4. DATA ANALYSIS

According to the questionnaire survey, and based on the interviews carried out as described in Chapter 3, the data analysis was carried out quantitatively in this chapter. The entire data analysis of the assessment of the technological capabilities and assessment of the technology components are given in the Appendix – 4.

In this Chapter, based on the objectives, all five important capabilities were assessed, firstly, to verify the transferor's status, transferee's adaptability and technology components. Thereafter, the transferred technologies were evaluated and checked for suitability with respect to purpose. Finally the barriers and problems were discussed to identify the possibilities for recommendations in order to eliminate the problems in a systematic manner.

4.1 Analysis Using RII Method

Assessment of Effectiveness of Technology Transfer Process

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$$RII = \frac{\Sigma (W\ n)}{A \times N} \times 100\ \%$$

Where,

W = Constant expressing the weighting given to each response.

A = Highest weighting

n = Frequency of responses

N = Total number in the responses

Based on the ranks obtained from the analysis, the capabilities were categorized as advanced level, medium level or low level. These levels were agreed upon after having the panel discussion with the expert team at the value engineering work shop.

Low Level (RII < 50%)

Medium Level (50% < RII < 70%)

High Level (RII > 70%)

4.2 Evaluating the effectiveness of Technology Transfer Process

From the questionnaire titled "Measuring the effectiveness of Technology Transfer Process" the data of participants are collected to ascertain the Technology Transfer Process Effectiveness based on the different aspects. A number of questions which were identified and grouped with past studies and Likert scale have been given to each question, where the respondents were asked to write down their score by considering their overall experiences. With expert's knowledge, questions for each capability have been grouped together in a manner where each capability can be determined by obtaining an average rank from the group of questions. The summary of the questions and the types are given below in Tables 4.1, 4.2 and 4.3. Detailed calculation is attached in the Appendix - 4.

4.2.1 Assessment of Technological Capabilities

Relative Importance Index method is used in this study in order to conduct analysis on the survey results for capabilities. It is a weighted average method in which the average rank for each question is calculated and then the rank for each capability is derived from the average of the ranks of the questions grouped under that capability. Technological capability of USL has been assessed based on the questions in the questionnaire Part B – Section 1, according to the quantitative analysis completed as described above. The results are summarized in Table 4.1. Details of the analysis are given in Appendix -2.

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Calculation :

Technology Capability

Converting/Transforming Capability

$$\text{Q1.RII} = \frac{131 * 100\%}{5 * 35} = 74.86\%$$

$$\text{Q2. RII} = \frac{128 * 100\%}{5 * 35} = 73.14\%$$

$$\text{Q3. RII} = \frac{126 * 100\%}{5 * 35} = 72.00\%$$

$$\text{Q4. RII} = \frac{105 * 100\%}{5 * 35} = 60.00\%$$

$$Q5.\ RII = \frac{122 * 100\%}{5 * 35} = 69.71$$

$$\text{Section Relative Important Index} = \frac{74.86+73.14+72.00+60.00+69.71}{5} = 69.94\%$$

Table.4.1: RII and Mean Values for Technology Capabilities

Technology Capability	RII Value Obtained	Mean Value	Rank of Satisfaction
Converting / Transforming	69.94%	3.498	Medium (50%<RII<70%)
Acquiring (sourcing & producing)	70.86%	3.542	High (RII>70%)
Vending	81.26%	4.062	High (RII>70%)
Modifying	71.09%	3.554	High (RII>70%)
Generating / Innovating	68.11%	3.406	Medium (50%<RII<70%)

The above technology capability assessment score sheet is graphically presented in Figure 4.1.a. This graph shows the Relative Importance Index as a percentage and the same results are further analyzed by comparing with the expected levels of capabilities using the radar diagram which is displayed in Figure 4.1.b.

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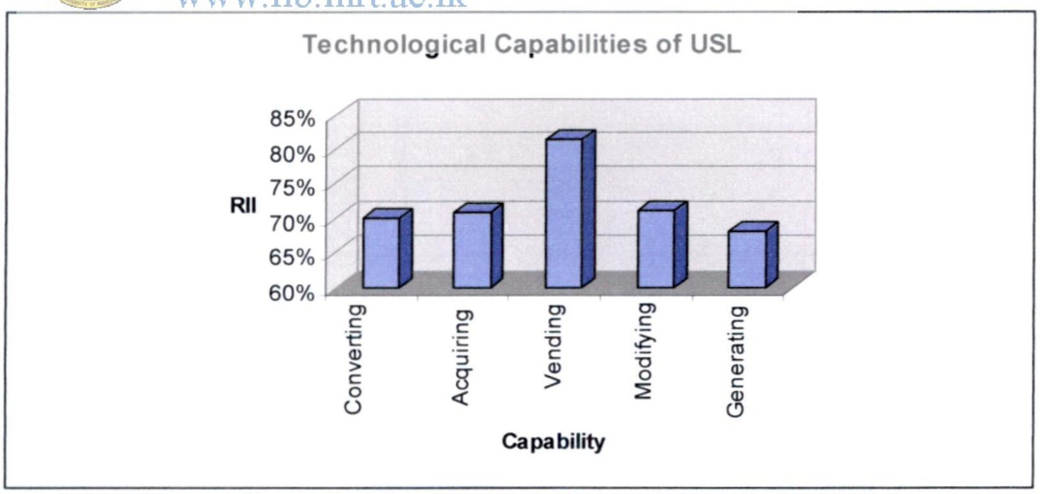

Figure 4.1.a: RII Bar Chart of Existing Capabilities in USL

Based on the research findings Vending capability is at higher level compared to other capabilities. Converting/Transforming and Generating/Innovating capabilities are not in a position which USL cannot be proud of it.

