a non-transparent, unacceptable manner and both entities have to improve their policies on public disclosure and consultation with the rakyat.

Over the New Year holiday on 2nd January 2012, the Ministry of Science, Technology and Innovation (MOSTI) announced that the Malaysia Atomic Energy Licensing Board (AELB) will display Lynas' application for a temporary operating licence (TOL) for public feedback for barely 11 working days at several locations - AELB headquarters in Dengkil, Selangor; the Pahang State Secretariat, Kuantan; AELB's site office at Lynas, Gebeng; and AELB's east coast branch office Kemaman, Terengganu. Those who want to read the document have to submit a form provided at the locations before noon on Jan 20th (sic).

These restricted locations and the process requirements are impediments to the public who want to view the document. The restrictions including the AELB form requirement is also tantamount to public intimidation.

In comparison, the Department of Environment (DOE) allocates a much longer review period without any requirement to fill up a form beforehand. The DOE allocates 5 weeks for a review of a Preliminary EIA (PEIA) report and 12 weeks for review of a Detailed EIA (DEIA) report. (For example, the DEIA Report for the Proposed Hydroelectric Project Hulu Terengganu by Tenaga Nasional Berhad was on public display from 30 Sept - 31 Oct 2008 at several specific locations and at all State offices of the DOE and the written comments must be submitted by 13 November 2008. The Executive Summary of the DEIA was also available online on the DOE website. The DEIA could even be purchased from a clearly indicated address. (Source: http://www.wwf.org.my/about_wwf/what_we_do/policy_main/policy_what_you_can_do/detailed_environmental_impact_assessment_for_public_review_2.cfm). There was no requirement for members of the public who wanted to review the DEIA to fill up a form, as is currently required by the AELB).

It is important to note that the DOE EIA Review process is clearly explained in DOE documents such as its widely published EIA Guidelines, Handbooks and also on the DOE official website, including details of the composition of the Review Panel etc. In stark contrast, the AELB seems to be an ad hoc, non-transparent, non-independent and much hurried process which may be susceptible and has clearly led to unfair and unprofessional practices. This indicates that the AELB has poor governance and has not fulfilled the recommendations made by the IAEA report to significantly improve AELB, inter alia, AELB technical skills and capacity as well as independence in order for AELB to handle regulation of industries such as Lynas.

Other impediments include, inter alia, members of the public who made time to view Lynas' application were given ONE hour to read the 300-400 page technical document, and barred from carrying cameras, handphones and videocameras when inspecting the document. Some members of the public was escorted to the AELB office by Lynas staff, once again indicating that AELB is not independent. This also reveals the utter disregard and contempt the authorities, including the AELB, have for public accountability and transparency. The level and quality of engagement and consultation with the rakyat have been woefully inadequate. The project was hurriedly approved in 2008, without public consultation; a series of public discussions that had been planned were abruptly cancelled after only two sessions. The MB of Pahang refused to meet and hold talks with groups who opposed the project and called them irrational.

By not adhering to a credible process of public review as recommended by IAEA, the AELB should reject the Lynas project application for a temporary or permanent operating licence.

IAEA general safety guideline on and Classification of Radioactive Wastes

According to the IAEA's general safety guides (GSG) on Radioactive Waste Classification (GSG-1), the radioactivity level of Lynas' WLP solid waste which is reportedly at 6.2 Bq/g is categorised as Low Level (radioactive) Waste. The IAEA GSG-1 states that wastes in this class requires robust isolation and containment for periods of up to 300 years and is suitable for disposal in engineered near surface facilities. The typical safe storage depth is from the surface down to 30 meters.

According to Dr Lee Chee Hong in his comments (August 2011) on the IAEA Report, if the classification of Radioactive Wastes Safety Guide (GSG-1) was to be enforced for the WLP residue, then the RSF (Residue Storage Facilities) disposal method proposed by Lynas would be violating the IAEA standards.

Thus, a temporary operating licence (TOL) for Lynas would be contrary to the IAEA standards, safety guidelines and its specific recommendations on how AELB and the Malaysian government should be managing Lynas.

TOL under Act 304 does not fulfill IAEA recommendations

The temporary operation licence (TOL) is a stipulation of the Malaysian Radiation protection (Licensing) Regulations 1986 of the Atomic Energy Licensing Act 1984 (Act 304) – the main law governing radiation protection. However, Act 304 and its subsidiary regulations are sadly lagging behind international standards. Act 304 is very general in nature and woefully inadequate to handle rare earth processing plants especially the regulation of the safety aspects of the rare earth process, the radioactive waste disposal and storage, clearance threshold, radiation leakage, and health and safety damages caused by radioactive elements. Act 304 does not even regulate NORM (naturally occurring radioactive materials) and TENORM (technologically enhanced naturally occurring radioactive materials). More significantly, the Act invests wide ranging discretionary powers to the AELB and the Minister.

Thus, as far as the archaic Act 304 is concerned, theoretically, industries such as Lynas are potentially allowed to accumulate and dispose the water leach purification (WLP) radioactive solid waste residue on site if they obtained a written authorisation (e.g. TOL) from AELB. This is one way that Lynas can bypass the permanent waste storage impasse.

Given that the licensing and approval process hinges on the safe disposal and storage of radioactive wastes, it appears that Lynas has failed to come up with a credible solution to meet the conditions set out by the IAEA review. This is attested by the fact that Lynas has made five submissions (officially three) which were all rejected and the current one on display is the 6th revised version (officially the 4th).

According to Lynas Malaysia managing director Ahmad Marshal in a media event in December, the plan is to process the wastes into, among others, fertilisers and gypsum boards for sale. Under the current Act 304 and its subsidiary regulations that do not set disposal limits or the method of safe disposal and storage of radioactive wastes, what Lynas proposed could be done albeit with potential future consequences. It is left to the incompetent AELB alone to decide the exemption limits and methods for safe disposal and storage.

However, the TOL and its consequences would be contrary to IAEA standards, guidelines (e.g. the GSG-1) and specific recommendations for AELB and Lynas. IAEA recommendations have called for AELB to improve its human, financial and technical resources, competence and independence before it is deemed fit to regulate Lynas. To date there is no evidence that the Malaysian government and AELB have adhered to the IAEA recommendations. Currently, AELB cannot and is incapable of regulating Lynas and similar industries.

TOL is against Precautionary Principle

A temporary licence for activities generating radioactive wastes does not make sense neither is it based on international best practices principles – as once the wastes is produced, it is there. This is also not in keeping with the Precautionary Principle that Malaysia has agreed to in many environmental agreements and guidelines. The Precautionary Principle states that in the absence of scientific consensus that the action or policy is harmful, the burden of proof that it is not harmful falls on the proponent. The principle promotes social responsibility to protect the public from harm.

As well the Malaysian authorities have failed to observe international best practices and legal principles other than the Precautionary Principle e.g. the Local Agenda 21 on sustainable development; public consultation and participation and the principle of prior informed consent; and public accountability and transparency.

AELB Independence: Ministry responsible is MITI or MOSTI?

The Ministry of International Trade and Industry (MITI) indicated that AELB will meet on 30 January 2012 to decide on Lynas' TOL application. It is highly perturbing that MITI continues to overstep its jurisdiction by yet again overtaking the role of MOSTI/AELB in the Lynas regulation process.

When the PEIA and RIA were made available to the public as a result of public pressure, there were serious doubts on the whole approval procedure and due diligence process. In fact, the poor governance made the credibility of the regulatory process doubtful. The regulatory authorities revealed that they were incapable of safely monitoring the Lynas operation, the radioactive wastes storage, disposal and decommissioning process in the future. To compound the problem further, MITI overstepped its jurisdiction and became the self-appointed spokesman endorsing the safety of Lynas's plant operations. As it is, MITI is not the qualified ministry for the governance of ultrahazardous radioactive activities and public health and safety concerns. This again shows the poor governance and lack of due diligence in the whole process.

The MB of Pahang had said that the radiation level from Lynas' plant is lower than bitumen used to resurface roads. AELB's previous public announcements have also stretched the public's credulity to the limit e.g. AELB DG Raja Datuk Abdul Aziz Raja Adnan had in April said that Lynas' radioactive waste was so safe 'you can just tabur (scatter) everywhere'. Such unqualified endorsements that the Lynas plant was safe by both unqualified politicians and the civil authorities can only mean they have become the spokespersons for Lynas.

The 'seamless' roles of Lynas employees and AELB's officials makes the latter's independence and authority highly questionable. When Lynas revealed in May 2011 that it had paid a sum of money to the Malaysian authorities as an indemnity for radioactive waste as part of AELB requirement, the DG of AELB denied this. 'It's got nothing to do with AELB. You got to check with MIDA. Check with MITI' he was quoted. Till today no information has been forthcoming from any authority.

This poor governance structure and non-transparency has resulted in the IAEA international experts to make a clear recommendation that the AELB/MOSTI must have independence from other influences in order to be able to regulate industries such as Lynas.

Conclusion

The AELB should not issue a temporary operating licence (TOL) to Lynas.

Further, for the Malaysian government to regain public credibility and confidence CAP-SAM urges the following:

• A judicial review of the government's role and responsibilities in relation to public information disclosure and public participation;

• A transparent process with a detailed and integrated approach that incorporates a socio economic impact assessment, health and safety impact assessment, a detailed EIA and RIA which will be coordinated and reviewed by an independent panel of technical experts;

• A total review and revamp of Act 304 and its subsidiary regulations. At present it is a weak and toothless law and it needs to meet the requirements of international standards;

• AELB/MOSTI, DOE/MNRE, MIDA/MITI and MOH must be independent and must be seen to be independent when it comes to issues which are within their jurisdictions. They must exercise integrity, professionalism and competence in their duties and work. This is in line with good governance;

• MITI and MIDA (Malaysian Investment Development Authority) must beef up its capacities and expertise. There must be a review of MITI and MIDA and how it promotes foreign investments. They need to attract clean, sustainable and job creating industries instead of dirty toxic ones;

• MITI and MIDA should respect the authority and competency of the regulatory authorities and should not guarantee projects which have not been approved by other regulatory bodies;

• In the interest of good governance, there should be public disclosure and access to proposed MOUs with foreign investors. In light of this, the government must disclose how much it will have to pay Lynas Corp if the project is cancelled;

• The government must ensure that all impact assessment studies have high standards of integrity, professionalism and expertise. Consultants who fail to meet the standards should be deregistered and blacklisted; and

• The government must seriously improve its governance.

Letter to the Editor - 11 January 2012

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23. Information required for application to site, construct and operate a milling installation.

(1) An application for a licence to site, construct and operate a milling installation shall contain the information specified in Chapter 1, and shall also contain the following information:

(*a*) a detailed flow sheet, including a calculation of the input and output of materials and water balance and a description of the sump system, including its capacity, if any;

(*b*) the proposed dust control system;

(*c*) a description of the measures designed to control mill site drainage;

(*d*) information on the grade and quantities of the materials to be processed and, if the materials are to be imported, the average monthly or yearly quantities to be imported;

(*e*) the emergency preparedness programme and mitigative measures to deal with accidental releases, including emergency monitoring and removal of released tailings;

(*f*) a detailed engineering plan of water diversions and treatment facilities and detailed monitoring plans and contingency measures for the construction phase of the facility; and

(*g*) the anticipated quantities of any tailings or waste rock material to be used for backfilling at the facility.

(2) An application for the temporary operation stage of the operation part shall, in addition to the information mentioned in sub-regulation (1), contain the following information:

(*a*) the nominal daily and annual capacity of the mill, the anticipated recovery, and the anticipated composition of mill feed, concentrates and tailings;

(*b*) the procedures for handling and storage of materials containing radioactive materials, nuclear materials or prescribed substances; and

(*c*) the plan and programme for the stabilization of tailings and rehabilitation of the tailing areas.

24. Information required for application to site, construct and operate a waste treatment facility.

An application for a licence to site, construct and operate a waste treatment facility shall contain the following information:

(*a*) a detailed flow sheet including a calculation of the input and output of materials and water balance;

Lynas paints 'worst-case scenario' for toxic waste

By Shannon Teoh
January 16, 2012

KUALA LUMPUR, Jan 16 — Lynas Malaysia has said a permanent depository facility (PDF) for radioactive waste from its controversial rare earth plant in Kuantan will only be needed in a "worst-case scenario" where it is unable to reprocess the waste into a commercial product.

The local subsidiary of the Australian miner also said that in such an event, "we have 17 years before we even need to identify where is the PDF" as it has constructed a residue storage facility (RSF) at the RM2.5 billion refinery in the Gebeng industrial zone.

Local residents and environmentalists have criticised Lynas Corp for not having a long-term waste management plan and claimed the company would store radioactive waste onsite, which is about 2km from the nearest residential area.

But Lynas Malaysia managing director Datuk Mashal Ahmad **(picture)** told *The Malaysian Insider* "we are working on commercial applications and coming to the conclusion. Once we find all this, we can even forget about a RSF."

He said the PDF only came about during the review by the International Atomic Energy Agency (IAEA) in June which was ordered by the government.

"Why did the PDF come about? It is because the IAEA said 'very good but tell us the worst-case scenario.' That is why this topic came about. Not because Lynas doesn't know what to do.

"If you go to the site today, the RSF is only for 1.5 years of operation because of the high level of confidence in finding the solution," Mashal added in an interview last week.

According to Lynas, refining rare earth ore from Mount Weld, West Australia will result in three forms of residue, two of which have a radiation level of below 1 Becquerel per gramme (Bq/g) which is considered non-radioactive and outside of regulatory control by both international and local authorities.

However, its water leach purification (WLP) residue is projected to have a radiation level of 6 Bq/g, which is regarded as "very low-level" radioactive waste.

Professor Ismail Bahari, the company's radiological safety adviser, said Lynas was "very confident" it can dilute the WLP to below 1 Bq/g to be used as a base in road building.

"The public has been poisoned with misguided information that you cannot work with any level of radiation. But even if you mix it (WLP) with 10 times the amount in soil, it is already at ground level (radiation)," the former Universiti Kebangsaan Malaysia radiology professor said.

Mashal said Lynas was serious about reusing its waste commercially as it had spent RM750,000 to produce 40kg of residue from its pilot plant for the sake of research.

"We spent three quarters of a million just to make rubbish. Why? Because we are proactive and we are already able to bring it below 1 Bq/g and come out of regulatory control," he said.

Lynas Malaysia has also said its application for a temporary operating licence meets requirements and if approved by the government at the end of the month, it can fire up its plant in six weeks.

Putrajaya bowed to public pressure in April after sustained opposition from local residents and environmentalists due to fears of radiation pollution and put the project on ice pending the review by the IAEA.

In July, the government agency adopted 11 recommendations set out by the review of the refinery being built in the Gebeng industrial zone and said it would not allow Lynas to begin operations or import rare earth ore until all conditions, which include a comprehensive, long-term and detailed plan for managing radioactive waste, are met.

According to Lynas, AELB will meet on January 30 to decide on whether to issue a pre-operating licence which will be followed by a full licence within two years if the plant meets safety requirements outlined in its application.

Lynas is anticipating a windfall of RM8 billion a year from 2013 onwards from the manufacture of rare earth metals that are crucial to the manufacture of high-technology products such as smartphones, hybrid cars and bombs.

Mashal also said the RSF was not susceptible to leaching into groundwater under the site of the refinery as claimed by opponents of the plant.

He said that although the water table was only one metre below ground level, the previous landowner had built up another three metres of clearance and the RSF would have a base that is another metre high, giving it a five-metre distance from the groundwater.

He added the RSF would be lined with high-density plastic and compacted clay which has low permeability and thorium — the radioactive material found in the rare earth ore — has a high affinity to clay.

