Malaysia's Rare Earth Processing Plant: Nurturing Greening Capabilities

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ABSTRACT

DESCRIPTION
The context of growth and development within industrializing nations like Malaysia is increasingly becoming a sensitive issue from the context of triple bottom line impacts and whether further growth could coincide with high levels of societal well-being and environmental conservation. The role of business organizations as business citizens and stewards for a better future is without a doubt critically analysed by concerned local and international stakeholders. This learning case will demonstrate the major concerns and move towards building a social capacity for change, via the Lynas Advanced Materials Plant (LAMP). It draws from three critical areas of analyses: a value chain analysis, a risk-impact assessment analysis, and a value tradeoffs analysis. The eventual aim of this learning case is to build a new inertia and positive outlook towards the potential role of the private sector in facilitating change for sustainable production and consumption.

Learning objectives:
To conduct value chain analysis and propose greening capabilities.
To analyse undesirable risks based on impact-risk assessment.
To scrutinize value tradeoffs and implications for sustainable production and consumption (SPC) policy.

Subjects covered:
Impact-risk assessment; Green business; Natural capitalism

Setting:
- LAMP, Kuantan, Pahang, Malaysia

DISCLAIMER

This learning case was developed based on research using publicly available information. Views and opinions are based on the research and consultancy by the individual authors and do not necessarily reflect those of any organisation. This is an illustrative case only, which may not contain complete or accurate information, and is primarily intended for aiding in understanding the key concepts related to SPC.

BACKGROUND ON THE RARE EARTH INDUSTRY

Despite their importance, rare earth minerals rarely exist in economically viable concentrations. In addition, they are often difficult to extract. Rare earth minerals are one of a set of 17 minerals or chemical elements which consists of yttrium and scandium, as well asthe 15 lanthanide elements (lanthanum, serium, praseodymium, neodymium, promethium, smsrium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium). Rare-earth minerals (when added to magnetic elements like iron), create uniquely strong magnets, and are useful for the production of miniaturized and lighter electronics systems, in addition to electric cars. These minerals are widely used in automotive catalytic converters, fluid cracking catalysts in petroleum refining, phosphors in colour televisions and flat panel screens, displays (cell phones, portable DVDs, and laptops), permanent magnets and rechargeable batteries, generators for wind turbines, numerous medical devices, and in defense applications. The major significance is the application of these magnets in the renewable energy and microelectronics industries.

While the demand for these minerals is increasing due to industrialization and technological improvements in products which require the application of rare earth metals, competitive interests in exploring and mining new rare earth supply sites is also emerging (Karpel 2012). The estimated world demand for rare earth elements is 136,000 metric tons per year; this demand is projected to rise to 185,000 metric tons annually by 2015. What makes the discourse about this industry more complicated is when international trade is factored in. For instance, China's output is projected to be 140,000 metric tons in 2015. However, due to its own internal demand and concerns for environmental issues, as well as a desire to control supply, it has placed restrictions on exports, sparking concerns among manufacturers from Japan and the USA. The World Trade Organisation has called on China to ease its export restrictions. Figure 1 explains the output of the rest of the world (ROW) compared to China's. China has about a third of the world's rare earth reserves but supplies about 90 percent of what is consumed (Great Western Mineral Group 2013). An effort to tame the consumption of rare earth metals will be difficult as the Figure 1 shows. Currently, an efficient non-Chinese total supply chain and a reduction in cost structures are the main concerns for the rare earth industry.

In general, the rare earth total supply chain comprises exploration, mining, mineral processing, separation, and metal-making as inputs for end-use alloy-making of products. While rare earth oxides (REOs) could be turned into, or applied in the production of, various types of products, the availability of each different rare earth elements varies. Different supply chain exists for each product output, and thus, different metal supply chain bottle neck situations exist. In addition, the supply-demand of rare earth metals depends on a combination of many factors, including stiff competition, price, green supply chain requirements by downstream processors, ability of product to be recycled, and the extent to which downstream processors want supply security. As such, products which depend upon rare earth metals are affected by their availability. The shortages or limitations of supply of rare earth metals would have serious impact on many industries, especially for the alternative energy industry such as solar and wind power, which are expected to account for the biggest energy growth markets over the next 20 years. (Spence 2011).

