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Report of the

International Review Mission on the

Radiation Safety Aspects of a Proposed Rare Earths Processing Facility (the Lynas Project)

29 May - 3 June 2011, Malaysia

DIVISION OF NUCLEAR FUEL CYCLE AND WASTE TECHNOLOGY

CONTENTS

INTRODUCTION AND MAIN CONCLUSIONS

One of the main services provided by the IAEA to its Member States is the organization of international peer reviews at the request of Member States. Such review services are becoming increasingly popular. Some countries, as well as one region (the European Union), have incorporated the concept of international review missions into their legislation. The IAEA has organized about 250 international review missions during the past five years, reflecting the growing popularity of this service and a clear indication of its usefulness.

Therefore, the IAEA is pleased to commend the Malaysian Government for requesting the mission and for its commitment to improve radiation and nuclear safety in the region.

On 3 May 2011, the Malaysian Government approached the IAEA with a request to organize an independent expert review of the radiation safety aspects of a rare earths processing facility currently under construction in Malaysia. This facility forms part of the Advanced Materials Project being developed by the Lynas Corporation Ltd. The IAEA's Director General, Mr Yukiya Amano agreed to offer the IAEA's support. The Advanced Materials Project involves the mining and concentration of rare earth ore at Mt. Weld, Western Australia, followed by shipment of the concentrate to a rare earths processing facility at Gebeng, Pahang State, Malaysia, where further processing will take place to produce high purity rare earth compounds. The processing of the ore will therefore be carried out in two plants, the latter being the subject of this review mission:

1. An ore concentration plant in Western Australia, involving crushing and grinding, flotation, concentrate handling, water treatment and residue management, and utilities;
2. A facility for the processing of the rare earths concentrate at Gebeng, Pahang, Malaysia, involving cracking, waste gas treatment, leaching, upstream extraction, downstream extraction, post treatment, utilities, water treatment and residue management.

In Malaysia, the licensing of this type of facility is a sequential process involving the granting of five different types of licence: a siting licence, a construction licence, a pre-operational licence, an operational licence and a decommissioning licence. At the time of the review mission, Lynas had obtained a construction licence for the rare earths processing facility and about 40% of the construction had been completed. For clarity, the review team emphasizes that the project documentation made available to it for review was related to this licensing phase only. The review carried out by the review team is not intended nor considered to be sufficient for the next licensing phases. Accordingly, the review team understood that updated documentation will, in due course, be prepared by Lynas and submitted to the Malaysian Atomic Energy Licensing Board (AELB) for its consideration in terms of the subsequent licensing phases.

When viewing the proposed rare earths processing facility in a global context, the review team makes the following observations:

(a) Many similar plants producing rare earth compounds are operating in various parts of the world – the proposed Lynas plant is not unique in this regard;
(b) The planned importation of feedstock from Australia and management of the process residues within Malaysia is in line with mineral processing practices worldwide, including those involving naturally occurring radioactive material (NORM).

(c) Many of the mineral concentrates processed in other countries under similar arrangements are considerably more radioactive than those to be processed in the Lynas project. Most of the facilities involved are operated in compliance with the international safety standards.

The review team carried out its review against international radiation safety standards and good practices.

IAEA safety standards

The IAEA is authorized in terms of its Statute to establish or adopt safety standards for the protection of health and minimization of danger from ionizing radiation. A comprehensive set of high quality standards under regular review, as well as the IAEA's assistance in their application, are key elements of a stable and sustainable global safety regime.

The IAEA embarked on its safety standards programme in 1958. Since that time, the safety standards have undergone a continuous process of expansion and updating and reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from the harmful effects of ionizing radiation. Regulating safety is a national responsibility, but many countries have decided to adopt the IAEA's standards in the formulation of their own national regulations.

The scientific considerations underlying the IAEA safety standards provide an objective basis for decisions concerning safety. However, decision makers must also make informed judgements and must determine how the benefits of an action or an activity are best balanced against the associated radiation risks and any other detrimental impacts to which the activity gives rise.

The preparation of the IAEA safety standards makes use of best competences available in the IAEA's Member States and other important international organizations. All IAEA Member States may nominate experts for the safety standards committees and may provide comments on draft standards. The findings of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP), are taken into account in developing the IAEA safety standards. Some safety standards are developed in cooperation with other bodies in the United Nations system or other specialized agencies, including:

(a) The Food and Agriculture Organization of the United Nations,
(b) The United Nations Environment Programme,
(c) The International Labour Organization,
(d) The OECD Nuclear Energy Agency,
(e) The Pan American Health Organization and
(f) The World Health Organization.

Scope of the review mission

The review mission was technical in nature. It did not engage in policy or other types of discussions as these were not within its mandate. As is the case with other IAEA review

missions and stated in the mutually agreed Terms of Reference, the review mission was mandated to deal with the radiation safety aspects of the proposed project. The scope of the mission covered the following areas from a radiation safety viewpoint:

(a) Radiation protection – occupational, public and environment – including monitoring systems,
(b) Waste management,
(c) Decommissioning and environmental remediation,
(d) Transport,
(e) Safety assessment.

The IAEA safety standards address, in broad terms, public information and involvement and, as with most review missions, the review team did discuss this area. The review team appreciated the Malaysian Government's wish to include public communication aspects in the scope of the mission and benefited from the various public submission sessions during which several groups expressed their views, opinions and concerns to the review team.

The review team

The IAEA assembled a team of international experts using the mechanism established in terms of its technical cooperation programme. The review team was composed of experts from Canada, India, the Netherlands, South Africa, the United Kingdom and the IAEA. The members of the review team have a wide knowledge of the IAEA safety standards and broad professional experience in their respective disciplines covering the scope of this mission. To preserve the international expert panel's impartiality, the review team did not include individuals whose participation could have led to a conflict of interest. The review team members are listed in Annex III.

The review process

The review process consisted of the following main elements:

(a) A review of the relevant documentation provided in advance to the review team by the Malaysian counterpart;
(b) The review mission to Malaysia, 29 May – 3 June 2011, which included:

- Discussions with the relevant Malaysian officials, Lynas project staff and other stakeholders;
- A visit to the Lynas project site and the nearby harbour to which the feedstock will be shipped from Australia.

(c) An evaluation of the observations and reporting of the results in a clear and concise manner.

The review team conducted and completed its review mission in a transparent, open and good working atmosphere and received good cooperation from all the parties involved in discussions throughout the mission. Many technical details during technical sessions as well as views, opinions and concerns during the public submission sessions were brought to the

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 11th 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.

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,

decommissioning and environmental remediation, transport, safety assessment and, finally, public communications.

1. RELEVANT LEGAL AND REGULATORY FRAMEWORK

Basis for the review

Since the mission was mandated to review specifically the proposed rare earths processing facility, the review team considered only the legal and regulatory infrastructure relevant to the radiation safety aspects of that facility. Therefore, the review team did not examine in detail those parts of the legal and regulatory framework that were not related to the facility. The following Malaysian laws, regulations and supporting documents (or relevant parts thereof) were reviewed:

(i) Atomic Energy Licensing Act 1984, Act 304;
(ii) Environmental Quality Act, 1974 (Amendment, 1985);
(iii) Environmental Quality Act, 1974 (Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) order 1987);
(iv) Radiation Protection (Licensing) Regulations 1986, P.U.(A)149;
(v) Radiation Protection (Basic Safety Standards) Regulations 1988, P.U.(A)61;
(vi) Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2011, P.U.(A)46;
(vii) Radiation Protection (Transport) Regulations 1989, P.U.(A)456;
(viii) Radiation Protection (Transport) Regulations 1989, Corrigendum, P.U.(A)146;
(ix) Radiation Protection (Transport) (Amendment) Regulations 1991, P.U.(A)145;
(x) Guidelines for the Application of License from the Atomic Energy Licensing Board for Milling of Materials Containing or Associated with Radioactive Materials, LEM/TEK/28;
(xi) Guidelines for Decommissioning of Facilities Contaminated with Radioactive Materials, LEM/TEK/56, April 2008;
(xii) Guidelines for the Preparation of a Radiation Protection Program for TENORM Activities, LEM/TEK/45 (Part E), April 2011;
(xiii) Checklist for Application of Class A (Milling), LEM/SS/11, 18/02/2010 rev. 2;
(xiv) Checklist for Application of Class G Licence, LEM/SS/14, 18/02/2010 rev. 2;
(xv) Radiological Impact Assessment (RIA)/EIA, LEM/TEK/30, LEM/TEK/49 etc.;
(xvi) Guidelines on Radiological Impact Assessment (RIA) Study Regards to TENORM Activities –LEM/TEK/41 (Draft 1), November 2001.

The information on the relevant legal and regulatory framework was reviewed for compliance with the IAEA safety standards. The applicable IAEA safety standards and supporting publications are:

(a) Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1 (2006);
(b) International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, IAEA Safety Series No. 115 (1996);
(c) Governmental, Legal and Regulatory Framework for Safety, IAEA Safety Standards Series No. GSR Part 1 (2010);
(d) Predisposal Management of Radioactive Waste, IAEA Safety Standards Series No. GSR Part 5 (2009);
(e) Disposal of Radioactive Waste, IAEA Specific Safety Requirements No. SSR-5 (2011).

(f) Management of Radioactive Wastes from the Mining and Milling of Ores, IAEA Safety Standards Series No. WS-G-1.2 (2002);
(g) Release of Sites from Regulatory Control on Termination of Practices, IAEA Safety Standards Series No. WS-G-5.1 (2006);
(h) Environmental and Source Monitoring for Purposes of Radiation Protection, IAEA Safety Standards Series No. RS-G-1.8 (2005);
(i) Occupational Radiation Protection, IAEA Safety Standards Series No. RS-G-1.1 (1999);
(j) Occupational Radiation Protection in the Mining and Processing of Raw Materials, IAEA Safety Standards Series No. RS-G-1.6 (2004);
(k) Application of the Concepts of Exclusion, Exemption and Clearance, IAEA Safety Guide, Safety Standards Series No. RS-G-1.7 (2004);
(l) Assessing the Need for Radiation Protection Measures in Work Involving Minerals and Raw Materials, IAEA Safety Report Series No. 49 (2006);
(m) Radiation Protection against Radon in Workplaces Other than Mines, IAEA Safety Reports Series No. 33 (2003);
(n) Monitoring and Surveillance of Residues from the Mining and Milling of Uranium and Thorium, IAEA Safety Reports Series No. 27 (2002);
(o) Extent of Environmental Contamination by Naturally Occurring Radioactive Material (NORM) and Technological Options for Mitigation, IAEA Technical Reports Series No. 419 (2003);
(p) The Application of the Principles for Limiting Releases of Radioactive Effluents in the Case of the Mining and Milling of Radioactive Ores, IAEA Safety Series No. 90 (1989);
(q) Decommissioning of Facilities for Mining and Milling of Radioactive Ores and Closeout of Residues, IAEA Technical Reports Series No. 362 (1994).