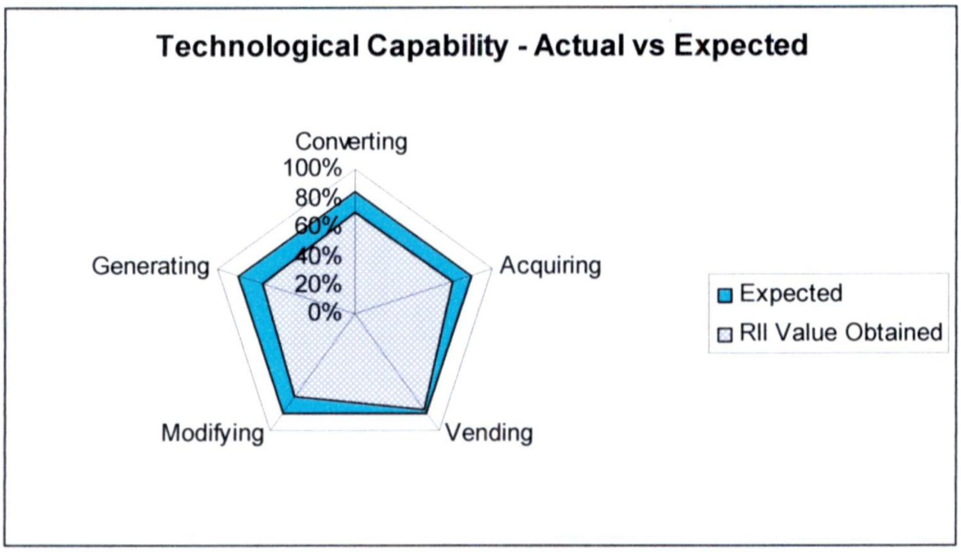

Figure 4.1.b: Radar Diagram of Actual and Expected Level of Capabilities

The most important finding on comparison between the RII value obtained and the RII expected value, is that USL has a clear gap between the expected and the actual results in each and every capability except Vending capability.

4.2.2 Assessment of Technology Components

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The technology components in USL have been methodologically assessed in Part B – Section 2 of questionnaire. The technology components in USL for both process technology and product technology have been analyzed. According to the quantitative analysis completed, as described above, the results are summarized in Table 4.2.

Table 4.2: RII and Mean Values for Technology Components

Technology Component	Value Obtained	Mean Value	Rank of Satisfaction
Technoware	72.57%	3.628	High (RII>70%)
Humanware	69.03%	3.452	Medium (50%<RII<70%)
Orgaware	69.71%	3.486	Medium (50%<RII<70%)
Infoware	70.29%	3.514	High (RII>70%)

The above technology component assessment score sheet is graphically presented in Figure 4.2.a. This graph shows the Relative Importance Index as a percentage and the same results are further analyzed by comparison with expected levels of capabilities using the radar diagram which is displayed in Figure 4.2.b.

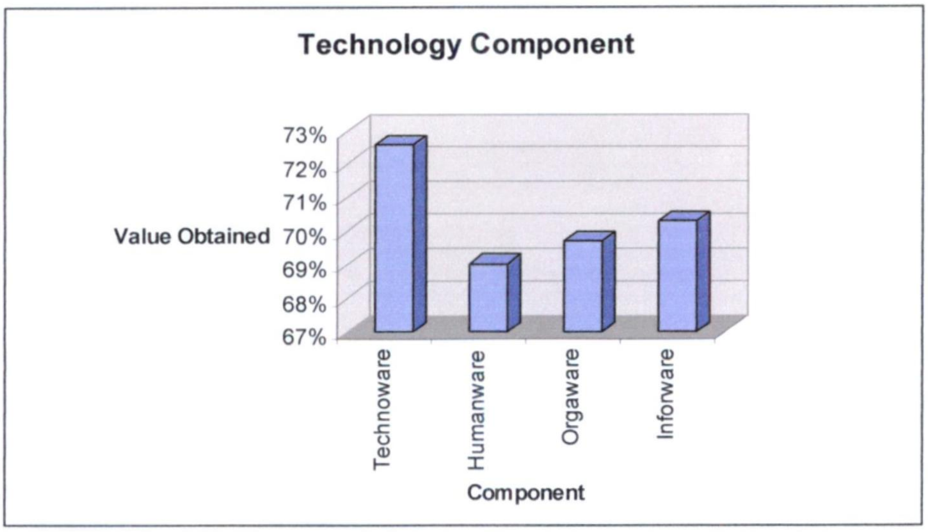

Figure 4.2.a: Level of Technology Components

Based on the research findings, the Technoware component is at a higher level compared to the other components. Humanware component in USL scored the lowest marks in this research.

