Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

Rare earth ore refining in Kuantan - Malaysia

The next legacy ahead?

Gerhard Schmidt, Oeko-Institute, Darmstadt

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Production of REEs

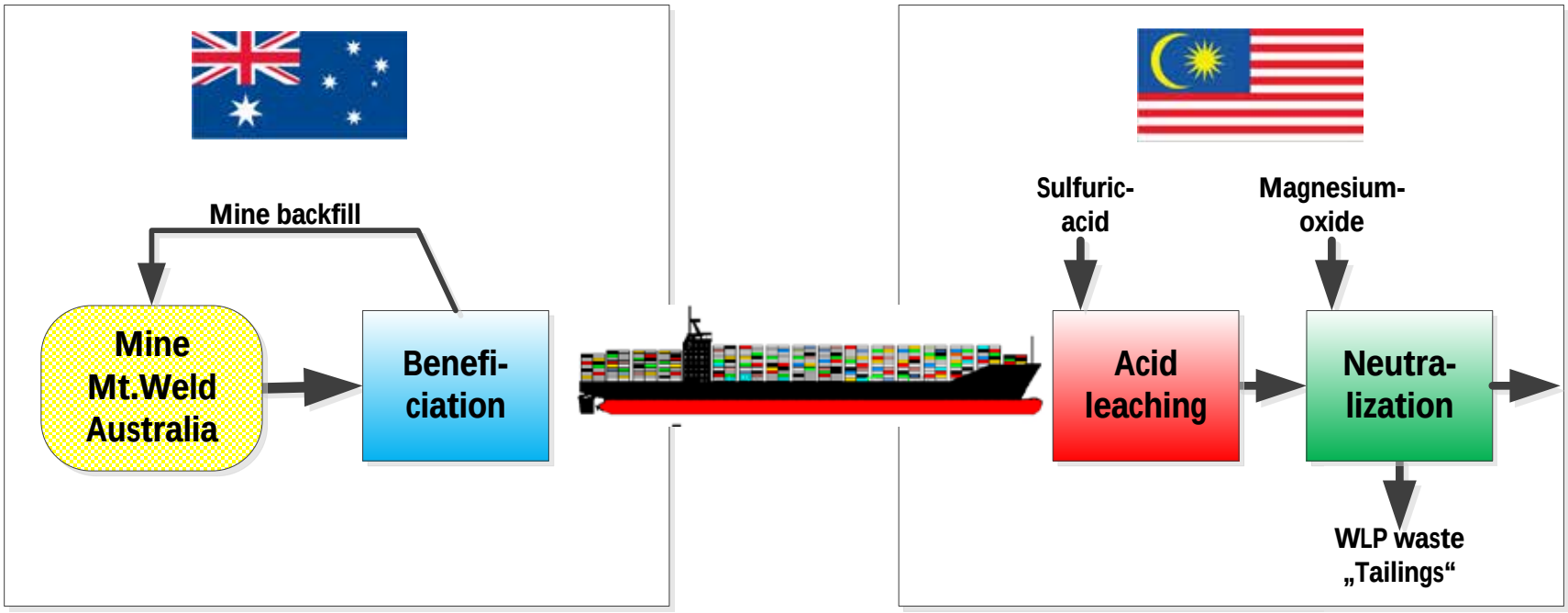
- is necessary for many modern „green“ appliances, such as permanent magnets in gearless wind converters or electictricity powered car motors, etc.,
- is often associated with thorium and uranium by-products and other toxic metals,
- is currently mainly performed in China (Baotou etc.), under environmentally catastrophic conditions such as
  - waste losses to the public domain,
  - large doses from tailings waste re-use for brick production,
  - enormeous discharges,
- could be produced in a much cleaner way by
  - state-of-the-art offgas and water treatment,
  - a consequent waste management.