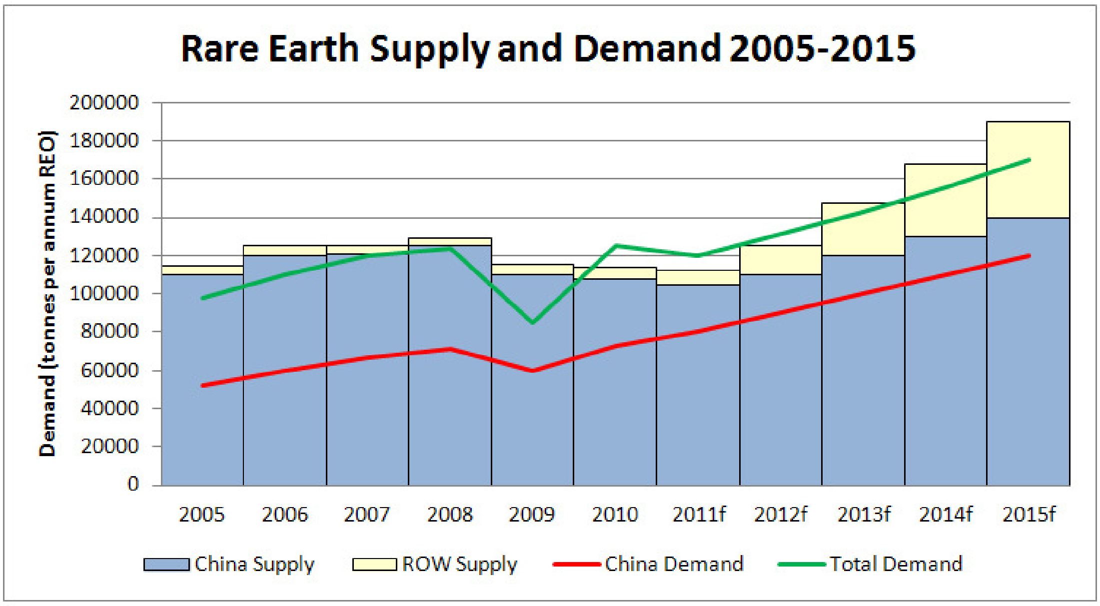

Figure 1. Supply of rare earth domination by China (Great Western Mineral Group 2013)

In order to stabilize supply-demand of rare earth elements, new producers outside China (Toph 2012) are offering new supply options for western countries which depend on these elements (Massari & Rubeti 2013; Metal Bulletin Ltd 2012; Morrison & Tang 2012; Grasso 2012). In fact, exploration of new European mine sites is pertinent since Europe depends on imports for nearly all of its rare-earth metals. The critical metal report (Moss et al. 2011) listed 14 economically vital raw materials that are prone to supply disruption and concluded that supply disruption would threaten Europe's goals for cleaner transport and sustainable energy since rare earth metals are used in products using green technology, such as hybrid/electric vehicles, carbon capture systems, wind power generation, low-energy lighting, and energy efficient flat-screen displays. Five of the 14 metals at high risk due to expanding global demand and potential shortage of supply include the rare earth metals neodymium and dysprosium, as well as the by-products (from the processing of other metals) indium, tellurium, and gallium.

Sustainable production and consumption

For the rare earth industry, sustainable development as a concept is akin to a double-edged sword. While one can consider the urgent need of rare earth minerals for the sake of green technology advancements, one also needs to consider the environmental impacts in the production of the rare-earth minerals and the over use of natural resources to meet the demand for consumption of products with rare-earth minerals. The triple-bottom line impacts of this industry and negative consequences from such material growth and increasing trends towards green consumerism are important considerations, as governments and industries begin to chart new economic policies with regards to the growth of rare earth industry (Richard 2010).

The global demand for natural resources such as rare-earth minerals and the race for wealth generation amongst nation-producers, has caused harm to the environment and to society. For example, in May 2010, China announced a major, five-month crackdown on illegal mining of rare earths in Baotou, Inner Mongolia, in order to protect the environment and its resources. This crackdown campaign concentrated in the South, where mines – commonly small, rural, and illegal operations – were particularly prone to releasing toxic wastes into the general water supply. Molycorps rare earth plant, the only operational plant in the USA, was in fact closed down over ten years ago for ground water pollution. The challenge then with rare-earth minerals industries is with regards to what extent ethical rationality (Ellisha & Reevany 2006) is being championed and to what extent eco-stewardship (Ali 2014) is being practiced over and above the pursuit for profit. Enforcing the principle of environmental stewardship – sustainable functioning of ecosystems and the services they provide – and its strategies must be integrated within the goals and long-term growth of such industry (Chapin et al. 2009).

An efficient process that applies sustainable production and consumption would be very important for this industry. An efficient technology will expand output and mitigate supply chain bottlenecks.The recovery of pre-consumer waste and post-consumer waste would also assist in the expansion of outputs. Successes in this aspect would compensate for the volatility in the price of rare earth minerals, which is affected due to supply-demand constraints.