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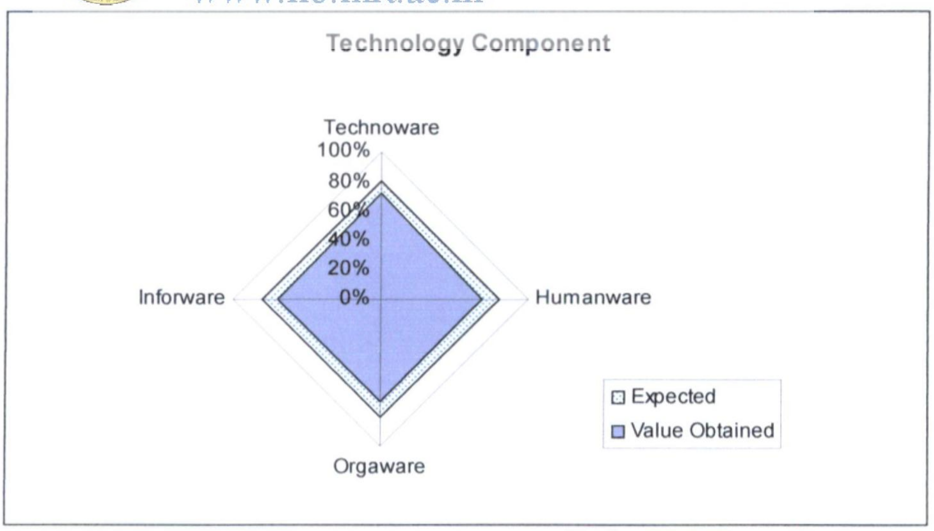

Figure 4.2.b: Radar Diagram of Actual and Expected Level of Technology Components

The most important finding in this comparison between the RII value obtained and the RII expected value, is that USL has a clear gap between the expected and the actual results in each and every component.

4.2.3 Assessment of Enabling Environment for Technology Transfer

The enabling environment for technology transfer in USL has been methodologically assessed based on the questionnaire Part B – Section 3. Transferee, Transferor, Greater Environment and the Barriers have been analyzed. According to the quantitative analysis completed, as described above, the results are summarized in Table 4.3.

Table.4.3: RII and Mean Values for Enabling Environment for Technology Transfer

Technology Transfer	Value Obtained	Mean Value	Rank of Satisfaction
Transferee	69.14%	3.457	Medium (50%<RII<70%)
Transferor	70.57%	3.529	High (RII>70%)
Greater	67.43%	3.372	Medium (50%<RII<70%)
Barriers	69.13%	3.466	Medium (50%<RII<70%)

The above enabling environment assessment score sheet is graphically presented in Figure 4.3.a which shows the Relative Importance Index as a percentage and the same results are further analyzed by comparing with the expected levels of capabilities using the radar diagram which is displayed in Figure 4.3.b.

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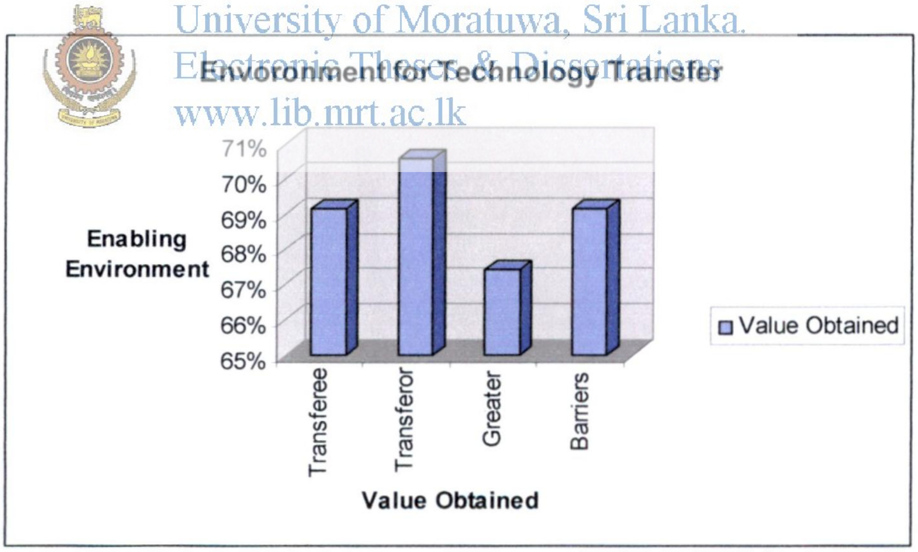

Figure 4.3.a: Enabling Environment for Technology Transfer

Based on the research findings, it clearly shows that transferor environment is at a higher level compared to the other components. Greater environment has the lowest marks based on the research findings.

