Annexure 1.2.1

IGEA report guideline

Energy Efficiency Market
Nepal Energy Efficiency Programme (NEEP)

D. Pawan Kumar
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BACKGROUND

- Towards ensuring desirable quality requirements and also as a consistent template for IGEA reports, to enhance their utility for M & E, an IGEA report structure along the following lines is recommended for adoption.

- While the report structure compliance in entirety is desirable from programmatic perspective, flexibility needs to be accommodated, as, the extent of detailing; customization and client centric information may vary as per specific situations, warranting simplified presentation on the one hand or far more elaborate detailing on the other.

- In presentation part, a good balance between quantitative and qualitative detailing and text and visual content is desirable, for the purpose of readability, understandability, and utility from client perspective.

- Based on experiences acceptance and feedback from stakeholders like beneficiary industry, a standardized flow of an IGEA report with illustrative examples is presented as follows.
TITLE SHEET OF THE REPORT TO INDICATE:

- Nature of audit namely: Investment grade energy audit. (Or other as relevant)
- Name of the industry/audited entity
- Name of the auditing entity
- Duration of audit
- Sponsors, stakeholders as applicable

OPENING PAGE:
Opening page of report may contain table of contents of IGEA report indicating referred item and page number in a chronological sequence.

ACKNOWLEDGEMENTS:
The acknowledgements page may acknowledge contributions of key stakeholders associated in audit activity from client side as well as any other sponsors as relevant, preferably signed by team leader of audit with date.

STUDY TEAM:
On this page, the list of study team members with designations may be presented, for future references.

ABBREVIATIONS/NOMENCLATURE USED IN REPORT:
In this page, the report may list the abbreviations, nomenclature used in report, for ease of understanding purposes.

LIST OF INSTRUMENTS USED:
In this page, the list of instruments used in energy audit need to be mentioned

EXECUTIVE SUMMARY:
In this section, the report may present the synopsis of study findings, which would at-least, include:

- Baseline details of the audited entity.
- EE Option summary listing in a table, covering all EE opportunities identified in electrical and thermal areas the option wise identified annual energy savings potential, Rupee savings potential per annum, Investment needs and simple payback period.
Prioritized options listing as short term (less than one year simple payback period); medium term (one to three year simple payback period); long term (over three year simple payback period)

An illustrative template of executive summary is presented as exhibit 1 of these guidelines.

HEADERS AND FOOTERS:
The report may have consistent headers and footers as per relevance for easy accessibility.

CHAPTER 1: INTRODUCTION:

1.1 Background of the study:

(Suggested text for IGEA reports as part of NEEP is as follows):
As part of “Nepal Energy Efficiency Programme,” (a bilateral initiative between Government of Nepal and Government of Germany), GIZ Nepal is supporting Energy Efficiency Center, (an autonomous center functioning under the Federation of Nepalese Chambers of Commerce and Industry FNCCI), in promoting energy efficiency in industrial enterprises, with capacity building in Energy Audit as an area of focus. Accordingly, a team comprising of engineers, after an intensive training on energy audit by experts from National Productivity Council, India, undertook the pilot investment grade energy audit at -------------, guided by BEE accredited energy auditor/expert ------------- along with local long term expert ------------- and team leader from GIZ- INTEGRATION.

--------------, is one of the leading ----------- in the region, and was selected for the pilot investment grade energy audit based on their expression of interest and a MoU with EEC.

--------------, is situated in -----------. The pilot energy investment grade audit was conducted during --------------, covering both electrical and thermal energy utilization areas. This report presents the results of the pilot investment grade energy audit and presents findings along with energy conservation opportunities with cost benefit analysis.

1.2 Scope of pilot energy audit: (Coverage may refer to MoU or ToR)

An illustrative template is presented as exhibit 2 of these guidelines.

1.3 About the unit:

(Coverage may present location, year of establishment, products, production capacity, current level of production, shifts/day and days/year normal operation, Electrical energy and thermal energy consumption and costs per annum.)
CHAPTER 2.0: PROCESS DESCRIPTION

(IGEA report to present Process overview with relevant flow diagrams especially briefing energy linkages/energy using equipment)

An illustrative template is presented as exhibit 4 of these guidelines.

In case of hotels and commercial buildings, the coverage may be modified to present information along the following lines)

Number of floors:
Number of rooms (standard; executive; suites; cottages)
Number of conference facilities
Number of business centers
Number of lounges
Number of restaurants
Total area sq m
Total built up area sq m
(Any illustrative visuals are welcome)

Energy requirements at the hotel are essentially to meet the needs of:
Comfort air conditioning (common areas as well as hospitality areas)
Lighting(Outdoor; common areas and hospitality areas)
Laundry and Kitchen equipment (applications)
Bakery
Captive power plant (as backup source)
Water Pumping
Hot water and steam generation for kitchen and laundry

CHAPTER 3.0: PLANT ENERGY SYSTEMS

3.1 Electrical Energy Use features:
Coverage to present plant/facility features relating to electrical energy and load management practices, grid, diesel generation, cogen costs, power factor, time of use tariffs, maximum demand trends, specific electrical energy consumption, major equipment (like drives, refrigeration, pumping, compressors,) consuming power, breakup and factors affecting consumption.
3.2 Thermal Energy Use features:
Coverage to present plant/facility features relating to thermal energy use areas, sources, costs, major equipment, typical operational and performance indicators, specific thermal energy consumption, major equipment consuming fuels, breakup, and factors affecting consumption. An illustrative coverage is presented as exhibit 5 of these guidelines.

CHAPTER 4.0: STRATEGIC ENERGY MANAGEMENT PROGRAM

(May cover rationale of a strategic energy management program at the unit, voluntary policy statement desirable as a measure of management commitment to energy efficiency, desirable features of a MIS system and any desirable upgrades in plant automation as relevant)

An illustrative template is presented as exhibit 6 of these guidelines.

CHAPTER 5.0: ENERGY EFFICIENCY OPPORTUNITIES

IGEA report to cover Energy efficiency opportunities in electrical and thermal systems in this chapter in a clear manner, presenting for each opportunity the following aspects:

1. Title of measure (EE opportunity)
2. Present situation
3. Recommendation
4. Cost benefits:
   - Cost benefits may present simple payback period of measure in months or years.
   - For proposals with long simple payback, ie over 3 years, it would be preferable to carry out feasibility analysis by IRR calculations, factoring in internal and external sensitivity factors like interest rates, debt equity ratios, any prevalent incentives, etc.
5. Vendor information as relevant. (Budgetary quotation would enhance comfort level for investment decisions).

The menu of EE measures are very exhaustive and sector and application specific and broadly may include measures such as:

- Maximum demand optimization, Load shifting for Time of Use tariff advantages
- Power factor improvement, Automatic Power Factor Controls (APFC)
- Drive efficiency improvements
Variable speed drive applications for energy efficient capacity control
Improving captive and Cogen system efficiency
Automation for process controls
EE in process utilities like pumps, fans, compressors, refrigeration and lighting
Renovation and Modernization and process modifications/upgrades
Thermal insulation in cold and hot piping
Combustion efficiency improvements in furnaces, boilers, thermic fluid heaters, hot water generators, ovens, melting baths.
Waste heat recovery in DG Sets, Furnaces, thermal equipment like boilers, heaters and ovens etc.
Steam trap and Condensate recovery improvements
Cogeneration
Automation like temperature controls, combustion controls, etc.
Loading improvements for better capacity utilization.
Housekeeping improvements to abate wastages and leakages.
Heat Exchanger performance improvements like de-scaling.
RE applications

An illustrative template of measures assessed, is presented as exhibit 7 of these guidelines.

6- EXHIBITS
Each IGEA report may include exhibits to support the report findings, as deemed necessary, for clarity, better understanding, and may include information like:

- Line diagrams,
- Technical Specifications
- Design data
- Detailed calculations like heat balance
- Details of motor load survey, lighting survey, steam trap survey, insulation survey etc.
- Vendor information on product literature
- Generic tips, Housekeeping measures, maintenance guidelines etc.

