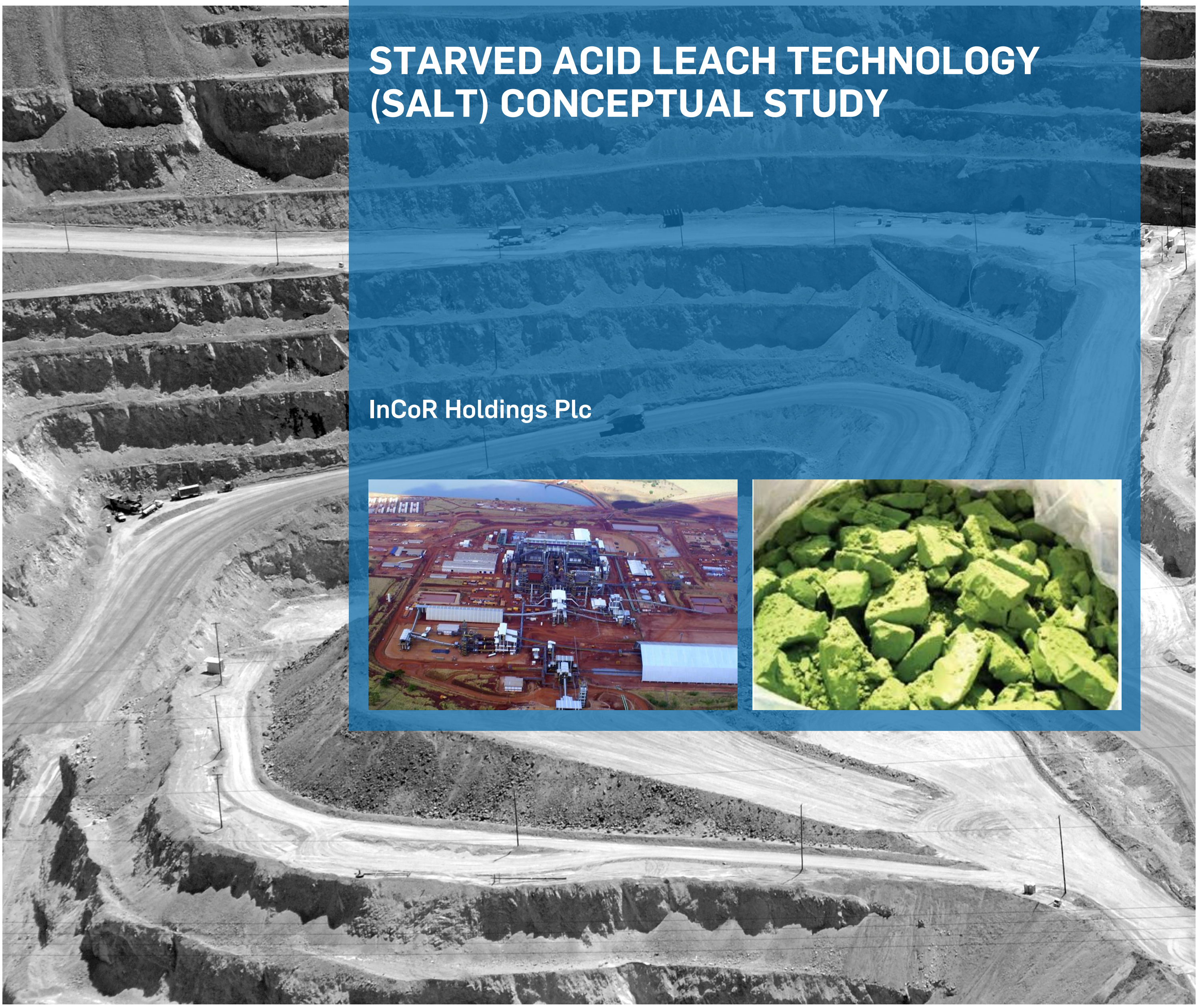
STARVED ACID LEACH TECHNOLOGY (SALT) CONCEPTUAL STUDY

InCoR Holdings Plc



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1 EXECUTIVE SUMMARY

InCoR Holdings Plc (InCoR) is currently investigating the potential of their proprietary SALT (Starved Acid Leach Technology) process to leach the low-grade saprolite ore. InCoR commissioned SNC-Lavalin to develop conceptual level engineering design and cost evaluation of the SALT process plant and supporting infrastructure aimed at producing a Mixed Hydroxide Product (MHP) for feed to the nearby PT Antam Ferronickel Smelter in Pomalaa, Indonesia.