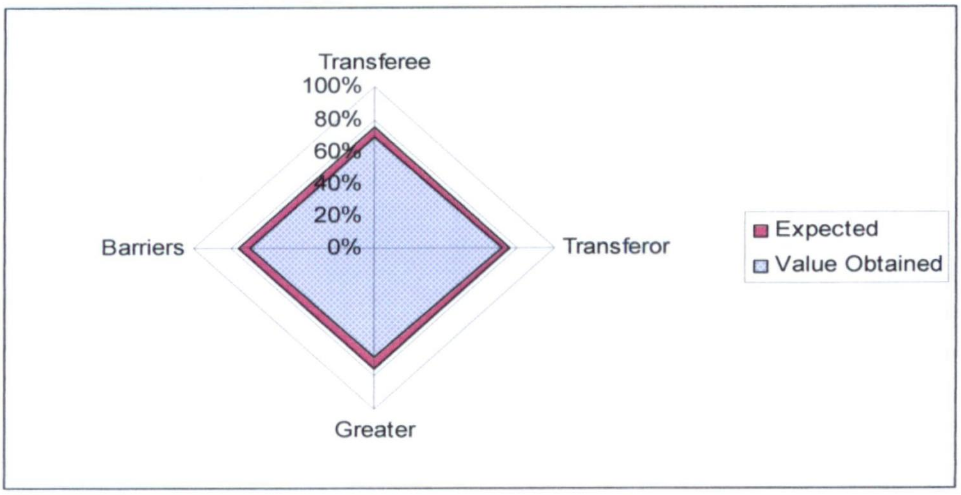

Figure 4.3.b: Radar Diagram of Actual and Expected Level of Enabling Environment for Technology Transfer

Similar to the previous analysis the most important finding on comparison between the RII value obtained and the RII expected value, is that USL has a clear gap between the expected and the actual results in each and every components similar to the previous analysis.

4.3 Assessing the Biomass Boiler operation in USL

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Unilever Grandpass is a manufacturing complex with production plants for Edible Fats, Soaps and Personal Products. The total annual capacity is about 85,000 MT and is supported by a common utility facility. Steam generation is done using three packaged type furnace oil fired boilers with a total generation capacity of 24 MT/hr. Two of these are on generation and one on stand-by at any given time and the actual steam requirement is 13 MT/hr.

Considering the growing environmental concerns and observing the term of *"Adding Vitality for Life"*, USL has decided to set up a biomass boiler at Grandpass site (see Figure 4.4). The dependence on furnace oil for steam generation has had a significant adverse impact on the conversion cost, especially on Soaps and Edible Fats which have a high dependency on steam. Cost of steam accounts for 15 % of the total conversion cost of Soaps and Edible Fats. Figure 4.5, 4.6 and 4.7 illustrate the trend in global crude oil price and the Rupee devaluation against the US Dollar.

Figure 4.4: Biomass Boiler at USL

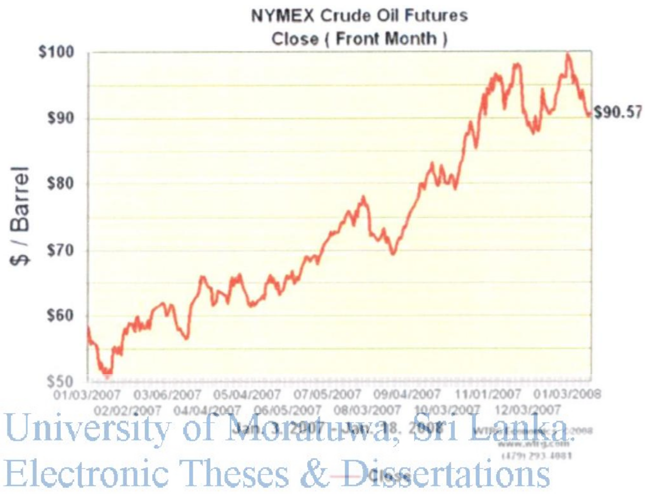

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Figure 4.5.a: Global crude oil prices (2007 January to 2008 January)
*(Source:*www.wfrg.com)

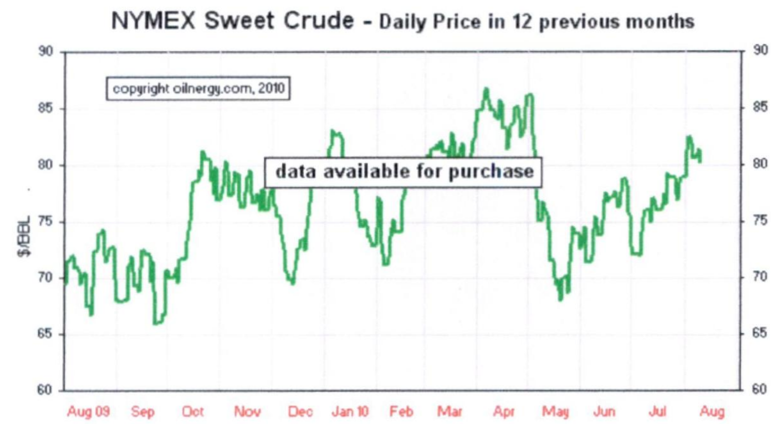

Figure 4.5.b: Global crude oil prices (2009 August to 2010 August)
*(Source:*www.wfrg.com*)*