Findings

Laws, regulations and guidelines

The Atomic Energy Licensing Act 1984 (AEL Act) is the primary legislation that provides for the regulation and control of atomic energy in Malaysia. This legislation, although still in force, is being revised to make it more comprehensive and consistent with the relevant international legal instruments and IAEA standards.

The AEL Act establishes the Atomic Energy Licensing Board (AELB) as the regulatory body in the country and provides for its functions in general terms, including the exercising of control and supervision over the use of atomic energy. Section 11 of the AEL Act empowers the Minister to give the Board directions as to the policy to be followed in the performance of the Board's functions and the exercise of its powers.

Any activity involving radioactive material is subject to a licence issued by an appropriate authority which may impose conditions to the licence. Similarly, the disposal and accumulation of radioactive waste are subject to an authorization. The difference between a licence and an authorization is not clear. In addition the term "appropriate authority" is not defined.

Finally, Section 27 of the AEL Act makes it clear that any radioactive material produced, kept or used in any premise and accumulated and retained there for a period of not

less than three months is presumed to be radioactive waste. The appropriate authority is authorized to direct the licensee to take any corrective measure to rectify the situation if it appears that adequate facilities are not available for the safe accumulation and disposal of radioactive waste.

The review team has concluded that the Malaysian laws and regulations regarding radiation safety are in good conformity with the above-mentioned IAEA standards. In general, they are comprehensive and can be applied for the regulation of NORM industries. In some cases, the Malaysian regulations are even more strict. For instance:

(a) The control of doses received by members of the public is more stringent than required by IAEA standards, in that the dose constraint of 0.3 mSv per year for the disposal of radioactive waste (in accordance with IAEA standards) is applied also to all other exposures of the public;
(b) The control of doses received by workers is more stringent than required by the international standards as a result of the use of an 'operational dose limit' of 10 mSv per year, as compared with an overall dose limit of 20 mSv per year.

However, there are also some comments to be made with regard to the regulatory framework:

(a) There is no specific definition of radioactive material given in terms of activity concentrations, neither for artificial nor for natural radionuclides;
(b) According to the AEL Act, any exemptions relating to materials with very low activity concentrations can only be made at the discretion of the Minister;
(c) There are also no specific provisions for the regulation of NORM activities in the AEL Act, nor in the Radiation Protection (Basic Safety Standards) Regulations;
(d) NORM activities are addressed only in Guideline LEM/TEK/28 (Application of Licence from the Atomic Energy Licensing Board for the Milling of Materials Containing or Associated with Radioactive Materials). These guidelines, and the related checklist, fill a gap in the regulations with respect to NORM activities. The guidelines are written as "shall" statements and the AELB assured the review team that such guidelines are binding on the licensee.

The review team considers that it would be advantageous for the regulatory body to have in place a programme for regularly reviewing the regulations in accordance with the latest versions of the international standards.

The AEL Act provides for inspections and enforcement on the part of the AELB. During discussions with the AELB, the review team was informed that a programme for scheduled and no-notice inspections is in place. The review team concluded that the regulations and legal provisions with respect to inspection and enforcement are in conformity with the IAEA standards.

The AELB

According to the IAEA General Safety Requirements (IAEA Safety Standards Series No. GSR Part 1) the activities of the regulatory body include the following:

(a) Authorization of facilities and activities;
(b) Review and assessment of information relevant to safety;
(c) Inspection of facilities and activities, and enforcement;
(d) Establishing and maintaining regulations and guides;
(e) A graded approach to review and assessment and to inspections of a facility or an activity (meaning that the intensity and strength of regulatory activities and measures should be commensurate with the risks involved – the greater the risk, the stronger the regulatory activity);
(f) Communication and consultation with interested parties (this is discussed further in Section 7 of this report).

Regarding all of its regulatory activities, the review team discussed the AELB's resources (in terms of finances, manpower, equipment and facilities) and the competencies of its staff, as well as foreseen future developments. At the moment, the AELB has a staff of about 160, of which about 30 are graduates, and it is foreseen that another 40 mainly graduate staff will be recruited. A system of continuous personal development is in place. The review team considers it of great importance that the AELB has sufficient resources, competence and independence to carry out its regulatory functions, especially those associated with inspection and enforcement in situations such as the proposed rare earths processing facility.

The AELB informed the review team of its activities in creating and establishing a new model for an Independent Malaysian Regulatory Technical Support Organization (TSO). The review team appreciated the AELB's approach, which included reviewing corresponding regulators' TSOs in eight different countries. Based on the discussions with AELB, the review team believes that the proposed new model can provide an independent regulatory TSO, which by carrying regulatory research activities, can effectively support the AELB's regulatory activities.

The review team concluded that AELB is capable of carrying out its duties. The review team considered that the main strengths of the AELB included:

(a) Dedication, commitment and professionalism to become a first class regulator in protecting people and the environment, in particular in the case of the Lynas project to protect the people of Kuantan and the public at large from the harmful effects of radiation;
(b) A good understanding of radiation safety on the international level and at the detailed technical scale of the Lynas project;
(c) Providing clear and comprehensive regulations and regulatory guidance to licence applicants and licence holders.

Areas warranting further strengthening included the following:

(i) Implementation of the AELB's powers of enforcement;
(ii) Visibility and public communications (discussed further in Section 7 of this report);

(iii) Establishing and implementing a funding scheme that allows recovering actual and realistic costs of regulatory activities related to each licence application and licence holder to avoid any doubt about government funding being used to subsidize private or other organizations in the course of licensing and regulatory activities.

Compliance with international radiation safety standards

Regarding the relevant legal and regulatory infrastructure, the review team was not able to identify any aspect of the legal and regulatory framework that was not in compliance with the international radiation safety standards.

Recommendations

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

- 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 need to be updated.

2. RADIATION PROTECTION (OCCUPATIONAL, PUBLIC AND ENVIRONMENT) INCLUDING MONITORING SYSTEMS

Basis for the review

The following sources of information were taken into account in the review of the radiation protection aspects of the proposed rare earths processing facility:

(a) Various documents made available to the review team, including:

- The radiation protection programme for Lynas Malaysia Sdn Bhd;
- Regulation PU(A)46 of 2010;
- Guideline LEM/TEK/45 (Part E);
- The radiological impact assessment (RIA);

(b) Presentations to the review team by:

- AELB;
- Nuklear Malaysia;
- Department of Occupational Safety and Health;
- Lynas Malaysia Sdn Bhd.

Facilities for the processing of minerals containing NORM may give rise to elevated levels of radiation exposure of workers and, to a much lesser extent, members of the public residing nearby. In the case of the proposed rare earths processing facility, the exposure levels can be expected to be rather moderate because the radionuclides of natural origin contained within the process materials (mainly thorium-232 and its decay products) are at relatively low concentrations.

In terms of IAEA Safety Guide RS-G-1.7 and IAEA Safety Reports Series No. 49:

(a) Materials with radionuclide activity concentrations below 1 Bq/g are considered to be within the range of normal rocks and soil, and are not regarded as radioactive for the purposes of regulation;
(b) Materials with radionuclide activity concentrations between 1 and 10 Bq/g are regarded as radioactive for the purposes of regulation, but should be considered as possible candidates for exemption by the regulatory body. Typically, the granting of an exemption is the most appropriate regulatory option if the radiation doses received by individuals do not exceed 1 mSv per year.[2]

Against this background, it is noted that the activity concentration of thorium-232 in both the feedstock (rare earths concentrate) and the water leach purification (WLP) residue to be handled within the proposed rare earths processing facility is about 6 Bq/g. The activity concentrations in all other process materials are essentially at natural background levels. Therefore, in terms of international standards, the radioactivity levels in the feedstock and

[2] Experience has shown that the highest doses associated with NORM processing facilities are those received by workers in such facilities.

WLP residue would necessitate regulatory consideration, but with exemption being considered as an option, depending on the level of radiation dose that is likely to be received.

The proposed Lynas facility will employ 350–400 workers. The RIA predicts that the average dose received by exposed workers will be about 2 mSv per year, with a very small number of such workers receiving higher doses of the order of 10 mSv per year. While there is reason to believe that these doses have been overestimated as a result of the conservative assumptions used (see Section 6), it is nevertheless reasonable to assume that some workers will receive doses exceeding 1 mSv per year. Therefore, the granting of an exemption is not an appropriate option in this case. Instead, the facility would need to be licensed by the AELB. In terms of such a licence, a radiation protection programme (RPP) would be required, to protect both workers and members of the public.

The content of the RPP submitted by Lynas is described in the document entitled "Radiation Protection Program for Lynas Malaysia Sdn Bhd". It is stated that the design of this RPP is in accordance with the relevant AELB guideline (Guideline LEM/TEK/45 (Part E)) for achieving compliance with regulations under the Atomic Energy Licensing Act (Act 304) 1984. A review of the RPP shows that this is indeed the case. The RPP submitted by Lynas has also been examined to determine its conformity with international standards, as set out in documents such as the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (IAEA Safety Series No. 115), the IAEA Safety Guide on Occupational Protection (RS-G-1.1), the IAEA Safety Guide on Occupational Radiation Protection in the Mining and Processing of Raw Materials RS-G-1.6 and the IAEA Safety Guide on Management of Radioactive Waste in the Mining and Milling of Ores (WS-G-1.2). The topics that have to be addressed in an RPP, as defined in the international standards, can be summarized under the following headings:

(a) Dose limits;
(b) Optimization and dose constraints;
(c) Performance of safety assessments;
(d) Responsibilities of licensees, employers and workers;
(e) Establishment of policies, procedures and organizational arrangements (including assignment of responsibilities);
(f) Provision of suitable and adequate facilities, equipment (e.g. personal protective equipment, measurement instruments) and services;
(g) Workers' health surveillance;
(h) Training;
(i) Keeping of records;
(j) Classification of areas;
(k) Local rules and supervision, including the appointment of a radiation protection officer;
(l) Monitoring and dose assessment;
(m) Environmental monitoring;
(n) Discharge limits and monitoring/optimization of discharges;
(o) Management of residues.

Findings

The review team found that, in the RPP submitted by Lynas, each of the necessary radiation protection measures, including monitoring systems, had been addressed in a manner consistent with international standards. With regard to dose limits, the RIA makes reference to limits of 1 mSv per year for members of the public and 20 mSv per year for workers, in accordance with international standards. In addition, the RIA refers to further restrictions on dose in the form of a dose constraint of 0.3 mSv per year for members of the public and an 'operational dose limit' of 10 mSv per year for workers. These additional dose restrictions will contribute to the achievement of a level of protection that is similar to or higher than that required by international standards.

The review team was not able to identify any instances of non-compliance with the standards. It can therefore be concluded that, provided that the RPP is implemented in accordance with regulatory requirements, workers and members of the public will be adequately protected, such that there will be no discernable radiological health effects attributable to the operation of the facility. The review team does, however, wish to emphasize the following two points:

(i) With regard to monitoring systems, it is important that Lynas starts to develop a long term monitoring programme for a future site for solid waste disposal and for the environment surrounding that site, even though the location of such a site is not yet determined.