A result summary of the current study is presented in Table 1.1.

Table 1.1 – General Summary of Project Cost and Key Data

Item	Value
Ore Throughput to SALT, million dry tpa	2.0
MHP Produced, wet tpa	117 000
Contained Nickel, tpa	15 000
Project Operating Cost	
Million US$ per annum	119
US$/lb of nickel produced	3.60
Project Capital Cost	
Million US$	282
US$/lb annual nickel capacity	8.60

The current study was conducted to prepare order of magnitude capital and operating cost estimates for the project and identify key business drivers.

1.1 SCOPE OF WORK

The study investigates the installation of a 2 million dry tpa processing plant producing approximately 15 000 tpa of contained nickel in MHP. The overall plant includes a processing plant incorporating InCoR's SALT process with supporting services and infrastructures such as Residue Storage Facility (RSF).

1.2 METALLURGICAL DEVELOPMENT

Initial bench-scale testwork indicated 50 – 60% nickel extractions from Pomalaa low-grade saprolite sample utilising the SALT process leach while restricting the total iron extraction to near 10% for an acid addition of 350 kg acid per dry tonne of ore feed.

An integrated plant testwork program is recommended to obtain plant parameters required to design a full SALT plant. The testwork program should include ore preparation, settling tests of both milled ore and leached residue, mixed hydroxide precipitation and tails neutralisation.

1.3 CONCEPTUAL ENGINEERING

The conceptual engineering of the SALT plant is based on a process mass balance which has been developed from process design criteria and the overall process diagram (Figure 1.2). A plant availability of 70% (6 132 hours/year) has been applied for the Ore Preparation circuit and 93% (8 163 hours/year) for the rest of the plant including services and utilities.

Based on projected ramp-up and an analysis of similar projects in complexity, a three-year plant ramp-up has been applied.

The key process data and assumptions are shown in Table 1.2.

Table 1.2– Key Process Data and Assumptions

Item	Value
Plant Life, years	20
Ore Throughput to SALT, million dry tpa	2.0
Ore Feed	
Ni, dry w/w%	1.33
Fe, dry w/w%	8.1
Mg, dry w/w%	17.2
SALT Extraction	
Ni, %	57.9
Fe, %	10
Mg, %	46.5
SALT Acid Demand, kg/t ore feed	350
MHP Product Analysis	
Ni, dry w/w%	28.2
Total S, dry w/w%	4.93
Moisture, %	55
MHP, wet tpa	117 000
Contained Ni, tpa	15 000
Overall Plant Recovery	
Ni, %	~55

1.4 PROCESS DESCRIPTION

Refer to Figure 1.2 for the overall process flow illustration.

The ore for leaching is crushed, milled and thickened to produce a high solids density saprolite ore slurry.

In the SALT circuit, concentrated sulphuric acid (98.5%) is added to leach nickel from saprolite ore at atmospheric conditions. The acid addition is restricted to a minimum with the aim to recover the maximum amount of nickel while keeping the impurities extraction low.

The leached slurry from the SALT process is neutralised with limestone to reduce the levels of free acid and impurities. This neutralised slurry is washed in a seven-stage counter-current decantation (CCD) circuit.

The wash liquor is then neutralised with magnesia and lime to precipitate the nickel as an impure Mixed Hydroxide Precipitate (MHP). The MHP is filtered, washed and treated with soda ash solution to reduce impurities prior to being sent to the ferronickel smelter.