APPENDIX 4

List of Prescribed Activities Which Require Detailed EIA

1. Iron and steel industry.
2. Pulp and paper mills.
3. Cement plant.
4. Construction of coal fired power plant.
5. Construction of dams for water supply and hydroelectric power schemes.
6. Land reclamation.
7. Incineration plant (scheduled wastes & solid wastes).
8. Construction of municipal solid waste landfill facility (including municipal solid waste transfer station).
9. Project involving land clearing where 50% of the area or more having slopes exceeding 25 degrees (except quarry).
10. Logging covering an area exceeding 500 hectares or more.
11. Development of tourist or recreational facilities on islands in surrounding waters which are gazetted as national marine parks.
12. Construction of recovery plant (off-site) for lead-acid battery wastes.
13. Scheduled wastes recovery or treatment facility generating significant amount of wastewater which is located upstream of public water supply intake.
14. Non-ferrous - primary smelting.
15. Petrochemicals - all sizes.
16. Construction of oil refineries.
17. Prescribed activity using radioactive material(s) and generating radioactive waste(s).

30. Transport of radioactive waste with prior authorization of appropriate authority.

(1) No person shall transport any radioactive waste without the prior authorization in writing of the appropriate authority.

(2) Any authorization given by the appropriate authority under this section may be subject to such conditions as the appropriate authority may think necessary to impose for the protection of the public.

31. Discretion to consult Director-General of Environmental Quality.

In the performance of its functions under this Part, the appropriate authority may, if it thinks it fit so to do, consult the Director-General of Environmental Quality appointed under section 3 (1) of the Environmental Quality Act 1974 on any matter under this Part.

PART VII

APPEALS

32. Appeals.

(1) Any person who is dissatisfied with any decision of the appropriate authority made under this Act may within thirty days after being notified of such decision give notice of appeal in writing to the Minister in the prescribed manner.

(2) The Minister shall as soon as is practicable cause to be served on the appellant a written notice specifying the date, time and place at which the appeal is to be heard:

Provided that the date so specified shall in no case be earlier than thirty days from the date of service of such notice.

(3) The grounds of appeal shall be submitted to the Minister not less than ten days before the date fixed for the hearing of the appeal.

(4) At the hearing of the appeal the appellant may be present either in person or by counsel and the Minister may call for such evidence as he thinks fit.

I've read the article in the Malaysian Insider. I'm glad that people are finally picking up the shortcomings in the EIA process. PEIA is mainly processed in-house through the State DOE Office. The prescribed activity of Lynas comes under "ore processing, including concentrating for aluminium, copper, gold or tantalum" under the mining category. The EIA Guideline did not call for a DEIA for this prescribed activity in 2008. Thus, a PEIA was done. However, PEIA and DEIA are not mutually exclusive, meaning that when only a PEIA is called for, it does not mean that a DEIA will never be required subsequently. A DEIA would be deemed necessary when residual environmental or health impacts are predicted to occur. A residual impact is a long-term impact that may remain active even after mitigation measures are put into place. In the Lynas case, both the environmental and health impacts related to ionizing radiation are clearly residual in nature. Therefore, a scientific logic would call for a DEIA to follow or supplement the PEIA. The term preliminary EIA suggests that it may be followed by a more elaborate and detailed process, if necessary. However, most project proponents choose to go directly into the DEIA process (without doing a PEIA first) so as to save time and money if they know that a DEIA will eventually be necessary for their project. Hence, Lynas would have saved themselve a lot of hassle by doing a DEIA from the start.

Why did the Lynas PEIA not identify a residual environmental or health impact? This was mainly because it had conveniently omitted the radiological and health impacts which was assessed separately in an RIA report submitted to AELB. If these had been addressed within the PEIA, I doubt whether a DEIA could have been overlooked. On hindsight, it is obvious now that DOE agrees that a DEIA would be necessary for a prescribed activity such as Lynas. If not, it would not have updated their guideline to call for a DEIA for a prescribed activity generating radioactive wastes.

A DEIA is not only different from a PEIA in terms of public consultation. A DEIA would have to be submitted to DOE HQ in Putrajaya. An ad hoc review panel would have to be assembled by DOE to review first the terms of reference for the DEIA, and later the DEIA report itself. An ad hoc review panel will comprise of both individual experts and representatives from relevant government agencies. Usually, the ad hoc review panel would also conduct a site visit. A DEIA would require a detailed social impact and health impact assessment. A social and health survey will have to be conducted by the DEIA consultants. A public dialogue would also be mandatory. A cost-benefit analysis would also be necessary to assess the overall socio and economic feasibility of the project. Most importantly, the health impact assessment component would be able to quantify the lifetime excess cancer risk that the "population at risk" (for e.g. residents of Taman Balok Perdana) would experience from all possible human exposure pathways (inhalation, ingestion, skin contact, etc.) to both air emissions and waste management.

DOE is never an approving authourity in EIA. It only oversee the EIA process and approves the resulting PEIA or DEIA reports. It should be a one-stop-centre for the assessment of all environmental, social and health impacts related to a prescribed activity. All these should be addressed within a PEIA or a DEIA report. This is mainly because all impacts are interrelated to one another. For e.g. the air quality impacts relate to radiological impacts, which in turn relate to health impacts. If a DEIA was done, then the social and public imputs would also be there. The conduct of a separate PEIA and an RIA report is the main reason for the uncertainties surrounding the overall impacts of the Lynas project.

So, who is the approving authourity in the Lynas case? The approving authourity should be AELB as they are the one who will issue the operating license to Lynas. MITI could also act as a co-approving authourity as they control FDI into the country. So, the ideal situation would have been the conduct of a DEIA with a full-blown radiological and health impact assessment in one exercise and report which would also include public feedbacks and concerns. The DOE together with its appointed ad hoc review panel of experts would then review and scrutinize this DEIA report, ascertain that it was conducted according to the agreed terms of reference and relevant guidelines, before approving it. Based on recommendations from the DOE, the AELB and MITI will then decide whether to approve the project or not. There has been cases whereby the DEIA report was approved by DOE but the project was abandoned by the government due to other reasons. A case in point was the municipal waste incinerator project in Beroga.

Please note that I have said nothing about the safety or danger of the Lynas Project. To me, it is pointless to deliberate and speculate about the "hazardousness" of the project when a proper procedure which will enable us to do so has not been properly conducted. So, we are dealings with points and counterpoints from both sides of the fence. I thought that the PSC would help unsettle some of these pending issues, but I guess wrong. I have mentioned my concerns to the DOE and even to people in the PM Department. I guess this issue has gone beyond a point where people can retract back their steps.

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workplace monitoring, personnel monitoring and the operational environmental monitoring programme will be established and presented to AELB for approval as soon as construction of the plant is completed and the facility is ready for full operation.

10. CONCLUSION

The results of the assessment have indicated that operation of the plant would not cause undue radiological risk to workers and members of the public.

The highest possible doses to be received by workers resulting from operation of the plant for the first 10 years are below 13 mSv per year. The possible dose to be received by members of the public resulting from operation of the plant is 0 mSv per year.

These estimated doses are well below the annual dose limits allowed for workers and members of the public by the Radiation Protection (Basic Safety Standard) Regulations of 1988.

There are residues generated from the process, and one of the streams appears to be slightly enhanced in term of concentration of TENORM, but the method adopted to keep them during the entire operational period of the plant has proved that the resulting doses to workers and members of the public are within the permissible annual dose limit.

Based on the results of the radiological impact assessment, it is concluded that operation of the plant would not caused any radiological risk to the workers and members of the public living in the surrounding areas of the site beyond what is allowed by the regulatory authority.

11. RECOMMENDATIONS

Based on the results and the conclusion of the radiological impact assessment, it is recommended that:

a. the proposal for the plant operation at the identified site in Gebeng, Kuantan, Pahang be given due consideration by the regulatory authority .

b. the assessment is to be revised again when more operational data are available to ensure that the estimated doses obtained in this assessment are further refined and the conclusion derived from this assessment is indeed realistic and acceptable.

c. the input data and information to be updated and finalised, in particular, the radioactivity content of the lanthanide concentrate materials and WLP residue and water discharges.

d. final and permanent disposal of the NORM contaminated residue streams generated to be looked at and analysed and a decision and proper planning is made to solve their problem.

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IN THE MATTER OF THE ATOMIC ENERGY LICENSING ACT 1984 & ATOMIC ENERGY LICENSING (APPEAL) REGULATIONS 1990

(Regulation 3)

Reference No: Year 2012

BETWEEN

1. Tan Bun Teet .....Appellants
(No. Kad Pengenalan: 480425-06-5121)

2. Ismail Abu Bakar
(No. Kad Pengenalan: 480324-06-5262)

3. Tan Ah Meng
(No. Kad Pengenalan: 520818-06-5265)

4. Syed Talib bin Syed Sulaiman
(No. Kad Pengenalan: 520912-06-5229)

5. Abujavalli a/p Raman
(No. Kad Pengenalan: 550707-01-5422)

6. Hasimah binti Ramli
(No. Kad Pengenalan: 680408-11-5074)

AND

Atomic Energy Licensing Board ...Respondent

AFFIDAVIT STATEMENT

I, DR LEE CHEE HONG (NRIC No750612065183) of a Malaysian of full age and residing at 19th Floor, KH Tower, 8, Lorong P. Ramlee, 50250 Kuala Lumpur, do hereby solemnly and sincerely affirm and state as follows:-

1. I affirm this Affidavit in support of the appeal by the second, third and fifth named appellants abovestated ("appellants") against the decision of the Respondent (**"the Board"**) to grant a temporary operating license ("TOL") to the Lynas Malaysia Sdn Bhd (**"Lynas"**) to start operations at the latter's plant in Gebeng, Kuantan (**"the LAMP site"**).

A. MY PROFESSIONAL TRAINING AND CAREER

2. I am the SEA Regional Manager of Intetech Ltd, a firm of consultants whose head office is in England, with a representative house in Malaysia. I am a Chemical Engineer by qualification. My tertiary education is as follows:-

1999	:	B.Eng (Hons) Chemical. Universiti Teknologi Malaysia ("UTM")
2001	:	M. Eng. Chemical UTM
2007	:	Ph.D — Corrosion Science & Engineering University of Manchester (formerly UMIST)

3. My professional Affiliations include:-

- Member (295585) of International Corrosion Society, NACE;

- Associate Member of the Institute of Materials, Minerals and Mining, AMIMMM;
- Fellow (2778) of the Institute of Materials, Malaysia, FIMM; and
- EFC (European Federation of Corrosion) — Oil and Gas Working Party.

4. My professional career is as follows:-

2001 - 2003	:	Shimano (S) Pte. Ltd., Singapore, — Material Engineer.
2004 – 2005	:	University of Manchester, — Research Assistant, Tutor for Chemistry Department.
2006 – 2009	:	Intetech Ltd, UK — Corrosion Engineer.
2009 – present	:	Intetech Ltd, SEA — Regional Manager.

5. My professional practice in the firm of Intetech entails performing specialist corrosion studies and construction materials analyses with the aim of long term integrity of the structure and

facilities of the oil and gas sectors, power industries, nuclear, civil engineering and chemical process industries. I also review chemical processes in relation to corrosion control philosophies and material selection, to ensure practices are technically and economically sound.

B. MY INTEREST IN LYNAS

6. I was born and brought up in Kuantan. I studied in schools there. Although I now work in Kuala Lumpur, I regularly return to Kuantan, which I still regard as my true home. My extended family, relatives and friends still live there.

7. It was during my frequent visits to Kuantan in 2011 that my friends and relatives expressed their concerns to me on the potential impacts of the LAMP plant. They did not have the technical knowledge to comprehend the Lynas project. Nonetheless, they were anxious about it being sited near their homes. Some could recall Bukit Merah. When the Fukushima disaster occurred in early 2011, their fears were heightened.

8. It was against this background that I thought I should get interested in the matter. Around that time, through the media, I became aware that groups of Kuantan residents were protesting against the Lynas rare earth plant in Gebeng. I decided to support this good cause by sharing my experience and expertise with them.

C. STUDY OF THE RARE EARTH INDUSTRY

9. Being trained as a chemical engineer and a materials scientist, I can comprehend most chemical engineering processes and the characters of most materials. Though not precisely related to my areas of practice, my training and experience is such that I can come to grips with the rare earth process. In order to familiarize myself with the subject, I undertook much reading and research. I also conferred with many of my peers who generously shared their knowledge with me.

10. I have helped the campaign by studying and analyzing relevant information that is freely available in the public domain, especially the internet which has online hundreds of scientific papers, reports and the like. I then summarise this technical information in a "*layman*" version for easier understanding by members of the public, who would be the most affected by the LAMP site operations.

11. I have also commented on various technical documents in relation to the Lynas plant and rare earth process, including the reports of EIA, RIA, RWMP, the technical reviews/presentations, Lynas rare earth process data, etc. All comments have been validated and cited by third party publications, which are also available in the public domain.

12. On 26th June 2011, I presented a paper at the National NGO seminar held at the Swiss Garden Hotel, Kuantan to discuss the Lynas

project. The audience included representatives from the Bar Council, MMA, civil societies, and NGOs. Members of the public also attended. The purpose of my paper was to bring to the attention of the public the Lynas rare earth plant and its process, its waste and the potential hazards. Now produced and shown to me and marked as ***Exhibit "L-1"*** is a copy of the said paper.

13. As a result of public outcry, the Government of Malaysia requested the International Atomic Energy Agency ("IAEA") to initiate an independent expert review (peer review) of the LAMP site. According to press reports, IAEA's mission visited Malaysia from 29th of May to 3rd June 2011. They had meetings with local authorities, Lynas and other stakeholders, and visited the LAMP site. IAEA's report was published on 30th June 2011.

14. I studied the IAEA's report with great care. I thereafter wrote my comments on it. Now produced and shown to me and marked as ***Exhibit "L-2"*** is a copy of my comments.

15. I also prepared a Process Flow Diagram ("PFD") with the intention of creating an easier and clearer picture to show where the materials originated from and by which process the rare earth products and the wastes are produced. More importantly, it was intended to educate the public with the fact that the raw material is NOT from our homeland. Instead, it is to be shipped from Australia and just to be

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processed in Kuantan, leaving behind a copious amount of waste. I should state that the creation of waste is the inevitable consequence of such operations. In other words, operations cannot start and continue without the creation of waste.

16. The PFD has been disseminated electronically, and as printed version at conferences, talks, seminars. I prepared it based upon the technical documents released on Lynas' official websites (http://www.lynascorp.com/); several documents such as the Lynas Investors Presentation (February, March 2011); 2007, 2008 annual reports. Now produced and shown to me and marked as ***Exhibit "L-3"*** is a copy of the said PFD.

17. My principal aim in writing these documents in simple plain English is to make rigid technical data into presentable and comprehensible. These articles have been disseminated via e-mail, blog and other social network sites. The source of the data presented in the *"I'm just a layman, I read the papers I saw the news, but I want to know more....."* and *"All about the Lynas Advanced Materials Plant (LAMP) in Kuantan"* documents, are based on internet searches with regards to rare earth industries, the process, the generated wastes and the health and safety aspects. A quick comparison list was made in the *"What else do you need to know about Lynas Advanced Materials Plant (LAMP)?"* article, which mentioned what the statement given by Lynas/Authorities, and what are they actually mean to us. The sources

of the claims are quoted. Now produced and shown to me and marked as ***Exhibit "L-4"*** are copies of the abovementioned documents.

18. Major waste streams will be generated at the LAMP site. They are flue gas (99,344 m3/hour), waste water (up to 500 tonnes/hour), FGD gypsum (55,800 tonnes/year), WLP gypsum (64,000 tonnes/year) and NUF gypsum (170,600 tonnes/year), which information I obtained from the RIA report. "*Radiological Impact Assessment (RIA) of Advanced Materials Plant, Gebeng Industrial Estate, Kuantan, Pahang*", issued by Nuclear Malaysia June 2010].