(ii) The potential for significant worker doses from external exposure to gamma radiation should be investigated in more detail once the plant is in operation. Where appropriate, measures to reduce exposure to gamma radiation should be considered, in accordance with the principle of optimization. Such measures might include the use of specific work procedures to minimize the time spent close to bulk quantities of concentrate and WLP residues (including, as a last resort, job rotation) and the use of materials such as metal, bricks or low activity process material to provide shielding.

Recommendation

The recommendation given in Section 6 'Safety Assessment' concerning monitoring systems and measures to reduce doses also applies here.

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.

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.

[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.

4. DECOMMISSIONING AND ENVIRONMENTAL REMEDIATION

Basis for the review

The term ‘decommissioning’ refers to the administrative and technical actions taken to allow the removal of some or all of the regulatory requirements from a facility (except for a waste disposal facility, for which the term ‘closure’ rather than ‘decommissioning’ is used). A facility in this context means buildings and the associated land and equipment in which radioactive material is produced, processed, used, handled or stored on such a scale that consideration of safety is required. Historically, the decommissioning and environmental remediation of sites involving the processing or use of radioactive material was considered only at the later stages of the operational process. Experience has shown, however, that whenever decommissioning and environmental remediation are not properly integrated into the overall planning of an operation, there is a risk that funds will not be available for these activities, that an appropriate location for the disposal of the wastes will not be available and that the overall costs associated with the operations of decommissioning and environmental remediation will be far higher than necessary. Therefore, if proper care is not taken, and especially if decommissioning and environmental remediation are not properly planned and funded, there is a risk of generating legacy sites, leading to potentail exposure of members of the public to radiation. In addition, the costs associated with these operations can end up being borne by the government.

With these considerations in mind, the review team examined the documentation relevant to the decommissioning of the proposed rare earths processing facility, noting that environmental remediation activities are also an integral part of decommissioning planning. The review was based primarily on the requirements set out in IAEA Safety Standards Series No. WS-R-5 “Decommissioning of Facilities Using Radioactive Materials”, taking into account also the guidance contained in IAEA Safety Guide WS-G-1.2 “Management of Radioactive Waste from the Mining and Milling of Ores” and the technical recommendations contained in IAEA Nuclear Energy Series No. NF-T-1.2 “Best Practice in Environmental Management of Uranium Mining”.

The IAEA safety standards define the roles of the regulatory body (in this case the AELB) and the operating organization (in this case Lynas Malaysia). As stated in paragraph 3.5 of IAEA Safety Standards Series No. WS-R-5, the regulatory body is responsible for the regulation of all phases of decommissioning, from the initial planning to termination of the practice or final release of the facility from regulatory control.

In terms of the Atomic Energy Licensing Act of 1984, “any facility, which is directly or indirectly involved with the use or production of radioactive materials is to be controlled by AELB”. In this respect the AELB has produced specific guidelines (Guidelines for Decommissioning of Facilities Contaminated with Radioactive Materials, LEM/TEK/56, 2008) that present standard guides and procedures which have to be followed by the licensee (in this case Lynas Malaysia) “when embarking on decommissioning operation on any facility contaminated with radioactive materials”.

Decommissioning plans

In response to the established requirements associated with the decommissioning of the facility, Lynas Malaysia has developed a 'conceptual decommissioning plan'. The primary objectives of this plan are to:

(a) Provide detailed information on the decommissioning process to be followed by Lynas Malaysia;
(b) Document the assumptions for the decommissioning process;
(c) Establish the decommissioning funding programme and the mechanism for setting aside the necessary funds.

In its conceptual decommissioning plan, Lynas has assumed that the proposed rare earths processing facility will have an operational life of 20 years and that, upon cessation of operations, the plant (including contaminated equipment) will be decontaminated and decommissioned in accordance with the requirements of the AELB. It is important to note that, according to the plan, "the radioactive solid wastes generated from the plant operations over the 20 year period will be disposed within secure engineered cells constructed at a permanent disposal location to be determined by the AELB and the Pahang State Government". The conceptual decommissioning plan also makes reference to research and development work for the recycling and reuse of the residues. However, it is stated in item 7.0 of the plan (the Waste Management Contingency Plan) that as the planned RSF is designed for only 5 years capacity, provision will be made for all residue streams to be disposed of appropriately at a disposal facility approved by the local authority (Kuantan Municipal Council) in the event that recycling and reuse does not prove to be feasible. It is also stated that the most appropriate final disposal option requires further research and investigation. Finally, the plan mentions that "enquiry has been initiated with Local Authority or private sectors to acquire land in the vicinity area for the extended disposal plots".

It is also stated in the conceptual decommissioning plan that "the development of a detailed Decontamination and Decommissioning Plan (D&D Plan) will be initiated by Lynas 24 months prior to the date of the planned plant closure". This detailed decommissioning plan will be prepared by a team of experts comprising radiological, environmental and engineering consultants with guidance from the AELB. The findings of the RIA will be used as a basis for the plan. Lynas proposes to submit the detailed decommissioning plan to the AELB six months prior to the date of plant closure.

The review team could not find in LEM/TEK/56 a specific deadline for submission by the operating organization of the detailed decommissioning plan. In accordance with what is presented on page 60 (Flow Chart of Decommissioning Operation Implementation), the decommissioning plan is associated with a Class G licence application, which is defined in LEM/TEK/28 as a licence to, among other things, decommission a milling installation.

Paragraph 5.4. of IAEA Safety Standards Series No. WS-R-5 states that "For new facilities, consideration of decommissioning shall begin early in the design stage and shall continue through to the termination of the practice or the final release of the facility from regulatory control". In addition, it is stated that "the regulatory body shall ensure that operators take into account eventual decommissioning activities in the design, construction

and operation of the facility, including features to facilitate decommissioning, the maintenance of records of the facility, and consideration of physical and procedural methods to prevent the spread of contamination".

In order to reinforce the above observation it is appropriate to take into account what is stated in paragraph 5.12. of the Safety Guide on the Management of Radioactive Waste from the Mining and Milling of Ores (WS-G-1.2): "At a time agreed upon with the regulatory body, and at least five years before the anticipated closure date, the operator should submit a final closure plan (for the waste management facility) for regulatory approval. The objectives of closure should be to ensure that the waste management facilities are left in a condition that will ensure their continued compliance with the requirements for the protection of human health and the environment".

As recognized in item 10.41 of LEM/TEK/56, the decommissioning operation invariably involves the generation of radioactive waste. Such waste is usually of a different nature and form than the waste generated and handled during the operating period of the facility. Waste management should therefore be properly addressed in the decommissioning plan. Effort must be taken by the licensee to choose the right decontamination strategy and technique that can minimize the generation of waste.

Funding of the decommissioning and environmental remediation process

The issue of costs related to the decommissioning of the facility (including provisions for environmental remediation of the site) need to be considered. The following requirements are established in IAEA Safety Standards Series No. WS-R-5:

(a) Paragraph 6.2. requires that adequate financial resources to cover the costs associated with safe decommissioning, including the management of the resulting waste, shall be available when needed, even in the event of premature shutdown of the facility. Thus, in the case of the proposed rare earths processing facility, adequate financial arrangements acceptable to the AELB should be in place before authorization to operate the facility is given.
(b) Paragraph 6.5 requires that if the decommissioned facility is released with restrictions on its future use, adequate financial provision to ensure that all necessary controls remain effective shall be obtained before authorization is terminated.

In this respect, paragraph 10.61 (page 28) of LEM/TEK/56 states that "the plan should have descriptions on funding mechanisms, which are already present or will be in place for the completion of the decommissioning activities on a time scale as commensurate in the decommissioning plan". This requirement differs slightly from that in IAEA Safety Standards Series No. WS-R-5.

Findings

The review team considers that the prevailing Malaysian regulatory framework related to the decommissioning of facilities contaminated with radioactive materials is aligned with the requirements contained in the IAEA safety standards relevant to this situation, particularly those contained in IAEA Safety Standards Series No. WS-R-5 “Decommissioning of Facilities Using Radioactive Material”. The existing decommissioning guidelines (LEM/TEK/56) are considered by the review team as correctly reflecting the responsibilities assigned to the regulatory body as described in paragraph 3.6 of IAEA Safety Standards Series No. WS-R-5.

The review team also considers that appropriate regulatory provisions exist in Malaysia to clearly define the responsibilities and obligations of the operating organization with respect to decommissioning activities. In accordance with these regulatory requirements, Lynas Malaysia has presented a conceptual decommissioning plan, and a detailed decommissioning plan is to be prepared when application is submitted for a Class G license in accordance with LEM/TEK/28 “Guidelines for the Application of License from the Atomic Energy Licensing Board for Milling of Materials Containing or Associated with Radioactive Materials”. The decommissioning plan will give the assurance that contaminated plant equipment and machinery will be decontaminated and decommissioned in accordance with regulatory requirements, and that the radioactive solid waste will be isolated within a suitable disposal facility having minimal impact on the public and environment.

The review team was not able to identify any non-compliance with international radiation safety standards with regard to the decommissioning and environmental remediation process. However, the review team identified the following issues where it considered that improvements were necessary prior to the granting of the operating licence:

(a) The schedules contained in the conceptual decommissioning plan should be revisited and the time scale for the presentation of the detailed decommissioning plan (only 6 months prior to the end of the operations) should be reconsidered. The international consensus view on what is regarded as good practice in the uranium mining industry points out that both decommissioning and environmental remediation strategies should be consistently considered in the overall life cycle of the facility and should be adequately and thoroughly planned from the very beginning.
(b) There is a lack of a plan for managing the waste from the decommissioning and dismantling of the plant at the end of its life.
(c) It important for the AELB to establish clearance levels to be applied for material resulting from decommissioning activities that is released from regulatory control (see paragraph 4.7 of IAEA Safety Standards Series No. WS-R-5).
(d) There is a need for clear provisions for the establishment of a funding mechanism for the decommissioning process (including environmental remediation activities). In accordance with international standards, financial provision for decommissioning and environmental remediation needs to be in place before authorization to operate the facility is granted.

Recommendations

- 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.

- 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.

5. TRANSPORT

Basis for the review

The rare earths concentrate shipped from Mt. Weld to Kuantan is reported to contain 0.13–0.16% thorium and 0.0021–0.0029% uranium. The sum of the activity concentrations of Th-232 and U-238 is therefore about 6 Bq/g. The mineral ore is understood to be physically concentrated in Australia by milling and froth flotation prior to shipment. A chemical and a radiochemical analysis were variously available for several rare earths concentrates and the latter analysis confirms that the thorium and uranium decay series radionuclides are in secular equilibrium. Since the sum of the activity concentrations of Th-232 and U-238 is less than 10 Bq/g, the concentrate will fall outside the scope of the IAEA Regulations for the Safe Transport of Radioactive Material and can therefore be transported as non-radioactive material.