Nevertheless, the eco value chain for the rare earth industry has yet to be well explored. The extent of recycling and reuse of rare-earth related products is limited. In fact, the technology is still nascent. For products using rare earth elements, recycling and reuse is rather uncommon and expensive. Very few opportunities have been capitalized anywhere in the world (Dempsey 2011). However, research on substitution of rare earth metals with more common materials is underway. Scientists are figuring out how to make magnets that are less dependent on rare-earth elements, thus reducing or eliminating entirely the need for rare-earth elements in powerful permanent magnets inproducts.

There is a need for new producers from developed and developing nations to act responsibly towards managing earth resources collectively, and to view the rare earth metals as one of the many 'global commons' or shared resources which should be used responsibly and together (Denmark 2010). Corporate responsibility that is based on ethical values, and that which questions growth and consumption (Clifton 2011), must be nurtured, in partnership between government and industries, throughout the supply-demand chain, at both the national and global level.

LYNAS ADVANCED MATERIALS PLANT (LAMP)

Lynas Advanced Materials Plant (LAMP) is situated in Gebeng Industrial Estate, adjacent to the Balok River. The estate lies within the capital city Kuantan, in the Pahang state. Kuantan and its metropolitan area, which is located at the edge of the South China Sea, have a population of more than half a million. The Gebeng site is located just inland from a coastal mangrove forest, and several miles up a river that flows out to the sea past a fishing village. Gebeng bypass eases traffic flow from the industrial estate to Kuantan Port and has close proximity to Kuantan deep-water and all-weather port. It links Kuala Lumpur and Kuantan directly through the East Coast Highway. This route provides a cost effective and convenient means of transportation (see Figure 2-3).

Figure 2. Pahang state and its location in Malaysia (PSDC)

Figure 3. LAMP at Gebeng industrial estate (PSDC)

The estate, which drains into the nearby South China Sea, offers an industrial infrastructure where access to utility, chemical and petrochemical manufacturing business clusters is readily available. Major chemical corporations within the estate are Polyplastics Asia Pacific, BASF-PETRONAS, Petronas CUF, Petronas Centralises Emergency Facilities and PDH plant. It has easy access to sources of gas, water and electricity.

The LAMP plant, a subsidiary of Lynas, produces refined rare earth metals which are created througha number of processing steps. As a whole, the overall processing steps in producing refined rare earth metals are mining, milling, floatation and further processing, before it becomes final product. In the mining stage, the extraction of lanthanide concentrate from the Mt. Weld (Western Australia) involves a series of thermal, chemical and physical processes. It is then be transferred to LAMP where rare earth mineral extraction begins. The main processing activities associated with the rare earth extraction are cracking (ore calcining), waste gas treatment, leaching (primary, secondary, and tertiary), upstream extraction, downstream extraction, and product finishing. Input materials for the refining process are ore concentrate, water from water leach purification (WLP), natural gas, sulphuric acid, hydrochloric acid, magnesium oxide, soda ash, lime, oxalic acide, solvent, and kerosene. Following three stages of leaching and solid-liquid separation, solvent extraction will be used to separate, purify and concentrate the lanthanide elements. The lanthanide elements are finally precipitated and calcined to produce a range of carbonate and oxide products. The output materials are diverse rare earth elements, discharged waste water, discharge offgas, several wastes streams which must be stored, reused or disposed of, and used chemicals (especially solvents and kerosene) to be treated, cleaned and recycled externally.

The finished products at the plant are Lanthanum-Cerium Carbonate, Lanthanum Carbonate, Cerium Carbonate, and Samarium Europium Gadolinium (SEG), plus Heavy Rare Earths (HRE) Carbonate and Neodymium, and Praseodymium (Didymium) Oxide. The refined products are transported overseas to 54 companies worldwide as customers.

The development of rare earth industry in Malaysia

Malaysia will be the second Asian country after China, to enter the global supply chain of rare-earth metals production. LAMP will be the first rare earth processing plant in nearly three decades to be finished outside China, and would represent 8% of the world's rare earth market. Malaysia would contribute towards a global effort to break China's global chokehold on rare earth metals, securing supply in the global rare earths industry.

Malaysia's aspiration to move towards a high-income status society has led to it opening its doors by offering lucrative investments to multi-national corporations (MNCs). Malaysia's industrial clusters (as potential rare earth users) are expected to be the future hub for industry knowledge and rare-earth related industries. These industrial clusters are part of the nation's strategy of distributing wealth equally towards the whole regional areas (NCIA). LAMP contributes towards the nation's economic growth objective through the 3rd Industrial Master Plan (MITI 2010). There is a high expectation for advanced chemical companies to locate or co-locate around a stable, long-term, secure, safe supply of rare earth. The market for processed rare earth is expected to grow within the Gebeng Industrial Estate. Within such industrial infrastructure, LAMP has good access to knowledge infrastructure such as technical and trade skills, in addition to chemical industry experience.