19. I believe that with effect from August 2011, the AEL Radioactive Waste Management Regulations, 2011 came into force to provide regulatory guidance for the classification and management of radioactive wastes. In accordance with these Regulations, only the WLP gypsum is classified as Radioactive. The (radio)activity concentration of the thorium (Th-232) & Uranium (U-238) in the other 4 waste streams, viz, waste water, flue gas, FGD and NUF gypsums when compared to the concentration levels stipulated in the Second Schedule of the Regulation indicate that the activity concentrations for these waste streams fall within the "clearance levels" (at which Th-232= 1 Bq/g; U-238=10 Bq/g). Clearance level means the values established by the Board and expressed in terms of activity concentration or total activity at or below which the source of radiation may be released from the control of the Board as specified in the Second Schedule. Hence, the "non-radioactive" wastes may potentially

be released from the control of the Board, and would be without any regulatory supervision.

20. The radioactive thorium and uranium bind with the rare earth elements to form the lanthanide ore; their presence generates radiation and the radionuclides instantaneously and almost erratically. The environment, to which they emanated to, covers as early as the mine site to the refinery process and the residue storage facilities. This phenomenon can be illustrated by the Process Flow Diagram (Exhibit L-3); thorium and uranium decay chain diagrams in Exhibit L-5. Thorium and uranium, both radioactive and unstable in nature, decay into various radionuclides by emitting radiation, and settled as lead (also known as plumbum; an heavy metal and neurotoxin) eventually. Ore containing thorium and/or uranium emits radon gas that can accumulate in enclosed places such as underground mines. The radon (given as Rn in both decay chains) is a colourless and odorless radioactive gas, once it is extracted from the mine, it would be almost impossible to contain and segregate during transportation and at various stages of the process aboveground. Despite its short half-life at 55 seconds, one cannot overlook its presence (ref: RIA report, p 42, para 1, line 7; Nuklear Malaysia, June 2010) by regarding this toxic gas as "depleted naturally", because, even though at a much slower decay rate, the production of radon gas from its preceding radionuclides is incessant. Radon exposure is considered the leading cause of lung cancer in non-smokers [ref: http://www.epa.gov/radon/]

21. Owing to the above I believe that the hazards of radioactivity will be posed NOT ONLY from the wastes/residues at the end of the LAMP process, but wherever the presence of the ore, e.g. the Port of Kuantan, the route of the ore shipment, the LAMP premises and the residue storage facilities.

22. According to Lynas, the capacity and radioactivity of the wastes can be summarised in the following Table :

1	Waste/residues	Quantity	Thorium concentration, ppm	Uranium concentration, ppm	Radioactivity, Bq/g	Radioactive in accordance to RWM regulation (AELB 2011)?	Intended long term management plan
2	WLP	64,000 ton/yr	1655	22.5	6.1	Yes	Dilute then reuse OR dispose in permanent disposal facility (PDF)
3	FGD	55,800 ton/yr	12	0.3	0.044	No	Reuse
4	NUF	170,600 ton/yr	ND	ND	0.054	No	Reuse
5	Flue gas	99,344 m3/h	ND	ND	Neg	No	Discharge
6	Waste water	213 tonnes/hr	ND	ND	< 0.5	No	Discharge

ND: Not detected
[ref: RIA, 2011; LAMP, Radioactive Waste Management Plan (RWMP), 2011].

23. This Table indicates that it is the intention of Lynas to "*purge*" almost all radioactive materials (thorium and uranium) and to channel them to a sole waste stream, known as WLP. The radioactivity concentration in the other 4 waste streams is regarded as either non-detectable or negligible. Lynas thus claim that these 4 streams are non-radioactive.

24. I do not accept the position taken by Lynas. Firstly, the proposition is wholly disputable because Lynas has not had any prior experience operating such a project. Nor does Lynas possess a pilot-scale plant which would generate an industries-proven data to corroborate claims made in the Table.

25. LAMP recently invited 4 members of the public and 3 local media reporters for an onsite visit/interview. During this visit Lynas admitted that most of the process data presented by it in the public domain have been obtained from results which have emerged by process simulation* and laboratory analysis (Reported by Sin Chew daily, dated 9th Feb 2012. http://www.sinchew-i.com/sciWWW/node/274777?tid=881).

26. It must be kept in mind that "***Process simulation***" is used for the design, development, analysis, and optimization of technical processes and is mainly applied to chemical plants and chemical processes. When this computational process model/simulation is built, some phenomena are simplified, and consequently some parameters are disregarded or distorted in comparison with reality. In addition, some of the relationships between the parameters could be neglected. [ref: Tanase Gh. Dobre, José G. Sanchez Marcano. "Chemical Engineering: Modelling, Simulation and Similitude". John Wiley & Sons. pp 20. 2007].

27. What is far more valuable and far more accurate is actual data from real experience. Thus, if Lynas has actually been in this business they could have supplied real facts. Alternatively, Lynas could have provided the actual results from the Chinese experience.

D. Radioactive concentration in the incoming ore is too low to be true

28. The LAMP feedstock (also known as monazite ore or concentrates) reportedly contains only 1600 ppm (0.16%) of thorium and 29 ppm (0.0029%) of uranium [see: Lynas Investor presentation, March 2011; RIA report, 2011]. Both concentrations prepared by Lynas have been accepted universally during the course of all safety assessment such as EIA, RIA, RWMP and the IAEA peer review [ref: IAEA, "Report of the International peer review mission on the Radiation Safety Aspects of a Proposed Rare Earths Processing Facility (The Lynas Project)", NE/NEFW/2011, 2011].

29. Significantly, Lynas has not disclosed any official testimonials like QC and laboratory reports or certificate of analysis which verify the concentration of thorium and uranium in the monazite ore as what Lynas claims.

30. On the contrary, a thorough literature research has been carried out on the internet. An Australian Parliament Research Papers [ref: G. Baker. Parliament of Australia research paper no. 11 2007-08. 2007], states that the main source of thorium in Australia, i.e. monazite ore, generally contains 8 -10% of thorium. This statement is supported by another research paper written by Dr. P.M.B. Pillai (a member of the IAEA peer review team who visited the LAMP site) in rare earth process safety. [ref: P.M.B. PILLAI, "Naturally occurring radioactive material (NORM) in the extraction and processing of rare earths", Naturally Occurring Radioactive Materials (NORM IV), IAEA, Seville (2007), p.197 – 221.]. Pillai summarised the typical composition of the rare earth mineral in different geographical locations; the following Table is extracted from his paper:—

TABLE 1. TYPICAL COMPOSITION OF SOME RE MINERALS

	Composition (%)			
	TREO[a]	U_3O_8	ThO_2	P_2O_5
Monazite, Australia	61.33	0.34	6.55	26.28
Monazite, India	59.68 (60)	0.37 (0.35)	9.58 (8.0)	26.23 (27)
Monazite, Malaysia	59.65	0.24	5.90	25.70
Monazite, Thailand	60.20	0.44	5.76	26.52
Monazite, Rep. of Korea	60.20	0.45	5.76	26.52
Monazite, DPRK	42.65	0.18	4.57	18.44
Bastaesite	58–74	–	0.11–0.20	0.64–0.94
Xenotime, Malaysia	54.00	0.81	0.83	26.20
Gadolinite	32–46	–	up to 2	–

[a] Total RE oxides.

31. Given the substantial difference (up to 60 times) between the above scientifically tested figures, and that claimed by Lynas, the latter's claim that their ore feedstock contains radioactive substances at such low concentration should be disregarded. Should the feedstock

imported from Australia and supplied to LAMP site contain thorium concentration as high as 10%, the risks and hazards posed by the LAMP process to the public and the environment would be escalated to a much higher level.

32. Even if the 0.16% thorium & 0.0029% uranium concentrations supplied by Lynas are assumed to be correct, by generating 64,000 tonnes of radioactive WLP gypsum waste, the LAMP site will still produce a massive 106 tonnes of thorium and 5.6 tonnes of uranium every year (both substances to be mixed in a large quantity of lime to formulate the WLP gypsum). One cannot ignore the production of these radioactive substances in such quantity. The totality or cumulative effect is striking. If, on the other hand, the thorium content is 10% as the independent experts state, one cannot imagine the magnitude of thorium production when 64,000 tonnes of radiation waste is produced at the LAMP site.

E. OPINION

33. Having closely studied voluminous scientific and other materials pertaining to the rare earth industry in general, and the manner in which Lynas will carry on its operations at the LAMP site, it is my opinion that allowing Lynas to start such operation endangers not just the areas of the vicinity of the LAMP site, but the whole of

Malaysia with the risk of another environmental disaster. If such a disaster were to occur, it would be on a much greater scale and magnitude than Bukit Merah.

34. In my opinion, Lynas cannot guarantee that such an environmental disaster can be ruled out.

35. This is particularly so because Lynas has no previous experience in operating a plant like the LAMP site or handling hazardous radioactive waste which would inevitably be created at the LAMP site if operations begin.

36. It is wholly unrealistic to accept the Lynas claim of zero risk and zero radioactivity on the LAMP site, which is solely based on a hypothetical basis and driven by computer simulation and laboratory analysis.

37. The consequences of any mishap at the LAMP site in the process would result in radiation fallout and release of substantial radioactive particles into the Malaysian environment. Indeed, one cannot rule out the escape of these particles to Thailand and Singapore.

38. In my opinion, the safety assessment conducted by Lynas was not carried out in a professional way which would be acceptable to the highest international standards of safety. With the welfare of about 700,000 inhabitants within 30 km radius of the LAMP site, and a potentially environmental disaster not being ruled out, I cannot understand why Malaysia is prepared to tolerate the potential hazards to occur here from a plant which will give no substantial benefit of Malaysia because of the pioneer status granted to Lynas for 10 years.

39. For these reasons, it is my sincere opinion that Lynas should not be permitted to operate its LAMP site.

To an affidavit by one deponent)
DR LEE CHEE HONG)
Affirmed on the day of)
April, 2012 at Kuala Lumpur)
[Interpretation not required])

....
(DR LEE CHEE HONG)

Before me

COMMISSIONER FOR OATHS

LETTER TO THE EDITOR OF THE STAR

LAMP NEEDS A HEALTH IMPACT ASSESSMENT

As a professor of environmental health with some 18 years of experience conducting environmental impact assessment (EIA), health impact assessment (HIA) and health risk assessment (HRA) for various types of development projects in Malaysia, I am deeply concerned with the uncertainty surrounding the potential health impacts of the Lynas Advanced Materials Plant (LAMP) Project in Gebeng, Kuantan.

I reserve my judgement as to the nature of public safety or danger LAMP will pose to the population at risk, as I believe that most of the existing technical documents I have reviewed do not allow me to make a definitive and quantitative judgement on its potential health risks to the public. I have looked into the preliminary EIA (PEIA) report, the radiological impact assessment (RIA) report and the IAEA report. Yet, I remained unconvinced that the short and long-term health impacts on the affected human population have been adequately addressed and assessed.

In Malaysia, the accepted practice is to conduct a HIA within an EIA for a development project that is subjected to an EIA. Moreover, the HIA must be conducted by an HIA consultant that is registered with the Department of Environment. There is no indication anywhere that these conditions have been met for the LAMP Project.

A HIA is a methodological approach comprising the 4 basic steps of hazard identification, dose-response assessment, exposure assessment and risk characterization. Risk characterization is the determinitive step which allows us to assess human health risk either qualitatively or quantitatively. This can be done for both carcinogenic (cancer-causing) and non-carcinogenic health risk.

From what I can see, only exposure assessment was done for the LAMP Project which estimated both total external radiation exposure for workers and the public, in comparison to the accepted radiation exposure limits of 20 mSv/year for workers' exposure and 1 mSv/year for public exposure. Due to the conservative approach taken in the RIA, some of these exposure assessments may actually have been overestimated. However, it still fails to convince me on two counts. One, the radiation exposure assessment for the public was hypothetical, not site-specific and not targeted to the population at risk. Two, it did not proceed to the risk characterization step which would have allowed the quantification of the risk of cancer amongst the population at risk.

A proper HRA and HIA could have answered the question of what is the lifetime risk of getting cancer amongst the residents of Taman Balok Perdana due to potential chronic (long-term) inhalation exposure to radon and thoron from the smoke stack emission as a result of the lanthanide ore processing, and that due to chronic ingestion exposure to uranium and thorium in the waste residues through contaminated drinking water and food consumptions. These are questions which besieged the minds of residents around Kuantan and captivated their fears of the project.

There are other outstanding health issues that I cannot adequately address here. Suffice to say that a proper HIA will be beneficial not only for the public, but also for LAMP, as well as all regulatory agencies concerned, in order to facilitate an informed decision-making process. Some other issues that come to my mind are whether the groundwater table which is only 0.95 to 3.5 m below ground may also be contaminated by the waste residues? Will the lanthanide cracking process in the rotary kiln which burns at 650° C also produce hazardous heavy metals like lead, mercury, arsenic, cadmium and nickel; the last 3 being also proven human cancer-causing agents. Obviously, this was not assessed by the RIA.

LAMP and the government owe it to the people of Kuantan to address their health concerns, whether their fears may be real or perceived. Scientific means should have been given precedence over political manoeuvres which have clouded an otherwise straight-forward environmental issue. Local experts should have also been consulted instead of relying solely on foreign expertise. It would now be almost impossible to regain the trust of the people once your credibility is gone with the wind.

Prof. Dr. Jamal Hisham Hashim

Kajang, Selangor 29 February 2012

NAMA DOKUMEN	ULASAN	CADANGAN
Document 1,2 Objective	This submission still does not address the main objective of permanent disposal of WLP as the location is yet to be determined. This is not fulfilling the IAEA recommendation.	As the amount of WLP will be enormous for the next 20 years (64,000tpaX20=1.28 million tonnes), it is necessary for the related government authorities to decide NOW a suitable location for PDF. The Bkt Merah-Papan history should not be allowed to repeat . the present radioactive dumpsite at Bkt Kledang is less than satisfactory.
Document 1,2 *The FGD and NUF residues are now released from the control of AELB (AELB,2011)*	The estimated radioactivity of these waste is yet to be confirmed in practice. Thorium is more soluble in acidic condition where during the production highly concentrated strong acids are used. This will result in higher concentration of Thorium when precipitated out as FDG and NUF later. Therefore FGD, NUF cannot be classified as cleared wastes unless proven otherwise in PRACTICE. The margin of error in a laboratory model (Lynas has no pilot plant) when applied to such a large scale production can be in the range of hundredth to thousandth times.	AELB should monitor the contents of FGD and NUF for at least 2 years (duration of Temporary Operation) to determine later if these can be classified as radioactive or scheduled wastes. <u>Because of the great half life of Th & U, monitoring must be as long as the waste material is not removed from Gebeng. Lynas fail to disclose what remedial obligations it will undertake for any spillage esp. for any leacheate. Without any remedial obligations, it is senseless to monitor.</u>
Document 2 Safety Principles and Safety Requirements Principle 1—Responsibility of Safety *The prime responsibility rests with Lynas.*	The possibility of presence of Thorium and Uranium in the waste water discharge after treatment is not addressed. Chemical reactions cannot be **assumed** to be 100% efficient in practice. <u>From Lynas EIA, only the Th & U contents in the solid wastes are reported and it claims that there are none in its gaseous wastes. Then, any Thorium or Uranium present in the ore concentrates that has not been accounted for in the solid wastes must report in the waste water and likely in the soluble form (Solution by acids during the crackling process). This will pose the</u>	Lynas need to prove its claims on the concentrations of Thorium and Uranium content based on a pilot plant for this large scale of production. <u>Its submission is purely conceptional and based on estimated values. It has not even bother to back up its estimates with solid test work information. It is lucridous to expect AELB to grant any operating licence if Lynas does not disclose the amounts and contents and potential toxicity or radioactive hazards of all its waste streams. Then, it has to discuss in detail its remedial strategy to render any</u>

	greatest health hazard. No licence can be issued to Lynas before it addresses this and providing adequate assurance that zero amounts are discharged into S. Balok. AELB must insist that LAMP must adhere to zero liquid waste discharge as required at Moutain Pass Mine and also at Mt. Weld for its beneficiation plant.	hazards harm free and environmentally sustainable permanently. Ideally, Lynas is made to transport all wastes to be removed from Malaysia and has a zero discharge of all its liquid wastes. The onerous is on Lynas to convince the authorities its alternative strategy is acceptable.
Document 2 Safety Principles and Safety Requirements Principle 2 – Role of Government	It is the responsibility of the Malaysian government to determine a suitable site for PDF. By not addressing this vital issue from the beginning, the government is allowing history to repeat-- the ARE saga. Proposal by Lynas is to address this critical issue a few years before the closure of LAMP is not acceptable. It will be a case for trying to rectify something "after the horse has bolted".	The Dept of Environment should upgrade the present regulations (Standard B of Industrial Effluent) to that of latest International standards tailored for such industry ie GB26451-2011. To gain public confidence, it is essential to employ Independent experts to counter monitor the parameters in all the- wastes streams and environmental effects. Lynas must be made to be responsible to render any of such wastes free from harm and environmentally ~~Transparency~~sustainable. Transparency of reports deemed necessary.
Document 2 Safety Principles and Safety Requirements Principle 5—Optimization of Protection	Certain groups of workers on the site are particularly at risk to inhale dust ie workers handling the concentrated ore (thorium 1600ppm), besides those handling the wastes. Although the external radiation dose is expected to be below the occupational dose constraint, this does not guarantee safety from **Internal Radiation.**	The method of handling RE ore onsite (unloading of ore to conveyer belt) need to be reviewed. **Specific** (type of dust mask) personal protection gear should be implemented to give optimum protection to workers . Suggestion to include compulsory shower and change of clothing before the worker leaves after work. A dust-free area with air-conditioning for workers to have their meals. **All workers and even regular visitors to LAMP site**