The rare earths concentrate will be packed into bags of 1 or 2 t capacity at the Mt. Weld site and the bags will in turn be loaded into 20 t sea–land containers (SLCs). The containers will be transported by road to Perth or a nearby port for shipment to Singapore and from there by a smaller vessel to Kuantan port. Up to this point the rare earths concentrate will be transported as normal non-radioactive material, in accordance with international regulations. From Kuantan port, the containers will be transported by road to the Lynas facility at Gebeng Industrial Park 15 km away. Under Malaysian regulations, the final transport leg of the rare earths concentrate has to be transported as radioactive material. The transport will be performed by a selected haulier and trained truck drivers.

The scope of the transport regulations terminates once the material arrives within the Lynas facility, which is subject to appropriate safety regulations in force in the establishment. Once delivered to the establishment it is anticipated that there will be no further movement on public roads.

The following documents were reviewed:

IAEA Safety Standards:

- Safety Series No. 6, Regulations for the Safe Transport of Radioactive Material, 1985 Edition;
- Regulations for the Safe Transport of Radioactive Material, 2009 Edition, No. TS-R-1;
- Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material, No. TS-G-1.1 (Rev. 1) [2008 Edition];

Documents provided by Lynas:

- Emergency Planning & Preparedness for Radiation Protection 2010, KUA-SHES-P-033-Emergency Planning for Radiation;
- Mt Weld Rare Earths Concentrate Compositions, May-2002;
- Ansto environmental radiochemistry: Certificate of Analysis 02MR0116#14, Dec-2002;
- Arah Rancang Sdn Bhd: Traffic Impact Assessment (TIA), Nov-2007;
- Nuklear Malaysia: Radiological Impact Assessment of Advanced Materials Plant; Gebeng Industrial Estate, Kuantan, Pahang, Jun-2010.

Malaysian Laws and Regulations:

- Atomic Energy Licensing Act 1984;
- Guidelines on Radiological Monitoring for Oil and Gas Facilities Operators Associated with Technologically Enhanced Naturally Occurring Radioactive Materials (NORM), September-1996;
- Occupational Safety and Health Industry Code of Practice for Road Transport Activities 2010 (OIR);
- Radiation Protection (Basic Safety Standards) Regulations 2010;
- Radiation Protection (Licensing) Regulations 1986;
- Radiation Protection (Transport) Regulations 1989.

The review team had the opportunity to visit the harbour and interview its responsible staff.

Findings

According to the 2009 IAEA Transport Regulations, the exemption levels listed in Table 2 for both Th(nat) and U(nat) are 1 Bq/g. According to paragraph 107(e) of those regulations, "Natural material and ores containing naturally occurring radionuclides which are either in their natural state, or have only been processed for purposes other than for extraction of the radionuclides, and which are not intended to be processed for use of these radionuclides" are not subject to the Transport Regulations if the sum of the Th-232 and U-238 activity concentrations does not exceed 10 times this exemption value (i.e. 10 Bq/g). Consequently the rare earths concentrate, at a combined activity concentration of 6 Bq/g, is not subject to the regulations and may be transported internationally as an ordinary non-hazardous material from a radiation safety point of view. In accordance with international standards, they pose such a low radiation hazard during transport that there is no net benefit in regulating them.

The 1989 Malaysian Transport Regulations are closely based on the older 1985 IAEA Transport Regulations. However the Malaysian regulations do not include a key clause, namely that the IAEA regulations define "radioactive material" (Para. 139) as: "Radioactive material shall mean any material having a specific activity greater than 70 kBq/kg (2 nCi/g)." Without this definition in the Malaysian Transport Regulations, there is no exemption level and therefore the regulations apply to all radioactive materials. The term "radioactive materials" is in turn defined by the Malaysian 1984 Atomic Energy Licensing Act (AEL Act). According to the AEL Act, "radioactive material" means any nuclear fuel, radioactive product or radioactive waste. There is no follow-on definition for "radioactive product", therefore the AELB takes this to mean any material that emits radiation or contains thorium or uranium. This broad definition covers all materials that surround us in everyday life even at background or trivial levels. In order to avoid regulating this, the AELB limits the application of the AEL Act to materials with thorium and/or uranium above a "clearance level" defined in the Radiation Protection (Basic Safety Standards) Regulations 2010 as "…the values established by the appropriate authority and expressed in terms of activity concentration and/or total activity, at or below which the source of radiation may be released from the control of the appropriate authority". The Radiation Protection (Basic Safety Standards) Regulations do not

however contain such values and therefore it remains the responsibility of the AELB to set any clearance level.

For the transport of radioactive material, the Malaysian 1986 Radiation Protection (Licensing) Regulations require a Class D licence to be issued and the regulations specify detailed requirements for obtaining this licence.

At the port there is one person trained in all ‘dangerous goods’, as well as a ‘hazmat’ emergency response team that undergoes regular training with the federal fire service. The incoming SLCs will be stored at the port as general cargo for up to three days, a limit set by the port. Customs generally open a certain number of containers to visually verify the contents, maintaining the right to open any and all containers if they should find cause to do so. The freight forwarder will then label the containers as Class 7 immediately prior to them leaving the port. The port staff were unaware of the requirement for the material to be transported as radioactive material for the road journey to the site.

It should be considered whether the containers should be classified as radioactive material as soon as they cross the ship’s rail and come under Malaysian jurisdiction, in which case they would not be allowed to remain in the port and should be transported to the site immediately. This situation would require a fleet of tractor trailers sufficient to keep pace with the ship unloading rate, which is understood to be governed by the cranes which can unload 20 containers per hour.

The Malaysian OIA is a voluntary code of practice which, among other things, recommends vehicle operators to prepare an emergency response plan, stipulates maximum driving and working hours per day and the preparation of risk assessments. If this code of practice is followed, it will limit a driver to eight hours of driving per day and, assuming half that time is spent driving loaded trucks, to four hours of exposure per day.

The transport of raw material from the port to the plant site will generate additional heavy traffic. While the low radiation hazard posed by this material does not warrant special consideration for transport, the international principle of optimization of radiation protection encourages to examine how the radiation safety might reasonably be improved. The person most exposed to the dose arising from the transport is the truck driver. In order to minimize the dose to the driver, the principles of time, distance and shielding should be applied, in that order of priority. To reduce the exposure time, the quickest route from the port to the plant site should be identified, which may not necessarily be the shortest when traffic is taken into account. A traffic impact assessment (TIA) can be used for this purpose. The TIA proposes a route which passes through the busiest part of Gebeng. An alternative, which is not identified in the TIA but which its data indicates may have the least traffic, would be north on Federal Route 3, west onto the Jalan Gebeng Bypass as far as the turning into the industrial estate by the Sungai Balok, south from there to the railway spur and finally east along the railway to the Lynas site. It is recommended that the alternatives be compared to identify the quickest route. Since this material is not likely to pose a radiation hazard in the event of a road traffic accident (RTA), whether to the individuals involved in the accident, the emergency response crew or a clean-up team, minimizing the risk of an RTA need not be considered from a radiation safety point of view.

The Lynas Emergency Planning for Radiation document provides an overview of various working procedures including transport and then details how to handle emergency situations such as spillages in/outside the site. Whilst already comprehensive, the document does omit some details – for instance, in the event of a spillage outside the site (6.7), who would contact Lynas and how would they find the contact details if the driver was not able to do this? For minor liquid spills (6.9), the procedure appears disproportionate to the small amount of liquid being considered. Other sections which may benefit from more realistic procedures appropriate to the risk are 6.11 and 6.12. Lynas has not advised of any intention to utilize sealed sources, therefore sections 6.16 and 6.17 are not relevant and may cause confusion. The review team expects that the AELB will review the Emergency Planning for Radiation document.

Recommendations

The recommendations related to the updating of regulations (presented in Section 1) and public communication (presented in Section 7) apply also here.

6. SAFETY ASSESSMENT

Basis for the review

The objective of radiation safety, including radioactive waste management and disposal, is to protect people and the environment from harmful effects of ionizing radiation now and in the future without placing an undue burden on future generations. In accordance with the international safety standards, populations in the future deserve the same level of protection against radiation as the present generation. The potential hazards and radiological impacts of a facility or activity are evaluated by means of a safety assessment that covers both short and long term situations. To be in line with international radiation safety standards, the safety assessment has to take into consideration a wide range of natural processes, as well as physical and chemical factors such as those related to hydrology, geology, meteorology, topography, leach rates, absorption, radionuclide transport parameters (e.g. erosion rates and flow rates) and parameters describing pathways to humans (e.g. uptake of radionuclides by drinking water, consumption of fish). A set of different circumstances ('scenarios') should be considered, representing normal and expected developments over time as well as abnormal and worst case situations. The results of these analyses are then compared with the relevant regulatory limits and requirements.

The depth and scope of the review and assessment of the facility or activity by the regulatory body has to be commensurate with the radiation risks associated with the facility or activity, in accordance with the graded approach to regulation.

There are many international safety standards dealing with safety assessment. The two safety standards that are most relevant to the proposed rare earths processing facility are the following:

(i) Predisposal Management of Radioactive Waste, IAEA Safety Standards Series No. GSR Part 5 (2009), which outlines the general requirements for a safety assessment;
(ii) Management of Radioactive Wastes from the Mining and Milling of Ores, IAEA Safety Standards Series No. WS-G-1.2 (2002).

As outlined in IAEA Safety Standards Series No. WS-G-1.2:

(a) The assessment should include all phases of the project, from initial operations through to final decommissioning and waste management. The assessment should consider all significant scenarios and exposure pathways by which the workers, members of the public and the environment may be subject to radiological and non-radiological hazards. The resulting doses are compared against the appropriate limits for workers and the public.
(b) The uncertainties in the input information should be noted. This includes approximations in the models used, and any limitations in the understanding of the processes involved.
(c) With regard to public exposure, the safety assessment should include an estimate of the exposures arising from the wastes produced. Specifically, the critical groups (those most likely to receive the highest exposures) should be specified. In such analyses, it is usually sufficient to consider exposure scenarios and make assumptions that are based

on the lifestyles and living conditions of individuals residing in the general vicinity of the waste management facilities.

(d) The operator should determine which institutional controls may be applicable after closure of the waste management facility, and the time frame over which they should be assumed to be effective. The controls should be proposed to the regulatory body and should be reviewed as part of the closure plan.

(e) Possible future events that could increase risks, for instance through failures of institutional and engineering controls, should be considered. Such events include human activities (e.g. future use of the sites), natural processes and events which could affect the integrity of the containment (e.g. flooding, erosion) and internal processes (e.g. differential settlement).

(f) The optimization of radiation protection efforts to control doses should be examined.

The AELB, on receiving an application for a Class A licence to site and construct a facility, requires the operator to prepare and submit a safety assessment. The safety assessment for the proposed rare earths processing facility was carried out on behalf of Lynas by Nuklear Malaysia and is presented in the RIA. Since the RIA covers areas needed for the safety assessment, it is a key document in the licensing process. In accordance with international safety standards, Lynas remains responsible for the RIA and its results, even though the preparation of this document was contracted out to Nuklear Malaysia.