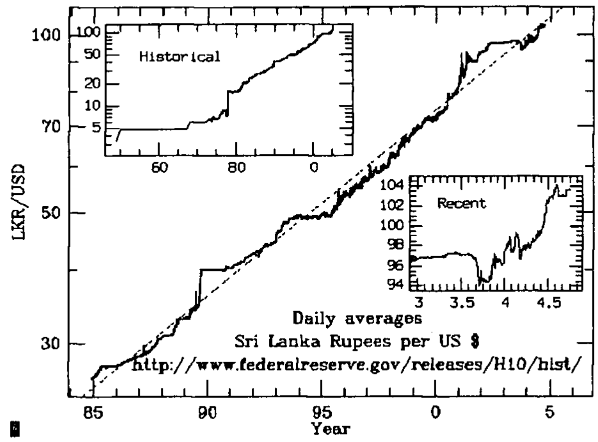

Figure 4.6: Rupee against the dollar
*(Source:*www.federalreserve.com*)*

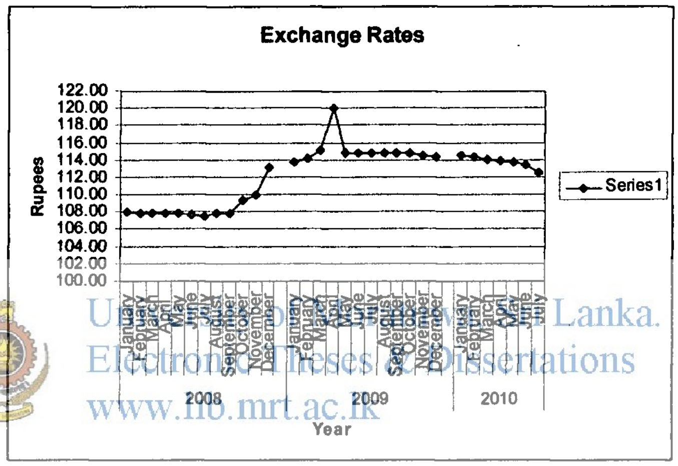

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Figure 4.7: Exchange Rate (Rupee against the dollar)
*(Source:*www.cbsl.gov.lk*)*

In steam generation furnace oil amounts to 92% of the total cost of steam produced. Over the considered two years (2006 to 2008) there has been a 135% increase in furnace oil prices owing to the rise in global crude oil prices and depreciation of the Sri Lankan rupee against the US Dollar. Figure 4.8 depicts furnace oil prices in Sri Lanka from June 2004 to 2008.

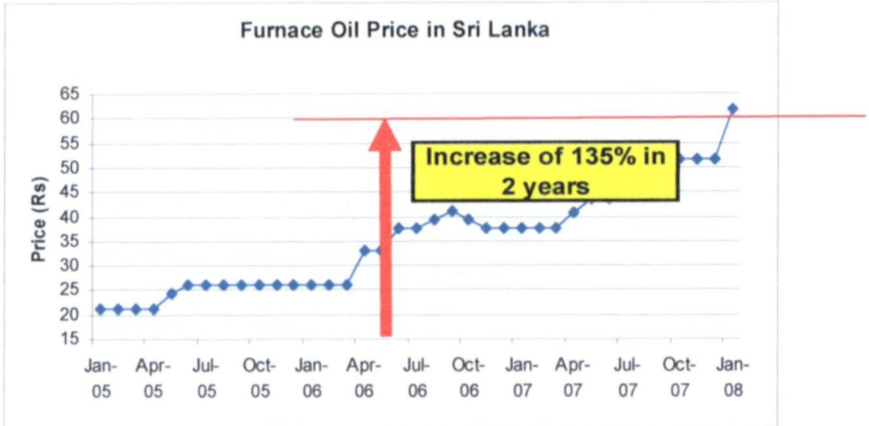

Figure 4.8: Price of furnace oil in Sri Lanka

(Source: Unilever finance department)

Overview of technology

M/s Thermax India Ltd was selected as the supplier of the boiler. This is a 12TPH boiler which has an Inclined Water Cool (IWC) grate, which is capable of burning a range of fuels. IWC type furnace was chosen over a Fluidised Bed Combustor (FBC). The main fuels to be used are crushed coconut shells, wood chips and saw dust. All these are considered as Biomass and will be qualified to obtain Certified Emission Reduction (CER) under the Clean Development Mechanism (CDM) of the Kyoto protocol.

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Operation

USL planned to operate this technology with a third party operator. This option minimizes the risk associated with USL getting involved in sourcing biomass material and operating the boiler. The party operating the boiler is liable to lending the institutional financing of the project as mentioned in Table 4.4. This will enforce the party into a longer term of contract in operating and supplying steam to USL. The party identified has already commenced operations of a similar boiler project in Sri Lanka.