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		must be made to wear radiation badges and the radiation doses these people must be monitored to avoid them from being exposed to any unaccepted risks.
Document 2 Safety Principles and Safety Requirements Principle 6—Limitation of Risks To Individuals *Lynas compares the safety record of Uranium mining industry .*	The China-Mongolian RE mine and refinery has a proven record of significantly higher risk of lung cancer among its workers. This was attributed to inhaled carcinogenic Thorium dust at work place. The CERRIE expert panel failed to reach a consensus on the low level exposure to internal radiation. The KiKK study has rekindled debate on the adequacy of existing quantitative risk models for assessing risks from internal radiation. Japanese scientists have published studies on previously unknown health hazards of lanthanides. (more evidence is compiled to be presented to Ministry). Lynas fail to make any references to these but quoting Uranium mines operating in in the 1960s when compliance requirements were lower or non-existent. Such analogy bears no releverance to REO enrichment operations.	The uncovered / uncontained design of RSF is unsatisfactory to minimise air-borne Thorium dust under the Malaysian weather. Waste encapsulation is a preferred option in view that the WLP may be kept onsite for years. This also minimise spillage and contamination when the WLP residue has to be transported from RSF to PDF or to be recycled later .
Document 2 Safety Principles and Safety Requirements Principle 7 – Protection of Present and Future Generation	This protection relies on the onsite radioactive wastes handling and offsite permanent radioactive wastes disposal plan. The risk of exposure is inadequately dealt onsite—workers' protection, uncontained storage of WLP, lack of **radioactive** monitoring of FGD,NUF, **waste water after treatment.** The suggestion to recycle the wastes need to be	All the mentioned issues need to be addressed **comprehensively** before a Temporary Operating Licence can be considered. As this industry has far and wide implications, various sectors including the **health sector** should be consulted before a decision is made. The Malaysian Medical Association strongly recommends that **health , marine life and agricultural experts** be

	carefully reviewed as to the **potential hazardous effects** on health and environment, **present and future.** It is well known that Thorium is found in plants and animals even cow milk, besides the marine life. Additional external radiation in living quarters and roads is not advisable and should be avoided. Without the determination of a safe permanent disposal site and plan, the future generation cannot be guaranteed protection at all.	included into the panel for consultation. <u>Extra caution must be taken as Lynas, in its submission neglects to take any responsibly of all its wastes dumps after the closure of LAMP. It estimates of rehabitation costs of US$ 8 to 16 million with a yearly monitoring budget of US$30,000. This is grossly under estimated. It never offered any period of responsibility either. Lynas must be made to be responsible as long as those dumps exist. Otherwise, the dumps must be removed from Malaysia. Soil covers and dump liners should not be taken to be permanent (permanency is taken to be in perpectuality for radioactive material with such a long half life) as they would crack or the dumps become unstable with higher risks if stacked higher to limit the sterilized are to accommodate them)</u>
Document 1,2 *Classification of WLP as VLLW and Lynas claimed that WLP cannot be classified under Schedule One*	The WLP with its Thorium and Uranium contents cannot be classified as VLLW. Instead it should be classified **as LLW** (having long lived radionuclides but at relatively low levels of activity concentration) or **LILW-LL** (Schedule One, Atomic Energy Liciencing (RWM) Regulations,2011)	The Schedule One Radioactive Waste Classification is comprehensive and **AELB, Nuclear Malaysia** should be the authorities in deciding such matters, not Lynas! <u>Lynas' dictatorial attitude in its submission borders to challenging the sovereignty of Malaysia.</u>

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Statement of Chan Chee Khoon

Brief biography:

My name is Chan Chee Khoon. I was a professor at Universiti Sains Malaysia until my retirement in 2006. Currently I am an academic consultant at Universiti Malaya (Dept Social & Preventive Medicine, Faculty of Medicine).

I graduated with bachelor and master's degrees in life sciences from the Massachusetts Institute of Technology (1975), and I also earned a Doctor of Science degree in epidemiology from Harvard University (1990) with a thesis on the epidemiology of nasopharyngeal carcinoma. In the summer of 1986, I worked at the Massachusetts Cancer Registry in Boston where I helped to analyse childhood leukemia clusters in the vicinity of the Pilgrim Yankee nuclear power plant at Plymouth, Massachusetts. I was a founding member of the Penang Cancer Registry, and also a founding executive board member of the International Society for Equity in Health. In the last 10 years, I have served on the editorial boards of the *International Journal for Equity in Health, Global Social Policy,* and *Global Health Promotion.*

My interest in Lynas:

Lynas is a public interest issue. As a public health professional, I have a duty to contribute towards an informed public discussion of the technical, policy and operational aspects of this matter. As a Malaysian citizen, I also expect a transparent and accountable process in the governance of public health matters, with meaningful consultation and engagement of all stakeholders.

Background documents reviewed and my professional view:

Aside from IAEA's report on Lynas and the RIA and RWMP submitted by Lynas itself, I have also read the pertinent literature and key documents on radiation risk from internal emitters (radioactive particles that end up in the human body through inhalation, or ingestion via food and water) (CERRIE 2004, ECRR 2010; Chen et al 2005, among others), and I have come to the following conclusions:

1. The 'safe thresholds' of 1 mSv/yr (public) and 20 mSv/yr (occupational) that Dr Looi Hoong Wah (Kuantan physician), Dr Che Rosli Che Mat (MP, Hulu Langat), Lynas, AELB, and IAEA have repeatedly invoked are derived from ICRP risk models

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which are currently under critical scrutiny and challenge[1], in the wake of excess childhood leukemia near nuclear power plants that cannot be explained by radiation exposures which are much below the 'safe thresholds'. Most recently, two large epidemiological studies in Germany (KiKK, 2008) and in France (Geocap, 2012) have reported statistically robust findings of a doubling of leukemia risk among children living within a 5km radius of a nuclear power plant, where radiation exposures were much below 1 mSv/yr. Could the excess leukemias be due to inhaled or ingested radioactive particulates not satisfactorily accounted for in ICRP's risk models?[2] A UK expert panel (2004, www.cerrie.org) could not arrive at a consensus regarding the health risks of low level exposure to these internal emitters. Opinions among the UK panel members ranged from negligible adverse effects to an underestimation of risk by at least a 100 fold. Could the excess leukemias be due to electromagnetic radiation from high voltage power cables linked to the nuclear power stations? or to population mixing and vulnerability to infectious agents suspected of causing leukemia? (Kinlen hypothesis). No one can be sure.

2. In other words, nobody really knows at this point how hazardous the Lynas refinery may turn out to be, given that much of the radioactive solid wastes will be in powdery form, i.e. respirable as suspended particulates, or ingestable from contaminated surfaces. In a situation of uncertainty such as this, the precautionary principle becomes even more important in public health practice (let's recall that obstetric X-rays were considered safe by the medical and scientific community

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[1] It is quite contentious whether these existing ICRP risk models - largely calibrated against external sources of irradiation, most importantly, the Hiroshima/Nagasaki atomic bomb blasts – are adequate for assessing the health risks arising from irradiation by ingested or inhaled *internal* emitters.

[2] the Lynas Radiological Impact Assessment submitted by Nuklear Malaysia (dated June 2010) does attempt to estimate the risks from inhaled emitters for LAMP employees (average volume of air intake, presumed level of dust concentrates and associated radioactivity internalised by the employee) (p.56) but it then proceeds to compare the absorbed radiation dose - averaged over the whole body - with existing norms of 'safe' thresholds of exposure. This is precisely what was contentious in CERRIE's deliberations on the bio-kinetics and micro-dosimetry of internal emitters. By way of analogy, averaging the absorbed radiation dose over the whole body is equivalent to saying that a burning cigarette butt on your palm doesn't hurt because the heat is negligible when averaged over your whole body. Aside from cancer biology, radiation risk can also be approached from an epidemiological perspective. One of the few empirical attempts at this was a 1993-1994 study of male miners at a combined iron ore-rare earth minerals mine in China which was reported in the *Journal of Radiological Protection* in 2005. In that study, highly dust-exposed miners had 5.15 times the age-adjusted lung cancer rate as compared to the rate among Chinese males in the general population. The less-exposed mining staff had 2.30 times the general population rate. Both groups had similar smoking rates (78%, vs. 67% for the general adult male population). On this basis, the authors concluded that the excess lung cancer risk among the less-exposed was largely due to above-average smoking, and the further difference between the two miner groups was due to high exposure to airborne crystalline silica particulates (mainly) and to thorium-containing dusts and its radioactive daughter nuclides such as thoron gas. These conclusions are highly debatable, and it should also be noted that the ores that the Chinese miners were exposed to contained 400 ppm of thorium. The rare earth oxide concentrates that will be arriving shortly at Kuantan port will have 1600 ppm of thorium. The US Public Health Service (1990) reports that the natural background level in soil is typically ~ 6 ppm of thorium.

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until the 1950s, when Professor Alice Stewart (Oxford) raised the alarm with her findings of increased risk of childhood leukemia. These findings were initially also dismissed as a fringe minority opinion - by Sir Richard Doll, no less, doyen of cancer epidemiologists and Regius Professor of Medicine at Oxford - but Professor Stewart's persistence eventually saw them incorporated into mainstream medical practice).

3. In asserting that the LAMP refinery is unquestionably safe, Dr Looi, Dr Che Rosli, Lynas and AELB are taking the precautionary principle rather lightly, in contrast to California for instance, where Molycorp must comply with a zero liquid wastes discharge requirement despite the limited solubility of thorium compounds in most circumstances; or in Germany, where the popular will has obliged Angela Merkel to phase out nuclear power plants even as scientists and researchers continue to lock horns over the unexplained excess of childhood leukemias in the vicinity of nuclear power plants and nuclear reprocessing facilities.

We recall that the ARE rare earths refinery at Bukit Merah, like LAMP, had no long-term waste management plan. *Ad hoc* arrangements, including the aborted Papan dump-site, eventually led to a situation of indiscriminate dumping of radioactive thorium-cake wastes at Lahat, Menglembu, Pengkalan, Jelapang, Buntong, Simpang Pulai among other locations: http://www.merdekareview.com/bm/news_v2.php?n=11823

It would be sad if the Kuantan-Kemaman community ended up as lab rats in a natural experiment.

April 12, 2012

http://www.australianminesatlas.gov.au/aimr/commodity/rare_earths.html#Resources

file:///C:/Users/User/Documents/LYNAS%20Related-Rare%20Earths%20-%20AIMR%202011%20-%20Australian%20Mines%20Atlas.htm

Production

Historically, Australia has exported large quantities of monazite from heavy mineral sands mined in Western Australia (WA), New South Wales (NSW) and Queensland (Qld), for the extraction of both rare earths and thorium. Between 1952 and 1995, Australia exported 265 kilotonne (kt) of monazite with a real export value (2008 dollars) of $284 million (Australian Bureau of Statistics 2009)[5].

Small-scale production of rare earths has taken place in Australia but records on these activities are incomplete. The following information on historical attempts to establish a rare earth production industry in Australia is drawn from Cooper 1990[6]. In the 1950s, Zircon Rutile Ltd at Byron Bay, NSW, processed a small quantity of monazite to produce cerium oxide for use in glass polishing. In 1969, Rare Earth Corporation of Australia Ltd, operating at Port Pirie SA, began producing cerium, lanthanum, yttrium and thorium compounds from locally produced monazite. However, the plant ceased operations in mid 1972 because of a lack of working capital and difficulty breaking into world markets for processed rare earths.

In January 1987, it was announced that the French chemical company Rhone-Poulenc proposed to build a two-stage monazite processing plant at Pinjarra in WA to produce rare earths from monazite, but the project was suspended. Deckhand Pty Ltd, a wholly owned subsidiary of Currumbin Minerals, was blocked in 1988 on environmental grounds from establishing a rare earths processing plant at Lismore, NSW. SX Holdings Ltd of SA was planning to establish a plant at Port Pirie to process monazite with a 2000 tonnes per annum (tpa) cracking and separation plant but the project did not proceed.

Industry Developments

Lynas Corporation Ltd: The Mount Weld deposit in WA is within the lateritic profile over an alkaline carbonatite complex. In September 2010, Lynas announced new resource figures for the Central Lanthanide deposit of Measured, Indicated and Inferred Resources of 9.88Mt with total lanthanide oxides (TLnO) at 10.6% and 990ppm Y_2O_3 (heavy REO) and the newly named Duncan heavy REO deposit with Measured, Indicated and Inferred resources totalling 7.62Mt at 4.5% TLnO and 2570ppm Y_2O_3 . In another part of the carbonatite complex, the Crown Polymetallic deposit, there are Indicated (1.5Mt) and Inferred (36.2Mt) Resources totalling 37.7Mt, which include total lanthanides at 1.16% and 0.09% Y_2O_3. The company completed the first stage of mining activities in 2008 and commenced construction of a concentration plant at Mount Weld and an advanced materials plant in Malaysia.

The concentration plant was commissioned in May 2011 and by the end of October, Lynas Corporation reported that the plant achieved a concentrate grade of 36.8% REO and a recovery of 64%. In Malaysia, construction of the company's advanced materials plant was 78% complete at the end of September 2011 and its September 2011 quarterly reported that the first feed to kiln was expected to occur in the first quarter of 2012. Subject to receipt of a pre-operational licence, the company anticipates the plant will reach commercial scale supply during the first half of 2012.

..dney Morning Herald - Nov 9, 1987

$300 million on paper as a result of falling share values, but in the same week had invested $70 million in a new business in time, and if I might say so with respect, a pretty old President who has had a lot of changes in top personnel in recent months."

Radioactive row over Lismore metals plant

By YVETTE STEINHAUER

A furious debate is raging in the northern NSW city of Lismore over a proposed mineral processing plant that would produce nearly 1,000 tonnes of radioactive waste a year.

The waste would be stored on-site in fuel drums, but the developer, Deckhand Pty Ltd, says a further 13 kilograms of thorium (one of the most radioactive substances) and 68 kilograms of uranium would enter local sewerage and rivers from the plant's water-dilution process.