Overview

1. Production scheme
2. Non-radiological impacts
3. Radiological impacts
4. Conclusions

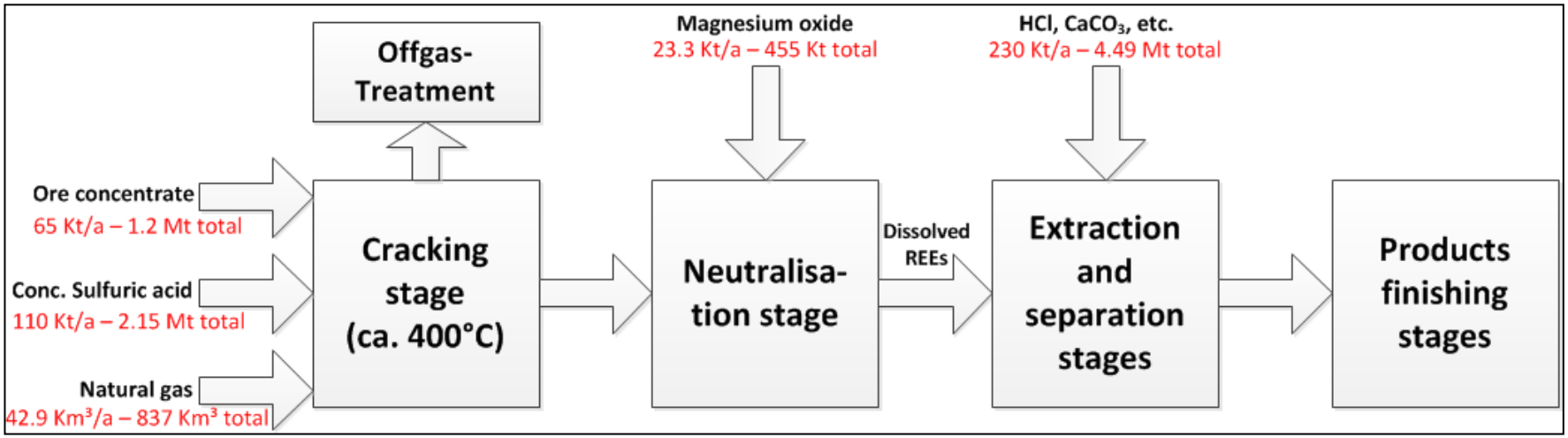
1. Production scheme

- The start-up company Lynas Corp. owns and operates the Mt.Weld rare earth mine in Australia.
- The mined ore is concentrated at the site in order to increase REE concentrations (by roughly double).
- Further processing is performed in Kuantan/Malysia.



1. Production scheme

Large amounts of chemicals are necessary to dissolve, separate and condition the produced 22.5 Kt/a (total: 438 Kt) of REEs.



The result is, that large amounts of

- wastes are generated,
- salts are produced (acid cracking and neutralization) and discharged .

The nearby sulfuric acid production plant – acid by pipe

2. Non-radiological impacts

- Acidic offgas: following treatment, 5 kg/h sulfuric acid emission over stack è 10 times higher than in EU sulfuric acid production plants
- Waste water discharge:
  - High chemical oxygen demand (COD), presumably via sulfite, avoidable by oxydation water treatment stage, but not installed
  - Discharged water has a salt concentration as high as seawater, waste water channel to Balok river will suffer from salty conditions (discharge of saltwater to nearby sea would be no problem)
  - No monitoring of the waste water for REEs just because no standards are defined in Malaysian water quality standards