Table 4.4: Financing plan

(Source: Unilever finance department*)*

	LKR	EURO
Total Project Cost	91,607,504	572,547
Unilever Investment	29,250,000	182,813
Investment By 3P	62,357,504	389,734

Application of TECC

Using the information from USL services department and accounts department an assessment of the installed biomass boiler using the TECC is described below.

Technological complexity

With the experience USL has it is noted that a biomass boiler is not difficult to use or operate. With a short term training of operators and engineers the capability to operate this boiler has been developed by USL. Initial trainings were carried out by the boiler supplier. The following points have been considered when operating this unit. Firstly, the biomass boiler is larger than the USL's conventional oil fired boiler which gives the same steam output. Secondly, to store saw dust USL has to provide a considerable space. This increases the additional storage space required and this directly links to the increase in storage cost. Thirdly, biomass handling issues occurred which would have resulted in a near fatality.

Quality characteristics

There is no evidence that the steam generated from biomass boiler has increased the quality of our products. Service provider has to maintain the temperature at 80 centigrade or above to get the agreed steam price per kilogram of steam.

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Energy Intensity

The biomass boiler project has generated the following cash flows to the USL business:

In year 2009	32.8 Millions
In year 2010 (August 2010)	(26.7) Millions

This loss is due to the unexpected crude oil price reduction in the world market.

Ecological Stability

Girard (1992) points out that the equivalent of carbon dioxide emitted per Ton of oil equivalent (TOE) of energy generated after burning by different technologies are:

Coal	1.0
Oil	0.8
Gas	0.6
Wood	0.3
Biomass energy residue	0.3

The use of biomass for steam generation is said to have a beneficial impact on the environment. It has even been pointed out that the carbon dioxide generation by using biomass energy sources will be removed later through photosynthesis of growing crops and trees. In addition, since biomass does not, in general, contain sulphur, there is no toxic and environmentally degrading sulphur dioxide produced.

Thus use of biomass boiler has beneficial impacts on the environment in the following manner as well:

- Eradicate river pollution caused by dumping of wood wastes into the rivers. This is one of the major issues in Bolgoda lake, Moratuwa.
- Reduce the high pollutant exhausts caused by inefficient incinerators which are used to burn the generated wood dust.
- Reduced the carbon dioxide and sulphur dioxide emissions normally caused by the use of diesel or furnace oil fired boilers

Waste recycling

Biomass boiler mainly uses saw dust and coconut shell as fuel and thereby it has a beneficial impact on the environment. Similarly this unit can use rice husk and straw as well if collected in proper manner.

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Cost

In 2009 the following costs were identified with the biomass boiler project:

Total capital cost	=	92 Million
Annual fixed costs	=	142.3
labour costs	=	7.1
annual maintenance cost	=	3.0
utilities	=	5.8
Variable costs		
fuel costs	=	14.5
lubricants and water	=	0
treatment	=	0 (for both 4.7 million)

Due to this project operating nature (3P) the above cost break down is not clearly declared by the 3P operator. USL is paying as per ton rate for the steam consumed from the biomass boiler according to the agreement with the 3P operator.

Profitability

In 2009 the various financial benefits gained per annum through the use of biomass boiler is as follows,

Steam generated cost savings = Rs. 32.8 (due to the furnace oil price drop in 2009 expected savings were not able to achieved)

The above profitability is calculated after considering all the costs incurred for this plant with regard to operation and maintenance. Profitability can be further enhanced if this boiler is utilized in a more efficient manner. In this regard the furnace oil boiler usage must be minimized.

Utility adjusted price ratios

The savings in the first year of operation was Rs.32.8 million due to the unexpected furnace oil price drop in the market. In 2010, due to a further drop in furnace oil price, USL is making a Rs.26.7 million loss in Aug- 2010. The main sensitivity of the project would arise from the Biomass boiler not providing the expected quantities of steam and hence USL has to fire the furnace oil boilers. Nonetheless, USL is not achieving the environmental goals set by Unilever.

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The key success factors of the project savings would be derived from:

- Maximum operation of the Biomass boiler
- Coconut shell or saw dust availability
- Continuous supply chain
- Controlled emissions
- Ensuring benefits of lower manning and repair costs are achieved

Productivity

The productivity of the biomass boiler, with respect to the cost of producing steam by using furnace oil fired boiler is assessed here.

Biomass boiler steam cost	=	163.60 Rs/Lit
Furnace oil boiler steam cost	=	196.40 Rs/Lit

This is calculated based on the 2009 figures and detailed calculation is in Table 4.5. The productivity is more attractive in biomass boiler when compared with furnace oil boiler.