Mr Brian Thomas, a director of Deckhand who also heads the Department of Physics at Queensland Institute of Technology, said the plant was "completely and utterly safe" because the amounts of thorium and uranium were way below the permissible levels set by the NSW Radiation Act.

Despite these assurances, widespread community opposition in Lismore has forced the city council to hold a public commission of inquiry, which begins tomorrow.

It will hear submissions from residents who oppose the plant, including lawyers' and doctors' groups, environmentalists and farming bodies.

The inquiry is independent. ... tralia's first rare-earth processing facility, which would extract pure metals from monazite — the main by-product of sand mining.

Australia produces 65 per cent of the West's monazite. At present it is exported to France and Japan for processing into pure metals to be used in new technology and as superconductors.

Until now, Deckhand expected to receive State Government backing. A recent Department of Mineral Resources report on mining and mineral strategy listed a rare-earth processing plant as a high priority among industries with high-yield export potential.

Mr Unsworth said the Government wants to encourage the industry, but he has "serious concerns" about the plant.

One opponent of the plant is the Norco Dairy Corporation, which fears it would be disastrous for the dairying industry because of possible radioactive contamination of local waterways and farmlands.

The local beef industry is also worried. Mr Ken Somerville, a beef farmer whose land borders the proposed site, said it could ruin the already precarious beef trade to Japan.

The Lismore Chamber of Com-

- All activities that may result in the potential release of hazardous materials to the ground such as changing of engine oils and lubrication oils from construction vehicles, equipment and generators on site will be performed only on designated sealed areas or on drip trays to reduce the risk of direct spill into the underlying soil and groundwater. Spent oil must be handled and disposed of as scheduled waste;

- Any accidental spills of fuel, oil or other hazardous chemicals will be cleaned up immediately. The recovered media (contaminated soil, absorbent pads, rags etc) should be disposed of as scheduled waste; and

- Appropriate sanitary facilities will be provided and properly maintained for construction workers throughout the construction stage. Direct discharge of untreated sewage into underlying soil, groundwater or surface water is prohibited. If portable toilets are procured to the site, they must be of sufficient numbers and meet the requirements of Department of Sewerage Services, Ministry of Housing and Local Government.

8.3.2 Operational Phase

The areas of concern for the potential soil and groundwater contamination during the operational phase include:

- Lanthanide Concentrate Storage Shed;
- Residue Storage Facility (RSF);
- WLP Retention Pond;
- NUF and FGD Retention Pond;
- Acid storage area (tank farm);
- Chemical Store;
- The 10,000-litre aboveground diesel storage tank;
- The emergency firewater pumphouse (with 1,000-litre diesel storage tank);
- Diesel generators (with 5,000 litre diesel storage tank each); and
- Scheduled wastes (waste oil, expired chemicals, etc) storage area.

In addition, other potential sources of impact include the periodic handling and dispensing of chemicals with the process areas, spills of fuels and lubricating oils, albeit in small quantities, may lead to minor spills and leakages. Such accidental releases are usually a result of poor chemical handling practices and may likely occur at the maintenance workshop and hazardous substances handling and storage areas.

Impacts to soil and groundwater resources associated with plant operations could be easily addressed, prevented and overcome by implementing appropriate mitigation measures discussed in the following subsection.
Prevention and control measures include the following:

- The diesel fuel storage tank and reagent storage tanks will be located within concrete-bunded enclosures capable of containing 110% of the contents of the tank within each enclosure. The floor of the bunded enclosures will be concrete-lined with an impermeable liner to prevent contaminant from permeating into the ground;

- Appropriate instrumentation and control/trigger alarm to warn of possible overfilling and to provide an alert mechanism in the event of significant fuel/chemical loss should be provided for the storage tanks;

- Operational control which includes regular/routine surveys, inspection and maintenance of the diesel fuel tank, chemical tanks and their ancillary facilities (pumps, valves and pipes) will be integrated into the plant's environmental management practices so as to identify and rectify any significant product losses or ongoing spills/leakages which may be occurring;

- Areas where regular or periodic handling and dispensing of liquid chemicals are undertaken, such as maintenance workshop and hazardous waste storage areas, should be concrete-paved with appropriate secondary containment (drip trays and bunded areas) provided.

- Any accidental spills will be assessed on a case by case basis and remedied, including excavation and disposal of any contaminated soil (classified as scheduled wastes) at a secure disposal facility.
- Procedures and work instructions on proper chemical handling should be effectively communicated to all operations and maintenance personnel;

- Hazardous materials and waste storage, handling and disposal procedures will be developed; and

- Corrosion protection for steel tanks and their ancillary facilities (pumps, valves and pipes) will be provided to prevent leaks.

In addition, groundwater should be monitored on a regular basis during the lifetime of the plant operation. If contaminants are present at concentrations above the groundwater quality screening levels such as the Dutch Intervention Values (DIVs), further assessments will be necessary to determine the nature and extent of the contamination, as well as to remove the potential source(s) of contamination.

8.4 NOISE

8.4.1 Construction Phase

Major noise sources during the construction phase of the project include:

- Site preparation works;
- Building construction activities including piling; and
- Transportation of construction equipment and materials: Vehicular noise will be generated from the ingress/egress of trucks carrying materials to/from the site.

The nearest noise sensitive receivers are the residential properties located at Kampung Sg. Ular (3 km northeast of the site), Kg. Gebeng (2.5 km east of the site) and Tanah Kemajuan Gebeng (2.5 km southwest). The noise impacts arising from the plant will not impact the noise environment at these receivers.

Based on the assessment of construction noise, the impacts during predicted are short-term, transient and localised to the site and its immediate surrounding (within the buffer zone of the industrial area).

The following standard noise control practices and measures will be implemented during the construction phase:

- Machinery and construction vehicles that may be in intermittent use will be shut down between work periods or will be throttled down to a minimum;
- The impact of piling noise can be minimised by the selection of quieter pile drivers such as hydraulic pile, or bored piles.
- Material stockpiles and other structures will be effectively utilised, where practicable, to act as a screen for noisy equipment operating within the construction works area.
- Noisy equipment, such as generators, will be checked for proper installation of engine silencers to reduce emitted noise. Other machinery with high noise level should be operated within enclosures.
- All transport vehicles must comply with the noise requirements made under the *Environmental Quality (Motor Vehicle Noise) Regulations 1987*. The maximum sound level permitted for trucks used in the transport of goods or materials should not exceed 88 dBA. Moreover, transportation vehicles should not be overloaded to avoid driving with full engine capacity which results in higher noise being emitted.

- In terms of workers safety and health, workers spending long hours on site, operating machinery and equipment that generate loud noise, will be provided with protective ear mufflers to prevent hearing impairment/loss.

8.4.2 Operational Phase

The primary dominant noise sources during the operational phase of the plant include the following: (the respective noise levels, when measured at one metre from the plant, is also specified):

- Rotary Kiln 97 dB(A)
- Cooling Tower 99 dB(A)
- Kiln Blower 97 dB(A)
- Covered Conveyor 70 dB(A)
- Conveyor Drive 97 dB(A)
- Exhaust Fans 96 dB(A)
- Compressor House 85 dB(A)
- Pumps 98 dB(A)
- Front-end Loaders 100 dB(A) – (or 86 dB(A) at 5 metres)

The future noise levels at the plant site boundary were quantitatively predicted with the use of a well established computer modelling programme *SoundPlan 6.2* (developed by Braunstein + Berndt, GmbH and accepted for use by the regulatory authorities in Australia).

A single scenario was modelled which represents the combined noise levels from the operation of the plant and the movement of trucks transporting raw material (lanthanide concentrate), reagents and finished products.

The predictions are based on two assumptions:

- Worst-case environmental conditions when the prevailing wind blows 100% of the time in the direction of the receiver, i.e. in a north-easterly-easterly direction.
- All equipment and machinery within the plant are operating simultaneously.
- Truck movements consisting of 68 trucks per day for the reagents and 18 trucks per day for the concentrate;
- Trucks operating 24 hours per day; and

----- Forwarded Message -----
From: "Bradsher, Keith" <kebrad@nytimes.com>

Sent: Friday, 3 February 2012 11:48 AM
Subject: RE: Malaysian Insider

Hi
Thank you very much, and this is very, very clear. I really doubt that Lynas will have the audacity to contact The New York Times and seek a correction. But if they do, this will certainly give me lots of ammunition. And I'll certainly hold on to this for when there's an accident.
Best regards,
Keith

From:
Sent: Friday, February 03, 2012 11:38 AM
To: Bradsher, Keith
Subject: Malaysian Insider

Hi Keith,
A few FACTS about the situation

1) Derakane 411 is an excellent vinylester however it can NOT be applied to concrete with a moisture content above 5%
2) The contract calls for Derakane 411 or equivalent, their are many copy cat manufacturers/suppliers of the product who are much cheaper & don't have the same integrity of Dow Chemicals, it is most likely one of these is being used.
3) International Paint intended to have personell on site for the duration of the project to ensure AxoNobel product was applied correctly on acceptable substrate (concrete) so as to be in a position to warrant the lining system.
4) It is unlikely Trepax will have such 3rd party supervision and any warranty will be their own (2 years only)
5) Cradotex & international Paint intended to give back to back warranty with Cradotex warranting the application & International Paint warranting the lining system.
6) Trepax intended to use one of their products MB100 as a primer to seal the moisture, then apply AxoNobel system , this is when AxoNobel withdrew supply as the adherence between the two systems is unproven.

Re cracked walls

A) The British Standard states these lining systems (corrosion Barriers) are NOT to be placed under mechanical load and their strength is NOT to be included in any calculations.
B) Trepax intend to apply the MB100 to the cracked walls to bridge the cracks (must be pretty good stuff) then apply AxoNobel system, this was another reason for AxoNobel declining to supply.
C) The success of the corrosion barrier depends on excellent adherence to the concrete, the expansion rate of the lining system and the concrete are different, so the inevitable movement created when the tanks are heated (expansion) plus many hundreds of tonnes of product are loaded may eventually cause the lining system to fail and allow the tank contents to reach the already breached concrete, plus 6 of the tanks have an added brick/tile lining adhered to the corrosion barrier, further complicating the adherence issue to the concrete.

Hope i have written this clearly for your understanding, contact me with any clarifications.

Regards

3.6 Radioactive Waste Management (RWM) in Malaysia

NUCLEAR MALAYSIA was established in 1972 as the Tun Ismail Atomic Research Center (PUSPATI). Infrastructural development on the 27-hectare at Bangi commenced in January 1979, culminating in its coming into full operation in June 1982 with the commissioning of its nuclear research reactor. PUSPATI was later renamed the Nuclear Energy Unit (UTN) in June 1983 on being placed under the auspices of the Prime Minister's Department. A second 81-hectare complex, about 3km apart, Kompleks Dengkil site was acquired in 1984. In October 1990, the UTN was retransferred to the Ministry of Science, Technology and the Environment (MOSTE). On August 10, 1994 the cabinet approved a new name for the UTN as the Malaysian Institute for Nuclear Technology Research (MINT) (see Figure 3.6-1 MINT Organizational Chart). As a result of Ministers of the Federal Government (Amendment) (No.2) Order 2006 of the Ministerial Functions Act 1969, MINT has again been renamed as Malaysian Nuclear Agency (Nuclear Malaysia) effectively from 13 April 2005.

In view of the advancement in nuclear technology, the previous Radioactive Substances Act 1968 has to be repealed to extent the coverage of regulatory functions. Hence, the Atomic Energy Licensing Act of 1984 or Act 304, was formulated, paving the way for the establishment of the Atomic Energy Licensing Board (AELB) as a separate entity, in February 1985

3.6.1 RWM Policy

The setting up of Nuclear Malaysia with 1 MW TRIGA Mk II research reactor has been a catalyst for the use of nuclear technology in various fields in Malaysia. With regard to nuclear power program, the Government has reaffirmed that the national energy policy will continue to be based on five fuel policy namely, oil, gas, hydro, coal and renewable energy. It excludes nuclear energy as one of the option. With this decision, the amount of radioactive waste in future is not expected to increase significantly. Since Malaysia has no plans to embark on a nuclear power program, it limits nuclear activities to the applications of such technologies in the industrial, medical, agricultural, and environmental sectors.

Malaysia has a long history of tin mining activities. Certain minerals, such as monazite, illuminate, and zircon - which contain natural radioactive elements such as uranium, thorium and radium - coexist with tin ore or cassiterite in the ground. In the process of extracting tin, these radioactive elements become more concentrated and become by-products of mineral processing industries. These activities generate a sizable volume of radioactive waste.

In 1997, a special Committee to formulate National Policy for the Safe Management of Radioactive Waste was set up. The task of the Committee was to provide guidelines for the safe management of radioactive waste. The Committee consisted of various groups of people, including those from non-government agencies, who might have interest on radioactive waste. A draft policy has been submitted to the Ministry of Science, Technology and the Environment for comments and approval in early 1999.

Since Malaysia does not have any specific regulation on disposal and management of radioactive waste, AELB (see Figure 3.6-2 AELB Organizational Chart) enforces the waste management policy through its licensing procedure and conditions of license issued to the licensee. Details of the process are shown in Table 3.6-1.

Table 3.6-1 Radioactive Waste Management Policy

Waste Generator	**Industry**	**Hospital/University/ Research Institute**		**Activities Related to TENORM**	
Types of Waste	Sealed sources	Sealed sources	Liquid waste	Solid waste	Liquid waste
Policy	Return to the supplier	Return to the supplier	Sent to National Radioactive Waste Management Center	Stored by the user	Stored by the user
Licensing requirement	Undertaking letter from the supplier to accept back the waste	Undertaking letter from the supplier to accept back the waste	Undertaking letter from the center to accept the waste	Waste storing facility which must be comply with AELB criteria	Waste storage tank
License conditions	Waste shall be returned to the supplier. Or send to the Nuclear Malaysia	Waste shall be returned to the supplier. Or Send to the Nuclear Malaysia	Waste shall be sent to National Radioactive Waste Management Center.	Waste shall be stored in the waste storing facility. For disposal purpose, the licensee are require to carry out a risk assessment to any proposed disposal site as to demonstrate that the discharge will not exceed the limit for the member of the public (1 mSv/yr)	Can be discharged to the environment if the radioactivity for liquid below the discharge limit, for example 1 Bq/L

Comments on waste management related to the Lynas Advanced Materials Plant (LAMP) Malaysia

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Executive Summary

1. The main waste of radiological concern is the Water Leach Purification (WLP) waste which has a head-of-chain activity concentration of just over 6Bq/g (inclusive of the small amount of uranium-238 head-of-chain activity, with a total decay chain activity of over 62Bq/g. Overall, over the 20 year lifetime of the LAMP 1.248 million tonnes of radioactive WLP waste (1.8 million m^3-equivalent to an area over 1.3km by 1.3km at a depth of one metre) will be generated and requiring isolation and containment for hundreds to perhaps thousands of years. Additional waste will derive from the decommissioning of the LAMP after 20 years.

2. The WLP waste is most accurately categorised as Low Level Waste based on the revised IAEA generic classification. However, this should be seen only as a guide for the appropriate treatment of radioactive waste. A waste management option that varies from that indicated by the generic waste classification scheme may also be determined as safe and viable on the basis of a specific safety assessment.

3. The Lynas Safety Case is deficient, even allowing for the recommended IAEA graded approach:

    - It does not adequately address uncertainties inherent in their assessments of safety
    - It does not adequately address future human intrusion scenarios beyond the 300 year institutional control period, and indeed is contradictory on this point, claiming passive controls whilst emphasizing adminstrative controls (zoning, buffers)
    - Failure to account for the "zero option" case ie if no disposal site is found. This may result in over one million tonnes of radioactive waste being stranded at the LAMP site which will become the de facto permanent waste disposal facility without community consent.
    - Indicating that the LAMP site might be used as the PDF when this has been excluded by the local authorities.