The nickel barren solution is further neutralised with lime to reduce the manganese content to a suitable level for ocean outfall. This stream is mixed with the washed residue slurry and sent to the residue storage facility.

The modular residue storage facility is developed in stages and includes provision for decant liquor return to the plant and to ocean outfall for disposal.

Although the proposed site is within the complex of an existing ferronickel smelter, the SALT plant also requires some specific infrastructure and the upgrade of existing infrastructure to support the overall plant operation. These are identified as follows:

- Temporary construction facilities to accommodate the construction workforce.
- Site works for the process plant and other facilities.
- Berth and ship unloading facilities upgrade at the port for reagents such as limestone, MgO and coal.
- Process plant roads, haul roads, and upgrade of the existing roads.
- Utilities and services including water supply (630 m^3/h), power supply (11.3 MW), waste treatment and disposal.
- Site and process buildings.
- Plant loading and unloading facilities for limestone, coal and ore stockpiles.
- Communication facilities to provide telecommunications and computer data.
- Residue Storage Facility to contain the treated plant residue.
- Mobile equipment

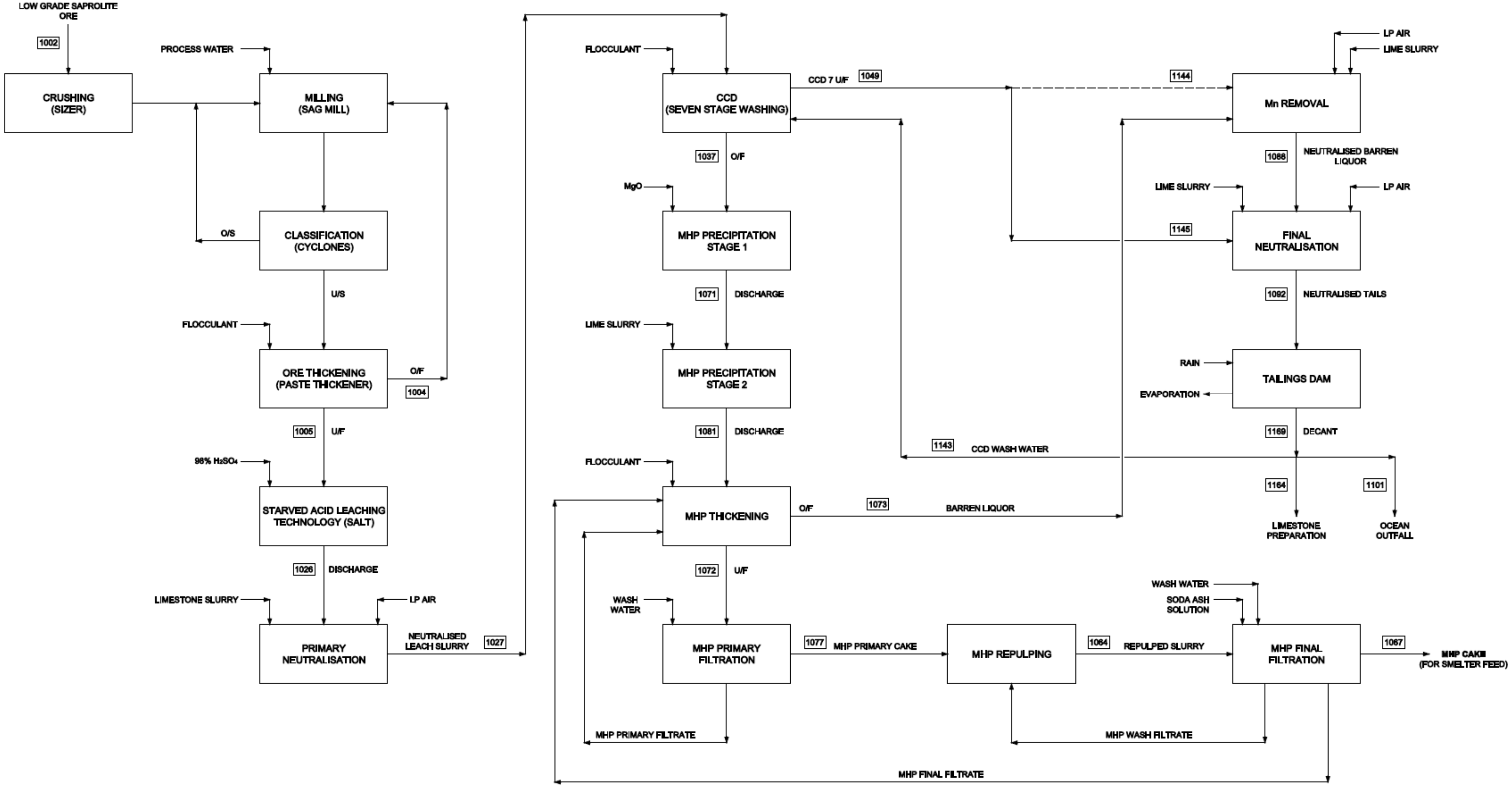

Figure 1.2 – SALT Process Plant Block Flow Diagram

1.5 CAPITAL COST ESTIMATE

The conceptual capital cost estimate for the project has been prepared in accordance with SNC-Lavalin estimating guidelines for a Class 5 estimate (order of magnitude estimate). The capital cost estimate has a +40% / -30% accuracy.

The capital cost estimate is developed using the factored estimating technique. The summary of the SALT plant capital cost is presented in Table 1.3 in January 2014 United States dollar (US$) values.

Table 1.3 – Capital Cost Summary

Area Description	Cost, US$
Ore Preparation	20,400,000
Starved Acid Leach Technology (SALT)	5,740,000
Primary Neutralisation (PN)	1,810,000
Counter Current Decantation (CCD)	20,000,000
Mixed Hydroxide Precipitation (MHP)	9,470,000
Tailings Neutralisation – Manganese Removal	1,260,000