The RIA first discusses the licensing setting relevant to the proposed facility and then describes the project at a level of detail sufficient for evaluating the radiation safety aspects. These details include the plant location, the site characteristics (topography, hydrology, geology, meteorology and demography), the present and future land use and a description of the production process. An assessment of the current radiological state of the environment is also included, in order to serve as a baseline against which changes due to the plant operation can be measured. The impact assessment describes the assessment data and methodology, radiation protection criteria, source term determinations, exposure scenarios and characterization of critical groups, dosimetry modelling and impact analysis. The results of the analysis and the related sensitivity analysis are then presented. At the end, the RIA discusses mitigation measures and the monitoring programme before presenting final conclusions.

The input data and assumptions used in the analyses were based largely on data provided by Lynas. The review team was informed that the AELB was currently in the process of reviewing the RIA, including the input data and assumptions used.

Findings

The safety assessment process

In general, the review team concluded that sufficient information is available on the safety assessment method, models, scientific data and site-specific data for making an adequate evaluation of the potential short and long term radiological impacts on humans and the environment. The safety assessment process, as documented in the material made available to the review team, was found to be consistent with international standards and no

instances of non-compliance with the standards were identified. More specific findings related to radiation protection and waste management are discussed in Sections 2 and 3, respectively.

Radioactivity levels in the process materials

The documentation examined by the review team revealed that the rare earths concentrate to be imported from Australia is expected to have a ThO_2 concentration of 1 600 ppm and a U_3O_8 concentration of 28 ppm. These concentrations correspond to a Th-232 activity concentration of 5.7 Bq/g and a U-238 activity concentration of 0.29 Bq/g. The decay progeny of these radionuclides are expected to be in approximate equilibrium with their parents. Of the three residues produced at the facility, only the WLP residue is expected to contain elevated levels of radioactivity. This residue is expected to have a ThO_2 content of 1 655 ppm and a U_3O_8 content of 22.5 ppm. These concentrations correspond to a Th-232 activity concentration of 5.9 Bq/g and a U-238 activity concentration of 0.24 Bq/g. For the purposes of the safety assessment, the Th-232 and U-238 decay series radionuclides are assumed to be in equilibrium. Confirmation of these activity concentration values and the basis for the assumption of radioactive equilibrium should be provided in the next licensing phase.

Estimates of dust releases from the proposed rare earths processing facility have been developed as part of the RIA. Radioactive equilibrium is assumed in estimating the radionuclide content of the dust. This is valid for most release points, with the possible exception of high temperature emissions, such as from the kilns. The high temperatures (approximately 600^{o}C) may produce increased emissions of the more volatile radionuclides Pb-210 and Po-210. This situation is known to occur at elemental phosphorus plants, where the phosphate rock feedstock contains uranium and where discharge limits on such emissions are generally imposed. The Pb-210 may become concentrated to significantly elevated levels in stack scrubber wastes. Therefore, the review team considers it important that the radioactivity of the scrubber wastes during production be measured to assess this issue and to allow AELB to take any necessary regulatory actions.

Assessment of doses to workers and members of the public

From the information presented in the RIA, it can be concluded that the major potential exposure pathway during operation of the proposed facility will be external exposure of workers to gamma radiation. Depending on the actual dust levels in the workplaces once the plant is operational, internal exposure of workers via the inhalation of long-lived radionuclides in airborne dust may also need to be considered. The inhalation of thoron (Rn-220) and radon, whether by workers or members of the public, is not expected to be a significant exposure pathway. Similarly, worker exposure due to ingestion of process material is not expected to be significant. A simple calculation shows that a daily ingestion of 100 mg of material with a Th-232 activity concentration of about 6 Bq/g would give rise to a worker dose of only 0.2 mSv per year.

Examination of the review material revealed that the assessment of worker doses from exposure to gamma radiation had been based on simple models (e.g. cylindrical source geometries) referenced to IAEA documents. These models are conservative and will therefore overestimate the dose. The conservatism in the results is acknowledged in the RIA, but the

magnitude of the uncertainties is not addressed. The average dose received by workers was predicted by the modelling calculations to be about 2 mSv per year. At only 10% of the occupational dose limit, this is not a cause for any concern, especially in view of the conservative nature of the assessment. The highest dose (almost 13 mSv per year) was estimated to be received by a single individual working near the rare earths concentrate stockpile and feed bin. Data provided in IAEA Safety Reports Series No. 49 suggest that the gamma dose rate (in the absence of shielding) at a distance of 1 m from a very large stockpile of thorium-containing material is 0.39 μSv/h per Bq/g of Th-232. For exposure to process material with a Th-232 concentration of about 6 Bq/g, the dose for a full working year (2000 h) would therefore be less than 5 mSv, almost three times lower than the estimate in the RIA.

In actual plant conditions, the annual dose from gamma radiation can be expected to be even lower than 5 mSv because the source is likely to be smaller, the average distance from the source is likely to be greater and the annual exposure period is likely to be shorter. A good example of the doses to be expected in such real life situations can be found in a plant at Baotou, China, where rare earths are produced using a process similar to that proposed by Lynas, using a feedstock with similar thorium concentrations. On the basis of gamma dose rate measurements made in that plant during actual operating conditions, the doses from gamma radiation were determined to be about 0.3–0.4 mSv per year.[5] These doses are up to 35 times lower than those predicted in the RIA submitted by Lynas.

The exposure of workers due to the inhalation of radionuclides in airborne dust will need to be considered once the plant is in operation. Lynas expects the dust concentration levels in the workplaces to be, at most, 0.5 mg/m^3. This seems reasonable, given the significant moisture content of the various process materials throughout the rare earth extraction process. Assuming that the activity concentration in the dust is the same as that in the bulk material (6 Bq/g), it can be shown that the maximum dose received by a worker from inhalation of dust will be less than 0.3 mSv per year, which is of no significant concern. However, airborne dust needs to be monitored once the plant is in operation to confirm that this is indeed the case.

Exposure of members of the public as a result of the contamination of surface water bodies is expected to be negligible, since all liquid effluent will be treated before discharge to remove any harmful contaminants. Nevertheless, this should be confirmed by discharge monitoring and environmental monitoring, as provided for in the RPP.

As identified in the RIA, the short half-life of thoron and the relatively low concentration of uranium (the parent of Rn-222), in the feedstock mitigate against the potential for elevated thoron or radon levels. The review team suggests that monitoring during operations be used to confirm the expected low levels, including at off-site locations. For the latter, monitoring locations used during the baseline/pre-operational monitoring programme should be used. The results of the monitoring should be used in the evaluation of exposures of

[5] WU QIFAN, et al., “The use and management of NORM residues in processing Bayan Obo ores in China”, Naturally Occurring Radioactive Material (NORM VI), (Marrakech, Morocco, 22–26 March 2010), Proceedings Series, IAEA, Vienna (in press).

members of the public to confirm the very low doses (0.002 mSv per year) predicted in the current version of the RIA.

Provided that all discharges of dust, thoron/radon and liquid effluent are properly monitored in accordance with the RPP to ensure that they remain at insignificant levels, it can be concluded that there will be no discernable risk to the public arising from the operation of the facility.

Since the RIA has identified the potential for significant doses to be received by some workers, the review team emphasizes that, once the plant is in operation, more reliable assessments of worker doses need to be made, based on actual measurements made in the plant. It is also important that the AELB have the necessary capabilities to undertake confirmatory monitoring. The measurements made during operation of the plant should include gamma dose rates and airborne dust activity concentrations in the various workplaces throughout the plant and it is noted that provision for such measurements is made in the RPP. Should the gamma dose rate measurements confirm the potential for significant worker exposures as predicted in the current version of the RIA, dose reduction measures should be implemented in accordance with the principle of optimization of radiation protection (see Section 2).

Recommendation

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.

7. PUBLIC COMMUNICATIONS

The review team appreciated the Malaysian Government's wish to include public communication aspects in the scope of the mission. The review team also appreciated the positive and genuine atmosphere during the sessions and took careful note of the opinions, views and concerns expressed.

Basis for the review

The review team had the benefit of participating in public submission sessions on 30–31 May in Kuantan and 2 June in Putrajaya. During the sessions, 17 groups of up to six persons at a time expressed their views, opinions and concerns to the review team. In total, 66 persons representing 5 political parties, 4 professional bodies, local residents (12 individuals), 1 trade association and 7 NGOs met with the review team. For each session, 30 minutes were reserved. Some groups provided their views also in writing.

At the international level, the IAEA safety standards address public information and involvement in a broad manner. Paragraph 2.4 of Safety Standards Series No. GSR-1 requires that "Legislation shall be promulgated to provide for the effective control of nuclear, radiation, radioactive waste and transport safety. This legislation shall […] define how the public and other bodies are involved in the regulatory process." Paragraph 3.3 of the same document requires that "In order to discharge its main responsibilities, the regulatory body shall [...] communicate with, and provide information to, other competent governmental bodies, international organizations and the public."

The Atomic Energy Licensing Act 1984 (Act 304) does not provide specific provisions or requirements for public involvement in a project as a mandatory part of the decision-making process. However, the Environmental Quality Act 1974 provides an understanding, albeit administrative in nature, that the RIA is part of the environmental impact assessment (EIA). This EIA may involve public involvement, but in the case of the proposed rare earths processing facility, such involvement was not included in the decision-making process.

Findings

The review team found that the AELB communicates with and provides information to other competent governmental bodies, international organizations and the public. The AELB also provides information on its criteria and decisions on its website. The Ministry of International Trade and Industry (MITI) has recently created a Lynas 'info pack' on their website. Apart from the presentations given to limited stakeholder segments, Lynas has not yet been actively involved in informing the Malaysian public.

Among the various views of individuals, the following three themes came up consistently during the public submission sessions:

1. There was a need for public involvement in and detailed information on the proposed rare earths processing facility and the associated regulatory process. The information that was needed in this regard included factual, easily understandable information on radiation, information regarding other similar plants elsewhere in the world and their radiological impacts and, in particular, reliable information regarding possible events

and accidents involving the proposed facility and the corresponding emergency preparedness arrangements.

2. There was a need for a strong and visible national regulatory process, for stepwise licensing, for documents to be updated and for the regulatory body to control, monitor, inspect and enforce its decisions regarding the proposed rare earths processing plant.

3. There was a need for information and solutions regarding the long term management of the process residues, including information on where the waste would be finally disposed of.

In light of Lynas being solely responsible for the safety of the proposed facility, the review team fully recognized the needs of residents to be clearly informed on how Lynas intended to ensure safety and whether the AELB as the regulatory body accepted the plans submitted by Lynas as being appropriate for public health and safety.

The review team considers it necessary for the Government to address the three needs presented above. In particular, the review team considers it important to strengthen the regulatory process and the AELB and to make the activities of the AELB more understandable, transparent and visible. Also, the review team considers it important to:

(a) Develop binding guidelines with clearly assigned responsibilities (in particular those of Lynas as well as AELB) on how to inform and involve stakeholders about projects involving potential radiological impacts on people and the environment;

(b) Develop and implement strategies for involvement with stakeholders so that trust in the AELB's competence, integrity and impartiality can be established; this involvement should be regular and take place throughout the project – not only when there is a concern;

(c) Have a low threshold for informing the public and other stakeholders in the project;

(d) Create responsiveness to the public's needs on the part of the licence applicant and the AELB.