- The absence of analogous rare earth processing plants and the associated radioactive waste management to demonstrate the likely scenarios the state of Pahang might confront. Given that China provides over 70% of the world's rare earth supply this is the obvious comparison. Uranium ore bodies and tailings are not an optimal comparison to draw.

4. Lack of understanding of the key societal drivers of selection, operation and closure of a radioactive waste disposal facility. Lynas has failed to understand that a permanent waste disposal facility is granted by consent of the society in which it will reside for hundreds and probably thousands of years. A bottom up approach is required with broad stakeholder and community consultation and participation. From the timeline envisaged in the Safety Case and the criteria enunciated, Lynas have adopted an administrative and scientific top-down approach which will antagonise and alienate the community which will be asked to host the site, virtually ensuring failure of the process.

5. Lack of appreciation of the timescale required to locate suitable disposal sites and obtain community and stakeholder consent.

Purpose and Scope

The purpose of this report is to provide an opinion of the current proposal to dispose of waste from the Lynas Advanced Materials Plant (LAMP) rare earth processing plant being the Water Leach Purification (WLP) waste which contains radioactivity at a level that exceeds the exemption value of the head-of-chain isotope, Thorium-232. Assessment of the temporary waste storage facility at the LAMP is not in the scope of this report. Decommissioning waste is also not specifically in the scope of this report however it is assumed that the permanent disposal facility (PDF) to be used for regulated waste will also be used for this waste. Hence all comments will pertain also to decommissioning waste unless explicitly excluded.

Actual operational safety of the plant, non-radiological waste matters and occupational and population radiological hazards associated with operation of the plant are also beyond the scope of this report.

Also beyond the scope of this report is an assessment of the Malaysian radiation regulatory system. A good overview is however provided in the IAEA review mission report (2011) referred to below, which contains some constructive suggestions for improvement in operations and resourcing. I note however that Malaysia whilst a member state of the International Atomic Energy Agency, is not a member of the Joint Convention of the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management. This is a legally binding international treaty that commits parties to international best practice to achieve and maintain a high level of safety worldwide in spent fuel and radioactive waste management, through the enhancement of national measures and international co-operation, including where appropriate, safety-related technical co-operation.

Reference Documents

I have consulted the following documents:

- (Lynas, 2011a) Lynas LAMP Radioactive Waste Management Plan, 2011
- (Lynas, 2011b) Safety Case for Radioactive Waste Disposal (LAMP), 2011
- (IAEA ,2011). Review of the international review mission on the radiation safety aspects of the proposed rare earth processing facility (The Lynas Project)

andthe following references:

- IAEA (2009) : Classification of Radioactive Waste , General Safety Guide, GSG-1, IAEA Vienna.
- IAEA (1999) : Near Surface Disposal of Radioactive Waste WS-R-1, IAEA Vienna
- IAEA (2002) : Management of Radioactive Waste from the Mining & Milling of Ores, WS-R-1.2 IAEA Vienna.
- IAEA (1995): The principles of Radioactive Waste Management IAEA Vienna
- IAEA (2004) : Application of the Concepts of Exclusion, Exemption & Clearance Safety Guide RS-G-1.7, IAEA Vienna
- IAEA (2005) : Regulations for the Safe Transport of Radioactive Material 2005 Edition, TS-R-1, IAEA, Vienna
- IAEA (2006) : Storage of radioactive Waste IAEA Vienna
- IAEA (2008) : The Management System for the Disposal of Radioactive Waste, Safety Standards Series No. GS-G-3.4, IAEA Vienna
- IAEA (2011): Disposal of radioactive waste – Specific safety requirements SSR-5. Vienna.
- IAEA (2011): IAEA Safety Standards Series, Draft Safety Guide No. DS 355, The Safety Case and Safety Assessment for Disposal of Radioactive Waste, June 2011.

- IAEA-TECDOC-1372 (2003): "Safety Indicators for the Safety Assessment of Radioactive Waste Disposal".
- IAEA (1999): IAEA Safety Standards Series No. WS-R-1, "Near Surface Disposal ofRadioactive Waste Requirements".
- IAEA (2006): Release of Sites from regulatory control on termination of practices, Safety Guide WS-G-5.1
- IAEA (2011): Radiation Protection and NORM residue management in the production of rare earths from thorium containing minerals. IAEA Safety Report Series no. 68
- Policy for Long Term Management of Low Level Radioactive Waste in the UK, (2007). Department for Environment, Food and Rural Affairs, UK

Assessment Criteria

The overarching assessment criteria I have utilised are:
1) Whether what is proposed corresponds to international best practice, and,
2) Whether the proposed radioactive waste management provide optimal protection to humans and the environment over the time that the waste will pose a hazard

Background and overview of LAMP

Lynas is presently constructing the LAMP on 100 hectare-site located within the Gebeng Industrial Estate Kuantan, Pahang, Malaysia. Construction activities commented in May 2008 and are expected to be completed in 2012.

Once operational, LAMP will process up to 80,000 tonnes per annum ((tpa) wet weight basics) of lanthanide concentrate (equal to 65,000 tpa dry weight basic) and produce 22,500 tpa (lanthanide oxide) of lanthanide components.

The main feed stock, lanthanide (rare earths) concentrate, will be imported from the Mt Weld mine in Western Australia operated by Lynas Corp. Ltd (Aus). At the mine site in Australia, the lanthanide ore will be mined, stockpiled, crushed and concentrated to produce lanthanide concentrate. The concentrate will be placed in bucker bags and transported in containers by sea from Freemantle Ports (WA) to Kuantan Port in Malaysia. Upon arrival at the Kuantan Port, the containers will be transferred onto trucks for transport by road to the LAMP site.

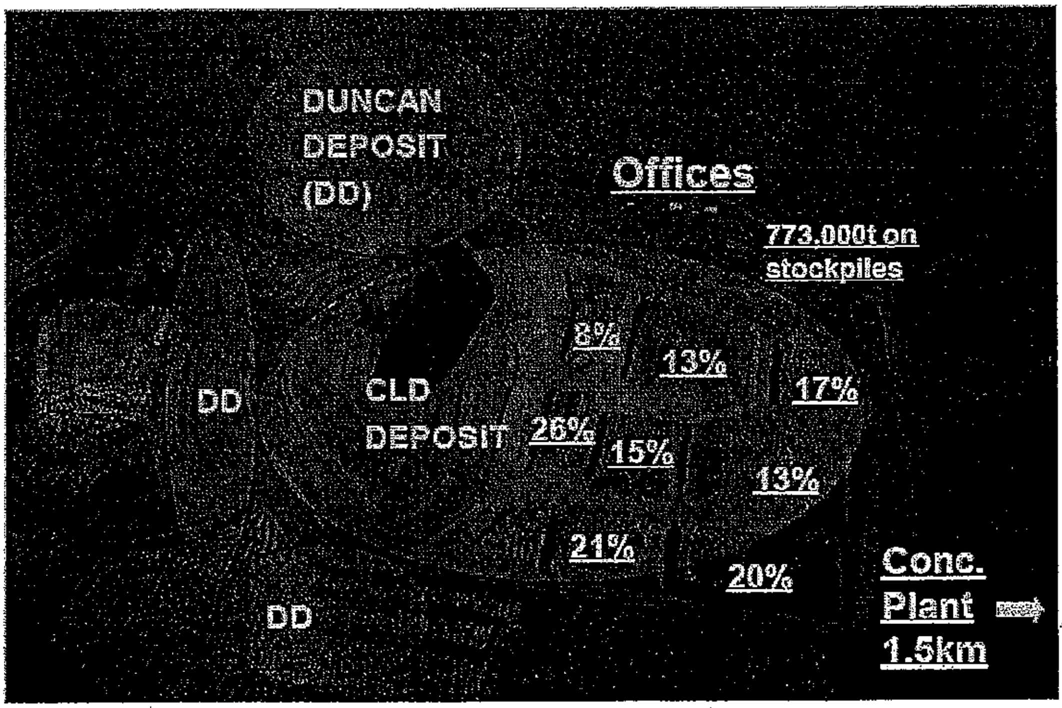
At the LAMP site, the lanthanide concentrate which is the primary feedstock will undergo several stages of processing to produce a suite of high purity lanthanide products comprising individual lanthanide elements or mixed lanthanide elements.

Mount Weld ore body:[1]

TABLE 17. RARE EARTH, THORIUM AND URANIUM CONTENT OF MOUNT WELD ORE

	Concentration (%)	
	Average	Maximum
Total REO	17–18	42
ThO_2	0.075	0.18
U_3O_8	0.003	0.006

During the initial mining campaign in 2007-8, 409,000 tonnes of ore at approximately 18% REO were mined and stockpiled. As of early 2012, this had increased to 773,000 tonnes at the following REO percentages:



* Lynas presentation BBY rare earths conference, March 13, 2012

The mine is in the Central Lanthanide Deposit, a resource of 15 million tonnes with an average REO percentage of 9.8%, according to the Lynas corp. presentation in March 2012. This grade conflicts with the assessment published in the aforementioned IAEA Safety Report Series no. 68, 2011. However, the discrepancy might be due to the lower percentage related to the overall ore body, with the higher percentage reflecting the

[1]Mining and beneficiation of rare earth ore at Mt. Weld, Western Australia, in, *Radiation Protection and NORM residue management in the production of rare earths from thorium containing minerals*. IAEA Safety Report Series no. 68, 2011

average stockpile concentrations. This also explains why with concentration to 40% REO (v.i.), the thorium concentration only increases just over two fold in the exported REO concentrate.

The Rare Earths are hosted in secondary Rare Earths phosphates that can contain up 60-70% REO. These are heterogeneously distributed in the ore body according to the monazite formations in which they lie. A comparison with rare earth deposits worldwide demonstrates that the Mount Weld deposit contains not only the richest deposit of rare earths in the world, but also the highest concentration of thorium in the world (as tends to be the case with monazite ores), except for some mineral sands, being up to 200 times the mean soil concentration of thorium.[2]

TABLE 2. RARE EARTH, THORIUM AND URANIUM CONTENT OF RARE EARTH DEPOSITS

Deposit	Country of origin	Concentration (%)		
		REO	ThO_2	U_3O_8
Bastnäsite–monazite ore	China	1–10	0.04–0.07	0.0002
Bastnäsite ore	China, USA	0.5–12	0.02–0.1	0.002–0.004
Rare earth bearing clay	China	0.05–1	0.005	0.005
Heavy mineral sands	Various	0.1–5	0.0006–0.4	0.0003–0.006
Rare earth ore, principally supergene monazite[a]	Australia	4–25	0.075 (max. 0.18)	0.003 (max. 0.006)
Loparite ore	Russian Federation	0.1		
Soil (median values) for comparison purposes [15]	Worldwide		0.0008[b]	0.0003[b]

[a] Some zones also contain churchite, a hydrated yttrium phosphate mineral.
[b] Derived from activity concentration data assuming that 1 g of natural uranium contains 12 350 Bq of U-238 and 1 g of natural thorium contains 4057 Bq of Th-232.

After crushing, the stockpiled ore is fed by a front end loader into a flotation concentration plant, this plant produces approximately 65 000 t/a of rare earth concentrate with an REO concentration of 40% and expected thorium and uranium concentrations of 0.17% ThO2 and 0.003% U3O8. The Mount Weld Concentrator is designed to process 121,000 tonnes per annum of ore and will produce approximately 33,000 tonnes per annum of concentrate in Phase 1 (years 1 and 2) and double this for

[2] *Radiation Protection and NORM residue management in the production of rare earths from thorium containing minerals. IAEA Safety Report Series no. 68, 201, Table 2, p10.*

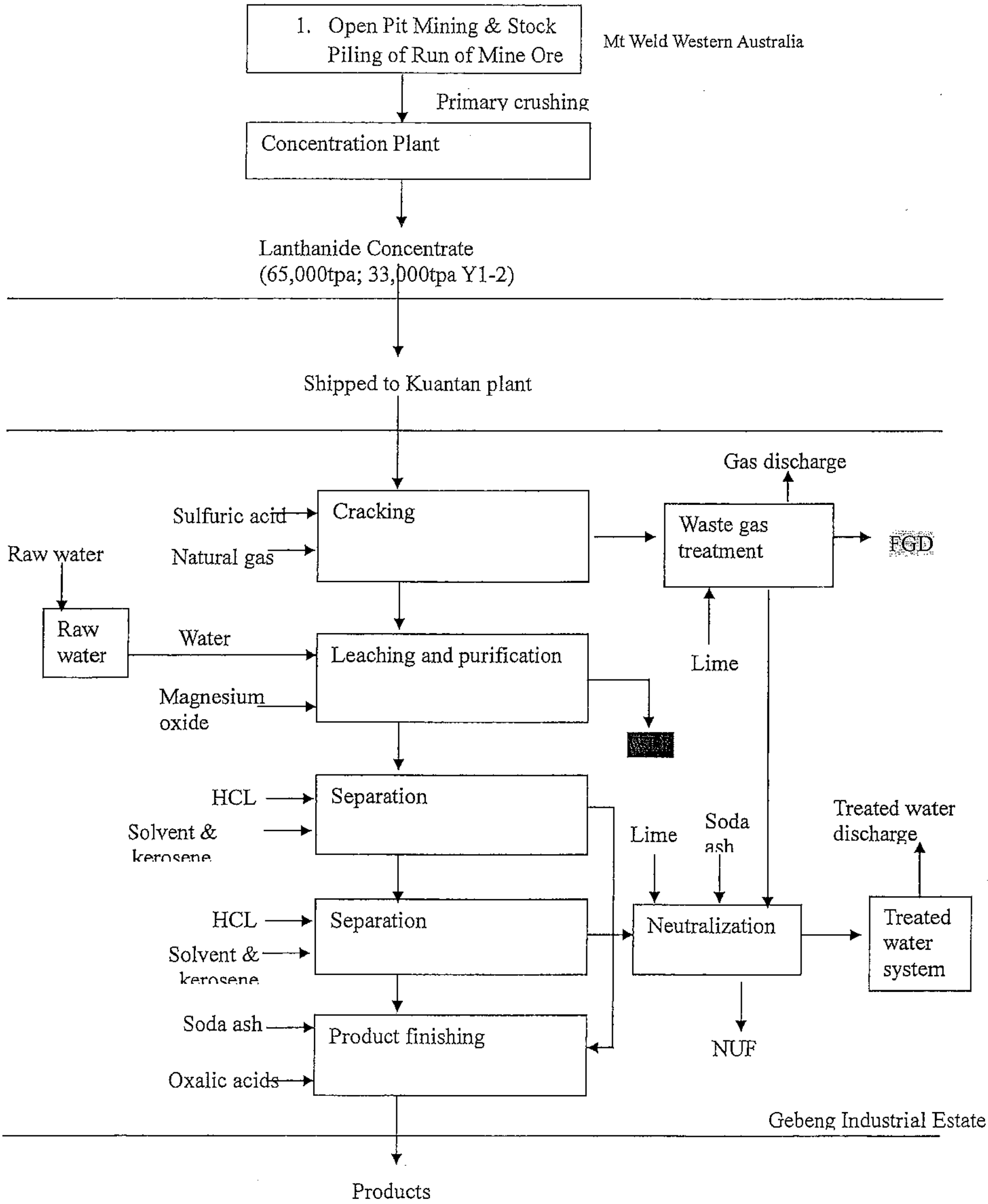
Phase 2 of the Lynas production plan. Phase 1 of the plan will see approximately 11,000 tonnes of separated REO produced in Malaysia.