Exhibits may also address any incentive schemes available from Government, Ministries, NEA, or Financial Institutions or International institutions, that are prevalent and applicable, to enhance the viability of the EE proposals.
EXHIBIT 1: TEMPLATE “EXECUTIVE SUMMARY”:

EXECUTIVE SUMMARY

.. Dairy Kathmandu, Ltd, is one of the leading dairy units in the region, and was selected for the pilot energy audit based on their expression of interest and a MoU with EEC. Pilot energy audit was carried out as part of “Nepal Energy Efficiency Programme,” (a bilateral initiative between Government of Nepal and Government of Germany). GIZ Nepal is supporting Energy Efficiency Center (an autonomous center functioning under the Federation of Nepalese Chambers of Commerce and Industry FNCCI), in promoting energy efficiency in industrial enterprises, with capacity building in Energy Audit as an area of focus. Accordingly, a team comprising of engineers, after an intensive training on energy audit by experts from National Productivity Council, India, undertook the pilot energy audit at Dairy, guided by expert from NPC India along with local long term expert and team leader (GIZ INTEGRATION).

Dairy is situated in Kirtipur, on the outskirts of Kathmandu. The pilot energy audit was conducted during 20-25 September 2012, covering both electrical and thermal energy utilization areas. An overview of the prevalent production and energy consumption related features prior to the study period as a baseline information are presented in the table below.

<table>
<thead>
<tr>
<th>Name of Industry:</th>
<th>………. Dairy (as a sample)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of Establishment:</td>
<td>…………………</td>
</tr>
<tr>
<td>Scale:</td>
<td>…………………</td>
</tr>
<tr>
<td>Product:</td>
<td>………………… Dairy</td>
</tr>
<tr>
<td>Capacity in Liters:</td>
<td>………………… millions LPA</td>
</tr>
<tr>
<td>Production in liters:</td>
<td>………</td>
</tr>
<tr>
<td>Location:</td>
<td>………</td>
</tr>
<tr>
<td>Contact Person:</td>
<td>………</td>
</tr>
<tr>
<td>Designation:</td>
<td>Director/ Finance Manager</td>
</tr>
<tr>
<td>Telephone Number:</td>
<td>………</td>
</tr>
<tr>
<td>E-mail:</td>
<td>………</td>
</tr>
<tr>
<td>Website:</td>
<td>………</td>
</tr>
<tr>
<td>a- No of shift:</td>
<td>………</td>
</tr>
<tr>
<td>b- Annual operation days:</td>
<td>………</td>
</tr>
<tr>
<td>No of Employees:</td>
<td>………</td>
</tr>
<tr>
<td>Presence of Energy Manager:</td>
<td>………</td>
</tr>
<tr>
<td>EOI on NEEP Activity</td>
<td>………</td>
</tr>
<tr>
<td>EOI on EE Investment</td>
<td>………</td>
</tr>
<tr>
<td>Compliance with any International/National Standard:</td>
<td>………</td>
</tr>
</tbody>
</table>

**Energy Aspects:**

A) Electrical Energy:

A1) From NEA Grid in kWh: ………
<table>
<thead>
<tr>
<th><strong>Key Parameters:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Turnover in Million in NPR:</td>
</tr>
<tr>
<td>Capacity Utilization in %:</td>
</tr>
<tr>
<td>Total Electrical Energy kWhr per kL</td>
</tr>
<tr>
<td>Total Thermal Energy litre/1000L</td>
</tr>
<tr>
<td>Total Energy Cost in NPR:</td>
</tr>
<tr>
<td>Total Energy Cost as% of turnover</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>A2) From Generators:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of Fuel used:</td>
</tr>
<tr>
<td>Fuel Consumed in Liters:</td>
</tr>
<tr>
<td>Total DG Capacity in kVA:</td>
</tr>
<tr>
<td>Diesel Energy Generated in kWh:</td>
</tr>
<tr>
<td>Total Cost of Energy Generated from DG Set in Nrs:</td>
</tr>
<tr>
<td>Energy Generated in kWh per liter</td>
</tr>
<tr>
<td>% of kWh Generated from DG:</td>
</tr>
<tr>
<td>Total Electrical Energy from NEA and DG in kWhr</td>
</tr>
<tr>
<td>Total Cost of Electrical Energy from NEA and DG</td>
</tr>
<tr>
<td>Per unit cost of Electrical Energy, NRs/kWh</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>B) Thermal Energy:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>B1) Types of Fuel used:</td>
</tr>
<tr>
<td>Quantity of Fuel Consumed:</td>
</tr>
<tr>
<td>Total cost of Fuel Consumed in NPR:</td>
</tr>
<tr>
<td>B2) Types of Fuel used:</td>
</tr>
<tr>
<td>Quantity of Fuel Consumed:</td>
</tr>
<tr>
<td>Total cost of Fuel Consumed in NPR:</td>
</tr>
<tr>
<td>Total Thermal Energy Consumed in liters</td>
</tr>
<tr>
<td>Total Cost of Energy used in Thermal Side</td>
</tr>
</tbody>
</table>
## EE Options Summary:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Energy Efficiency option</th>
<th>Annual Savings</th>
<th>Investment, NRs</th>
<th>Pay Back Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Electrical Energy, kWh</td>
<td>Thermal Energy, (Furnace oil, liters)</td>
<td>Cost, NRs</td>
</tr>
<tr>
<td>1.</td>
<td>Revising the approved electrical demand with NEA from 500 kVA to 400 kVA.</td>
<td>38 kVA/month</td>
<td>-</td>
<td>104,880</td>
</tr>
<tr>
<td>2.</td>
<td>Effective use of Ice Bank System</td>
<td>126,056</td>
<td>-</td>
<td>1,462,250</td>
</tr>
<tr>
<td>3.</td>
<td>Operating the Effluent Treatment Plant (ETP) during low tariff off peak period</td>
<td>-</td>
<td>-</td>
<td>97,455</td>
</tr>
<tr>
<td>4.</td>
<td>Operating ground water pump at night, off peak hours</td>
<td>-</td>
<td>-</td>
<td>46,183</td>
</tr>
<tr>
<td>5.</td>
<td>Installation of Desuperheater at ammonia compressor discharge</td>
<td>6,615</td>
<td>7,500</td>
<td>639,234</td>
</tr>
<tr>
<td>6.</td>
<td>Heat recovery from DG set flue gas</td>
<td>-</td>
<td>2,835</td>
<td>212,625</td>
</tr>
<tr>
<td>7.</td>
<td>Installation of a 1 KL/Day solar hot water system to generate hot water</td>
<td>-</td>
<td>2,100</td>
<td>157,500</td>
</tr>
<tr>
<td>8.</td>
<td>Milk chilling and Pasteurization efficiency improvements</td>
<td>12,059</td>
<td>3,684</td>
<td>458,500</td>
</tr>
<tr>
<td>9.</td>
<td>Insulation of chilled milk pipeline</td>
<td>7,525</td>
<td>-</td>
<td>87,290</td>
</tr>
<tr>
<td>10.</td>
<td>Installation of VFD for Chilled water pump</td>
<td>7,560</td>
<td>-</td>
<td>87,696</td>
</tr>
<tr>
<td>11.</td>
<td>Performance of Boilers and measures for fuel economy (Replacement of oil fired boilers with rice husk fired boiler)</td>
<td>-</td>
<td>-</td>
<td>8,331,600</td>
</tr>
<tr>
<td>12.</td>
<td>Insulation of Ghee boiling pan</td>
<td>-</td>
<td>375</td>
<td>28,125</td>
</tr>
<tr>
<td></td>
<td>Activity</td>
<td>Potential Savings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------</td>
<td>--------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Condensate Recovery from cream pasteurizer and ghee boiling pan</td>
<td>817.5 kWh, 61,312 L, 31,000 NRs, 06 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Recovering condensate during Diesel boiler operation</td>
<td>687 kWh, 68,013 L, 10,000 NRs, 1.8 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>159,815 kWh, 17998.5 L, 11,842,663 NRs, 8.06 months</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- On the whole, the identified energy efficiency options add up to 159,815 kWh of potential electrical energy savings per year and 17,998 kL of FO/Diesel savings per year amounting to NRs.11,842,663 per year savings on energy cost.
- Energy consumption reduction envisaged upon implementation will be 25.46 % in electrical energy and 15.55 % in fuel.
- The 14 nos. of Energy saving opportunities identified are worth NRs 11,842,663 annually, against an investment of NRs 79,54,000 and offer an overall simple payback period of 8.06 months.
Classification of options on the basis of payback period:

<table>
<thead>
<tr>
<th>SN</th>
<th>Energy Efficiency Options</th>
<th>Simple payback period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Short Term (less than one year payback period)</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Revising the approved electrical demand with NEA from 500 kVA to 400 kVA.</td>
<td>immediate</td>
</tr>
<tr>
<td>2.</td>
<td>Operating the Effluent Treatment Plant (ETP) during low tariff off peak period</td>
<td>immediate</td>
</tr>
<tr>
<td>3.</td>
<td>Operating ground water pump at night, off peak hours</td>
<td>immediate</td>
</tr>
<tr>
<td>4.</td>
<td>Effective use of Ice Bank System</td>
<td>2.46 months</td>
</tr>
<tr>
<td>5.</td>
<td>Installation of Desuperheater at ammonia compressor discharge</td>
<td>9.40 months</td>
</tr>
<tr>
<td>6.</td>
<td>Insulation of chilled milk pipeline</td>
<td>Less than a month</td>
</tr>
<tr>
<td>7.</td>
<td>Installation of VFD for Chilled water pump</td>
<td>6.8 months</td>
</tr>
<tr>
<td>8.</td>
<td>Performance of Boilers and measures for fuel economy (Replacement of oil fired boilers with rice husk fired boiler)</td>
<td>8 months</td>
</tr>
<tr>
<td>9.</td>
<td>Insulation of Ghee boiling pan</td>
<td>4.3 months</td>
</tr>
<tr>
<td>10.</td>
<td>Condensate Recovery from cream pasteurizer and ghee boiling pan</td>
<td>06 months</td>
</tr>
<tr>
<td>11.</td>
<td>Recovering condensate during Diesel boiler operation</td>
<td>1.8 months</td>
</tr>
<tr>
<td></td>
<td><strong>Medium Term (one to three year payback period)</strong></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Heat recovery from DG set flue gas</td>
<td>28 months</td>
</tr>
<tr>
<td>13.</td>
<td>Milk chilling and Pasteurization efficiency improvements</td>
<td>36 months</td>
</tr>
<tr>
<td></td>
<td><strong>Long Term (more than three years payback period)</strong></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Installation of a 1 KL/Day solar hot water system to generate hot water</td>
<td>38 months</td>
</tr>
</tbody>
</table>
EXHIBIT 2: TEMPLATE SCOPE:

The scope of the pilot energy audit included:

- Brief history of production and energy use
- Measurement and monitoring of plant facilities for energy consumption
- Assess energy efficiency improvements opportunities in the areas of
  - Power Factor improvement
  - Load Management
  - Electrical systems
  - Thermal systems
- Recommendation of potential energy saving options
- Feasibility study of major options

Exhibit 3: Template text on “about the unit”

- Dairy Kathmandu, Ltd, situated at Kirtipur, Kathmandu, was established in 1994, with an objective of helping the local farmers and milk vendors to generate substantive income and cater to their daily needs by procuring milk from the surrounding villages and distributing it to the cities. The sourcing milk collection centers for dairy are located at Chitwan, Rupandehi, Kavre, Nawalparasi and Biratnagar.
- Currently, Dairy Kathmandu, Ltd is one of Nepal’s leading dairy processing and distributing Industries, with production capacity of more than 51.1 million liters of milk per year (considering 14 hours of operation in a day).
- The dairy currently processes around 40,000 liters per day. The dairy products include standard pasteurized Milk, Butter, and Ghee. The dairy has plans to produce Paneer, Dahee, Flavored Milk, and Lassi in the near future.
- Energy consumption and costs: Furnace oil/Diesel for boilers and NEA/captive diesel electricity for electrical equipment are the major energy sources used in the dairy. For Dairy, the annual electricity cost (NEA plus captive diesel) is around Rs. 72.69 lakhs per annum and the fuel bill (Furnace oil and diesel) is Rs. 97.47 lakhs per annum totaling to energy cost of NRs 170.16 Lakhs per annum.
2.1 Main Dairy

The raw milk received from various chilling centers are received and pumped through reception chillers into a silo. From the silo the raw milk is taken for High Temperature Short Time (HTST) pasteurization through the steps given below.

The processes involved include:

- Receipt and filtration/clarification of the raw milk;
- Separation of all or part of the milk fat (for standardization of market milk, production of cream and butter and other fat-based products, and production of milk powders);
- Pasteurization;
- Homogenization (as required);
- Deodorization (as required);
- Product-specific processing;
- Packaging and storage, including cold storage for perishable products
- Distribution of final products.

After being held in storage tanks at the processing site, raw milk is heated to separation temperature in the regeneration zone of the pasteurizer. The milk (now hot) is standardized and homogenized by sending it to a centrifugal separator where the cream fraction is removed. The skim is then usually blended back together with the cream at predefined ratios so that the end product has the desired fat content. Surplus hot cream is cooled and usually processed in a separate pasteurizer ready for bulk storage and transportation to a cream packing plant.

The pasteurization process involves killing most of the bacteria within the raw milk to increase its shelf life. This is done by rapidly heating the incoming standardized milk to the pasteurization temperature in a simple holding tube, ensuring that the pasteurization temperature is held for the correct time (e.g. 72°C for 25 seconds) to destroy the bacteria. The hot milk is then passed through the regeneration zone, giving up its heat to the incoming cold milk, and cooled to a level where the growth of any surviving bacteria is slowed to a minimum, partially sterilizing the milk and increasing shelf life. Typically, this is an in-line process with the heating and cooling conducted in a plate heat exchanger.

Finally, chilled water is used to control the milk exit temperature from the pasteurizer at approximately 4°C. As the milk is heated and cooled within a few seconds there are intense heating and cooling demands. This process is therefore one of the largest emission sources within the industry, even though much of the heat is regenerated and re-used in the pasteurizer.
An overview of milk process flowchart indicating various linkages is presented as follows.

**PROCESS FLOW CHART OF STANDARD MILK, BUTTER AND GHEE**

Fig-1: Milk Process Flow Chart

2.2. Butter and Ghee production:
The dairy plant produces on the average 884 kgs of cream, 485 kgs of butter and 325 kgs of ghee per day. Butter is produced by churning cream, a process which damages the membranes of butter fat found in cream resulting in the production of small butter grains. These butter grains float in the water-based portion of the cream called buttermilk. The buttermilk is then drained to get butter and is stored at 18°C. The stored butter is then melted in melting vats to 75°C and then is taken to a ghee boiler where it is heated to 120°C. The molten ghee is clarified, stored and packed. The following figure presents butter and ghee making process linkages adopted.
2.3. Clean-In-Place (CIP)

CIP is the method of cleaning the interior surfaces of pipes, vessels, process equipment, filters and associated fittings without needing to remove them. It is common throughout the industry, as the processing facilities must be constantly cleaned to prevent microbes from growing and to remove fouling/scaling. CIP typically includes an initial rinse of recovered water to remove heavy soiling, followed by a hot detergent wash of caustic or acid solution, and a final rinse of clean potable water. Energy use and emissions associated with CIP are predominantly due to the heating of the processing equipment that is being cleaned as well as the heating of water which is subsequently wasted. CIP is a large consumer of water so there is a cost incentive to reduce CIP water usage as well as minimizing heat and chemical consumption.
3.1 Electrical Energy and Load management Practices:

- The approved maximum demand of the plant is 500 kVA. The dairy receives electric power from Nepal Electricity Authority, through a 500 kVA transformer at 11 kV which stepped down to 415 V for end use. The connected load of plant is about 580 kW.

- The monthly demand charges as charged by Nepal Electricity Authority are at the rate of 230/KVA. The minimum billable demand is 50 % of approved demand of 500 KVA. The energy tariff depends on the time of the day and currently, is as follows:

<table>
<thead>
<tr>
<th>Period</th>
<th>NRs/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak time (5 PM to 11 PM)</td>
<td>8.75</td>
</tr>
<tr>
<td>Off peak time (11 PM to 5 AM)</td>
<td>4.30</td>
</tr>
<tr>
<td>Other time (5AM to 6 PM)</td>
<td>7.10</td>
</tr>
</tbody>
</table>

- Two Diesel generator sets of 320 KVA each provide the backup in case of power failure.

