TERAX® System Value-Engineering Review for India

INTRODUCTION

The Bill & Melinda Gates Foundation's (BMGF) Water, Sanitation & Hygiene program focuses on developing innovative approaches and technologies that can lead to radical and sustainable improvements in sanitation in the developing world. The Omni-Processor portion of the Sanitation Technology Cluster's Strategic Goals focuses on developing innovative solutions to service population sizes between 10,000 – 500,000 inhabitants. As part of this programme, Terax were commissioned to evaluate the technology for deployment in India. This will provide the platform to advance the project to the next stage in meeting the Sanitation Technology Cluster Strategic Goals.

The Terax® Waste Conversion system ("Terax®") is a 100,000-person serving system (to manage 2,200 US dry ton of fecal sludge) that was developed in Rotorua, New Zealand, by Terax Limited Partnership (Terax). The Terax® system represents a potential viable technology that is already market ready but requires a detailed analysis to determine suitability for developing world markets and vulnerable regions requiring access to improved fecal sludge management options. A design engineering review examining the cost of building the system entirely in India, along with any value engineering for country-specific redesign to determine its applicability for other target markets was conducted to assess suitability of the Terax® technology and future options. The main aim of the exercise was to reduce cost for technology deployment in developing markets such as India.

The Terax® technology will alleviate the fecal sludge management issue in India through the implementation of a proprietary hydrothermal deconstruction process which breaks down the physical structure of the sludge and generates useable by-products. The technology comprises a unique combination of anaerobic fermentation and subcritical wet oxidation processes.

The Terax® process can be easily integrated into existing WWTP processes. It virtually eliminates biosolids transport offsite and the associated disposal costs, making it more cost effective than many other existing sludge treatment processes. Significant reductions in disposal costs are achieved through >90% solids reduction and by offering value added process outputs which improve overall economic efficiency for the Waste Water Treatment Plant:

- Fertiliser manufacture from recovered nitrogen and phosphorus side streams;
- Re-use of Carbon in the Waste Water Treatment Plant or energy generation as heat, methane or electricity by using the Terax® liquor depending on specific cost-benefit analysis of best use.

SCOPE OF WORK

The current plant design and cost model have been developed for a plant build in New Zealand. The treatment requirement, local regulations and procurement & construction costs for a plant installation in India will be considerably lower, leading to a better business case for implementing the Terax® technology. Using a local engineering firm that understands and has considerable experience in the Indian market will further increase the likelihood of success. As such, L&T Technology Services Ltd. (LTTS) were commissioned to lead the value-engineering exercise focusing on the technology deployment in India. In conjunction with this work stream, WorleyParsons New Zealand (WPNZ) were commissioned to evaluate more cost-effective process configurations. WPNZ have been involved with the development of the Terax® technology since the pilot phase. The scope of the project is summarised overleaf.

1. Review and re-engineer the existing Terax® Waste Conversion plant and process design as needed to service the Indian market. This plant specifications were reviewed and modified to meet local standards and regulations.

2. The scope further included evaluation of the capital cost for deploying the technology using local procurement and construction channels.

This report outlines the outcomes of the targeted 'value-engineering' exercise conducted by L&T Technology Services Ltd. (LTTS) to reduce the cost of build through local procurement and by WPNZ via process reconfiguration. The grant award for these value engineering scopes of work were US $55,000 for the capital costs study and US19,000 for the process reconfiguration study respectively.

PROJECT EXECUTION APPROACH AND METHODOLOGY

The approach taken by LTTS for executing the value engineering exercise for the Indian market was as follows:

- To study, review and understand all the design inputs documents / drawings provided by Terax.
- Identifying the differences in design & application of engineering standards, key consideration & assumptions for project implementation in Indian scenario/geographical conditions as compared with the existing set up in New Zealand.
- Recommending feasible value-added proposition in the existing design scheme with respect to Indian perspective standards & guidelines.
- Developing the tender documents and Bills of Quantities for arriving at the cost estimate.
- Carrying out the technical bid analysis of vendor quotations
- Delivering the final CAPEX Report with cost break up

WPNZ focused on establishing whether the current Terax® process configuration could be improved or modified to reduce the capital and operational costs for deployment in India. This involved modelling and quantifying the process inputs and outputs for a case where only wet oxidation is used for sludge management. The intent for this exercise was to establish the viability of this configuration and to assess the impact on capital and operational costs.

KEY FINDINGS

Capital Cost

This value engineering exercise yielded an average cost down of between 45% and 56% of the capital cost for the Terax® plant when redesigned for local regulations, procured, built and installed using local channels when compared to the capital cost for a plant build in New Zealand.

LTTS were unable to source some equipment items in the Indian market that had proprietary design or manufacturing requirements that were unable to be met in India. For these items, LTTS used costing provided by Terax and applied a cost down% based on fabricating some components in the local market and a factor for reduced installation cost in India.

Summary of capital cost down findings:

- LTTS received approximately 75% of the equipment cost estimates sourced in India.
- These costs indicate an average of 56% cost down ranging between 35% to 85% is achievable in India when compared to the New Zealand plant build costs.

Assuming the same cost down % can be realized for equipment that was unable to be sourced in India by LTTS provides the following capital cost estimate.