Lynas Advanced Materials Plant (LAMP) secondary processing:

The Lynas Advanced Materials Plant, built on 100 hectares, will be the largest rare earths processing plant in the world. Once the lanthanide concentrate is shipped to the Kuantan LAMP plant from Western Australia, it undergoes high temperature acid digestion and various hydrometallurgical processes, with solvent extraction of the rare earth products which are then 'finished' by being precipitated or calcined.

33,000 tonnes of concentrate will be processed in each of the first two years of operation and subsequently 65,000 tonnes (dry mass). It is anticipated that in the each of the first two years of operation 11,000 tonnes of separated rare earth oxides will be produced and double that amount in subsequent years (see next page):

Figure 1. Simplified process flow diagram (Lynas LAMP Radioactive Waste Management Plan, 2011; p22)



The processing of rare earths concentrate will give rise to three main solid residue streams, characterized by relatively large volumes of material and low concentrations of thorium, uranium and their decay products (Fig 2.)[3]:

i) Flue gas desulphurization (FGD) residue;
ii) Neutralisation underflow (NUF) residue;
iii) Water leach purification (WLP) residue.

Figure 2. Characteristics of Solid Residues from LAMP

Residue	Radioactivity concentration (Bq/g)		Dry mass, year 1 (t)	Assumed dry density (t/m^3)	Annual volume (m^3)		Volume after 10 years (m^3)
	Th-232	U-238			Year 1–2	Year 3–10	
FGD	0.04	0.003	27 900	1.05	26 600	53 200	478 800
NUF	0.03 combined		85 300	1.05	81 300	162 600	1 463 400
WLP	6	0.2	32 000	0.70	45 800	91 600	824 400
Biosolids[a]	–	–	913	0.28	3 318	6 636	29 864
Total	–	–	146 113	–	157 018	314 036	2 796 464

[a] This is a minor residue stream in the form of a sludge from the waste water treatment plant and has no radiological significance.

The processing method produces very large volumes of waste. Note that in the first year of production, despite 43,000 tpa (wet) and 35,000 tpa (dry) of concentrate feedstock, the total volume of waste solids will be 157,000 m3 (146,113 tonnes [dry]), of which WLP will comprise a similar weight but larger volume to the feedstock.

The WLP will contain over 99% of the thorium and radium radionuclides in the feed concentrate.[4]

Hence, the activity concentration of Thorium-232 in the WLP, the waste component of significant radiological impact, is comparable to that of the feedstock concentrate (6Bq/g).

Radioactive waste management and disposal

What is the risk?

The fundamental objective of radioactive waste management and disposal is to protect people and the environment from harmful effects of ionising radiation now and in the

[3] *Review of the International Review Mission on the Radiation Safety Aspects of a proposed rare earths processing facility (The Lynas Project), IAEA, 2011.*

[4] P.29 Radioactive Waste Management Plan, Lynas Corp. (2011)

future without placing an undue burden on future generations. The main risk to humans at the levels of exposure which may arise from the low levels of radioactivity present in the waste arising from the LAMP is stochastic ie cancer. Acute radiation effects at these levels are not a consideration.

Radiogenic cancer has a latency of at least 10-15 years and may take many decades to appear following exposure. The effects are cumulative, that is, repeated and/or continuous exposure to radiation increases stochastic risks commensurate with the cumulative dose in a linear fashion. The US National Academy of Sciences in its Biological Effects of Ionising Radiation (VII) report (2006), a consensus review that analysed and assessed the world's scientific literature on the subject at that time concluded: *"... there is a linear dose-response relationship between exposure to ionizing radiation and the development of solid cancers in humans. It is unlikely that there is a threshold below which cancers are not induced."* This 'linear no-threshold' (LNT) model of radiogenic carcinogenesis forms the basis and rationale of radiation regulatory regimes worldwide. At very small doses of radiation, the risk is commensurately very small but rises with increasing and cumulative dose.

Two broad types of ionising radiation are recognised: 1) External radiation, comprised of x-rays and gamma radiation which can be considered behaving like sunshine; and 2) Internal (particulate), comprising alpha and beta particles which need to be ingested or inhaled to achieve their effects as they have a limited ability to penetrate skin. Particulate radiation can be taken up by various organs and remain a hazard for years. The (small) fraction of thorium-232, the parent isotope in the WLP waste, which is absorbed after ingestion remains in bone with a biological half-life of 22 years, where the absorbed dose is magnified by and largely due to its decay chain components, particularly radium.

Regulation of exposure to radiation is not intended to remove all risk. At a basic level, background (natural radiation) cannot be regulated, however, steps to limit exposure to it can be implemented eg radon exposure in dwellings. Human activity can however both create radiation and enhance naturally occurring radiation. Regulation is therefore designed to minimise the risk of such radiation acknowledging that such activities can create benefits to society. The principle used to achieve these minimal levels of radiation exposure is known as 'As Low As Reasonably Achievable' (ALARA), which determines the lowest radiation dose achievable in a given practice that results in radiation exposure, with economic and social factors taken into account. This is bounded by dose constraints (restrictions on the doses to individuals) and risk constraints (the risks to individuals in the case of potential exposures) so as to limit the inequity likely to result from the inherent economic and social judgements. Therefore, statements of 'safety' of particular practices or exposures are value judgements and not absolute statements implying absence of risk.

It is important to note that whilst there is an inherent assumption that by achieving adequate protection of human health, an acceptable level of protection will be afforded to the environment, this may not be valid in all circumstances. Non-human biota might and probably do behave differently with their own varying susceptibilities to ionising radiation. Therefore, specific additional control measures may be required in various circumstances. This is an evolving field of radiation protection with many uncertainties.

Waste from mining and processing rare earth ores

Although mining and milling waste contains only naturally occurring radionuclides (NORM; naturally occurring radioactive materials), these radionuclides cannot be considered to be in their original states or concentrations, since their physical and chemical forms may have been altered substantially. The lanthanide feedstock is an example of this. Processing of lanthanide concentrate further enhances this by increasing the availability for release into the biosphere of the TENORM (technologically enhanced NORM). Waste thus produced also has potential for enhanced radionuclide release into the biosphere particularly as the thorium-232 has been liberated from its high affinity adsorption to mineral particles in its NORM state. Bioavailability is also further enhanced through the method by which the waste is managed. The disposal method chosen determines the potential for direct exposure to the TENORM and also the potential for surface water and groundwater contamination arising from it. Exposures attributable to such waste should not be regarded as exposure to natural background radiation and exposures of the public attributable to all processing waste should be included in the system of radiation protection for practices.

Despite the widespread occurrence of NORM, and notwithstanding the development of guidance material in some countries and by international authorities, there is no systematic international approach to regulating NORM in commodities and products, or for the management of NORM residues and wastes. International best practice must be ascertained from many sources however, the IAEA Safety Standards form the basis.

Once radionuclides are released into the environment, they can migrate via multiple pathways, thus leading to other types of exposure. The potential exposure pathways also depend on the local environment and demographics. Failure of institutional control over disposal sites resulting in a failure of the containment may lead to a release of NORM/TENORM into groundwater or as airborne dusts, and probably constitutes the major cause of human exposure. Given the long half-lives associated with NORM, institutional controls may need to be maintained in some form for a long time. This is particularly relevant in the case of WLP waste disposal where the parent isotope, thorium-232, will not decay appreciably in the timeframe envisaged for institutional control of around 300 years, and hence there will be no appreciable reduction in the level of radioactivity of the entire decay chain despite the remaining components having short half lives, assuming secular equilibrium.

Certain waste materials such as phosphogypsum are being used for civil engineering purposes. While this may not lead to appreciable exposure, decommissioning or rebuilding such structures and the ensuing dust generation or landfilling of secondary wastes may lead to exposure. The same waste materials are used to make a variety of mainly lightweight construction materials. Lightweight building blocks and plasterboard are typical examples with a potential to result in external exposures. The proposal to recycle WLP waste at the LAMP plant needs to be considered in this light, although it is acknowledged that it will only form a small proportion of any such building materials and thus a commensurately small level of radioactivity.

Classification of radioactive waste from LAMP

The preferred strategy for the management of all radioactive waste is to contain it (i.e. to confine the radionuclides to within the waste matrix, the packaging and the disposal facility) and to isolate it from the accessible biosphere. This strategy does not preclude the discharge (i.e. controlled release) of effluents, arising from waste management activities, which contain residual amounts of radionuclides, or the clearance of materials that meet the relevant criteria. International safety standards have been established covering both of these circumstances.[5]

IAEA Safety Standards Series No. RS-G-1.7 (IAEA, 2004b), *Application of Concepts of Exclusion, Exemption and Clearance*, sets exclusion levels for naturally occurring radioactivity in waste materials at 1Bq/g head-of-chain activity for the uranium and thorium decay chain radionuclides. These values are at the upper end of the world-wide distribution for naturally occurring radioactivity in soils. The activity concentration of 1 Bq/g is currently the internationally-accepted level for defining the scope of regulation for naturally occurring materials (NORM/TENORM) containing uranium or thorium.[6]

[5] Disposal of radioactive waste: Specific Safety Requirements SSR-5. IAEA 2011

[6]The primary radiological basis for establishing values of activity concentration for the exemption of bulk amounts of material and for clearance is that the effective doses to individuals should be of the order of 10 μSv or less in a year. To take account of the occurrence of low probability events leading to higher radiation exposures, an additional criterion was used, namely, the effective doses due to such low probability events should not exceed 1 mSv in a year.

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The main consideration for defining waste classes in this publication is long term safety. Waste is classified according to the degree of containment and isolation required to ensure its safety in the long term, with consideration given to the hazard potential of different types of waste. This reflects a graded approach towards the achievement of safety, as the classification of waste is on the basis of the characteristics of the practice or source, with account taken of the magnitude and likelihood of exposures.

The parameters used in classification schemes are:

- the **activity** content of the waste (which can be expressed in terms ofactivity concentration, specific activity or total activity of the waste);
- the half-lives of the radionuclides contained in the waste;
- the hazards posed by different radionuclides; and
- the types of radiation emitted.

Depending on the physical or chemical type of waste considered, activity levels may be expressed in terms of:

- total activity;
- activity concentration; or
- specific activity.

These parameters are not used to present precise quantitative boundaries between waste classes. Rather, they are used to provide an indication of the severity of the hazard posed by specific types of waste, and thus provide guidance as to the optimal form of disposal.

The specific aims of radioactive waste disposal are:
(a) To contain the waste;
(b) To isolate the waste from the accessible biosphere and to reduce substantially the likelihood of, and all possible consequences of, inadvertent human intrusion into the waste;
(c) To inhibit, reduce and delay the migration of radionuclides at any time from the waste to the accessible biosphere;
(d) To ensure that the amounts of radionuclides reaching the accessible biosphere due to any migration from the disposal facility are such that possible radiological consequences are acceptably low at all times.

The definition of 'waste' for purposes of radiation regulation is material 'for which no further use is foreseen.' Arrangements and procedures related to such a declaration may be subject to the approval of the relevant regulatory authority. Lynas Corp. has designated WLP as residue rather than waste due to their proposal to use it as a building material.

However, intent is not sufficient to make such a designation. There must be a realistic and feasible pathway to argue further use to be foreseen. Lynas Corp. has attempted significant R & D to develop recycling pathway for the use of the WLP and thus has designated it as 'residue' rather than 'waste.' However, their Radioactive Waste Management Plan fails to demonstrate commercial feasibility (contracts, customers, orders etc.) for the intended purpose and hence to designate it as anything else other than radioactive waste is unwarranted and self-serving at this stage. This is an instance where the Atomic Energy Licensing Board (Malaysia) might need to intervene to scrutinise this self appointed designation.

Referring to Figure 2, it follows that NUF and GUD solid wastes are appropriately exempted from radiation regulatory oversight. However, WLP waste (6Bq/g of mainly Th-232) is sufficiently radioactive to be regulated (total activity concentration Th-232 and U-238 chains 62.29Bq/g).

Malaysian radioactive waste classification scheme

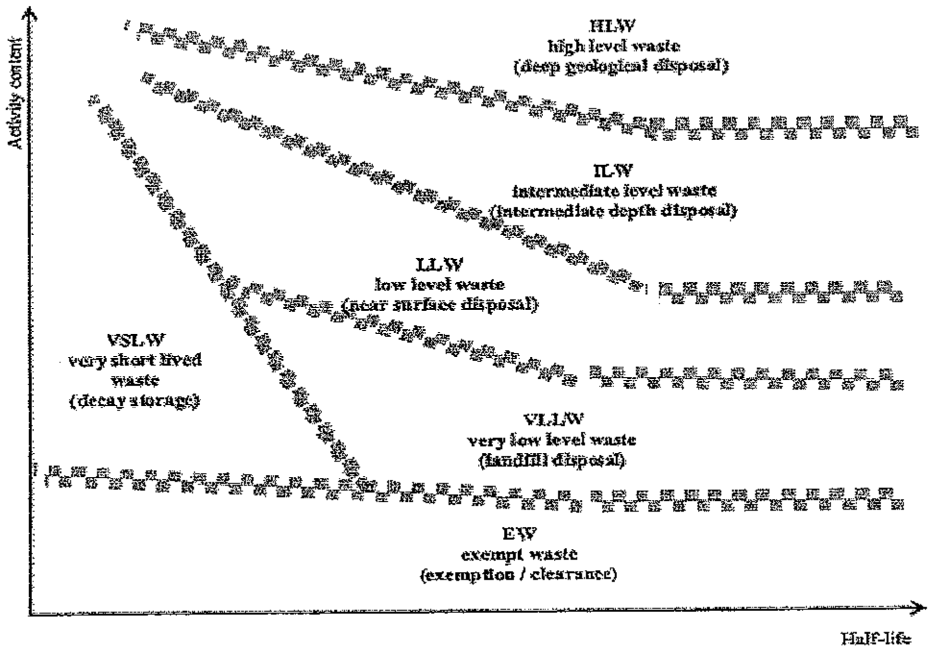
Schedule One (Radioactive Waste Classification), Atomic Energy (Radioactive Waste Management) Licensing Regulations, 2011

Class	Description
Cleared Waste	Materials containing levels of radionuclides at the activity concentrations less than those specified in the Second Schedule.
Low Level (Short Lived) Decay Waste	Low Level radioactive waste containing short lived radionuclides only (half lives less than 100 days) that will decay to clearance levels within three years after the time of its generation.
Low and Intermediate Level Short Lived Waste (LILW-SL)	Radioactive waste which will not decay to clearance levels within three years containing beta/gamma emitting radionuclides with half-lives less than thirty years or alpha emitting radionuclides with an activity concentrations less than 400 Bq/g and a total activity less than 4000 Bq in each radioactive waste package.
Low and Intermediate Level Long Lived Waste (LILW-LL)	Radioactive waste containing radionuclides with activity concentrations more than LILW-SL but which does not generate heat at above 2 kW/m^3
High Level Waste (HLW)	Radioactive waste containing radionuclides with activity concentrations more than LILW-SL but which generates heat above $2kW/m^3$

Lynas Corp. states that the WLP does not fall into any of the above categories. However, although there is some ambiguity as to the preferred category, it is possible to deduce a likely categorisation. Indeed, this classification scheme reflects the former IAEA classification scheme. Given the low activity concentration of the long-lived alpha emitting parent radionuclide Th-232 (and even taking into account the shorter half lives of the decay products), a possible classification of the WLP waste might be 'Low and intermediate Level Short Lived Waste (LILW-SL) which includes, "……or alpha emitting radionuclides with activity concentrations less than 400 Bq/g…" Note, however, the other constraint is no more than 4000 Bq in 'each radioactive waste package,' which would equate to a package of approximately 700 grams of WLP, although granted that this description does not appear to envisage bulk waste from mineral processing. The annual volume of WLP production is estimated to be 65,000 *tonnes, with the total produced over the estimated 20-year life cycle of the facility to be 1,248,000 tonnes.* Additionally, Lynas states in its RWMP (2011) that the disposal site will involve "…safe management and disposal of the radioactive residues over a period of 300 years under institutional control…"[7] and the long decay line of the secular equilibrium decay chain probably has elements of the next category. It therefore might be arguable that this type of waste straddles the LILW-SL category and 'Low and intermediate Level Long Lived Waste (LILW-LL).'