Lynas waste water discharge

Water discharge channel to river Balok

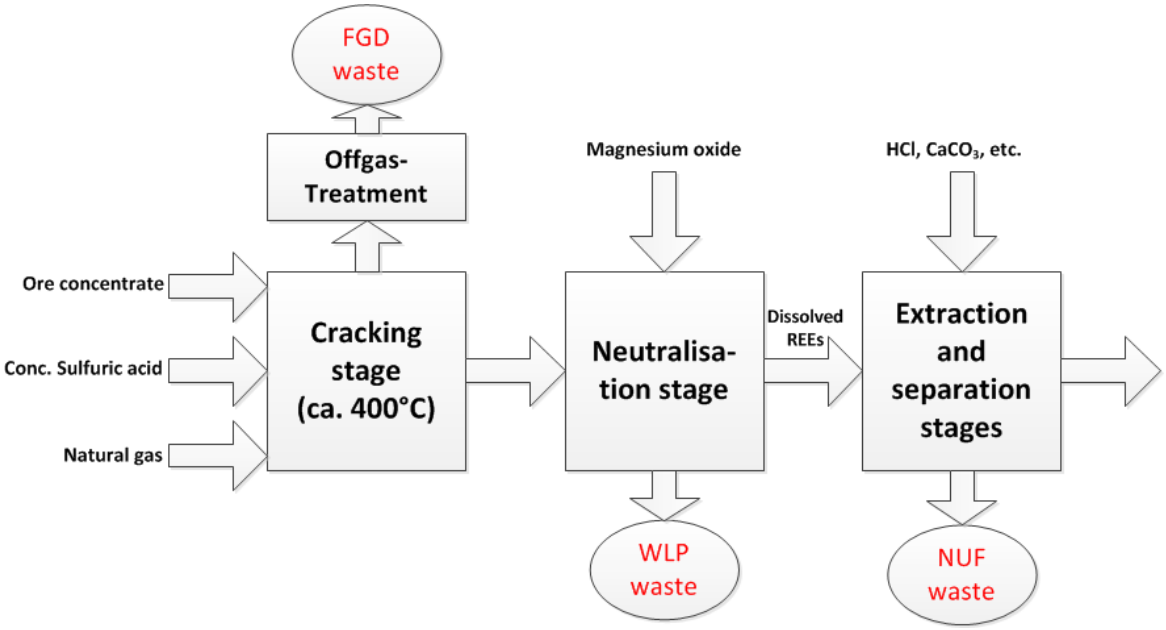
Conventional environmental effects

- All conventional impacts are either completely avoidable or can easily be minimised
- Would require a consequent regulatory regime, applying state-of-the-art requirements

Waste issues

Three major waste categories are generated:

- Waste from the water leach process (WLP): undissolvable ore constituents such as iron phosphate, insoluble precipitates from the neutralization of the acidic solution such as thorium and uranium
- Waste from the off-gas filter system (Flue Gas Desulfurization, FGD), gypsum
- Waste from the neutralization in the extraction and separation stages (Neutralization underflow, NUF)



Waste policy of the operator

Lynas follows a consequent re-use strategy and searches for applications of its wastes. This includes all three waste categories.

1. WLP: Even though this waste has 5.9 Bq/g Th-232 a re-use of this waste in road construction is planned. The formal clearance level of <1 Bq/g shall be achieved by dilution 1 + 6.
2. NUF, FGD: These gypsum wastes shall be used in various applications, mainly for soil conditioning. No informations are available on by-product contents such as lead and arsenic. No standards are defined for the by-product content. Currently a larger scale testing in a palmoil plantation has been started.

Waste management WLP waste

- Even knowing that the WLP waste clearly exceeds exemption levels for thorium, the IAEA mission in Malaysia in 2011 discussed about those potential re-uses and did not define clear radiological criteria for such re-uses.
- Nevertheless the IAEA mission recommended to identify a suitable site for the disposal of those wastes and to reach a consent with the affected host community.
- The temperary operating license required the operator to name a site for disposal of those wastes. The site was named but is kept secret.
- The interim storage facility for those wastes at the site was designed for only five years of production, so a solution has to be setup in a very short period of time.
-

Interim storage of WLP waste

Kuantan/Malaysia has monsoon seasons from November to February. In December 2013 the monsoon filled the interim storage facility nearly completely, with a danger of overtopping the dam structure and a catastrophic failure.

Source: SMSL

Doses from re-use of WLP waste for road construction

The doses from such a re-use were calculated from the gamma dose rate of WLP mix 1 + 6 for different scenarios.

Sce-nario	Assumptions, conditions, dose rates calculated	Collective Effective Dose (man·Sv per year)
City street	Typical user profile for an inner city street, pedestrians, 1,186 km roads constructed from 1.2 million tons WLP, dose rate 65.41 nSv/h	**221**
Free-way	Typical user profile of a highly frequented freeway, 1,186 km roads, dose rate 64.7 nSv/h	**99**
Loss of control	10% loss, 111,000 cases, 50% housing, 50% office construction, dose rate in 1 m distance 357.6 nSv/h	**318**

Re-use scenarios for WLP, results

Re-use of the WLP waste would be associated with large health damages (12 resp. 7 cases per year) due to small direct radiation rates, but the large population affected increases the total health effects.

