NEPAL RENEWABLE ENERGY PROGRAMME

ASSESSMENT REPORT ON FUEL SWITCHING OPPORTUNITIES IN SELECTED SUB-SECTORS

September 2022

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Executive Summary

The study was conducted in three sub-sectors namely Dairy, Paper and Brick Kilns with the main objectives of identifying the fuel switching opportunities to cleaner fuel based on relative cost advantage of different fuels and to prepare pipeline for SECF.

The study was conducted by literature review, meeting with related industry association and field visit of industries of each sub sector to analyze the technology and fuel type they are currently using. The study reveals that the industries using diesel as the primary source of fuel can be replaced by pellet. Similarly, industries using firewood purchased at the rate NPR 12.0 per kg or more can benefit economically and environmentally by switching to biomass-based pellet use. However, fuel switching from other traditional fuels like coal and rice husk by pellet is not economically feasible based the study. Thus, it is good opportunity to replace diesel with pellet which will give financial benefit to the industries as well as support to decrease the carbon emissions.

NREP should focus on the industries which use diesel as primary fuel and should provide technical as well as financial support for fuel switching in those industries.

1. Introduction

1.1 Programme Introduction

The Nepal Renewable Energy Programme (NREP) is a Government of Nepal programme funded by the British Embassy-Kathmandu (BE-K) aiming to transformational change in Sustainable Energy development in Nepal through increased private investment resulting in low-carbon economic growth and sustainable energy access for all. NREP operates in three Provinces: Madhesh, Lumbini, and Karnali. The Programme is implemented by the Alternative Energy Promotion Centre (AEPC) with Technical Assistance from the DAI Global UK Consortium—including DAI, Winrock International, Policy Entrepreneurs Inc., and Samriddha Pahad.

Briefly, NREP has been designed to increase private sector investment to develop distributed renewable energy markets, primarily in commercial, institutional, and industrial market sectors; increase universal energy access, and a corresponding higher quality of life, to Nepali citizens living in remote regions and facilitate a policy, planning, legal construct, and regulatory environment conducive to both enabling and sustaining progress in RE market development and universal energy access.

NREP goals, categorized by functional areas shown below in the left column, include:

MARKET ASSESSMENT & DEVELOPMENT	• To develop 16 MW of distributed renewable energy (DRE) projects, capped at 1 MW/project, by assessing the technical and economic merits of DRE projects and by offering financial assistance to: o Commercial, Institutional & Industrial markets, o 200 schools & health centres institutions, o 500 small businesses, and o Electric Vehicle charging stations.
UNIVERSAL ENERGY ACCESS	• To increase universal energy access (UEA) by the facilitation of: o 95,000 households being served by DRE, e.g. with electric induction cooking, o Solar microgrids, and o Grid-connected micro-hydro plants
INNOVATIVE FINANCE	• To de-risk private sector investment in DRE and UEA projects through Viability Gap Funding-based Sustainable Energy Challenge Fund (SECF) with specific Funding Windows designed to meet NREP Market Development & Assessment goals. • To identify financing mechanisms, that may not be currently used in Nepal, that will attract private sector investment in DRE.

ENABLING ENVIRONMENT	• To strengthen institutions and policies, e.g.: o Developing the capacity of public sector entities such as AEPC, NEA, MoEWRI, and ERC, o Developing the capacity of private sector entities such as the solar PV and battery energy storage industry associations, DRE project developers and investors, banks and lending institutions, and other market-driven interests, and o Strengthening DRE-related policies and regulations such as the National Renewable Energy Policy, and the related Renewable Energy Act and Electricity Act; Public-Private Partnerships; net metering and PPA agreements; electricity and EV charging tariff analysis; and Long-Term Strategy of Net Zero Energy by 2050 with Cross-Border Electricity Trade.
CLIMATE CHANGE MITIGATION	• To reduce CO2 emissions, by: o Reducing the emissions and human health hazards related to woody biomass and animal dung used in traditional cooking by facilitating market-driven solutions to widespread electric induction cooking and other clean cooking solutions. o Displacing diesel back-up generators with solar/storage systems at end-user sites; replacing significant portions of Nepal's imported coal-generated energy with larger solar PV projects. o Contributing to Net Zero Emissions by 2050 status, e.g. with hydro/solar seasonal complementarity and Cross-Border Electricity Trade with, e.g., India and Bangladesh.