Table 4.5: Costing sheet

	YOY incrs	Units	2008	2009	2010	2011	2012	2013	2014	2015
Total Steam Requirement		Tons	**62,057**	**51,563**	**43,443**	**43,443**	**41,271**	**39,207**	**37,247**	**35,384**
FO Price	15%	Rs/L FO	**62**	**44**	**33**	**38**	**44**	**50**	**58**	**66**
SM steam cost 1st half	15%	Rs/Kg st		2.80	3.46	4.00	4.62	5.34	6.17	7.13
SM steam cost 2nd half		Rs/Kg st		3.22	3.72	4.30	4.97	5.74	6.64	7.67
Avg steam price per year		Rs/Kg st		**3.01**	**3.59**	**4.15**	**4.80**	**5.54**	**6.41**	**7.40**
Cost of Steam on FO										
FO cost				175	110	127	139	151	165	181
Labour	10%		6.4	7.1	7.8	8.6	9.4	10.4	11.4	12.5
Repair & Maintenance	10%		5.4	5.9	6.5	7.1	7.8	8.6	9.5	10.4
Overheads	10%		4.3	4.7	5.2	5.7	6.3	6.9	7.6	8.4
Electricity Consumption	15%		3.7	4.2	4.9	5.6	6.4	7.4	8.5	9.8
Total				**196.4**	**134.6**	**153.8**	**168.5**	**184.7**	**202.4**	**221.8**
Cost of Steam with Biomass										
3P cost				142.3	143.0	165.3	181.4	**199.2**	**218.7**	**240.1**
Less Depreciation in Steam Price				-4.4	-4.4	-4.4	-4.4	**-4.4**	**-4.4**	**-4.4**
Less Finance Charge in Steam Cost				-9.4	-9.4	-9.4	-9.4	**-9.4**	**-9.4**	**-9.4**
FO 1month	15%			**14.5**	**9.2**	**10.6**	**11.5**	**12.6**	**13.8**	**15.1**
Electricity	15%		**5.0**	**5.8**	**6.6**	**7.6**	**8.7**	**10.1**	**11.6**	**13.3**
Labour	10%		6.4	7.1	7.8	8.6	9.4	10.4	11.4	12.5
Overheads	10%		4.3	4.7	5.2	5.7	6.3	6.9	7.6	8.4
R & M on FO boilers	10%		2.7	3.0	3.3	3.6	4.0	4.3	4.8	5.3
Total				**163.6**	**161.3**	**187.6**	**207.7**	**229.8**	**254.1**	**280.9**
Savings from Switching Fuels				**32.8**	**-26.7**	**-33.8**	**-39.1**	**-45.1**	**-51.7**	**-59.1**
Savings From CDM	15%			**18**	**13.9**	**10.8**	**7.9**	**5.5**	**3.7**	**2.3**

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Application of OCCC

Using the information from USL services department an assessment of the installed biomass boiler using the OCCC is explained below:

Scale of operation

Based on the capital cost of nearly 100 million rupees, it appears that this biomass boiler is suitable for medium and large scale companies in our county. However according to the study conducted it has been identified that this technology is difficult to be adopted by medium scale companies since the total expenditure is high.

Labour intensity

The labour requirements for operating a biomass boiler appear to be easily available in USL and Sri Lanka. In the trade there are well experienced and licensed boiler operators. This means the required engineers, operators and skilled workers are available for this project, but specific training is needed for the selected team to ensure a good understanding and proper usage of the technology.

Durability

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The depreciation for the main equipment has been made over a period of 15 years. This length of time is considered to reflect the durability of the equipment. Considering the nature of the equipment outlined in Table 4.6, it appears that the maintenance will not be difficult and is well within the capabilities of the engineers and technicians in USL and the 3P operator.

Technical Specifications

Table 4.6: Technical Specification
(Source : Thermax catalogue*)*

MODEL – COMBIPAC (CPIWG-120 / 17.5)

Sr. No.	Description	Unit			
A.	**PERFORMANCE PARAMETERS**				
1.	Maximum Steam Output F & A 100 °c	kg/hr	12000		
2.	Outlet steam condition				
2.1	Safety valve set pressure (gauge)	kg/cm^2	17.5		
2.2	Temperature	° C	Saturated at operating pressure		
2.3	Quality of steam		Saturated steam with 97% dryness fraction		
3	Fuel: • Wood chips size: 20 to 25mm & inlet to wood chipper shall be 5" dia max. • Coconut shell size: 20 to 25mm • Saw dust & wood chips will be premixed at inlet of fuel handling plant.		1. Crushed coconut shell: 3360 kg/hr. 2. Wood chips: 3200. 3. Saw dust: 1400 kg/hr. (60%) + 1260 kg/hr (40%)		
4	Fuel analysis considered for design				
4.1	Ultimate analysis of fuels		Crushed Coconut shell	Giliceria Wood Chips	Saw dust
	Carbon	wt %	31.98	25.92	51.77
	Hydrogen	wt %	3.52	3.96	6.85
	Oxygen	wt %	38.5	12.38	30.54
	Nitrogen	wt %	0.05	0.29	0.39
	Sulphur	wt %	0.117	0.1	0.05
	Mineral matter	wt %	0.82	7.35	1.65
	Moisture	wt %	25	50	8.75
	GCV	kcal/kg	2680	2950	3860
5	Water quality to be maintained				
5.1	Feed water limits				
	Total hardness	ppm	<5.0		
	pH value		8.5 to 9.5		
	Dissolved O_2 (max)	ppm	0.1 to 0.5		
	TDS (max)	ppm	200		
	Silica as SiO2	'mg/l	5		

