APS1013 Applying Innovation in Engineering – Final Team Projects, Fall 2010

An Investigation into Reducing the Energy Costs for a New-Build 200MW Nickel Smelter in Halmahera, Indonesia

The Approach & Scope

The purpose of this study is to determine a plan to provide reduced energy costs and increased efficiency to a new-build 200MW Electric-Arc furnace nickel smelting plant, which is located in Halmahera, Indonesia.

Executive Summary

The study starts by identifying the geographical location of the plant, and the environmental conditions that are apparent. This is achieved though a site analysis and survey through research in the hope to determine the natural resources available. It is found that:

1. the region is largely unpopulated (will relatively undeveloped infrastructure)
2. it has abundant geothermal resources and the topography of the island is very mountainous (with many river sources with high vertical gradient)
3. there are docks on the island in very close proximity to the mines providing import/export infrastructure
4. the Indonesian government offers incentives for sustainable development of energy production systems (such as geothermal plants), and
5. the coral reefs and tropical wildlife are closely followed and protected by various internationally renowned wildlife protection groups, making any disruption of natural habitats or ecosystems a very sensitive domain

With a clear picture of the environmental, sociological and political conditions, a map of the process is formulated, and a strategic plan was established for any areas of the life-cycle that can be improved. From the study it was determined that the concentration areas of strategic innovation are the following:

1. **Power Generation/Supply:** The techno-economical and performance aspects of the power generation system as the primary input to the smelting process; including all power plants, transmission lines, substations and infrastructural requirements.
2. **Process Innovation:** The smelting process itself, and the utilization of output materials; with the aspiration to create as much of a closed-loop lifecycle as possible and increase the efficiency of both the power usage and product development.

In the study of the most adequate power generation/supply system, fourteen of the most prominent energy supply systems were analyzed – including an assessment of the possibility of drawing power from the grid and/or a third party supplier – to check the feasibility based on criteria relevant to the scope such as cost, environmental impacts, life cycle and efficiency.

Through a process of elimination (using media such as matrixes and root cause analyses), the feasible options were narrowed down to the four highest ranking supply methods based on the criteria. At this stage drawing from the grid (or third party supplier) was also eliminated due to cost, infrastructure and supply restrictions. The final options for further analysis where: Geothermal Power, Hydroelectric Power, Gas Power, and Coal Power.

In the feasibility studies, the power systems and smelting process where first analyzed for the generic feasibility of integration to a project of such nature. Following this, each system was subject to a thorough root cause analysis for the fabricated scenario that the “energy cost is too much” (e.g. for geothermal; the analysis was based on: “Geothermal Power Costs Too Much”). It must be noted that in the analysis, the cost is not confined strictly to financial cost, but it is considered as any cost that may be incurred – such as environmental, social, financial, or efficiency. Based on the above data gathering, scrutiny of the systems and root cause analyses, a recommended (optimized for low cost and high performance) system was formulated. The recommendations are as follows:

Power Generation Methods

1. **Coal / Natural Gas Plant:** Combined Cycle; Brayton cycle gas turbine generator; Rankine cycle steam turbine generator; controlled extraction operation of the steam turbine
2. **Hydroelectric Dam:**2 x 25MW Generator **-** High Head Small Hydro Dam; Pumped storage system; Powerhouse Located Downstream
3. **Geothermal:** Double Flash System; Magma Reservoir System; Vapour Dominated System

Process Innovation

4. **Back Up Power:** 2MW Diesel Back Up Power Generator
5. **Smelter:** AC powered Electric Arc Furnace; SPLC Technology; Cooling Coils; Rotary Kiln; Heat Recovery System
6. **Nickel Slag Output:** Use for infrastructure development - granular base on local roads; Sale to distribution companies ($1 per kg) – to be used for blast cleaning etc.

Finally, with the optimum systems for each scenario developed, a final analysis was undertaken comparing the performance of the power generation methods. This analysis compared the final four methods with respect to 10 criteria – each weighted with their significance towards the scope. The criteria were as follows:

- Capital Cost
- Operations and Maintenance (O&M) Cost
- Total Levelized Cost
- Pre- Commissioning Time
- Project Life Duration
- Energy Efficiency
- Capacity Factor
- Emissions
- Land/Environmental Destruction
- Is the energy renewable?

The scores were based out of 5, whereby the higher the score, the better the performance (within the criteria). The scores where then weighted, and the average taken with the following results:

1st: Natural gas with 3.94/5,

2nd: Coal with 3.53/5,

3rd: Hydroelectric with 2.35/5

4th: Geothermal with 1.31/5

The scores clearly showed that natural gas and coal are superior (in performance vs. cost) to hydroelectric and geothermal but the paradox is in the fact that they are significantly higher CO_2 emission producers. Geothermal falls short due to the high risk, unorthodoxy of a plant of such size, and subsequent cost ranges. The final recommendation is that a hybrid system is used, with 150MW natural gas/steam generation and 50MW hydroelectric. It was chosen to include the hydroelectric because it can provide system support for peak loads, and can take advantage of the Indonesian CO_2 incentives whilst being of a size that does not cause much disruption to landscapes. It is believed by the team that this is the most practical fail-safe, closed-loop solution to provide low cost energy to a 200MW Nickel Smelter.