1.2 Background

Building on a strong foundation of cooperation, NREP and AEPC have worked together collaboratively to prioritize Year 4 activities to continue substantial progress to date on enabling environment activities, but with primary focus on market development activities including building an evidence base to support viability gap fund (VGF) financial assistance to distributed generation (DG) projects, maintaining the DG project pipeline, and Sustainable Energy Challenge Fund (SECF) operationalization including proposal evaluations, awards, disbursements, and monitoring and evaluation.

NREP and AEPC convened the *Electricity Access, Energy Reliability, and Energy Transition Strategy Meeting in* March 2022 with representatives of MoEWRI, NEA, MOF, MOFE, NOC, WECS, NPC, ERC, BE-K, and NREP. The overarching goal of the meeting was to identify what activities should be implemented and prioritized to meet Programme goals, within the context of increasing electricity demand and displacing fossil fuels, i.e., via fuel switching.

Meeting came up with three strategies; ***Electricity Access***, ***Energy Reliability*** and ***Energy Transition***. Electricity Access (बिद्युत् पहुँच): Refers to the provision of reliable and affordable access to electricity to all individuals and communities in Nepal. This includes ensuring that households, businesses, and institutions have access to electricity, as well as the necessary infrastructure and services to maintain a reliable and sustainable supply.

Energy Reliability (ऊर्जा विश्वसनीयता): Refers to the ability of the energy system to deliver consistent and uninterrupted energy supply, as well as the ability to quickly recover from disruptions such as natural disasters or equipment failures. This includes ensuring that the energy infrastructure is robust and resilient, and that there is adequate investment in maintenance and upgrades to prevent outages and ensure reliable energy supply.

Energy Transition (ऊर्जा परिवर्तन): Refers to the shift from traditional fossil fuel-based energy sources to renewable and clean energy sources such as expansion of hydropower, solar, wind, and other forms of renewable energy, as well as the adoption of energy-efficient technologies and practices.

Meeting participants had a robust discussion on the need and timing for energy transition; there were some contestation on the suitable time for energy transition. During the meeting, there was a thought-provoking discussion on whether the energy transition should begin simultaneously with Electricity Access and Energy Reliability initiatives or be initiated only after achieving these goals. As an energy transition, ***fuel switching*** from fossil fuel and/or other traditional biomass to electricity could greatly increase electricity demand. Equally, this will include displacing traditional and fossil fuel as the primary resource to more processed pellets and other domestically produced cleaner fuel in brick kilns, dairies and paper industries.

Based on the discussion on energy transition theme, in year four annual work plan, NREP planned to conduct a brief assessment of a few highly promising sectors for possibility of fuel switching and see if project pipeline for Sustainable Energy Challenge Fund (SECF) could be increased. In the context, two sub-sectors have been identified as per the Energy Efficiency baseline study that is being conducted by NREP, those are Dairy and Paper. This study is being conducted for preparing concept note for Green Climate Fund (GCF), the major selection criteria for the sub-sectors in the study are carbon reduction potential, replacement potential of fossil fuels by renewable energy. Currently, the dairy industry, paper industry and brick industry in Nepal are largely dependent on fossil fuels, particularly wood, coal and LPG. According to the National Energy Efficiency Programme (NEEP) Implementation Plan published by the Government of Nepal in 2020, the dairy industry in Nepal consumes approximately 0.12 million tons of oil equivalent (toe) of energy per year, while the paper industry consumes around 0.15 million toe of energy per year. Regarding the brick industry, the "Third National Communication to UNFCCC" states that the brick industry in Nepal contributes to around 20% of the total industrial energy consumption in the country and emits around 1,493 Gg of CO2 annually. This report also notes that the primary fuel used by the brick industry is coal, which accounts for around 85% of the total energy consumed by the industry.

1.3 Objectives

- Identify the fuel switching opportunities to cleaner fuel in Dairy, Paper and Brick Kilns based on relative cost advantage of different fuels.
- Identify and prepare project pipeline for SECF on fuel switching opportunities.

1.4 Methodology

Literature review has been conducted to gather facts, data and information, mainly the reports published on energy efficiency[1], Energy Efficiency baseline study[2] and third national communication to UNFCCC[3]. Based on the literature review, three sub-sectors have been selected. Meetings with respective associations have been organized to have broader understanding and identify the gaps. List of industries have been collected from the associations. Some industries per sub-sector have been visited to collect information on consumption of energy (Electricity, traditional/fossil fuels, renewable energy), cost of fuel used and to know their perception about the energy being used. Based on the primary information,

[1] The National Energy Efficiency Programme (NEEP) Implementation Plan was prepared by the Government of Nepal and was published in 2020.