- Monthly Electrical energy consumption of dairy plant, indicating share of NEA and Diesel Generated power, for one year is profiled as under.(Fig 3)

![Fig 3: Share of Grid and DG generated Electricity in kWh](image)
• It is seen that the diesel generation share in total reaches up to 52% and on the aggregate accounts for 19% of total electrical energy used.

• The main impact of this feature is that the weighted average price of electricity becomes higher as illustrated below.

**Annual NEA kWh purchased:** 507,939 kWh (2011-2012)

**Annual NEA energy Cost:** NRs. 4,154,144

**Annual DG Power generated:** 119,755 kWh (2011-2012)

**Annual DG Power Cost:** NRs. 3,131,063

**Aggregate annual energy consumption:** 627,694 kWh (2012-2013)

**Aggregate electrical energy cost:** NRs. 7,287,527

**Weighted average electrical energy cost/kWh = NRs. 11.60**

• **Diesel Power Generation Efficacy:**

Based on field trial during energy audit, the kWh/Liter figure was found to be 3.71 at 60% loading that reflects satisfactory efficacy of captive generation.

• **Time of Day Use Pattern of NEA Electricity:**

The Electricity use pattern in three time zones (in accordance with NEA billing criteria) over one year duration is presented in the following Fig 4.
The different time of use tariffs allow feasibility to maximize consumption at lowest billing time-zones for optimizing the NEA billing to be paid.

Analysis reveals the following on annual basis for the year 2011/12

a) 19.40 % of energy consumption is at R1 rate 8.75/kWh
b) 65.15% of energy consumption is at R2 rate ie 4.30/kWh
c) 15.45 % of energy consumption is at R3 rate ie 7.10/kWh.

- The Production planning schedules may be reviewed to benefit from lower billing rates during 11 PM to 6AM.
- The options could include water pumping for storage; ice bank storage etc.

- **Maximum Demand variation and Charges:**
  The billing demand charged by NEA is seen to be 250 kVA though the actual demand recorded is less. This is, because the contract maximum demand of the plant is 500 kVA and NEA billing demand charges are for 50 % of the contract maximum demand or actual demand recorded (whichever is higher).

- **Power Factor Variation:**
  The power factor at tail end of various loads as measured, is from 0.7 to 0.97. The plant has installed capacitor bank with automatic power factor control to ensure achieving a power factor of 0.97 to optimize maximum demand and charges thereof, which was dysfunctional but rectified by the energy audit team during study.

- **Production, Electrical Energy consumption and specific energy consumption trends:**
  The month-wise production and specific electrical energy consumption trends provide an indicator for plant energy performance, benchmarking and target setting.
  The milk production and specific electrical energy consumption trends of SGML as presented below (fig 5) indicate:
- Monthly specific electrical energy consumption variation from 32 kWh/1000liters to 58 kWh/1000 Liters during reference year 2011-2012
- Average specific electrical energy consumption of 44 kWh/1000 Liters for the reference year 2011-2012.
The factors affecting variations in specific electrical energy consumption have been analyzed to include:

- Capacity Utilization
- Product mix
- Incoming milk quality, quantity, temperature and additional chilling needs
- Ambient weather conditions and cold storage operations
- Operational efficiency at plant level

Given the high average electrical energy cost at NRs 11.60 /kWh, the electrical energy cost contribution per 1000 liters of milk processed works out to .510.00 corresponding to 44 kWh specific electrical energy consumption, the prevalent norms of 26-30 kWh/1000 liters as being achieved in contemporary Indian dairy plants could be considered as a target for achieving, through various good practices applicable.

**Electrical Energy use in equipment and share:**

The major applications drive ratings, indicative hours of use, measured kW loading and daily power consumption estimated are summarized as follows.

<table>
<thead>
<tr>
<th>Application</th>
<th>Rated KW</th>
<th>Measured KW</th>
<th>P.F</th>
<th>Hours of Operation</th>
<th>KWH/Day Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>-</td>
<td>7.91</td>
<td>0.97</td>
<td>11</td>
<td>87.01</td>
</tr>
<tr>
<td>Ref Compressor</td>
<td>55</td>
<td>26 to 42</td>
<td>0.89</td>
<td>19</td>
<td>798</td>
</tr>
<tr>
<td>Chilled water pump</td>
<td>5.5 x 2nos</td>
<td>11</td>
<td>0.86</td>
<td>19</td>
<td>209</td>
</tr>
<tr>
<td>Condensed water pump</td>
<td>3.7 x 2 (one run)</td>
<td>4.26</td>
<td>0.86</td>
<td>19</td>
<td>80.94</td>
</tr>
<tr>
<td>Homogenizer</td>
<td>75</td>
<td>39</td>
<td>0.7</td>
<td>5</td>
<td>195</td>
</tr>
<tr>
<td></td>
<td>Consumption/day</td>
<td>Consumption/day</td>
<td>Consumption/day</td>
<td>Consumption/day</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td></td>
</tr>
<tr>
<td>Air Compressor</td>
<td>11 x 3 (one run)</td>
<td>9.23</td>
<td>0.8</td>
<td>6</td>
<td>55.38</td>
</tr>
<tr>
<td>Milk pumps</td>
<td>16.5</td>
<td>14</td>
<td>0.85</td>
<td>4.5</td>
<td>63</td>
</tr>
<tr>
<td>Ground water pump</td>
<td>3.7 x 3 nos</td>
<td>5.9</td>
<td>0.82</td>
<td>8</td>
<td>47.2</td>
</tr>
<tr>
<td>ETP</td>
<td>22.25</td>
<td>10</td>
<td>0.7</td>
<td>8</td>
<td>80</td>
</tr>
<tr>
<td>Boiler 1</td>
<td>10.15</td>
<td>9</td>
<td>0.78</td>
<td>2.5</td>
<td>22.5</td>
</tr>
<tr>
<td>Crate Washing</td>
<td>11.1</td>
<td>11</td>
<td>0.76</td>
<td>6</td>
<td>66</td>
</tr>
<tr>
<td>IBT Agitator</td>
<td>5.5</td>
<td>5</td>
<td>0.8</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>Filling machine</td>
<td>13.5</td>
<td>8.19</td>
<td>0.8</td>
<td>6</td>
<td>49.14</td>
</tr>
<tr>
<td>Cream Separator</td>
<td>15</td>
<td>9.5</td>
<td>0.78</td>
<td>5</td>
<td>47.5</td>
</tr>
<tr>
<td>Boiler 2</td>
<td>10.1</td>
<td>9</td>
<td>0.77</td>
<td>5</td>
<td>45</td>
</tr>
<tr>
<td>Butter Cold Store 1</td>
<td>10</td>
<td>6.08</td>
<td>0.7</td>
<td>10</td>
<td>60.8</td>
</tr>
<tr>
<td>Raw milk agitator</td>
<td>8.6</td>
<td>6.45</td>
<td>0.8</td>
<td>3.5</td>
<td>22.575</td>
</tr>
<tr>
<td>Cooling unit fan motor</td>
<td>5</td>
<td>3.75</td>
<td>0.8</td>
<td>12</td>
<td>45</td>
</tr>
<tr>
<td>Total Consumption/day</td>
<td>535.22</td>
<td>211.27</td>
<td></td>
<td></td>
<td>2014.045</td>
</tr>
</tbody>
</table>

- Accordingly, for the daily electrical energy consumption of around 2000 kWh, the break-up among various users is presented as follows. (Fig-6)

**Daily energy consumption kWh/day**

![Pie chart showing energy consumption](image)

Fig 6: Section wise energy consumption in kWh/day
• It is recommended that management may initiate a practice of daily monitoring of milk processed, electrical energy consumed (NEA and Captive diesel), specific electrical energy consumption per 1000 Liters, as MIS and control parameter.

• It is recommended that management may incorporate time totalizers to all the major drives with over 10kW rating and monitor and track their hours of use monthly, as a component of MIS.

### 3.2 Thermal Energy Systems

• Steam for process heating and hot water needs are sourced from two boilers. Diesel and furnace oil are the fuels used in the boilers for steam generation. Diesel accounts for 42% of the total fuel fired into the boiler, while furnace oil makes up for balance. Diesel fuel is nearly 1.5 times more expensive than FO while the calorific value of Diesel and Furnace oil are almost the same.