The facility has created job opportunities as part of Malaysia's aspiration to move towards a high-income status society: nearly 2,700 new jobs, with job opportunities for 350 skilled workers in 2012. The total value of contracts available to Malaysia is RM 1.2 billion, of which RM 513 million is set aside for locally based contractors in the Kuantan area. The expected export revenue generated for Malaysia would be an additional RM 8 billion, contributing up to 1% of the nation's Growth Domestic Product (GDP).

The expected spinoffs from the presence of the rare earth industry in Malaysia are the development of downstream and upstream businesses, as well as Malaysia's very own indigenous rare earth industries, which could contribute towards the energy efficient vehicles

(EEV) programme (The Academy Sciences Malaysia and The National Professor's Council 2011).

The presence of rare earth business in Malaysia has brought forth the importance of environmental management policy and the role of national and international regulatory bodies. The Ministry of Science, Technology and Innovation (MOSTI), the Ministry of International Trade and Industry (MITI), and the Ministry of Natural Resources and Environment (NRE) are key government ministries responsible for awarding operating licences to the rare earth processing plants in Malaysia. The Atomic Energy Licensing Board (AELB) and the International Atomic Energy Association (IAEA) monitor the radioactive aspects of the operation plant – under the Atomic Energy Licensing Act of 1984, TENORM (Technologically Enhanced Naturally Occuring Radioactive Materials) wastes are monitored (AELB 2011). Waste streams are regulated by Department of Energy (DOE), under the Environmental Quality Act. Malaysia must also abide by its commitment under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. All mineral activities are governed by Mineral Development Act of 1994 and the State Mineral Enactment.

In addition, Malaysia's influence on multinational companies as an industrializing nation, as well as its role in sustainable production and consumption and its stewardship in this arena, have gone centre stage. Lessons learned from the green supply chain leadership of other local industries would be vital for this new industry (Eltayeb et al. 2011).

LAMP AND CORPORATE RESPONSIBILITY

Obviously, corporate responsibility should be at the top of leadership agendas within LAMP in order to ensure a successful new business venture such as this will continue to exist in the long-term. This need is demonstrated by merely observing the extraction process of the rare earth minerals. A particular hazard in the extraction process is the creation ofmildly radioactive slurry tailings, resulting from the common occurrence of thorium and uranium in rare earth element ores. The thorium is extracted from the processed water. Once extracted, the thorium is contained in a specially designed residue storage facility that needs to meet all international standards for safe storage and handling. The residue storage facility is built above ground level, with high-density plastic lining and a clay layer. LAMP needs to ensure that the expected low-level-emitting radiation from the thorium is classified as safe, non-toxic, and non-hazardous.

In addition, as a result of the lanthanide concentrate processing, three separate residue streams are produced: flue gas desulphurisation residue (FGD), neutralisation underflow residue (NUF), and water leach purification residue (WLP). The three residue streams are subjected to pressure filtration and assumed to be in paste form (moisture contents between 30% and 40%), once processed (LYNAS quarterly report). FGD and NUF are classified as hazardous waste since they also contain radioactive elements. All solid wastes will be buried underground in concrete bunkers lined with lead walls.

Since chemicals are used in large volumes to process the ores, awareness of hazards and controls in the production process as well as adherence to health and safety standards must be a constant part of standard operating procedure. The structural design of the plant needs to meet the required standards to deal with the abrasive and corrosive slurry of thorium as well as other by-products. The plant's HAZOP (hazard and operability) studies need to consistently show that the refinery is safe and up to industry standards and report zero contamination from the production processes (Lynas Annual Report 2013). Structural cracks, air pockets, leaks, and other forms of contamination from the structures could lead to emissions of radon, sulfuric acid, and hazardous dust, which would lead to ground, air and water pollution.

Protecting the surrounding swampland and preserving its biodiversity needs to be an important consideration for LAMP. Protecting the water table and preventing the underground river from being polluted from any by-products discharged into the Balok river needs proper attention. The challenge would be for LAMP to consistently produce zero liquid discharge into any waterways.

The most pressing problem for a rare earth plant is to mitigate any air pollution in the form radiation and gas emissions, such as fluorine gas produced during the fusion process. In order to address public concerns, LAMP has installed two Aerosol Monitoring Systems (AMS), both onsite and in Kuantan, to continuously monitor, measure and clearly demonstrate to the community that the facility will cause no harm. The Radiological Impact Assessment reports need to verify that the plant's operations would not pose any radiological risk to the public or the environment.