Reviewing the current generic International Atomic Energy Agency classification scheme provides further guidance.

***International classification scheme (IAEA)*[8]**



[7]Lynas LAMP Radioactive Waste Management Plan, 2011; p49

[8] IAEA Classification of Radioactive Waste, 2009 GSG-1

The boundaries between the classes are not intended to be seen as hard lines, but rather as transition zones whose precise determination will depend on the particular situation. The classification scheme is not intended to and cannot substitute the specific safety assessment required for a waste management practice or facility.A waste management option that varies from that indicated by the generic waste classification scheme may also be determined as safe and viable on the basis of a specific safety assessment. The ultimate arbiter of appropriate disposal is to determine that which provides the optimal protection for humans and the environment now and into the future.

Lynas Corp. argue in their RWMP (2011) p.57 that WLP waste should be categorised as 'Very Low Level Waste' described as, "…waste that does not necessarily meet the criteria of exempted waste, but does not need a high level of containment and isolation and therefore is suitable for disposal in near surface landfill type facilities with limited regulatory control. Such landfill type facilities may also contain other hazardous wastes. Concentration of longer lived radionuclide in VLLW are generally very limited."[9] *"Typical waste in this class includes soil and rubble with low levels of activity concentration. Concentrations of longer lived radionuclides in VLLW are generally very limited (IAEA, 2011)."*[10]

In order to determine whether a particular type of waste can be considered to fall into the class of VLLW, acceptance criteria for engineered surface landfill type facilities have to be derived. This can be carried out either using generic scenarios similar to those applied in the derivation of exemption and clearance levels or by undertaking a safety assessment for a specific facility in a manner approved by the regulatory body. In other words, this categorisation mainly applies to mining and milling waste and limited processing of ores, and not usually enhanced processed waste such as WLP. However, the IAEA does leave the option open for such a categorisation for a specific case if the safety case and assessment provide the requisite level of protection for humans and the environment.

The category of 'Low Level Waste (LLW)' is described as, *"Waste that is above clearance levels, but with limited amounts of long lived radionuclides. Such waste requires robust isolation and containment for periods of up to a few hundred years and is suitable for disposal in engineered near surface facilities. This class covers a very broad range of waste. LLW may include short lived radionuclides at higher levels of activity*

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[9] IAEA (2009) : Classification of Radioactive Waste , General Safety Guide, GSG-1, IAEA Vienna.

[10] IAEA (2011): Disposal of radioactive waste – Specific safety requirements SSR-5. Vienna.

concentration and long lived radionuclides, but only at relatively low levels of activity concentration."(IAEA, 2011).

It ranges from radioactive waste with an activity content level just above that for VLLW, that is, not requiring shielding or particularly robust containment and isolation, to radioactive waste with a level of activity concentration such that shielding and more robust containment and isolation are necessary for periods up to several hundred years (IAEA, 2009). Low concentrations of long lived radionuclides may be present in low level waste. Although the waste may contain high concentrations of short lived radionuclides, significant radioactive decay of these will occur during the period of reliable containment and isolation provided by the site, the engineered barriers and institutional control. Classification of waste as low level waste should, therefore, relate to the particular radionuclides in the waste, and account should be taken of the various exposure pathways, such as:

- ingestion (e.g. in the case of long term migration of radionuclides to the accessible biosphere in the post-closure phase of a disposal facility); and
- inhalation (e.g. in the case of human intrusion into the waste).

It is arguable that this broad category (LLW) offers the most optimal and prudent level of classification of waste that, although is low activity and thus does not require as robust containment or isolation as higher activity levels, clearly poses risks requiring regulatory control and institutional controls for several hundreds of years (as confirmed in the Lynas RWMP, 2011), but equally importantly enhances the confidence and trust of the public that safety is not being forsaken for economic considerations, as might be imputed.

Other classification systems

Although the IAEA classifications system has tried to standardise radioactive waste types, there is a lack of uniformity around the world and between jurisdictions. However, common themes recur despite such variations lending support to the LAMP WLP waste being classified as LLW. Within the UK,[11] 4Bq/g of activity is the upper threshold for classifying VLLW for high volume bulk waste; above this level it is classified as Low Level Waste (LLW). LLW is now classified as, "radioactive waste having a radioactive content not exceeding four gigabecquerels per tonne (GBq/te) of alpha [4Bq/g] or 12 GBq/te of beta/gamma activity." Similar activity levels are used in the USA although the categories have different designations. The commonality is due to the previous IAEA classification system which used activity concentrations as a primary determinant of

[11]Policy for Long Term Management of Low Level Radioactive Waste in the UK, (2007). Department for Environment, Food and Rural Affairs, UK

waste categorisation. Of course, activity concentrations and total activity levels still are relevant from a regulatory perspective despite the revised generic IAEA classification, with each being complementary.

Permanent disposal site selection

Selection of radioactive waste sites are justifiably fraught with health, social and ideological concerns in the minds of the general public. Lessons learned from the early years of radioactive waste disposal discussions internationally, are that it is difficult to make progress with the development of radioactive waste repositories without involving those who may be affected in the decision-makingprocess at an early stage. Several experiences of how the communications with affected parties have been managed in national projects have been described during international conferences and workshops. It is now generally recognised that ***openness, trust and participation*** are all essential for communication and stakeholder involvement on radioactive waste. The importance of using all available approaches and techniques for communication should not be underestimated.

Strong, transparent regulatory oversight of the highest order is required to provide public confidence that any health, environmental and social issues in radioactive waste management are being addressed.The technocratic and political dominance of radioactive waste management in many countries has led to profound mistrust and hostility. Politicians who use misleading, emotive and dishonest statements to force their will undermine the needs of a well-informed polity and lead to poor policy decisions and outcomes.

Even in Australia, with a large mining industry, attempts to establish a national radioactive waste repository to dispose of mainly low level waste (mainly contaminated soils from ore research from mid last century) it has taken 30 years to pass legislation and has yet to be built, due to fierce opposition. This compares to the many VLLW and LLW disposal sites that exist in Australia but are co-located with their source mines or nearby to the milling facilities – clearly a wholly different scenario to the Lynas LAMP waste.

The Lynas Safety Case (LSC)

The WLP residue contains the naturally occurring radionuclides of the Th-232 decay chain, along with a comparatively low amount of radionuclides from the U-238 decay chain. Management of WLP residue and management of radiological waste arising from the future decommissioning of the LAMP is the focus of the Lynas Safety Case (LSC).[12] In the terminology of the IAEA, a Safety Case is a series of arguments and evidence for the safety of a facility or activity. This normally includes the findings of a safety assessment and a statement of confidence in these findings.

Waste will also be generated by the decommissioning of the LAMP with radioactivity levels not likely to be greater than WLP. My comments regarding waste disposal also apply to decommissioning waste, although I do not explicitly refer to it.

The LSC hinges on 9 elements (my comments are in brackets):

1. low solubility of thorium (accepted)

2. high thorium and radium retardation factors (accepted)

3. 'short' half-lives of the radionuclides of the decay chain below Thorium-232 ('shorter' would be a more accurate description. For example, radium-228 has a half-life of 5.7 years requiring 25 years to decay sufficiently, although note that this does not mean it will disappear after this time given that the entire decay chain remains in secular equilibrium-equilibrium implies that all decay chain components remain in approximate stable proportions and absolute amounts)

4. low activity of the WLP waste (It is not only the activity concentration that is relevant but also the relative stability of the activity concentration over at least the 300 years of institutional control envisaged, and beyond due to the secular equilibrium with the parent radionuclide, thorium-232, as well as the total volume of the contaminated waste. Millions of tonnes of radioactive waste have a vastly different set of problems to be solved to, say, a small package of similar activity concentration.)

5. & 6. Analogy to a uranium ore body, and analogy to uranium mill tailings (A better analogy would have been to similar rare earth processing facilities around the world, particularly as the IAEA mission in their initial report indicated that there are similar plants were already operating. Using a uranium ore body of greater activity than the WLP is a misleading analogy due to; the uranium being bound in its natural state in rock formations, usually protected by overburden, and

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not bioavailable to the extent that WLP is. It is true that once it is mined and processed with also the need for uranium mill tailings it poses similar radiation hazards to other processed NORM/TENORM, but unless it is subject to a similar degree of chemical processing that the rare earth concentrate will be then the analogy is of limited value. More particularly, the argument that uranium mill tailings and ore bodies can be of greater volumes and possess greater radiological activities than rare earth processed waste is spurious – NORM and TENORM wastes pose lesser or greater problems worldwide irrespective of their origin. Furthermore, uranium tailings facilities are usually co-located with the uranium mines, usually in remote locations, thereby not introducing further hazards in existing mining and processing environment, unlike the PDF proposal which will be located distant to both the mine location (Australia) and the processing facility and hence will introduce risk to whatever location is chosen. The several case studies in the LSC relate to remediation efforts years after various processing facilities have closed and after populations have moved into the area. Once again, this is hardly the scenario envisaged here – the former is concerned with risk reduction of an existing exposure situation whereas the Lynas scenario concerns controlling the introduced risk of WLP disposal. It does not help the safety case to use spurious and arguably tangential and limited analogies when a specifically relevant comparison with rare earth secondary processing is more apt to the radiological issues confronting this proposal. Perhaps a few examples of the Chinese experience of rare earth processing could be provided, given that over 70% of the rare earth demand is served by China).

7 External doses from a semi-infinite plane of WLP residue (noted but gamma radiation comprises only a small amount of the radiation risk from WLP, most of it being particulate and hence due to ingestion and inhalation).

8 & 9. Doses from inhalation of WLP residue as dust, and ingestion of WLP residue (accepted, but there are several assumptions which may not apply involving the long-term integrity of the PDF, erosion, hydrodynamic variables, extreme weather conditions. To properly assess this and provide a comprehensive assessment of safety of the facility, it is necessary obviously to have a disposal site selected.)

Ideally, and the mechanism by which confidence in disposal of radioactive waste can be maximized, is to determine a permanent disposal facility location for operational radioactive waste and decommissioning waste prior to commencement of plant operation. This then allows a full disposal safety case to be assessed with fewer uncertainties. Unfortunately, this is not always possible. In the case of the Lynas LAMP operation, a safety case for the PDF was only prepared after the IAEA assessment (2011). It was originally intended that the residue storage facility (RSF) was to become the PDF, however, restrictions by the local authorities have precluded this. The LSC at this stage is merely a design concept. In essence, what the LSC demonstrates to date is that at least conceptually it is possible to build a PDF to house the WLP waste whilst maintaining exposures to the public below the required regulatory dose constraints. However, what the public needs to know is with what certainty this will apply and under what range of conditions and what compromises will be necessary if the optimal conditions are not met. There are many uncertainties involved in the LSC assumptions, very few of which are quantified or even quantifiable before a site is determined. In particular, detailed assessment of the final two elements of the LSC hinge on such details.

As the IAEA states when preparing a safety assessment of a disposal facility:[13]

"6.4. All steps in the safety assessment will entail handling uncertainties in the input information. These arise from:
(a) Approximations inherent in modelling complex systems;
(b) Limitations in the understanding of the processes that determine the behaviour of the site and the waste management system and uncertainties in the relevant parameters;
(c) Uncertainties in the relevant future conditions (for example, demographic conditions, the effectiveness of institutional control, climatic conditions) over long periods;
(d) Uncertainties about the likelihood and magnitude of external events such as earthquakes and floods that could affect the integrity of the waste management systems.

6.5. These uncertainties should be assessed and carried through the assessment so that the robustness of the conclusions drawn from the assessment is evident.

6.6. Some of the uncertainties can be reduced, though not eliminated, by better site characterization, by refining models or by obtaining more site specific data. The regulator should decide which sources of uncertainty need to be addressed in the safety assessment, in particular those that will need to be considered into the far future."

Regrettably, Lynas Corp. have not addressed these uncertainties or indeed made an effort to address any uncertainties other than to state their existence. Item 6.6 undescores the need to hasten the search for a disposal site to decrease such uncertainties and provide the public with confidence. This does not seem to be a priority for Lynas (v.i).

Further to the uncertainties that the long timeframe the contents of the PDF will pose a risk to humans and the environment:

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[13]IAEA Safety Standards Series No.WS G-1.2, "Management of Radioactive Wastefrom the Mining and Milling of Ores. p 24

The LSC states, inter alia, *"...It is assumed that until some future time at which institutional control are no longer in place (perhaps of the order of 100 or several hundred years) the PDF will be monitored and maintained such that no off site releases occurred. At sometime further into the future, perhaps of the order of 1,000 to 10,000 years and beyond, the passive safety feature of the design will provide the primary safety control."*

However, the LSC goes on;

"The characteristic of the waste help mitigate exposure scenario[s] where the waste is moved from the disposal facility to offsite location when members of the public are present. However scenario[s] in which the PDF become[s] forgotten and people build houses and grow food on top of the respective facility could lead to potentially significant doses. One passive mitigation measure to reduce the likelihood of this scenario is by placing restrictions on future land use in the property title and by controls through zoning and property record keeping. (Institutional control and buffers)."

Yet, institutional controls (including zoning and property records) cannot be expected to be reliably maintained for more than several hundred years (the IAEA suggests 300years), therefore future generations will be at risk and thus the passive mitigation measure suggested is ineffective. It is important to observe that the IAEA places no less of a safety obligation to future generations than present humans, and this is particularly the case for radionuclide decay chains which are unlikely to appreciably change in their activities over these timeframes.

Indeed, the LSC admits as much, stating, *"When the loss of knowledge or awareness of institutional controls is lost at a future date, assumed to be 300 years after closure...."*[14]

Another concern is the provision for the "zero option" case ie, the case where there is no approved disposal facility made available. The LSC, somewhat unsatisfactorily addresses this option,

"this must include the scenario in which the residue storage facility at the Lynas site becomes the disposal facility for the WLP solids(consideration of the RSF as the PDF was not considered in this study."[15]

14 Safety Case for Radioactive Waste Disposal LAMP, 2011, p42

15 Safety Case for Radioactive Waste Disposal LAMP, 2011, p34

The IAEA suggested Lynas canvass this option in the Review Mission report but only in response to Lynas' stating an intention to use the storage facilities on the LAMP site as the permanent disposal facility. However, Lynas states that this has subsequently been refused by the local authorities and is thus not suitable alternative proposal. To thus suggest it as a backup plan is unrealistic. The zero option case poses a clear risk that over one million tonnes of low level radioactive waste may become stranded at the LAMP site resulting in a de facto permanent disposal facility without authority approval or community consent.

Further to the aforementioned, it is clear that Lynas Corp. have made little if any progress in securing a PDF. They state that,
"...The site options for location of the PDF may include under utilized undeveloped land, former abandoned mining land or an uninhabited island. Irrespective of the selected location, the fundamental design will remain the same. The actual site shall be approved the AELB and the state government of Pahang."

Elsewhere, the LSC states, *"...The site for the PDF must be identified no later than 14 years after commencing operations at the LAMP to allow sufficient time to investigate, design and construct the PDF before decommissioning commences (schedule assumes decommissioning planning will commence after 18 years of operation of the LAMP; therefore providing four years to investigate, design and construct the PDF)."*

Both suggested locations and the applicable timeline are obviously aspirational. There is no appreciation of their likelihood, and implicit is the assumption that this is merely an administrative process underpinned by assessments of scientific suitability driven by a timeline based on logistical imperatives. Unfortunately, this indicates a significant oversight of the societal drivers and community and stakeholder consent that is required to make the process successful. A bottom up consultative approach is vital. Disappointingly, there is nothing in the LSC that indicates an appreciation of this or the requisite culture that is required to drive it.