• The technical specifications of the two boilers, namely, Pressels make fire tube type rated 1500 kgs/Hr (F.O. Fired) and Thermax make, once through, coil type, 850 kgs/Hr (Diesel fired), are presented as Exhibit-1 and the steam distribution diagram is presented as Exhibit-2 respectively.

• The steam generated is used mainly for pasteurization and CIP operations. Only condensate from pasteurizer is recovered. The steam costs NRs. 6.25 per kg with furnace oil firing while it is NRs. 8/kg with Diesel firing. The boilers are operated for about 7 hours per day from morning to noon, when the pasteurization is carried out.

• The audit findings about evaporation ratio and efficiency of both boilers are summarized as follows:

**Thermax Boiler (850kG/HR capacity, diesel fired):**

*Evaporation Ratio* = 13.3 (equivalent)

*Thermal Efficiency* = 80%

*Steam Cost* = NRs 7427/MT

**Pressels Boiler (1500 kgs/HR capacity, F.O. fired):**

*Evaporation Ratio* = 13.33

*Thermal Efficiency* = 80%
Steam cost = NRs. 5626.4/MT

Further details are presented as *Exhibit*.

**Specific fuel consumption:**
The month-wise production and specific oil consumption trends provide an indicator for plant thermal energy performance, benchmarking and target setting. The milk production and specific oil consumption trends of SGML as presented below (fig 7) indicate:

- Monthly specific fuel consumption variation from 7.44 Liters/1000 liters milk to 9.25 Liters/1000 Liters milk during reference year 2011/12.
- Average specific fuel oil consumption of 8 liters per 1000 liters milk for the reference year 2011/12.

- The factors affecting variations in specific fuel consumption have been analyzed to include:
  - Capacity Utilization
  - Product mix
  - Boiler Efficiency
  - Steam use efficiency at plant level

Given the high average fuel cost contribution per 1000 liters of milk processed works out to NRs. 687.28 corresponding to 8.16kg specific oil consumption, the prevalent norms of less than 5.0 kg equivalent/1000 as being achieved in contemporary Indian dairy plants could be considered as a target for achieving, through various good practices applicable.
3.3 Refrigeration systems

The refrigeration system consists of 3 chiller compressors, ice bank system, chilled water circuit and condenser water circuit. One chiller compressor is operated at any time.

The refrigeration system using ammonia as the refrigerant is largely used for the ice bank system. The liquid ammonia expands in coils chilling and creating ice around the coils submerged in water. The purpose of the ice bank is to build sufficient storage of ice to meet the peak load in the early hours of morning for pasteurization and for reception chilling of raw milk. The ice bank temperature is maintained between 1-2 °C. The evaporated ammonia is then compressed in a 45 TR reciprocating compressor of Kirloskar make. The compressed ammonia is sent to atmospheric condensers for condensation and collected in a receiver. From the receiver the liquid ammonia is sent to ice bank and also partly to chilling units in cold storage section. The cold storage section stores the sachets of milk packed for next day’s dispatch and is maintained at 0°C.

The cold room which is meant for storage of packed sachet milk before dispatch. Consist of 4 diffusers in the cold room each of 5 TR refrigeration capacities to accomplish the cooling requirements. Overview of ice bank system linkages is presented in figure 8 which follows:

Fig 8: Ice Bank System
The cold storage system linkages are presented in Figure 9, which follows:

Fig-9 Cold Storage refrigeration features:

3.4 Compressed Air System

The compressed air system is meant to cater to the needs of pneumatic packaging machines and for operation of control valves. The following are the specifications of compressors in use.

- Manufacturer: ELGI
- Capacity: 1535 liters/min = 50 cfm
- Working Pressure: 12 kg/cm²
- Double stage reciprocating type (2 Low pressure cylinders and 1 high Pressure cylinders)
- Receiver Capacity: 500 liters

Motor specification:
- Rating: 15 hp, P.F :0.84, r.p.m(N):1460
- Current: 20.6 A

An overview of the compressed air system along with uses of compressed air in the plant is given in the following figure.
Air Compressor Flow diagram

Compressed air system

Motor

Air Compressor

Receiver

• Milk packing unit 3
• Ghee packing unit

• Pasteurizer steam valve, solenoid valve
• De-odorizer - Flow diversion valve, flow regulating valve
• Cream pasteurizer - flow diversion valve, steam valve
• CIP: steam valve

Valve at user end

Fig-10 Compressed air system along with uses
 IMPLEMENTATION OF A WELL-DEFINED ENERGY MANAGEMENT POLICY

- Improving how energy is managed by implementing an organization-wide energy management program is one of the most effective ways to bring about energy efficiency improvements.

- Continuous improvements to energy efficiency occur only when a strong organizational commitment exists and a formal energy program is in place. A sound energy management program helps to create a foundation for positive change and to provide guidance for managing energy throughout an organization.

- Energy management programs help to ensure that energy efficiency improvements do not just happen on a one-time basis, but rather are continuously identified and implemented in an ongoing process of continuous improvement. Without the backing of a sound energy management program, energy efficiency improvements might not reach their full potential due to lack of a systems perspective and/or proper maintenance and follow-up.

- It is recommended that the progressive management of ..........Dairy may initiate Implementation of a well-defined energy management policy (an illustration follows):
Energy Management Policy

- Plant management is committed to excel in Energy Management Performance on a continual basis, through:
- Continual Upgradation of Technology, Systems and Services to optimize the Energy Costs.
- Declaring, Monitoring and Controlling the Energy consumption and specific electrical/thermal energy consumption effectively, on continuous basis.
- Providing Resources to achieve measurable objectives whenever necessary.
- Education and motivation of all the people Concerned through effective Communication & Recognition.
- Establishment of Benchmarking Standards in Dairy, in Energy Management.
- The organization has commitment to protect the Environment, by not disposing the effluents without treatment. The water treated with ETP has been used to feed fodder crop plots, medicinal plants, and gardening not discharging as waste.
- Our management is committed for the Health & Safety of its work force. A Safety Committee is constituted with employees working at different levels which meet periodically to analyze all aspects of employee’s health & safety during work. The Safety Committee recommendations are being implemented to improve the working conditions & safety of all.

Signed--------

Daily Production & Energy Consumption tracking and control chart suggested for adoption:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Description</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quantity Milk Processed (KL/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Electricity Consumed NEA plus DG (kWh)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Furnace Oil/Diesel Consumed for steam (KL)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Specific electrical consumption kWh/kL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Specific Fuel consumption MkCals/kL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.1. **Revising the approved electrical demand with NEA from 500 kVA to 400 kVA.**

**Present situation:**
- The NEA approved maximum demand is 500 kVA and minimum billing demand is 250 kVA.
- The actual maximum demand over the past two years has been less than 250 kVA.
- As run (normal) Maximum demand from TOD meter: 238kVA
- Operational Power Factor (P.F) : 0.81

During study, the APFC panel was rectified and made functional to achieve 0.98 power factor, through housekeeping improvements (loose connections and blown fuses attended to) at zero investment basis.

**Recommendation:**
- By improving the power factor to 0.98, the maximum demand reduces to 196KVA. Maximum Demand reduction achieved by improved PF= 238(present)-200 (minimum billing demand)= 38 kVA/month
- Potential demand charge reduction at Rs 230/kVA x 38kVA= Rs 8740/ month or 104, 880 per year
- This benefit will accrue only if the approved demand is revised to 400kVA from the present demand of 500kVA.
- Annual electricity Cost savings achievable by revising maximum Demand agreement with NEA from 500 to 400 kVA demand: 104,880
- Investment: NIL.

5.2. **Effective use of Ice Bank System:**

**Present Situation:**
- The Dairy has an ice-bank refrigeration system through which chilled water is delivered to the milk pasteurizer, raw milk chilling, butter pasteurizer for process and direct expansion with ammonia for cold room chilling where the milk is stored at 4°C.
- The refrigeration plant consists of three compressors 2 nos. of 45 TR and one of 60 TR capacities. Normally one 45 TR compressor is in operation.
- The operating schedule of the 45 TR compressor was observed as follows.