Final Neutralisation	14,600,000
Tailings Disposal	7,260,000
Sulphuric Acid Storage and Supply	4,890,000
Other Reagents Preparation and Distribution	4,420,000
Lime Calcining and Slaking Plant	49,710,000
Water and Air Supply and Distribution	14,750,000
Piperacks	1,750,000
Residue Storage Facility (Phase 1)	28,580,000
Mobile Equipment	7,510,000
TOTAL DIRECT COST	**192,100,000**
EPCM	48,250,000
Other Indirects	2,980,000
Contingency	38,600,000
TOTAL INDIRECT COST	**89,830,000**
TOTAL PROJECT COST	**282,000,000**

1.5.1 Scope of the Capital Estimate

The scope of the current SALT Project direct costs estimate includes the direct cost for the process plant and supporting services, utilities and RSF cells.

The indirect cost includes EPCM, capital and commissioning spares, vendor representatives and contingency.

1.5.2 Basis of the Capital Estimate

Process plant estimates are developed from process plant equipment of similar sized nickel projects, and adjusted for flow or equipment capacity and currency movements. Bulk material costs have been factored based on the ex-works cost of mechanical equipment by facility. The capital costs relate to a project based in Indonesia.

The cost for RSF is developed from preliminary material take off estimates, with costs based on a nickel project in Northern Philippines, where a similar RSF model is quoted.

The indirect costs were prepared on the basis of a project management team being retained to perform the services of engineering, procurement of major equipment and management of construction. This is estimated as 25% of the project direct cost.

A contingency of 20% has been applied to direct costs. The contingency reflects the state of development of the project, and allows a margin for changes to the process and equipment selection and sizing where specific design criteria are not yet available.

1.5.3 Exclusions

A number of costs had been excluded from the capital cost estimate for the current conceptual study as follows:

- Owner's costs;
- Mining and ore delivery related capital costs ;
- Technology fees, permits and licenses;
- Off-site infrastructure (except RSF);
- Existing port upgrade.