There was a clear indication from the public submissions that information was hard to find and that the mainly one-way communication did not meet the increased information needs of the public. The lack of information has also caused members of the public to conduct their own searches for information, leading to misunderstandings and misperceptions as well as to unnecessary fears for public health and safety that might have been avoided. Basic knowledge of the project and its impact on people and the environment are also missing to a large extent.

It became evident that the relevant stakeholders needed to be re-identified and that ways needed to be found to address the concerns of the public and other stakeholders, for example by:

(a) Producing basic level material on topics such as radiation, radiation safety issues and radioactive waste management for the general public that provided a consistent viewpoint among the various role players in the field of radiation;

(b) Broadening communication channels and utilizing them more effectively in order to enhance dialogue and enable response;

(c) Informing relevant parties (for example the media) on radiation and radiation safety issues.

It was also evident that sufficient resources and competence to carry out these functions should be ensured.

Recommendations

- 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.

- 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.

- 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.

APPENDIX I. MISSION TERMS OF REFERENCE

International Review Mission on Radiation Safety Aspects of a Proposed Rare Earth Processing Facility in Malaysia

1. Introduction

1. The construction and subsequent operation of a rare earth oxide facility in Kuantan, Malaysia has raised concerns in the country about the potential radiological health impacts associated with the presence of Naturally Occurring Radioactive Material (NORM) in the raw, processed and waste material.

2. Therefore the Government of Malaysia had decided on 22 April 2011 to propose the appointment of an independent panel of international experts to review the radiation safety aspects of this project, and to report to the Government of Malaysia its findings.

3. In this context, Malaysia approached the IAEA for assistance, and in response to the request made by the Malaysian Government, the IAEA has decided to assemble an expert team that will make the review of the proposed operation taking into account international applicable standards and the so called good practices. This document provides for the Terms of Reference including, the objective, scope, and mutual responsibilities in carrying out the overall review process.

2. Objectives of the Review

The objective of the mission is to review and conclude the compliance of the Proposed Rare Earth Processing Facility (the Lynas Project) in Malaysia with relevant International Safety Standards and Good Practices, and to provide an independent expert opinion on the safety, in particular on radiation safety aspects of the Project.

3. Scope

The scope of the review process will cover Safety Aspects as to include:

- Radiation Protection - occupational, public and environment - including Monitoring Systems
- Safety Assessment
- Waste Management;
- Decommissioning and Environmental Remediation; and,
- Transportation.

The review will be based primarily upon documentation, interviews, presentations and relevant data, as requested by the review mission team and to be provided by the Malaysian Government and other stakeholders, where appropriate.

4. Modus Operandi

The working language for the review mission will be English.

Two coordinators will be appointed, by the Government of Malaysia and the IAEA, respectively.

The appointed coordinator from the Malaysian Government will be responsible for:

- being the sole representative of the Malaysian Government to liaise on administrative matters with the IAEA Coordinator;
- providing supporting documentation in English to the IAEA Coordinator in a timely manner as per needs of the review team;
- ensuring that advance questions, if any, from the experts are dispositioned to appropriate specialists within the Malaysian Government and its support organizations, and other stakeholders, where appropriate;
- making administrative arrangements within Malaysia for the review mission; and,
- assisting to collate Malaysian comments related to the draft review report for factual accuracy, and to provide feedback on the experience of the review mission; the IAEA Coordinator will be responsible for:
- liaising with the appointed coordinator from the Malaysian Government, including other stakeholders;
- coordination of all IAEA activities relating to the review mission;
- facilitate establishment of the review team;
- facilitate conduct of the review mission; and,
- managing the development and publication of the report.

The review process will include preparatory work, the review mission itself and reporting. It will involve:

- Selection of the review mission team and its leader by the IAEA coordinator;
- Submission of primary review documents by the Malaysian Government to the IAEA coordinator. The primary documents to be reviewed and relevant safety standards against which they are to be reviewed are listed in Sections 9 and 10;
- Submission of advance questions and issues from the review mission team to the Malaysian Government or other stakeholders, where appropriate, for discussion during the review mission;
- Preparation of a detailed agenda for the review mission by the IAEA in consultation with the Malaysian stakeholders. The detailed agenda would include, open and closed working sessions (i.e. exclusive for the review team members), presentations by the Malaysian stakeholders and their supporting organizations, site visits, follow-up question and answer sessions, etc.;
- The on-site component of the review mission will be held over a period of 6 days, including a half a day pre-meeting of the review mission;

- Presentation by the review team leader of the main findings and initial recommendations of the review mission team at the close of the review mission in Malaysia;
- Editing and finalization of the report of the international review team after the review mission. The Malaysian Government will be asked to fact check the final draft report; and,
- Publication of the final report of the international review team.

5. Review Team

The IAEA will select a team of international experts to perform the review according to the present Terms of Reference. The review team will comprised of recognized international experts and IAEA staff with experience in the areas described below. The IAEA may consult with the Malaysian Government regarding the composition of the proposed review team prior to conducting the mission. However, the final decision with regard to the selection of international experts rests with the IAEA. To preserve impartiality, the review team will not include individuals whose participation may lead to conflict of interests.

The review team leader will be selected among review team's integrants.

The specialists, selected from IAEA Member States, will have knowledge of IAEA safety standards and broad professional experience in their respective disciplines, in particular those radiological safety aspects related to rare earth processing and Naturally Occurring Radioactive Material (NORM). The expertise of the review team may include, but will not be limited to, the following topical areas:

- Regulatory control and radiation protection (occupational, public and environmental);
- Safety assessment;
- Waste management,
- Environmental monitoring and surveillance;
- Decommissioning and environmental remediation;
- Transport safety; and,
- Public communications

6. Independent Observers

The Malaysian Government has the option to allow observers[6] (for example, local community representatives, other agencies of the Government of Malaysia, Non-Governmental Organizations or persons from neighbouring countries) at any open ended plenary sessions to be held between the Malaysian Government representatives and the international review mission team. The Malaysian Government should provide the IAEA with the names and

[6] Observers are interested groups or individuals who do not actively participate in the proceedings, but who monitor the progress of the review meeting.

contact information of observers who accept an invitation to participate in a specific activity of the review mission.

7. Reporting

The review mission team will prepare a report that documents its findings and recommendations. The report will reflect the collective views of the review team members in the context of international safety standards. The review mission report may be discussed with the Malaysian Government prior to its finalization - for fact checking only.

The distribution of the report is restricted to the IAEA, review team members, and the Malaysian Government and other stakeholders, deemed appropriate by the IAEA. Any further distribution is at the discretion of the Malaysian Government. In the interest of transparency, the Malaysian Government is encouraged to allow publication of the report by the IAEA.

8. Tentative Schedule of Activities

- Selection of the review team by 7th of May 2011
- Documents sent by the Malaysian Government to the IAEA coordinator by 7th of May 2011
- Review meeting to take place in the period from the 29th of May to 3rd of June 2011
- Completion of the draft report by 30th June 2011
- Publication of the final report

Presentation of the main findings and initial recommendations at the close of the review mission in Malaysia by 3rd June 2011.

The tentative schedule of activities can be amended by mutual agreement of the parties.

9. Supporting Documentation

Primary Documents:

Radiological Impact Assessment of Advanced Materials Plant Gebeng Industrial Estate Kuantan, Pahang.

Applicable Malaysian National Standards and Regulations (relevant parts thereof):

1. Atomic Energy Licensing Act 1984 (Act 304);
2. Radiation Protection (Licensing) Regulations 1986;
3. Radiation Protection (Basic Safety Standard) Regulations 1988;
4. Radiation Protection (Transport) Regulations 1989;
5. Panduan untuk mendapatkan lesen daripada Lembaga Perlesenan Tenaga Atom bagi pengilangan bahan yang mengandungi atau yang berkaitan dengan bahan radioatif – LEM/TEK/28 *(Guidance for the application of license to process material containing or related to, radioactive material*);

6. Panduan penyediaan Program Perlindungan Sinaran bagi aktiviti TENORM – LEM/TEK/45 (BAHAGIAN E), 17 Oktober 2001 *(Guidance for the preparation of Radiation Protection Programmes for activities involving TENORM, 17 October 2001);*
7. Radiological Impact Assessment(RIA)/EIA – LEM/TEK/30, LEM/TEK/49 etc.;
8. Guidelines on Radiological Impact Assessment (RIA) Study Regards to TENORM Activities –LEM/TEK/41 (Draft 1), Nov. 2001;
9. Environmental Quality Act, 1974 (Amendment, 1985);
10. Environmental Quality Act, 1974 (Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) order 1987)

10. IAEA Reference Documents

The findings and recommendations of the international peer review will be based upon the IAEA's safety fundamentals and applicable IAEA safety requirements. As appropriate, IAEA safety guides will also be used to inform the findings and recommendations. The applicable IAEA Safety Standards are:

Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1 (2006)

International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources, IAEA Safety Series No. 115 (1996),

Governmental, Legal and Regulatory Framework for Safety, General Safety Requirements Part 1, IAEA Safety Standards Series No. GSR Part 1 (2010)

Predisposal Management of Radioactive Waste, IAEA Safety Standards Series No. GSR Part 5 (2009)

Management of Radioactive Wastes from the Mining and Milling of Ores, IAEA Safety Standards Series No. WS-G-1.2 (2002)

Release of Sites from Regulatory Control on Termination of Practices, IAEA Safety Standards Series No. WS-G-5.1 (2006)

Environmental and Source Monitoring for Purposes of Radiation Protection, IAEA Safety Standards Series No. RS-G-1.8 (2005)

Occupational Radiation Protection in the Mining and Processing of Raw Materials, IAEA Safety Standards Series No. RS-G-1.6 (2004)

Application of the Concepts of Exclusion, Exemption and Clearance Safety Guide, Safety Standards Series No. RS-G-1.7 (2004)

Assessing the Need for Radiation Protection Measures in Work Involving Minerals and Raw Materials, IAEA Safety Report Series No.49 (2006)

Radiation Protection against Radon in Workplaces other than Mines, Safety Reports Series No. 33 (2003)

Monitoring and Surveillance of Residues from the Mining and Milling of Uranium and Thorium, Safety Reports Series No. 27 (2002)

Extent of Environmental Contamination by Naturally Occurring Radioactive Material (NORM) and Technological Options for Mitigation, Technical Reports Series No. 419 (2003)

The Application of the Principles for Limiting Releases of Radioactive Effluents in the Case of the Mining and Milling of Radioactive Ores, Safety Series No. 90 (1989)

Decommissioning of Facilities for Mining and Milling of Radioactive Ores and Closeout of Residues, Technical Reports Series No. 362 (1994)

The international experts may draw upon various supporting documents to supplement their findings and recommendations, such as IAEA technical reports.

11. Funding of the peer review

The review mission activities will be funded by the relevant IAEA Technical Cooperation projects.