<table>
<thead>
<tr>
<th>Hours of operation</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>19/day</td>
<td>7 am - 2 am</td>
</tr>
<tr>
<td>10/day</td>
<td>7am - 5pm</td>
</tr>
<tr>
<td>6/day</td>
<td>5pm - 11pm</td>
</tr>
<tr>
<td>3/day</td>
<td>11pm - 2am</td>
</tr>
</tbody>
</table>
• The current load works out to 57.26kW (being 42+11+4.26) which, in other words amounts to 1088 kWh for 19 hour working a day, towards meeting process, cold room chilling requirements.
• It is seen that the compressor is switched off from 2 AM to 7 AM in the morning when the tariff is the least on one hand and conditions most favorable for ice making on the other. (The cooling water temperature being lowest for good condenser effectiveness and better refrigeration efficiency)
• In addition, the ice buildup over the coils is found to be negligible. Thus, when peak demand for refrigeration occurs at 7 AM in the morning, the compressor is unable to meet the peak demand for raw milk chilling and pasteurizer. This results in higher temperature of the outlet milk from the pasteurizer (about 8oC as against the desired 4oC).

**Recommendation:**

Adapt revised operational timings of 45 TR chiller for ice bank build up and process needs; provide effective cold storage partitioning and dedicate a new 10TR chiller for cold room needs.

To overcome the quality issues arising from high milk output temperature and to reduce the energy costs by taking advantage of night time tariffs, the following operation schedule is suggested for the refrigeration compressor.

<table>
<thead>
<tr>
<th>Description</th>
<th>TR</th>
<th>Hours</th>
<th>Operation Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice making for Ice bank</td>
<td>45</td>
<td>6</td>
<td>11pm-5am</td>
</tr>
<tr>
<td>Process</td>
<td>45</td>
<td>3</td>
<td>9am -12pm</td>
</tr>
<tr>
<td>cold Room</td>
<td>10</td>
<td>5</td>
<td>12pm-5pm</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>6</td>
<td>5pm -11pm</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>6</td>
<td>11pm-4am</td>
</tr>
</tbody>
</table>

• The cold room requirement has been calculated to be 10 TR. It is suggested to provide effective partitioning and assign a new dedicated 10TR unit for maintaining the cold room temperature rather than running a big 45 TR compressor all through.
• By operating the 45 TR compressor during lean tariff hours from 11 PM to 5 AM, sufficient amount of ice buildup will take place, enabling the stored ice to provide relief during chilling peak load from 7 AM onwards as milk receipts commence.
• **Cost benefits of this option are summarized as follows.**

<table>
<thead>
<tr>
<th>Description</th>
<th>kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Electricity consumption with existing schedule of operation, considering 350 day working@1088kWh/day</td>
<td>3,80,800</td>
</tr>
<tr>
<td>Annual Electricity consumption, with suggested schedule of operation of 45 TR and 10TR new chiller(57.26kW<em>9Hrs plus 12.5kW</em>17Hrs)@ kWh</td>
<td>2,54,744</td>
</tr>
</tbody>
</table>
daily, over 350 annual working days

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Energy Savings with suggested operating schedule, kWh</td>
<td>126,056</td>
</tr>
<tr>
<td>Annual energy cost savings potential, @.11.60/kWh</td>
<td>1,462,250</td>
</tr>
<tr>
<td>Procurement cost of a new 10 TR chiller alongside effective partitioning in cold storage area, NR</td>
<td>3,00,000</td>
</tr>
<tr>
<td>Simple Payback period</td>
<td>2.46 months</td>
</tr>
</tbody>
</table>

It may be appreciated that benefits of better chiller efficiency in night hours, lower tariff advantage and better process efficiency add to the savings potential.

5.3. Operating the Effluent Treatment Plant (ETP) during low tariff off peak period - shifting ETP load of 10 kW over 6 Hr duration, from peak to off peak hours:

Present situation:

- Total measured kW drawn by ETP = 10 kW.
- At present ETP, is operating at peak time and normal time
- For peak tariff duration, electrical energy consumption and cost = 10 KW x 6 hours = 60 KWH and at Rs 8.75/kWh = 525 / day amounting to Rs 1, 91,625 /year considering 350 days working.
- For Normal tariff duration, electrical energy consumption and cost = 10 KW x 2 hours = 20 KWH@ Rs 7.10/kWh = 142 /day amounting to 51,830 /year.
- Total annual ETP running electrical energy cost = 191625 + Rs 51830 = 2, 43,455 per year.

Cost differential of operating ETP at off peak tariff hours:

- For off peak tariff duration, energy consumption and cost = 10 KW x 6 hours = 60 KWH @NRs 4.30 = NRs 258 /day amounting to 94,170 / year
- For normal tariff duration, consumption and cost remain the same as above.
- Thus, running energy cost with revised hours of operation to off peak tariff duration and normal tariff duration = NRs. 94,170 + 51,830 = NRs 1,46,000.
- Electricity cost Saving annually, with availing of off peak tariff advantage = NRs. 243455 – NRs. 146,000 = NRs. 97,455 per year.
- About 10 kVA of Maximum demand drawn is also likely to be saved once off peak operations are made operational.
- Investment: NIL
5.4. Operating ground water pump at night, off peak hours:

Present situation:

- Measured kW drawn by ground water pump= 5.9 kW.
- At present, ground water pump is operating at peak tariff time and normal tariff time.
- For Peak tariff time, energy consumption and cost= 5.9 kW x 6 hours = 35.4 kWhr@ NRs 8.75 = NRs 309.75 / day amounting to NRs. 113058.75 /year @ 350 day working.
- For Normal tariff time, energy consumption and cost = 5.9 kW x 2 hours @ NRs 7.10 = NRs 83.78 /day amounting to NRs 30579.70 /year
- Total operating cost/annum=NRs 113058.75 + NRs 30579.70 = NRs 143638.45
- With recommended option of operating ground water pump at off peak hours:
  - Consumption and cost for off peak tariff time = 5.9 kW x 6 hours = 35.4 kWhr = 35.4 x NRs 4.30 = NRs 152 /day=  NRs 55560.30 / year
  - Consumption and cost for Normal tariff time remains unchanged as above.
  - Annual operating cost by shifting pump operations to off peak hours = NRs 55560.30 + NRs 30,579.70 = NRs 86,140
  - Annual energy cost Saving by availing of off peak tariff advantage = NRs 143638.45 - NRs 86,140 = NRs 46,183
- Investment :Nil
- Additionally, the peak demand shift would lead to reduction of maximum demand by about 6.0 kVA.

5.5. Installation of Desuperheater at ammonia compressor discharge

Present situation:

The discharge temperature of ammonia refrigerant from the 45 TR compressor is around 130°C and is in superheated condition. This influences condenser load, compressor discharge pressure significantly alongside compressor power consumption. The present power consumption by compressor alone is 42 kW.

Recommendation:

A Desuperheater to be installed as shown in the following figure 11, to recover heat in the form of hot water from the superheated Ammonia refrigerant.

This measure would help:

- To produce hot water at 65deg C for process needs(CIP cleaning, washing, etc)
- To reduce the cooling load in the condenser, compressor discharge pressure
- To reduce compressor power consumption by about 5%.
Fig-11 Illustrative layout for de-superheater installation

**Cost Benefits of Option :**

Potential Hot water generation at 65 deg C, from 27 deg C inlet from 45 TR compressor =500 LPH

Hot water generated over 9 Hr working per day =4500LPD

Heat savings in kCal/day by waste heat recovery =171,000

Steam equivalent savings a day @ 600 kCal/kG =285

Fuel oil savings per day in kG at E.R of 13.3 =21.43

**Annual fuel oil savings @ 350 day working, in MT** =7.500

Annual fuel cost savings @NR 75000/MT in NRs =562,500

**Annual savings in compressor power @ 5% in kWh** =6,615

Annual electricity cost savings @ NRs. 11.60/kWh in NRs. =76,734

Total annual energy savings potential in NRs =639,234

Investment envisaged for procurement and installation of Desuperheater =NRs. 500, 000

Simple payback period =9.4 months

**Vendor information is provided as part of Exhibit 4**
5.6. Heat recovery from DG set flue gas.

Present situation

Hot water needs being met by boilers using F.O/Diesel
Diesel Generator exhaust gases leaving at 400 deg C
Average generator running hours per day = 03
Average fuel consumption = 30 liters/hour
Flue gas mass in kgs/Hr = 600
Exhaust temperature = 400°C

Recommendation

To incorporate a coil type/shell and tube type waste heat recovery unit for hot water generation from DG Waste flue gases:

Cost Benefits

Proposed Exhaust temperature after waste heat recovery = 250°C
Heat recovered from exhaust gases = 600*0.24*(400-250)
= 21600 kcal/hr
Hot water generation potential @80oC from 27degC = 21600/53
= 407 kg/hour
Hot water generation potential per day = 407x 3 hours
= 1221 kg/day
Equivalent fuel saving per day, at 13.3 boiler ER in kgs = 8.10
Annual fuel saving potential @350 day working in kgs = 2835
Annual cost savings potential @ NRs. 9/kG = NRs. 212,625
Envisaged Investment for waste heat recovery unit = NRs. 500,000
Simple payback period = 28 months

Vendor information is provided as part of Exhibit 4
5.7. Installation of a 1 KL/Day solar hot water system to generate hot water.