Hence, for this particular industry, corporate responsibility towards the environment and the consequent health impacts upon the community should not be underestimated. LAMP's ability and continuous improvements in its efforts to practice natural capitalism (Lovins et al. 2011), and as a result, nurture greening capabilities through these four imperatives, is urgent:

- increasing natural resources' productivity: developing dramatically more efficient production processes that stretch natural resources (energy, minerals, water, forests) 5,10, even 100 times further than they go today. The ultimate objective is maximize/optimize the usability of resources;

- imitating biological production models: every output of manufacturing processes is composted into useful natural resources or recycled for further production. The ultimate objective is to preserve ecosystems;
- changing business model: providing services instead of selling more products. The ultimate objective is to move clients towards getting access to products/services without needing to own the products ; and
- reinvesting in natural capital: reinvest in restoring, sustaining, and expanding natural habitat and biological resource bases. The ultimate objective is to gain a public reputation for environmental responsibility.

Nevertheless, in the pursuit of nurturing greening capabilities, understanding the link between such capabilities and the associated impact upon society (the social dimension), is of prime importance. A big part of any business operation is its ability to assure the public that it is genuinely interested in making a positive impact upon the community. LAMP's current efforts to develop trust amongst the residences are in the form of community development programmes. For instance, LAMP is a member of Gebeng Emergency Mutual Aid (GEMA), a voluntary crisis management organization, an alliance between Government agencies and private manufacturers in Gebeng (The Star 2011). Another example is the LAMP-supported Balok Ivory Tower academic programme for local Malaysian school children. Also important is ensuring that the livelihoods as well as health of society are not negatively impacted.

Moreover, the extent of engagement with its key stakeholders with regards to the health and safety of residents, as well as with key stakeholders inregards to environmental preservation, should never be underestimated. The politicisation of the environmental concerns by opposition parties in Malaysia influenced the government-public discourse as well as Lynas' role in allaying fears amongst the local residents. A number of stakeholder groups were politically-motivated as its members include politicians from the opposition parties (Phua & Velu 2012; Zandi et al. 2011). With support from international environmental groups, local residences have formed the Green Assembly, The citizen action group Save Malaysia Stop Lynas (SMSL), and Pertubuhan Solidarity Hijau Kuantan (PSHK). In a delicate situation such as this, the Malaysian government, as another key stakeholder which works closely with LAMP, needed to consider its appropriate role in balancing between adherence to ethical standards with regards to public disclosure and misinformation, and maintaining social harmony of a multi-ethnic nation. Appendix A narrates a sampling of the anti-Lynas camp point of view with regards to public discontent.. Appendix B narrates a sampling of the pro-Lynas camp point of view.

THE CHALLENGE AHEAD

The pros and cons of forging ahead with the growth of Malaysia's rare earth metal industry, may have equal weight. The LAMP business opens up a new, bigger question for Malaysia: what does sustainable production and consumption mean for Malaysian businesses? On the one hand, Malaysia's rare earth industry would contribute towards the needs of green technology which depends on rare-earth magnets, especially for solar and wind power. On the other hand, an assurance for the employees and community's health and safety should not be taken lightly. Perhaps, the more important question is not about taming the consumption of raw materials which would undoubtedly affect the ecosystem and its services, but more so, how could LAMP and Malaysia as a developing country nurture greening capabilities and lead the industry supply chain through sustainable production and consumption of rare-earth magnets? Hence, issues surrounding sustainable production and consumption need to be thoroughly examined. These issues not only cover the production methods, but also the societal-political context which influences the policymakers as well as business decisions. For a country such as Malaysia, the politicization of the environmental issues concerning LAMP's production is an important element which influences government-public engagement, government-corporate engagement, and the discourse on sustainable production and consumption.

LAMP needs to determine the best way forward as a business which handles pressing issues related to economic, environmental, and social dimensions. The future goals of Lynas operations in a developing economy such as Malaysia should be the integration of SPC issues into policy. A current and future impact assessment analysis which leads towards nurturing greening capabilities for LAMP, as well as contributing towards new policy actions, would be a good place to start. With this type of action, the industry could be a good example for other polluting business industries in Malaysia. Ultimately, a thorough analysis of the value chain, the associated risks, and the tradeoffs would need to be conducted in order to steer the discussion away from contradictory viewpoints (either from the pro-Lynas camp or anti-Lynas camp) towards more value-added solutions.