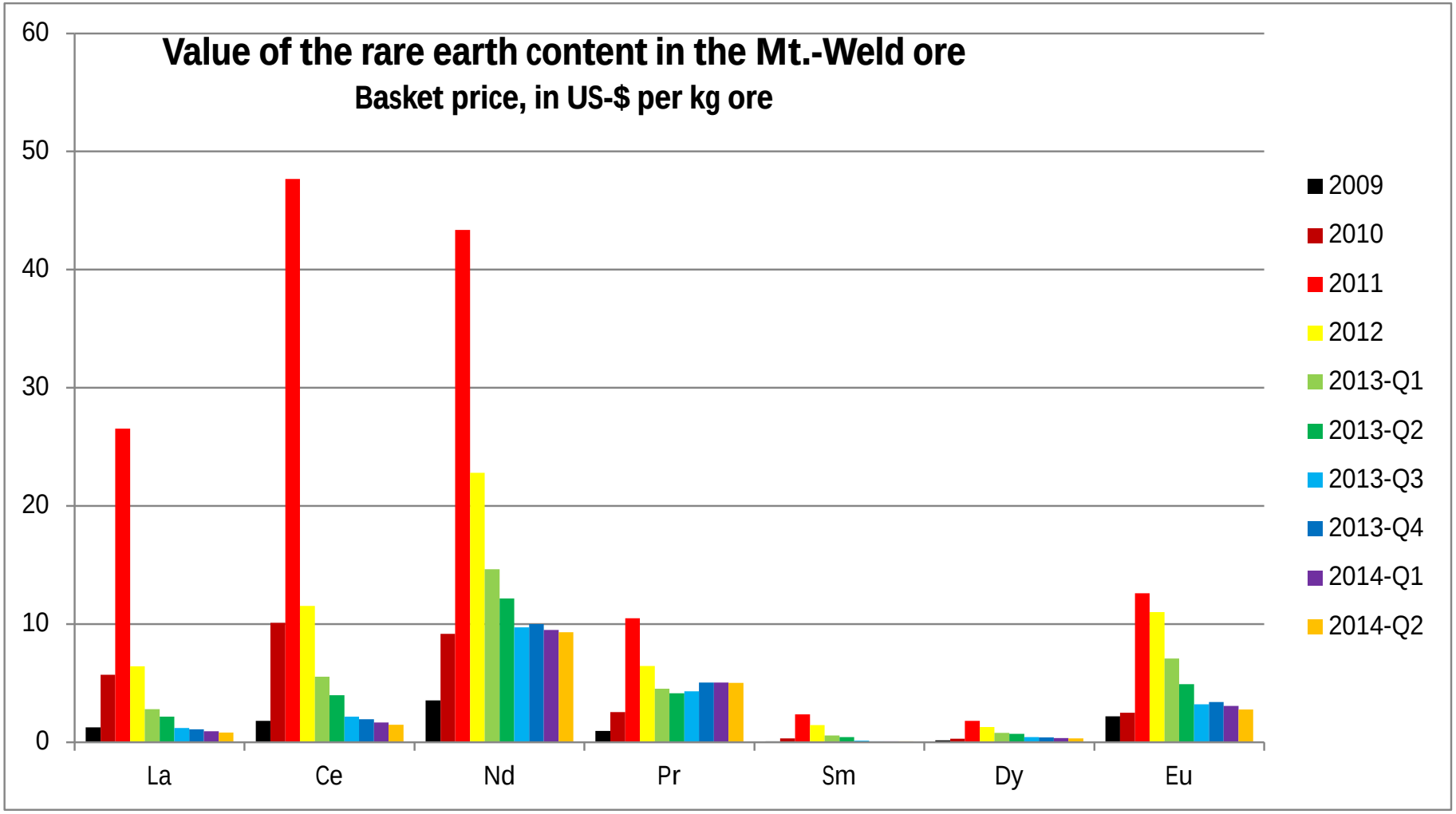
The loss-of-control over small portions of the material (and their use in building construction) would be associated with the highest health damages (16 cases per year).

è The re-use of WLP wastes in road construction is unsustainable due to large health effects