1.6 OPERATING COST ESTIMATE

The project operating cost has been developed for 20 years of plant operation based on the projected ramp-up. Year 3 is considered to represent the full nameplate production. The operating cost estimate has a +40% / -30% accuracy.

Table 1.4 presents the summary of the project operating cost at Year 3 onwards in January 2014 US dollar (US$) values.

Table 1.4 – Operating Cost Summary (Year 3+)

Items	Cost, US$	US$/lb Ni
	Year 3+	Year 3+
Reagents and Consumables		
Sulphuric Acid, 98.5%	58,800,000	1.80
MgO	10,300,000	0.31
Limestone	6,950,000	0.21
Sub-bituminous Coal	4,850,000	0.15
Other Plant Reagents	2,320,000	0.07
Process Plant Consumables	2,720,000	0.08
Power Consumption	8,150,000	0.25
Utilities and Services Reagents & Consumables	1,300,000	0.04
Labour	4,240,000	0.13
General Expenses	5,000,000	0.15
Maintenance Materials	3,740,000	0.11
Contract Services	3,770,000	0.12
RSF Sustaining Capital	6,530,000	0.20
PROJECT OPERATING COST	**119,000,000**	**3.62**

1.6.1 Basis of the Operating Cost Estimate

The operating cost estimates are based on the process design criteria, flowsheet and mass balance.

Key inputs to operating cost are as follows:

- Manning levels are evaluated for each project area according to similar plant operation. Labour rates at different salary levels, including on-costs, are sourced from a database of Indonesian projects.
- Reagent and consumables quantities are based on the process mass balances and unit pricing is sourced from either budget pricing or from data for recent projects.
- The costs of maintenance consumables, which are replacement parts necessary to maintain equipment, are estimated using historical ratios for similar scale plants based on the installed equipment costs
- Contract expenses were estimated for a range of services provided to the project on a contract basis, including:, contract maintenance, periodic metallurgical testing and consultants fees in areas such as safety and training

- Administration and general expenses are estimated for a range of miscellaneous expenses associated with providing services to the project, including: safety equipment and training, medical costs, community relations, environmental costs, human relations costs, telecommunications costs, and business travel.
- The RSF sustaining capital of the project is the deferred cost of progressively building and decommissioning RSF cells 2-5 necessary to store the plant residue. The cost also includes the decommissioning of Phase 1. The total cost is annualised from Year 3 through to the life of the plant at Year 20.

No contingency has been applied to the operating cost estimate as it is assumed that inputs to the operating costs have been comprehensively covered.

1.6.2 Exclusions

The exclusions to the operating cost are:

- Mining and ore delivery;
- Replacement cost (e.g. mobile equipment);
- Some government charges;
- Royalties
- Marketing costs;
- Duties, customs and other imposts.

1.7 TECHNICAL DISCUSSION

1.7.1 Technical Drivers

The following are key technical drivers that have been identified for the success of the SALT Project.

- *Acid Consumption* – at 350 kg/t demand, it contributes to about 50% of the operating cost and is consumed by the MgO uptake. The current evaluation is based on 13-20% Mg content in the ore, but will require further testwork to evaluate the capacity of SALT to treat different ore profiles.
- *Solids Settling Properties* – Good settling properties produce higher U/F solids in thickeners, which is required to optimise the downstream processing equipment. Lower solids concentration and poor settling conditions will result in bigger ore and CCD thickener requirements and larger RSF surface area, which increases the capital cost.
- *Nickel Recovery* – Higher nickel recovery would mean lower ore throughput, smaller plant equipment and thus lower capital cost.
- *Ocean Outfall Limits* - The manganese concentration limitation on outfall composition drives the lime usage, requiring significant additional capital and/or operating costs.