Discussion Questions

1. Based on the value chain analysis, what are the enabling green opportunities for LAMP?
2. What are the risk mitigation opportunities arising from an impact-risk assessment?
3. Based on value tradeoffs analysis of the STEEP dimensions (societal well-being, technological advancement, preservation of environment, political stability), what are the implications related to SPC policy?

Working Sessions

There are two working sessions which ultimately link a company's green capabilities with SPC policy. The first working session consists of two worksheets. Worksheet 1 allows participants to understand LAMP's value chain and discover key opportunities for LAMP to build on. These opportunities are oriented towards building an eco-advantage strategy for LAMP. Worksheet 2 allows participants to extend the analysis towards the future by understanding the future impact of LAMP operations on the environment and society. Within this worksheet, participants will analyse those associated risks which needs mitigation in the future through green capabilities.

The second working session and Worksheet 3 takes another step forward by analyzing the current dilemma faced by developing nations which may prioritise one dimension over other dimensions of STEEP (societal, technological, environment, economic, political). The associated value tradeoffs will allow participants to recommend the core requirements for SPC policy formulation.

Working Session 1: Value chain analysis and risk-impact assessment

Working session 1 starts with Worksheet 1, a value chain analysis, which display a four-column grid comprising value chain factors, issues arising from value chain factors, key leadership actions to consider, and greening capabilities to nurture. Refer to Appendix C for an elaboration of the concept of value chain analysis. The steps involved are:

1. Decide on LAMP's status in the value chain, whether upstream, focal, or downstream; identify the issues in connection with each value chain factors (refer to Table 1 below).
2. Consider the key leadership actions for change.
3. Analyse the opportunities available for LAMP. These opportunities should deal with new solutions that either steers towards operational improvements within LAMP or collaborative initiatives with upstream/downstream sources.

Table 1. Value chain factors and SPC issues (Esty & Winston 2006)

VALUE CHAIN FACTORS	SPC ISSUES RELATED TO VALUE CHAIN FACTORS
Focal point	• How big is our environmental footprint? • What resources are we most dependent on (energy, water, materials), and how much do we use? • What emissions do we release into the air or water? • How do we dispose of waste? • How up-to-date is our environmental management system? • What are our chances of a spill, leak, or release of hazardous materials? • Have others in our industry had problems? • What local, state, federal, or international regulations apply to our business? Are we in full compliance? Are these requirements getting tighter?
Upstream	• What resources are our suppliers most dependent on? Are they abundant or constrained, now and in the near future? • Do our suppliers pollute? Do they meet all applicable laws? Will legal requirements get tighter for them?

	• What substances go into the products suppliers sell to us? Are they toxic?
Downstream	• How much energy (or water or other resources) does our product require customers to use? • Are there hazardous substances in our products? • What do customers do with our products when they are done with them? What would happen if we were required to take the products back?

Worksheet 1: Value chain analysis and nurturing greening capabilities

Value chain factors	**Issues arising from value chain factors**	**Key leadership actions to consider**	**Greening capabilities to nurture**
Upstream situations: Raw materials from suppliers Suppliers and environmental footprints			
Focal point situations: Production methods Environmental management system Industry-related problems			
Downstream situations: Negative social and environmental impacts Customer			

assurances Stakeholder assurances			

In order to contextualize the analyses above into the future, one has to understand that there are two key drivers of the future, climate change and industrialization (Olson 2010). The impact from both of these drivers can be seen in four key areas: water stress, natural resource and raw material scarcity, public pressure for environmental stewardship, and national security and safety concerns. The underlying future concerns with regards to each of these impacts are delineated in Table 2.

Table 2. Future key concerns for Impacts from drivers

Impacts from Drivers	**Future key concerns**
Water stress	What is the possibility of short water supply due to climate change? Would change in weather patterns affect global/regional/local distribution of fresh water?
Natural resource and raw material scarcity	Would the future show a dire need for conservation of resources?
Public pressure for environmental stewardship	Would stakeholders represent more of a negative driving force than a positive force?
National security and safety concerns	What kind of protectionist economic barriers would be imposed by countries with available natural resources? What happens if countries form new political alliances to protect natural resources, which shift global economic strength? How about military action to protect sovereign borders? What is the impact of public unrests? What about the safety of living organisms and habitats due to climate change/natural disasters?

An impact-risk assessment for each of these impacts needs to be conducted. The risks associated with these impacts are economic risk, regulatory risk, reputational risk, market risk, and operational and supply chain risk. Table 3 demonstrates what each of these risks imply with regards to future challenges.