APPENDIX II. DRAFT MISSION PROGRAMME

Day	Date/Venue	Agenda
1	**28.05.2011 (Saturday)**	**Review Team Arrival in Putrajaya** 1800 - 1900: Team meeting
2	**29.05.2011 (Sunday)** **Room:** JW Marriot Hotel Putrajaya	**1000 - 1015: Opening Remarks** *By Y. Bhg. Datuk Dr. Rebecca Fatima Sta Maria* *Secretary-General* *Ministry of International Trade and Industry (MITI)* *By Dir Tero Varjoranta* *International Atomic Energy Agency (IAEA)* *Review Mission Team Leader* **Chair:** *Y. Bhg. Datuk Dr. Rebecca Fatima Sta Maria, Secretary General, MITI* **Co-*Chair***: *Y. Bhg. Dato' Madinah Mohamad, Secretary General, MOSTI* **1015 - 1200: Introductory Session** Briefing of International Review Mission Program and Logistics *by Ms. Wan Zaharah Wan Mohamad, Program Coordinator* Briefing on Media *by Mr. Syed Muhamad Syed Nazir* **1200 - 1300: Lunch** **1300 - 1600: Technical Briefings on the Lynas Advanced Materials Project Review** 1. Project description and technologies 2. Relevant legal and regulatory framework 3. Radiation protection – occupational, public and environment – including monitoring systems 4. Safety assessment 5. Waste management 6. Decommissioning and environmental remediation 7. Transportation 8. Public communications *by YM Raja Dato' Abdul Aziz, Director General, AELB* *and Mr. Hasmadi Hasan, Director of Licensing, AELB* **1600 - 1700: Radiological Impact Assessment (RIA) on Lynas** *by Dr. Muhamad Omar, Director of Radioactive Waste Management, NMA* **1700 - 1800: Independent International Panel of Experts Team Meeting (closed)** **1830 - 2000: Dinner hosted by The Honourable Ministers and Deputy Ministers of MITI, MOSTI and NRE** ***2200: End of Day 29 May Agenda***

<table>
<tr><th>Day</th><th>Date/Venue</th><th colspan="2">Agenda</th></tr>
<tr><td rowspan="4">3</td><td rowspan="4">30.05.2011 (Monday)

Kuantan</td><td colspan="2">0730 - 0800: Meeting with The Honourable Minister MITI

0810: Depart for KLIA, Flight MH1268, ETD 0910 hours,
Arrival Kuantan, ETA 0950 hours</td></tr>
<tr><td colspan="2">1045 - 1130: Interview Chief Minister of Pahang and State EXCO Members
Venue: <u>Yayasan Pahang</u>

1200 - 1330: Check-in Hotel and Lunch</td></tr>
<tr><td>Interviews in thematic small groups (Relevant legal and regulatory framework, radiation protection, safety assessment, waste management, decommissioning and environmental remediation, transportation, public communications)
Venue : <u>Yayasan Pahang</u>

1400: Dr Ahmad Kamarulnajuib Che Ibrahim
Director
State Department of Environment (DOE),
Tingkat 4-6, Bangunan Asia LifeJalan Telok Sisek

1530: Mr Abdul Aziz Yahya
Director
Department of Occupational Safety and Health (DOSH)Tingkat 3, Bangunan Wisma Persekutuan, Jalan Gambut

1645: YBhg Dato’ Abdul Wahab Mat Yasin
Director
Malaysian Fire and Rescue Department, Jalan Bukit Ubi</td><td>Public submission session 1
(30 minute session for each party)
Venue: <u>Hyatt Regency Hotel, Kuantan</u>

1430: Resident’s Association

1500: Dato’ Ti Lian Ker
Ketua Pemuda MCA
(Head MCA use)

1530: YB Fauziah Salleh,
MP Kuantan

1600: UMNO Kuantan and Indera Mahkota

1630: State Youth Council & Federation of Malaysian Manufacturers East Coast Branch</td></tr>
<tr><td colspan="2">1800 – 1900: Team meeting (closed)</td></tr>
</table>

Day	Date/Venue	Agenda	
4	**31.05.2011 (Tuesday)** **Kuantan**	**Interviews in thematic small groups** (Relevant legal and regulatory framework, radiation protection, safety assessment, waste management, decommissioning and environmental remediation, transportation, public communications) **Venue: <u>Yayasan Pahang</u>** **0900: Dato' Hj Lias Mohd Noor** Chief Executive, Pahang State Development Corporation Kompleks 16, Kompleks Teruntum **1030: Dato' Hj Zulkkifli Hj Yaacob** Yang Dipertua, Kuantan Municipal Council, Jalan Tanah Putih **1200: Dato' Rohimi Che Wan** Director, Minerals and Geoscience Department Malaysia Pahang, Tingkat 11, Wisma Persekutuan, Jalan Gambut **1430: Dato' Hj Zulkefli Hassan** Director, Department of Irrigation and Drainage Pahang, Tingkat 8, Kompleks Tun Razak, Bandar Indera Mahkota	**Public submission session 2** (30 minute session for each party) **Venue: <u>Hyatt Regency Hotel, Kuantan</u>** **0930: YB Syed Mohammad ADUN Berserah** **1000: Dato' Phang Tsu Ming ADUN Teruntum** **1030: Bar Council Pahang** **1100: YB Choong Siew Onn DAP Kuantan** **1400: Rukun Tetangga** **1430: Malaysian Medical Association of Pahang** **1500: YB Syed Hamid B Syed Mohamad** **1530: Independent Geologists** **1600: Save Malaysia Committee** *(The invitation to attend session on 31 May 2011 was declined by the President due to fear of his security. Second invitation on 2 June 2011 was declined due to travelling difficulties)* **1630: Federation of Tionghua Associations Residents of Pahang, Hospis Pahang, People's Green Coalition**
		1700 - 1800: Drafting mission report per each review area by drafting leads 1800 - 1900: Team meeting (closed)	

Day	Date/Venue	Agenda
5	**01.06.2011 (Wednesday)**	**0745 - 0845: Kuantan Port, Review Material Handling and Custom Procedures for DG** **0900 - 1130: Interview Datuk Mashal Ahmad** Chief Executive Officer, Lynas Malaysia Sdn Bhd **1200 - 1300: Familiarisation of the site: Lynas Advance Material Plant (LAMP)** No. 72 Jalan Gebeng 1/24 Bandar Industri Gebeng Jaya, 26080 Kuantan, Pahang. Phone: +60 (9) 583 4445 Fax: +60 (9) 583 4446 Email: general@lynascorp.com
		1300 - 1500: Return to Hyatt Regency Hotel for Lunch and Check-out 1500 - 1600: Drafting mission report per each review area by drafting leads 1600 - 1700: Team meeting (closed) 1700: Depart for Kuala Lumpur *Flight MH1281, ETD 1915 hours and ETA 2000 hours*

<table>
<tr><th>Day</th><th>Date/Venue</th><th colspan="2">Agenda</th></tr>
<tr><td rowspan="2">6</td><td rowspan="2">02.06.2011
(Thursday)</td><td>Interviews in thematic small groups
(Relevant legal and regulatory framework, radiation protection, safety assessment, waste management, decommissioning and environmental remediation, transportation, public communications)
Venue: <u>Multimedia Room Level 13 MIDA, Block , Plaza Sentral, Station Sentral 5,Kuala Lumpur</u>

1100: Dato’ Ir. Dr. Johari Basri
Director General, Department of Occupational Safety and Health (DOSH)

1400: Datuk Dr. Hasan Abdul Rahman
Director General, Ministry of Health

1500: Datuk Jalilah Baba
Director General, Malaysian Industrial Development Authority (MIDA)

1600: Dato Hajah Rosnani Ibrahim
Director General
Department of Environment (DOE)</td><td>Public submission session 3
(30 minute session for each party)
Venue: <u>Garden Ballroom 3, JW Marriott, Putrajaya</u>

1000: ISTIC Governing Board
(Not attending)

Malaysian Medical Association (MMA)
(Not attending)

1100: Federation of Malaysian Consumers Associations
(FOMCA)

1200: SM Mohamed Idris
President, Consumer Association of Penang

1400: Prof. Dr. Lee Sze Wei
Task Force Committee for Lynas Issue, Institute of Engineers Malaysia

1500: Consumers’ Association of Penang</td></tr>
<tr><td colspan="2">1800: 1st draft of the mission report including preliminary mission findings only for mission review team members
Team meeting (closed)</td></tr>
<tr><td>7</td><td>03.06.2011
(Friday)</td><td colspan="2">1. Drafting of the mission report (team members only)
2. Discussion of the mission, feedback (team members and the Counterpart)</td></tr>
<tr><td>8</td><td>04.06.2011
(Saturday)</td><td colspan="2">Review Team departs Malaysia</td></tr>
</table>

APPENDIX III. LIST OF PARTICIPANTS

III.1. Review Team

IAEA STAFF MEMBERS	
Tero **Varjoranta** Team Leader	Division of Nuclear Fuel Cycle and Waste Technology
Axel Magnus **Vesterlind** Deputy Team Leader	Waste and Environment Safety Section Division of Radiation, Transport and Waste Safety
Horst **Monken Fernandes**	Waste Technology Section Division of Nuclear Fuel Cycle and Waste Technology
Hanna M. **Kajander**	Division of Nuclear Fuel Cycle and Waste Technology
Hiroko **Ratcliffe**	Division of Nuclear Fuel Cycle and Waste Technology
INTERNATIONAL EXPERTS	
Leo M. **Lowe**	SENES Consultants Ltd., Canada
Ulric **Schwela**	Tantalum-Niobium International Study Centre, United Kingdom
P.M.B. **Pillai**	Bhabha Atomic research Centre, India
Jan **Van Der Steen**	Private consultant, Netherlands
Dennis **Wymer**	Tantalum Niobium Study Centre, South Africa

III.2. Official Liaison Officer

Wan Zaharah **Wan Mohamad** Ministry of Science, Technology and Innovation (MOSTI)

III.3. List of people the Team met during the Mission

NAME	COMPANY/ORGANIZATION
Abdul Aziz Yahya	Department of Occupational Safety and Health (DOSH)
Abdul Mukhtar B Engah	Resident Associations
Abudullah Johari B Hamzah	Bar Council (Pahang)
Ahmad	People's Green Coalition
Ahmad Zubir B Omar	State Assemblymen of Semantan
Alex Chow	Malaysian Chinese Association (Political Party)
Andansura Bin Rabu	State Assemblymen of Beserah
Arazmi Johari	LYNAS, Malaysia
Arifin B Ahmad	Independent Geologists
Aw Dai Kooi	Residence of Kuantan
Azrul Khairi	State Youth Council
Bahazelan B Abd Wahab	United Malay National Organization (UMNO) Kuantan and Indera Mahkota Division
Chan Woon Zet	Residents of Pahang
Cheah Kim Hung	Democratic Action Party (Kuantan)
Chin Pek Hing	Resident of Kuantan