Costs in Millions	US $7.74		
NZ Capital Cost	% Cost Down in India		Indian Capex
Confirmed Indian Equipment Price	US $5.99	56%	US $2.6
Estimated using NZ costs	US $1.75	56%	US $0.8
Total	**US $7.74**	**56%**	**US $3.4**

In the worst case, conservatively allowing a cost down of 10% for equipment that was unable to be sourced in India, provides an estimated total cost down for a plant build in India to 45% and at a total cost of US$4.2m as summarized in the table below.

Costs in $NZ Millions	US $7.74		
NZ Capital Cost	% Cost Down in India		Indian Capex
Confirmed Indian Equipment Price	US $5.99	56%	US $2.6
Estimated using NZ costs	US $1.75	10%	US $1.6
Total	**US $7.74**	**45%**	**US $4.2**

Based upon the work done to date we believe the Capital Cost in India will range between US$3.4 and US$4.2m. This represents a cost down range of 45% to 56% through the value engineering exercise conducted by LTTS.

Another area of cost down was realized through utilizing alternative materials of construction for large tanks, valves and pumps.

No other value engineering opportunities were identified by LTTS.

Indirect costs were established using industry norms that LTTS had established through their experience in executing similar scale projects in India. As a % of direct costs, these were as follows:

- Third party inspection charges 2%
- Detailed site engineering 15%
- Construction management 10%
- Commissioning & Training 7%
- Commissioning spares 1%
- Project management 3%

Process Value Engineering

The Terax® waste conversion process produces Volatile Fatty Acids ("VFA" - Terax® Liquor) that can be used in the Waste Water Treatment Plant as a Carbon supplement to help treat Nitrogen and Phosphorus in Enhanced Biological Treatment Processes. The use of supplemental Carbon has been on the rise recently with stricter effluent discharge regulations coming into effect. This is the best use for the Terax® liquor as it not only has an economic benefit to the Waste Water Treatment Plant but also offsets other fossil-fuel derived Carbon sources such as ethanol and methanol that are currently being used. Alternatively, this VFA-rich stream could be used in an anaerobic digestor (if available) to create higher value biogas for electricity generation.

Other up and coming, innovative uses of VFA include production of Polyhydroxyalkanoates (PHAs). Due to its biodegradability and potential to create bioplastics with novel properties, much interest exists to develop the use of PHA-based materials. PHA fits into the green economy as a means to create biodegradable plastics from non-fossil fuel sources. This research will ultimately place a much higher value on VFA production.

The anaerobic fermenter utilized in the Terax® process improves the overall VFA yield of the sludge deconstruction process. In instances where there is no value attributed to producing VFA for use either back in the treatment process or to produce biogas, this value-engineering work concluded that wet oxidation alone would be the more cost-effective option. In this process configuration where the fermentation step is not used, the capital cost would be reduced further by 10%.

ASSUMPTIONS and QUALIFICATIONS

1. Currency conversion factor used 1 Indian Rupee = 0.013 USD
2. All prices are as received from vendors & not negotiated
3. Engineering best practice values were for estimating the indirect costs
4. The Basis of Deign was kept identical to that of the plant designed for the New Zealand
5. Freight is considered at 2% on the basic supply cost
6. Insurance is considered at 0.5% on the basic supply cost

INDICATIVE BUSINESS CASE

Below are the summary results for an indicative business case for a plant operating in India. This analysis uses the updated conservative capex of US $4.2M for Terax® in India, as developed by LTTS and using the financial model developed for deploying the plant in New Zealand.

Financial Model Inputs

Sludge Volume	10,000 wet tonnes per annum (@ 20% dry solids)
Sludge treatment charge	US $105 per wet tonne; this is made up of
Avoided sludge disposal cost	US $75 per wet tonne,
Avoided dewatering cost	US $10 per wet tonne,
Offset supplemental Carbon	US $10 per wet tonne,
Offset other chemicals and electricity	US $10 per wet tonne.

Chemical costs	
Lime	US $200 / tonne
Polymer	US $6,200 / tonne
Sulphuric acid	US $170 / tonne
Power cost	US $0.07 / kWh
Maintenance and Supervision	5% of capital cost
Discount rate	3.4%
Cost and price escalation	1.0%
Annual sludge volume escalation	0.7%
Annual Operating Cost	US $440,000
Maintainable capex allowance	US $200,000/yr
Internal Rate of Return	**13.8%**

The above analysis utilities cost rates as determined for the plant operating in New Zealand. LTTS were unable to provide an expected cost down for these costs citing the potential for large variances across the country. Although considering most commodity prices are reasonably comparable worldwide, Terax have conservatively used the New Zealand costs to provide a view of the operating cost for a plant in India. Thus, any savings achieved through reduced utilities costs will positively impact the estimated IRR making for a more attractive business case. Another key aspect that impacts this analysis is the sludge disposal cost. Even small variances in this value will have a significant impact on the overall business case and IRR.

This high-level analysis provides a strong case for further evaluation of deploying Terax® in India. As higher value uses of VFA are identified from ongoing research, the business case will improve further.

Recommendations

Given the significant reduction in capital cost realized through this exercise, Terax recommend that the next stage should involve identification of a suitable Waste Water Treatment Plant in India to complete a full business case analysis of capital and operating costs. Ideally the selected plant would have the following attributes:

- Relatively high sludge disposal costs or a difficult sludge disposal route
- Discharging into an inland lake or river and thus have a strict limit on Nitrogen and/or Phosphorous concentrations
- Implementing a Biological Nutrient Removal process that requires supplemental Carbon dosing to meet discharge consent limits

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