[2] The Energy Efficiency Baseline Study titled "Energy Efficiency Baseline Study for Commercial and Industrial Sectors in Nepal was conducted by the Nepal Renewable Energy Programme (NREP) and the Alternative Energy Promotion Centre (AEPC) in 2018. The report was published by the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF) and is titled "Energy Efficiency Baseline Study for Commercial and Industrial Sectors in Nepal".

[3] The report titled "Nepal's Third National Communication to the UNFCCC" prepared by the Ministry of Environment, Science and Technology (MOEST) in Nepal and was submitted to the UNFCCC in 2014. It provides information on the country's greenhouse gas emissions, mitigation actions, and adaptation measures.

cost comparison between traditional/fossil fuel and pellet has been done and an assessment report has been prepared including cost benefit analysis, technology options and technical aspects for each sub-sector.

1.5 Delimitations

- This study is based on information provided by respective industry associations, consultation with some industries visited and some secondary data.
- Based on the interaction with industry associations, site visit of sample industries was conducted.
- During interaction with industry associations and also during consultation with some industries, data regarding use of electricity in processing could not be identified. They were unaware about the use of electric boilers and electric furnaces in the industries. Dairy association shared that most of the industries use firewood and some use diesel as primary fuel, brick kilns use coal and most of the paper industries use rice husk in the boilers. Therefore, due to unavailability of data of electric boilers, electricity is not considered for fuel switching opportunity. So, as intermediate fuel, processed biomass pellet has been considered as the potential source of cleaner fuel for all sub-sectors and cost comparison of existing fuels has been conducted with pellet.

1.6 Brief Information about Selected Sub-sector

Dairy:

Dairy is an important and growing food industry in Nepal. According to National Dairy Development Board, there are 330 dairy industries in Nepal with cumulative processing capacity of 1500.35 kiloliters[4]. The dairy industry is characterized by multiple product mix, seasonal demand and capacity utilization variations, which impact specific energy consumption. Conventionally, the Nepalese Dairy Industries are producing standard milk as well as other milk products like yoghurt, ice-cream, cheese and butter. There are three major process steps for milk and milk products, namely chilling of raw milk for intermediate storage, Pasteurization of milk and, finally, cooling for storage and distribution. Dairy industry uses significant amount of electrical and thermal energy[5] for its operations and processes (GIZ/NEEP, 2012). Specific energy consumption (SEC) of dairy sector is 103.04 kWh/kl

[4] http://nddb.gov.np/storage/uploads/fm9WQcMT3gHXLXj7xFENqdlNvv1M5AZwUar4qoRH.pdf

[5] Details on fuel type and use data is not available.

(Electrical) and 1.79 GJ/kl (Thermal).[6]The study will focus on the fuel switching possibility only for the pasteurization process where the energy consumption is the maximum.

Paper:

The pulp and paper industry have been in production in Nepal for almost four decades. According to the National Industrial Survey National Report 2019/20 by the Central Bureau of Statistics, the total number of manufacturing units in the pulp and paper industry in Nepal is 51, providing employment to 2,093 people. The total input value in the sector is about NPR 1.831 billion with an output value of NPR 4.306 billion. Out of the 51 manufacturing units, seven are mechanized pulp and paper mills, while the majority of the paper industries are handmade units. The average installed capacity of the paper plant is 45.8 Tons per day (TPD), while the average production is 21.1 TPD. Currently, the paper industries in Nepal produce mainly two types of products: Bleached writing/printing & newsprint paper, and unbleached craft paper. The sector uses two types of fibers for papermaking, with 63% non-wood pulp and 37% used/scrapped papers. The specific energy consumption (SEC) of the paper industry is 879.3 kWh/MT (Electrical) and 17.49 GJ/MT (Thermal). The study will focus on the fuel switching possibility only for the boiler operation where the thermal energy consumption is maximum.