Table 3. Risks and key challenges for consideration

Risks	**Key challenges for consideration**
Economic risk from energy, water and other natural resource prices	Price volatility Meeting long-term demand through raw materials substitution Alternative energy sources
Market risk from poor response to changing consumer preferences	Environmentally friendly products Companies with good corporate responsibility practices
Regulatory risk from government action and legislation	Global agreements Industry-wide regulatory proposals National, state, local level of legislations
Reputation risk from failure to strengthen corporate social responsibility	Environmental stewardship
Operational and supply chain risk from inefficiencies and environmental change	Environmental hazards Natural disasters High operating costs Polluted water supply

Worksheet 2: Impact-risk assessment

In worksheet 2, for each of the impacts below, determine the associated risks for LAMP and how LAMP could mitigate the risks.

Future impact from climate change and industrialization	How LAMP/rare earth industry contributes towards future risks	How LAMP/rare earth industry is affected by future risks	How LAMP could mitigate future risks
Water stress			
Natural resource and raw material scarcity			
Public pressure for environmental stewardship			
National security and safety concerns			

Discussion Question

4. Revisit the value chain analysis on greening capabilities in Worksheet 1. Based on what needs to be done to mitigate the future risks, which part of the value chain is critical and requires more effort?

Working Session 2: STEEP analysis, values tradeoff, and implications for SPC policy

Pursuing greening capabilities must be followed through, hand-in-hand with new SPC policy initiatives which counter the foreseeable tradeoffs. Worksheet 3 allow participants to analyse each of the STEEP dimensions (societal well-being, technological advancement, economic growth, preservation of environment and political stability), their underlying assumptions, what value tradeoffs exist, and what it means for the development of SPC policy by government sectors and what it means for LAMP's own sustainability policy, which complements the nation's policy. In worksheet 3:

1. Discuss the assumptions underneath the societal dimension, its value tradeoffs/potential losses when it is prioritized over other dimensions, and the SPC policy change need to address the imbalance from the tradeoffs.
2. Repeat the analyses for all other dimensions.

Worksheet 3: STEEP analysis and values tradeoffs

STEEP Dimension:	**Assumptions underlying the dimension**	**Value tradeoffs/potential losses from prioritization of the dimension**	**Implications for SPC policy actions to address the imbalances from value tradeoffs**
1.Societal well-being			
2.Technological advancement			
3.Economic growth			
4.Preservation of Environment			
5. Political stability			

Discussion Question:

5. Reflect on the answers for discussion questions 1-4. In terms of ensuring ethical and balanced outcomes, based on Worksheet 3, what key principles should LAMP be guided by when it charts its future SPC policy?

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Appendix A: Key historical background about Lynas and grouses on public disclosure

The citizen action group Save Malaysia Stop Lynas (SMSL) and Stop Lynas Coalition (SLC) were instrumental in organizing protests against LAMP since March 2011 after a report from *The New York Times* (Bradsher 2011) on the safety issues related to the LAMP operations plant. The anti-Lynas movement was comprised of highly educated and middle class professionals and received strong support from the Malaysian Medical Association and the Pahang Bar (Legal) association. The government's opposition party, Pakatan Rakyat, jumped on to the growing anti-Lynas bandwagon. The Himpunan Hijau (Green Gathering) peaceful assembly, which was held in October 2011, was coordinated by the Save Malaysia Stop Lynas campaign. In March 2012, SMSL, with the support of 48 Malaysian NGOs, requested that the Malaysian government suspend the Temporary Operating Licence (TOL) issued to Lynas and stop rare earth ore transportation to LAMP in Gebeng, Kuantan. The main discontent amongst stakeholders was that public disclosure from the Malaysian government was sparse and contradictory. A Parliamentary Select Committee (PSC) was set up in March 2012 to soothe concerns about public health and safety arising from radioactive wastes. Consequently, Lynas was given 10 months to propose a permanent disposal facility (PDF) upon being granted a two-year Temporary Operating License (TOL) in September, 2012. Two years after the expiry of the licence in September 2014, Lynas was awarded a two-year Full operating stage licence (FOSL). The current press report shows that Lynas does not intend to build the PDF in the long-term since it is making efforts in ensuring that the by-products such as WLP could be recycled as safe commercial products.

Appendix B: Press statement by a rare earth expert

The quote below is an extraction of a press statement made by a rare earth expert who visited LAMP in early 2012 and concluded his views on its state-of-the-art operation and earth technology at a Symposium on rare earth industry, in Pahang:

"The open issue now is not chemical engineering, but marketing. The plant became operational behind schedule not because of technical issues but rather due to political ones. An environment activist group claimed first that the LAMP would release too much radioactivity, and would not be able to manage this waste. This argument has been overcome by multiple expert panels and site surveys and finally by the Malaysian courts and government, so the anti-Lynas group has now switched to the cry that the plant will emit toxic chemical wastes (as well as radioactive ones).