Present situation:

Hot water needs for CIP, washing etc. are met through costly boiler steam route.

Purpose of Utilization of solar hot Water: CIP Requirements, boiler makeup water pre-heating replacing corresponding fuel use in boilers:

Recommended capacity of Solar Water Heater = 1000 LPD

Expected temperature of Hot water from 27 deg C = 75 deg C

Cost Benefits:

Thermal energy capture potential per day in kCal = 1000 x (75-27)

=4, 80,00

Fuel savings potential in kG/day @13.3 boiler ER =48000/600*13.3

=6.0

Annual fuel oil savings @350 day working = 2100 lit.

Annual fuel cost savings @NRs 75/lit = NRs.157,500

Envisaged Investment for 10 KLPD solar HW system = NRs. 500,000

Simple Payback period = 3.18 years

Suggested technology: Heat tube collector based SHW system (Australian Technology)

Illustrative Vendor reference: Sun Works Nepal (Niraj Shrestha, Tele: 01-4330854)

http://www.sunworksnepal.com.np/

5.8. Milk chilling and Pasteurization efficiency improvements.

A. Ensuring lowest milk temperature at receipt, close to 4 deg C:

- Incoming milk is being received at temperature ranging from 7 deg C to 10 deg C (average 8.5 deg C), whereas the pasteurization is designed for 4 deg C basis, leading to additional chilling needs, upon receipt during processing, affecting quality as well.
- Given a typical 40 KL processing a day, an additional chilling duty of 4.5 deg C relates to an extra chilling load of 59.5 TR (40,000*4.5/3024); valued at 75.6 kWh energy input worth NRs. 877 every day at NR 11.60/kWh.
Ensuring lower receiving temperature of milk receipt by suitable improvements at supply end bulk chillers, and transportation, annual saving of NRs. 71,750 for every deg C margin, in addition to improving quality and process efficiency.

Refrigerated tanks, need based supply side chilling improvements are interventions called for, and an envisaged investment of NRs. 300,000 is justifiable for a 2 deg C margin and 2 year simple payback period.

B. Ensuring pasteurization regeneration efficiency and temperature controls:

As per design data, the milk temperature after pasteurization needs to be maintained at 4°C. However due to the higher temperature of the incoming milk which varies from 5-9°C the pasteurizer milk outlet temperature is also high leading to quality problems and returned milk. A comparison of actual versus required parameters in pasteurizer is given in the table below.

<table>
<thead>
<tr>
<th>Requirement as per manufacturer</th>
<th>Actual at site</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R1 inlet temp</strong></td>
<td>4</td>
</tr>
<tr>
<td><strong>R1 outlet temp</strong></td>
<td>50</td>
</tr>
<tr>
<td><strong>R2 outlet temp</strong></td>
<td>72.5</td>
</tr>
<tr>
<td><strong>Heating outlet Temp</strong></td>
<td>80</td>
</tr>
<tr>
<td><strong>After regeneration from R2</strong></td>
<td>57.6</td>
</tr>
<tr>
<td><strong>After regeneration from R1</strong></td>
<td>11.6</td>
</tr>
<tr>
<td><strong>Chiller outlet temp</strong></td>
<td>4</td>
</tr>
</tbody>
</table>

**ANALYSIS:**

- Design heating cycle regeneration efficiency = \[(72.5-4) \times \frac{100}{(80-4)}\] = 90.13%
- As run heating cycle regeneration efficiency = \[(71-8) \times \frac{100}{(78-8)}\] = 90%
- Design cooling cycle regeneration efficiency = \[(80-11.6) \times \frac{100}{(80-4)}\] = 90%
- As run cooling cycle regeneration efficiency not measurable.
- As per design the heat duty from 72.5 deg C to 80 deg C for 40 KL a day works out to:
- Around 500 KG of steam \[(40,000LPD \times 7.5 \text{ delta T})/(660kCal/kG-60kCal/ kgs)\]
- Around NR 3175 as cost of fuel @ NR 6350 per MT of steam.
- Similarly, chilling duty from 11.6 deg C to 4 deg C would for 40000LPD would mean a TR load of about 100,(40000*7.4/3024)which works out to a power requirement of 125 kWh every day (@1.25kWh/TR)worth NR 1522.5.
• Cost of Pasteurization per KL as per design data amounts to NR 117; or NR 4698 a day or NR 16, 44,300 per annum, a significant sum.
• Present instrumentation and automation level is inadequate and deserves an Upgradation.
• Present temperature profile across pasteurizer indicates shift, mainly on account of higher incoming milk temperature.

RECOMMENDATIONS:

Given the importance and significance of energy intensity of pasteurization. It is strongly recommended to:

1. Upgrade, in consultation with OEM, the existing pasteurizer, by way of instrumentation, automatic control, addition of plates as warranted, to ensure operation with a regeneration efficiency of 93%, at full capacity, while enabling monitoring of performance too.
2. An improvement of regeneration efficiency from 90 to 93 % would mean a reduction of heating and chilling duty to an extent of 2.1 deg C. On a pro rata basis, this would mean:
   • A heat duty reduction by 28%, ie by 140 KG steam equivalent(3.684 tons of oil equivalent per annum at E.R. of 13.3 and 350 day working); worth NR 889 a day or NRs. 311,150 per annum plus
   • A Chilling load reduction by 2.1 deg C would mean a pro-rata saving of 27.63% valued as 34.54 kWh a day (12059 kWh an year) worth NRs. 139,884 an year.
   • The total energy savings potential worth NR 4, 58,500 could justify an investment of NRs 1,350,000 towards upgrades and modernization of pasteurizer, for a three year simple payback period.

5.9. Insulation of chilled milk pipeline

Milk lines from RMST to pasteurizer, are left bare resulting in heat gain. Insulation of milk lines is suggested, to avoid heat gains and reduce refrigeration load.

<table>
<thead>
<tr>
<th>Rise in temperature from RMST to Balance tank</th>
<th>1.3°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilling load to maintain the same temperature/day</td>
<td>40,000<em>1</em>1.3/3024</td>
</tr>
<tr>
<td></td>
<td>17.20 TR per day</td>
</tr>
<tr>
<td></td>
<td>17.20TR*1.25 kW/TR</td>
</tr>
<tr>
<td></td>
<td>21.5kWh/day (7525 kWh/yr)</td>
</tr>
<tr>
<td>Annual savings at NRs 11.60/kWh</td>
<td>87,290</td>
</tr>
<tr>
<td>Investment envisaged for cold insulation</td>
<td>3,000</td>
</tr>
<tr>
<td>Payback period</td>
<td>Less than a month</td>
</tr>
</tbody>
</table>
5.10. Installation of VFD for Chilled water pump

**Present situation:**

The common chilled water pump supplies chilled water to pasteurizer, incoming milk (reception) chiller and cream pasteurizer. More than 80% of the time only one of these equipment requires chilled water i.e. they don’t operate simultaneously. This results in idle flow through equipment even if they are not in operation.

**Recommendation:**

The valves to idle equipment can be closed diligently and a VFD can be fitted to chilled water pump to avoid throttling and reduce the pumping power.