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6	Flue gas temperature		TYPICAL –MAY VARY
6.1	At boiler outlet	° C	280 – 300
6.2	At WPH outlet	° C	180
7	Cyclomax in series with wet scrubber	mg/Nm3	• 150 for crushed coconut shell. • 150 for wood chips. • 300 for saw dust.
8	Draught in furnace	mmwc	-2 to –5
9	Combustion type considered is		Non-FBC
10	Mode of charging fuel		Screw feeder
11	Mode of ash removal		manual
B.	**DESIGN DATA**		
1	Code followed for design		IBR 1950 with latest amendment
2	Design pressure	kg/cm2 (g)	17.5
3	Material of construction		
3.1	Shell		SA 515/516 Gr. 70
3.2	Tubes (membrane panel, shell tube)		BS 3059 Part I Gr. 320 ERW
4	Heating Surface area -		(May very during detail engineering without affecting performance)
4.1	Shell	m2	324
4.2	Membrane panel	m2	45
4.3	Grate Area	m2	7.0
4.4	Shell tubes	OD x thk. x L	Shell: 76.2 x 3.66 x 4.5 ERW BS-3059 MPA: 63.5 x 3.66 ERW BS-3059
5	Furnace type		Inclined Water cooled grate
6	Quantity of combustor	no	2

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Ease of operation

Standard operating procedures (SOP) have been developed based on the information and training USL has received from the supplier. The SOP's for operating the plant are developed in such a way that it can be easily understood and learnt. However, good plant management practices have to be implemented in order to uplift its operating and maintenance standards.

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State of the art

Although biomass steam generation is not a new technology to the country and to the world, it is a new technology to USL business. This project was not able to give USL the expected savings during the last year due to the unexpected oil price decline in the world market.

Interaction

From an organisational point of view, the use of biomass boiler is beneficial because it reduces the steam cost and this is directly connected to the reduction of conversion cost. This reduced conversion cost will definitely help USL to be more competitive in the region and to become one of the preferable sourcing units for Unilever business.

Application of ODCC

Using the information from USL services department an assessment of the installed bio mass boiler using the ODCC is carried out below:

Supplier actions

The Indian company Thermax India Limited provided biomass boilers to India, Sri Lanka and Bangladesh. At the same time they have an office in Sri Lanka as well. This will be an advantage for USL because USL can expect a much better service from the supplier. Similarly if they receive good feedback from USL it will pave way for Thermax India Limited to have future business opportunities with Unilever.

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Government actions

There is no direct involvement from the government for this project. But this year USL has won the third place in National Energy Efficiency Award 2010. This is in recognition of the contribution by USL to reduce energy use through effective and efficient energy management efforts.

Sectoral effectiveness

This technology directly contributes to the USL business only. Thus, sectoral effectiveness will reduce the conversion cost and thereby USL has the ability to make larger profits by penetrating to all segments in the society.

Raw material requirement

The biomass boiler uses only locally available raw materials like coconut shell and saw dust. However, seasonality in terms of supply could be a concern. Deterioration of saw dust during storage prior to use and high storage cost due to the bulky nature of raw materials will increase the raw material cost. Handling of saw dust also gives USL considerable problems.

Rural orientation

This project feasibility has been conducted only for USL. Thus, there is a need to do a feasibility study before commenting on its suitability for the rural operation.

Delocalization

This can be easily cascaded to other local industries since it will save a lot of foreign expenses on crude oil.

Income disparity reduction

This project will not cater to the above aspect directly.

Socio cultural stabilization

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The use of biomass boiler can reduce the pollution caused by dumping, especially wood waste into rivers. This is a major problem in the Moratuwa area, many saw mills dump the waste into Bolgoda lake.

Local ownership

Since biomass boiler operation is not a very advanced technology, the outright purchase by USL will result in a full local ownership of the above unit.

Conclusion

The Grandpass Unilever factory is a complex site comprising of manufacturing plants of Soaps, Edible Fats and Personal Products. The utility needs of all the manufacturing plants are met by a central unit. The steam supply for the entire site was done with two furnace oil boilers. The cost of furnace oil in Sri Lanka has increased significantly during the last few years, owing to the increase in the global prices of crude oil. This adversely affected the conversion cost and greatly damaged the Unilever business. Due to this reason, the company has taken a firm decision to have a solid fuel boiler to cope up with the issue.

This is one of the major projects that USL has completed considering only the financial out come. No interest, what so ever, was cast on the project to see whether proper technology choice was made or not. This analysis highlights the importance of adopting a concept like technology choice in investing on a mass scale project like this. It clearly covers all the important areas which need consideration when selecting a new technology. The Researcher highly recommends this concept for USL in its future TT projects.

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