This argument falls flat with regulators who have noted that the industrial park in which the LAMP is located, also has large operations of BASF, W.R. Grace, and Tennessee Eastman, all three of which process immense volumes of oil and organic chemicals to make plastics, organic intermediates, and pharmaceutical intermediates. A spill from anyone of those plants would be far more toxic than ANYTHING that could be leaked from the LAMP! Further the LAMP has triple-redundant spill control systems that are among the most impressive I have ever seen. I wonder if the LAMP's Global 1000 neighbors are held to the same standards?

A national election will be held next month, and the anti-Lynas environmental faction is campaigning only for candidates who are willing to openly state their opposition the LAMP. The "anti-" group recently commissioned a study by a well-known German industrial advisory group that without visiting the site condemned it as unsafe. This argument did not fly with the Malaysian Supreme Court which refused further injunctive relief to the "anti" group. The leader of that group threatened two weeks ago to "burn down the plant" if his group doesn't get their way. The tragedy is that if this very deluded man, who is apparently a doctor of medicine, were to do any such thing the danger would be not from LAMP but from its surrounding Global 1000 chemical processing plants. Many thoughtful people in Malaysia who were supporting the "anti" group have now drifted away due to the irrational actions of the group's founder.

I note that on June 30 if LAMP reaches its goal of full capacity, then it will be the largest capacity REE separation plant on earth, and if it further reaches the Phase II capacity of an additional 11,000 metric tons per annum then it will be not only the largest RE separation plant in the world but the largest one ever built anywhere. Until and if Molycorp's Project Phoenix is in the same stage as the LAMP, then the LAMP will be at least one-half of the non-Chinese world's capacity to separate/refine light rare earths. Thus, at that time, Malaysia will be second only to China in RE separation capacity."

Jack Lifton, rare earth expert at Kuantan Symposium on rare earth technology, 2012 (Lifton 2013).

Appendix C: Value chain analysis

An understanding of the organisation's value chain provides new insights into the core sustainability decisions which are driven from a business organisation's proactive desire to nurture its own social capacity for change, to positively impact the environment. This change, in the form of greening capabilities, signifies not only a serious tendency towards sustainable production and consumption, but also a leadership within and beyond the industry in building a culture for sustainable production and consumption.

Figure 4 below shows how the lifecycle chain is constructed from the traditional supply chain inside the "four walls" of a company. It also includes processes from the traditional value chain that include supplier and customer activity, and expands beyond traditional boundaries to include farther-reaching processes for both upstream and downstream operations.

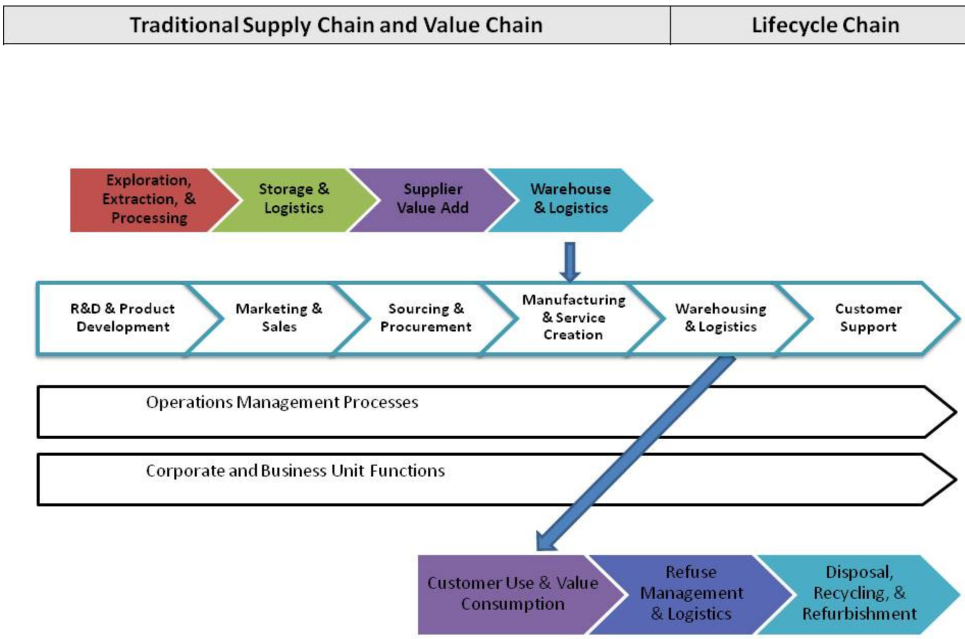

Figure 4. The Value chain perspective (Olson 2010)