![Fig-12 Location of VFD installation](image)

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power drawn by existing chilled water pump</td>
<td>4.8 kW</td>
</tr>
<tr>
<td>Power requirement at rational flow with VFD</td>
<td>2.4 kW</td>
</tr>
<tr>
<td>Savings in power, kW; kWh per day</td>
<td>2.4 kW</td>
</tr>
<tr>
<td></td>
<td>21.6 kWh/day</td>
</tr>
<tr>
<td>Annual energy savings @ 9 hrs operation per day, 350 days, in kWh and in NR @11.60/kWh</td>
<td>7560 kWh/yr</td>
</tr>
<tr>
<td>Annual cost savings in NRs. @11.60/kWh</td>
<td>NRs. 87,696</td>
</tr>
<tr>
<td>Investment towards a variable frequency drive.</td>
<td>NRs. 50,000</td>
</tr>
<tr>
<td>Payback period</td>
<td>6.8 months</td>
</tr>
</tbody>
</table>
5.11. Performance of Boilers and measures for fuel economy:

Present Situation:

FO Boiler assessment indicates the following features:

Efficiency by indirect method: 80%
Evaporation ratio: 13.3
Cost per MT of steam generated: NRs. 5626
Key losses due to high excess air: exit temperature

High cost of FO and steam cost accordingly, a concern.

Diesel fired Boiler is of coil type:

Efficiency is around 80 %
Steam quality is suspect indicated by ER of 19.78

Indicative cost of steam at equivalent 13.3 ER =NRs. 7427

Recommendations:

Going for of a new energy efficient boiler with husk firing is strongly recommended for cost reduction and GHG emission avoidance, and, in immediate context, excess air control and heat recovery can be considered for immediate benefits, as discussed below:

Reducing excess air by tuning the FO boiler

The existing level of excess air is 110% reflected by oxygen % of 11 in flue gas. The ideal %oxygen in flue gas should not exceed about 5 % corresponding to an excess air of 31 %. This will result in 2 % improvement in boiler efficiency.

Heat recovery from the exhaust of FO boiler

The FO boiler exhaust temperature has been measured to be 260°C. This is quite high compared to best practice of 180°C. Due to the high exhaust temperature the efficiency is only 80%. It is suggested to incorporate a heat exchanger in the exhaust to generate hot water at 80°C. This can be used for CIP cleaning, pasteurizer, butter melting and other heating applications which will in turn reduce the heat demand.
The heat recovery system, envisaged to cost NR 300,000 offers one year simple payback period.

Replacement of oil fired boilers with rice husk fired boiler.

Considerations and rationale:

- Two boilers, (one Furnace oil fired 1500 KG/Hr capacity fire tube boiler, with an operational efficiency of 80% and evaporation ratio of 13.33 and one diesel oil fired coil type boiler of 850 kg/Hr capacity) serve to meet the steam and hot water needs of dairy.
- Annual fuel oil consumption is 67 MT while diesel consumption for boiler is 45 MT.
- The equivalent steam generation per annum at ER of 13.33 is 1493 MT.
- At FO cost of NR 75000/MT and Diesel cost of NR 99000 per MT, the fuel costs for boiler operations work out to NR 94,80,000 reflecting an overall steam cost of NR 6350/MT.
- Findings on boiler performance are presented as exhibit 3.
- Given the high cost of steam and significant cost implication in manufacturing cost, as also the fact that dependence on imported fuel is warranted, it is recommended to install a rice husk based 1.5 TPH capacity state of the art energy efficient boiler, replacing both existing boilers.
  A turn down ratio of above 4 and Atmospheric Fluidized Bed Combustion technology choice are desirable.
- The Agro fuel use would also enable FO and diesel oil based GHG emission mitigation.
- Supply chain of rice husk at reasonable cost is desirable for viability

Cost Benefits:

- At an envisaged evaporation ratio of 3.9, the husk requirements for same annual steam generation Works out to 382.8 TPA, which, at an indicative cost of NR 3000/MT, amounts to NR 1,14,80,000, leading to a cost reduction of NR 8,331,600.
- The indicative procurement cost of a rice husk boiler of 1.5 TPH rating with efficiency over 75%, is NRs. 55,00,000.
- The measure offers an attractive simple payback period of 8 months and could be considered for implementation in short term.
Names of two illustrative vendor sources are as follows:

**Ekta Engineering & Marketing P. Ltd**
Flat no.-402, fourth floor, Bagmati Chambers
Tripureshwor- Teku Road,
GPO Box-11482, Kathmandu, Nepal
Phone- 00977 1 4247676
Fax- 00977 1 4238131
Mobile- 00977 9851036530

<table>
<thead>
<tr>
<th>M/S</th>
<th>Industrial boilers; Regional Office, Delhi</th>
</tr>
</thead>
<tbody>
<tr>
<td>79-80, Satkar, Nehru Place, New Delhi – 110 019</td>
<td>79-80, Satkar, Nehru Place, New Delhi – 110 019</td>
</tr>
<tr>
<td>Tel. : +91-11-26453194 / 26453195 / 26417983</td>
<td>Tel. : +91-11-26453194 / 26453195 / 26417983</td>
</tr>
<tr>
<td>Fax</td>
<td>+91-11-26453197</td>
</tr>
<tr>
<td>Email : <a href="mailto:delhi@indboilers.com">delhi@indboilers.com</a>, <a href="http://www.indboilers.com">www.indboilers.com</a></td>
<td>Email : <a href="mailto:delhi@indboilers.com">delhi@indboilers.com</a>, <a href="http://www.indboilers.com">www.indboilers.com</a></td>
</tr>
</tbody>
</table>

5.12. **Insulation of Ghee boiling pan**

**Present situation:**

Un insulated hot surface of ghee boiler is leading to avoidable heat losses

**Recommendation:**

it is recommended to provide thermal insulation to the bare surfaces as assessed in cost benefit analysis which follows:

- Current surface temperature =76°C
- \( S = (10 + (T_s - T_a)/20) \times (T_s - T_a) \) = 610KCal/hr.m²
- Surface temp with insulation = 35 °C
- \( S = (10 + (T_s - T_a)/20) \times (T_s - T_a) \) = 83.2 Kcal /hr.m²
- Surface Area to be insulated = 3.77m²
- Net heat Saving = (610-83.2)*3.77 = 1986Kcal/hr = 3.31 kgs steam
- Fuel oil saving = 3.31/13.3 = 0.25 kg per hour
- F.O saving @5 hr/day,300 days/year = 375lit /year = worth NR 28125
- Investment for thermal insulation = NR 10000
- Simple payback period: = 4.26 months
5.13. Condensate Recovery from cream pasteurizer and ghee boiling pan:

Present situation:
At present all the condensate other than from pasteurizer is drained which results in loss of heat as well as good boiler quality feed water.

Cost benefits of recovery are presented as follows:

- Condensate of cream pasteurizer and ghee boiler is at around 75 liter per hour at 85°C which can be returned back to boiler.
- Heat Saving = 75*(85-30)=4350 Kcal per hour(7.25 kg steam equivalent)
- Annual fuel oil saving = 7.25 /13.3 = 0.545 KG F.O/Hr (817.5 lit FO/year)
- Annual Monetary savings @NR 75/KG = NRs. 61,312
- Investment for common pit + Level control pump (0.5HP) and piping = NRs. 30,000
- Operation cost of pump = NRs. 1000/year
- Net Saving annual= NRs. 60,312
- Simple Payback period = 6 months

5.14. Recovering condensate during Diesel boiler operation

Present situation:
Though condensate is recovered from pasteurizer, it is used only with FO fired Pressels boiler, due to non availability of interconnecting piping. Hence, when the Diesel boiler is operating alone, the condensate is drained.

Recommendation:
It is suggested to have piping, insulation, interconnection to Diesel boiler so that the condensate can be used at all times.

Measure Cost benefits are as follows:

Estimated condensate loss/day = 365K
Heat loss in kCal and steam = 365 * (85-30)=18250kCal/day =30.42 KG steam.
Diesel loss @13.3 ER = 2.29KG/day
Diesel savings considering 300 day working= 687lit/yr
Diesel cost savings/year@NR99/KG= NRs. 68,013
Envisaged Investment needs for interconnections = NRs. 10,000
Simple payback period = 1.8 months.