1.7.2 Risk and Opportunities

- *Product Quality* – Several ferronickel plants which trialled MHP feed highlighted the following product quality issues as:
    - Sulphur content is recommended to be limited to <1% as it adds to the total SO_x emission of the plant.
    - Low nickel and high impurity content will potentially displace high grade saprolite feed.
    - There is no cobalt credit gained from MHP as it is an impurity in ferronickel.
- *Project Scale* – Bigger scale favours a more economical project due to the high cost of off-site infrastructure requirement such as RSF and port.
- *Project Location and RSF Area* –Previous studies on Pomalaa had highlighted the limited availability of area for large surface area RSF cells. Project location should be within the proximity of the port, RSF and existing infrastructure to minimise cost and logistics.
- *Size and Location of Resources* – Due to lack of information, it is assumed that there is sufficient resource to feed the SALT plant for 20 years.
- *Ore Beneficiation* – Rejecting larger size fractions to increase the ore feed grade and thus reduce downstream equipment size.
- *Mn Limits on Ocean Outfall* – Determining the likely environmental constraints to provide possibly a lower lime requirement reducing the capital and/or operating costs.
- *Alternative Liquor Disposal* – Examine alternative to ocean outfall to improve the water balance and lime requirement of the tailings neutralisation.
- *High Mg Leaching* – An option to reduce the amount of liquor to be disposed of by recycling it to ore preparation, while also possibly providing leach advantages.
- *Sulphuric Acid* – The volatility of sulphuric acid price and unstable long term supply will expose the project to a significant commercial risk. Opportunities are identified in the current study to mitigate this risk:
    - *Locally sourced sulphuric acid* – securing a long term contract with locally sourced sulphuric acid from major operating and/or emerging copper concentrators in the country.
    - *Acid pipeline from the port* – acid transport via overland piping to minimise the cost of acid transport and risk of handling.
    - *Acid plant installation* – consideration to install a Chinese acid plant (with integrated power and demineralised water plant) utilising Western technology license. Cost reductions of up to 50% have been quoted and the waste heat can be converted to supply the power for the plant.
- *Limestone* – The cost of limestone represents around 6% of the overall project cost which is based on crushed imported supply. Locally sourced limestone within the area can potentially reduced the overall cost.

- *MgO*– The cost of magnesia represents around 9% of the overall project cost which is based on the highest reactive product. Potentially cheaper and lower chemical grade MgO sources should be tested to determine if operating cost reductions are possible.
- *Power supply* – Power contributes to about 7% of the project operating cost based on national grid supply. The lack of major power grid infrastructures in Sulawesi Island and current national power crisis can prove risky for the project. The following options are suggested to address this issue:
  - Enter a negotiation to purchase power from PT Antam which has an existing 102 MW and is currently constructing 2 x 30 MW coal-fired power plants in Pomalaa.
  - Power to be provided from the sulphuric acid plant waste heat conversion. Preliminary calculations estimated a surplus of 13 MW (net of the steam and power required for the process plant and sulphuric acid/power plant), which can be sold to the grid and potentially improve the project operating costs.
- *Opportunities for Cost Reductions* – such as optimisation of CCD washing stages and use of cheaper type of kiln and slaker for the lime plant.
- *Port Upgrade* – a major infrastructure requirement of the project. Bathymetric data and a berthing schedule are required in order to evaluate the extent of port upgrade cost.

1.7.3 Recommendations

The preliminary engineering evaluation of SALT suggests that the technology has the potential to process low-grade saprolite ore. The overall operation incorporates simple and proven atmospheric leaching and precipitation processes. This will enable the plant to have fast ramp-up and achieve high availabilities.

The order of magnitude project costs of $282 million capital cost and $3.60 /lb nickel produced indicate that the SALT process has potential to be economically attractive in comparison to other nickel laterite processes such as PAL and AL.

Numerous risks and opportunities were identified that should be pursued in future work to mitigate risk and maximise returns. These were summarised into seven major recommendations;

1. Testing of the integrated plant and investigation of the flowsheet modification opportunities.
2. Trade-off study for sulphuric acid and power sources for optimum project costing.
3. Locating and testing lower cost limestone sources.
4. Locating and testing lower cost MgO sources.
5. Determination of ore resource available.

6. Full assessment of the infrastructure required for the project for a complete assessment of the capital cost.

7. Assessment of environmental and community requirements.