Chong Hong Seng	State Assemblymen of Teruntum
Cik Gan Mui Hwei	Ministry of International Trade and Industry (MITI)
Cik Suhana Jalil	Atomic Energy Licensing Board (AELB), MOSTI
Dato' Azman Mahmud	Malaysian Industrial Development Authority (MIDA)
Dato' Dr. Sharifah Zarah	Ministry of Science, Technology and Innovation (MOSTI)
Dato Hajah Rosnani Irahim	Department of Environment
Dato' Hajjah Mahadiah Mohamad	UPEN
Dato' Hj Lias Mohd Noor	Pahang State Development Corporation
Dato' Hj Zulkefli Hassan	Department of Irrigation and Drainage Pahang
Dato' Hj Zulkkifli Hj Yaacob	Kuantan Municipal Council
Dato' Ir. Dr. Johari asri	Department of Occupational Safety and Health (DOSH)
Dato' Madinah Mohamad	Ministry of Science, Technology and Innovation (MOSTI)
Dato' Mohammad Rumai Puteh Abdullah	Tenaga Nasional Berhad Pahang
Dato' Rohimi Che Wan	Minerals and Geoscience Department Malaysia Pagang
Datuk Dr. Hasan Abdul Rahman	Department of Health (DOH)
Datuk Dr. Rebecca Fatima Sta Maria	Ministry of International Trade and Industry (MITI)
Datuk Jalilah Baba	Malaysian Industrial Development Authority (MIDA)
Dr. Ahmad Kamarulnajuib Che Ibrahim	State Department of Environment (DOE)
Dr. Ailin Razali	Malaysian Medical Association of Pahang
Dr. Carmen Chew	Malaysian Medical Association of Pahang
Dr. Chan Chee Khoon	The Concern Citizens of Kuantan
Dr. Chong Jen Lim	Malaysian Medical Association of Pahang
Dr. Jayabalan	Consumers' Association of Penang
Dr. Muhamad Lebai Jun	Nuklear Malaysia, MOSTI
Dr. Muhamat Omar	Nuklear Malaysia, MOSTI
Dr. Muhd Noor M.Yunus	Nuklear Malaysia, MOSTI
Dr. Pushpa Ratnam	Hospis Pahang
Dr. T Jayabalan	People's Green Coalition
En. Abd. Majid Kiliran	Ministry of International Trade and Industry (MITI)
En. Hasmadi Hassan	Atomic Energy Licensing Board (AELB), MOSTI
En. Kamel Mohamad	Ministry of Science, Technology and Innovation (MOSTI)
En. Khairuddin	Nuklear Malaysia, MOSTI
En. Mohd. Yusuf Mohd Ali	Nuklear Malaysia, MOSTI
Faridah Bt Azir	Resident Associations
Foon Weng Lian	Federation of Malaysian Consumers Associations (FOMCA)
Hamrah B. Mohd Ali	Atomic Energy Licensing Board (AELB), MOSTI
Heong Fook Seng	Democratic Action Party (Kuantan)
Hing Hung Yong	Ministry of International Trade and Industry (MITI)
Hon Kai Ping	Bar Council (Pahang)
Ismail Sulaiman	Nuklear Malaysia, MOSTI
Khairul Salleh bin Jais	LYNAS, Malaysia, General Manager, Plant
Khoo Khiam Ping	Malaysian Chinese Association (Political Party)
Lai Min Sing	Federation of Tionghua Associations (Kuantan)
Lee Boon Tai	Federation of Tionghua Associations (Kuantan)
Lee Sze Wei	State Assemblymen of Teruntum
Lim Chong Kiow	State Assemblymen of Beserah

Lim Siong Kun	Residence of Kuantan
Mageswari Sangaralingam	Consumers' Association of Penang
Mahmud Yaakub	State Assemblymen of Beserah
Mastura Ahmad Mustafa	Ministry of International Trade and Industry (MITI)
Mazlina Bt Mohd Lazim	United Malay National Organization (UMNO) Kuantan and Indera Mahkota Division
Md Jamil Fauzi	State Youth Council
MD Jushoh B Darus	State Assemblymen of Semantan
Michael John Vaisey	LYNAS, Vice President, Research & Technology
Mohammad Izuddin Idris	Ministry of International Trade and Industry (MITI)
Mohd Arif B Babu Salam	United Malay National Organization (UMNO) Kuantan and Indera Mahkota Division
Mohd Helmi B Ibrahim	Resident Associations
Mohd Ibrahim Hashim	PKNP
Mohd Sharir B Abdullah	United Malay National Organization (UMNO) Kuantan and Indera Mahkota Division
Mohd Zulkifli	Democratic Action Party (Kuantan)
Mohideen Abdul Karim	Consumers' Association of Penang
Monalija Kostor	Atomic Energy Licensing Board (AELB), MOSTI
Nazuha Moh Jai	Atomic Energy Licensing Board (AELB), MOSTI
Noor Jehan B Bakar	Bar Council (Pahang)
Nordin B Hussain	Resident Associations
Norman B Mansor	Malaysian Chinese Association (Political Party)
Patrick Khoo	Malaysian Chinese Association (Political Party)
Pn. Halimah Hassan	Department of Environment
Pn. Wan Zaharah Wan Mohamad	Ministry of Science, Technology and Innovation (MOSTI)
Roshidah Mazlan	Malaysian Industrial Development Authority (MIDA), Pahang
Salina Bt Arshad	Resident Associations
Siew Fook Chan	The Concern Citizen of Kuantan
Sim Chon Siang	The Concern Citizen of Kuantan
Siti Afidah Awang	Atomic Energy Licensing Board (AELB), MOSTI
Supt. Hj. Borhan Daud	Police Department (PDRM)
Syed Azimal	United Malay National Organization (UMNO) Kuantan and Indera Mahkota Division
Syed Mohamad Syed Nazir	Ministry of International Trade and Industry (MITI)
T. Zulkifly Bt. Ahmad	United Malay National Organization (UMNO) Kuantan and Indera Mahkota Division
Tan Ka Kheng	People's Green Coalition
Tee Kai Ming	LYNAS, Malaysia
Viji Samuel	ENVIRON Consulting Services
Wan Emril Nizam	State Youth Council
Wan Zaharah Wan Mohamad	Ministry of Science, Technology and Innovation (MOSTI)
Wee Hoe Chong	Residence of Kuantan
Wee Tiat Eng	LYNAS, Malaysia, Engineering Services Manager
Wong Meng Chuan	Residence of Kuantan
Wong Ming Hui	The Concern Citizen of Kuantan
YB Choong Siew Onn	Democratic Action Party (Kuantan)
YB Dato' Abdul Wahab Mat Yasin	Malaysian Fire and Rescue Department
YB Dato Pang Tsu Ming	State Assemblymen of Teruntum

YB Dato' Mas'ut B Awang Samah	Federation of Malaysian Manufacturers (FMM) East Branch
YB Dato' Mash'al Ahmad	LYNAS, Malaysia
YB Datuk Ti Lian Ker	Malaysian Chinese Association (Political Party)
YB Norol Azali Sulaiman	State Youth Council
YB Puan Fuziah Bt Salleh	The Concern Citizens of Kuantan
YB Syed Hamid B Syed Mohamad	State Assemblymen of Semantan
YB Syed Mohammed B Tuan Lonnik	State Assemblymen of Beserah
Yh Dato' Chow Liong	Federation of Tionghua Associations (Kuantan)
YM Raja Dato' Abdul Aziz	Atomic Energy Licensing Board (AELB), MOSTI
Yusri B Mohd Ali	Independent Geologist
Zai Akmal Arawi	Ministry of International Trade and Industry (MITI), PAHANG
Zaiton Bt Madon	Resident Association

APPENDIX IV. LIST OF REFERENCE MATERIAL PROVIDED BY THE MALAYSIAN COUNTERPARTS

[1] Radiological Impact Assessment of Advanced Materials Plant Gebeng Industrial Estate Kuantan, Pahang

[2] Atomic Energy Licensing Act 1984 (Act 304);

[3] Radiation Protection (Licensing) Regulations (1986)

[4] Radiation Protection (Basic Safety Standard) Regulations (1988)

[5] Radiation Protection (Transport) Regulations (1989)

[6] Panduan untuk mendapatkan lesen daripada Lembaga Perlesenan Tenaga Atom bagi pengilangan bahan yang mengandungi atau yang berkaitan dengan bahan radioatif – LEM/TEK/28 *(Guidance for the application of license to process material containing or related to, radioactive material*)

[7] Panduan penyediaan Program Perlindungan Sinaran bagi aktiviti TENORM – LEM/TEK/45 (BAHAGIAN E), 17 Oktober 2001 *(Guidance for the preparation of Radiation Protection Programmes for activities involving TENORM, 17 October 2001)*

[8] Radiological Impact Assessment(RIA)/EIA – LEM/TEK/30, LEM/TEK/49 etc.

[9] Guidelines on Radiological Impact Assessment (RIA) Study Regards to TENORM Activities –LEM/TEK/41 (Draft 1) (Nov. 2001)

[10] Environmental Quality Act, 1974 (Amendment, 1985)

[11] Environmental Quality Act, 1974 [Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) order 1987]

APPENDIX V. LIST OF RELEVANT IAEA STANDARDS

[1] Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1 (2006)

[2] International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources, IAEA Safety Series No. 115 (1996)

[3] Governmental, Legal and Regulatory Framework for Safety, General Safety Requirements Part 1, IAEA Safety Standards Series No. GSR Part 1 (2010)

[4] Predisposal Management of Radioactive Waste, IAEA Safety Standards Series No. GSR Part 5 (2009)

[5] Management of Radioactive Wastes from the Mining and Milling of Ores, IAEA Safety Standards Series No. WS-G-1.2 (2002)

[6] Release of Sites from Regulatory Control on Termination of Practices, IAEA Safety Standards Series No. WS-G-5.1 (2006)

[7] Environmental and Source Monitoring for Purposes of Radiation Protection, IAEA Safety Standards Series No. RS-G-1.8 (2005)

[8] Occupational Radiation Protection in the Mining and Processing of Raw Materials, IAEA Safety Standards Series No. RS-G-1.6 (2004)

[9] Application of the Concepts of Exclusion, Exemption and Clearance Safety Guide, IAEA Safety Standards Series No. RS-G-1.7 (2004)

[10] Assessing the Need for Radiation Protection Measures in Work Involving Minerals and Raw Materials, IAEA Safety Report Series No.49 (2006)

[11] Radiation Protection against Radon in Workplaces other than Mines, IAEA Safety Reports Series No. 33 (2003)

[12] Monitoring and Surveillance of Residues from the Mining and Milling of Uranium and Thorium, IAEA Safety Reports Series No. 27 (2002)

[13] Extent of Environmental Contamination by Naturally Occurring Radioactive Material (NORM) and Technological Options for Mitigation, IAEA Technical Reports Series No. 419 (2003)

[14] The Application of the Principles for Limiting Releases of Radioactive Effluents in the Case of the Mining and Milling of Radioactive Ores, IAEA Safety Series No. 90 (1989)

[15] Decommissioning of Facilities for Mining and Milling of Radioactive Ores and Closeout of Residues, IAEA Technical Reports Series No. 362 (1994)