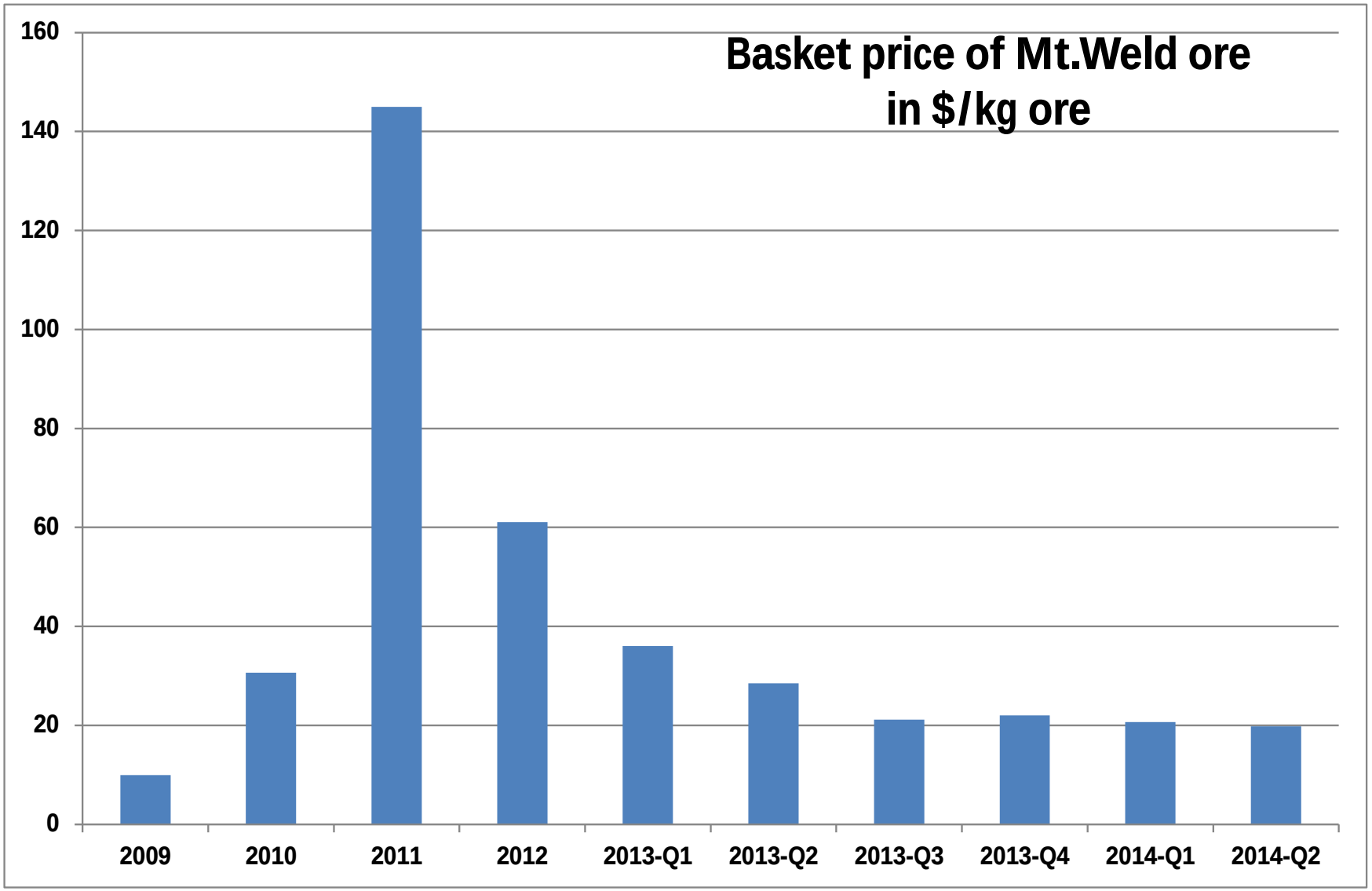
è The disposal of those wastes would not be associated with relevant health effects, but the operator is not taking the necessary steps to implement this management option

The Misubishi Bukit Merah LTSF for thorium wastes from REE production

Prices of rare earth elements (China, FOB)



Basket price of Mt.Weld ore



Resolving the WLP waste issue?

- Another temporary operating license has been issued by the regulatory agency recently.
- The waste management for WLP wastes is not resolved and still left open.

Speculation about the situation in 2020:

- An application for the fourth temporary operating license has been filed, the licensing board issues that license after thorough evaluation.

Speculation about the situation in 2025:

- A total of three interim storage facilities for WLP are operated at the site.
- The content of (in total) one of those facilities has been lost in massive monsoon flooding events.

The end?

- The company has processed its ore and sold all products, it is not required any more and ends its listing on the Australian stock exchange.

2040:

- The Government of Malaysia still discusses about who should be held responsible for the clean-up of the LAMP facility and the disposal of the accumulated waste.

2050:

- Australia and Malaysia conclude a contract to ship the WLP waste back to Australia, to fill it into a dry open pit mine and to install a cover on top. The costs for those operations are halved between Australia and Malaysia.

Vielen Dank für Ihre Aufmerksamkeit!
Thank you for your attention!

Haben Sie noch Fragen?
Do you have any questions?