Brick Kiln:

Brick is a primary building material in many parts of Nepal, particularly in Kathmandu Valley and southern plains of Terai. Brick demand has increased dramatically for housing over recent decades. It is estimated that about 1100 Brick kilns are in operation in Nepal where approximately 200 brick kilns are operating in Kathmandu Valley[7]. The capacities of these kilns range from 15,000 to 50,000 bricks per day. Clay is the main raw material for brick making, which is available at very low cost. Brick making is an energy and labor-intensive process. Hand molding of green bricks is widely practiced in Nepal. Majority of industries are seasonal and operates mostly for about six months during dry season (Dec to Jun). Natural draft system or bull trench kiln (BTK) predominant kiln types in Nepal. Moving Chimney BTKs that were prevalent in Nepal have been replaced widely by the fixed chimney BTKs after Government intervention in 2003. Apart from BTKs, Clamp, Hoffman and Vertical Shift Brick Kilns (VSBK) also exist in Nepal. Government has promulgated the standards on chimney height and emission standards for the brick kiln Industries in 2008 (GIZ/NEEP, 2012). Brick

[6] WECS, 2019/20.

[7] Brick Kilns in Nepal-A Situation Report, Health Research & Social Development Forum, 2016.

Kilns are the largest contributor to CO_2 emission in this sector with 1493 Gg of CO_2 (66%) followed by cement industries and others[8]. The study will focus on the fuel switching possibility for the brick burning process where coal is used as primary fuel.

2. Analysis of Fuel Switching Possibility

2.1 Dairy

2.1.1 Process Description:

The processes involved in milk processing 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)
- Pasteurization
- Homogenization (as required)
- Packaging and storage, including cold storage for perishable products
- Distribution of final products

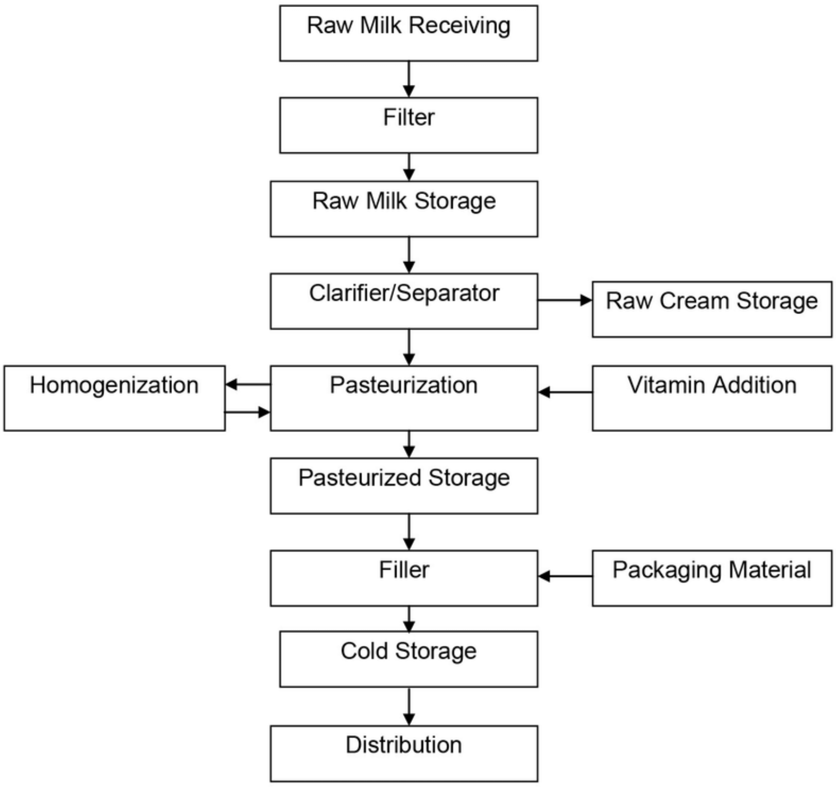
After being held in storage tanks at the processing site, raw milk is heated to separation temperature in the regeneration zone of the pasteurizer. The milk (now hot) is standardized and homogenized by sending it to a centrifugal separator where the cream fraction is removed. The skim is then usually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

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

[8] Third national communication to the UNFCCC.

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.



2.1.2. Existing Energy Use Pattern

Thermal energy is required for the operation of boilers to generate steam for the pasteurization of milk and other processes. Main thermal energy consumption is in pasteurization process where steam boilers are used. Currently most of the dairy industries are using firewood as primary fuel for boilers and some industries are using diesel fired boilers for steam generation. Apart from thermal energy, electrical energy is mainly consumed by motors, drives and utilities like compressors (both air and refrigeration), pumps and lighting.

Example:

Name of the Industry: XXX

Capacity: 5,000 liters/hour

Annual Production: 6,230 kiloliters

Type of fuel used: Firewood

Quantity of fuel used: 330,000 kgs/year

Cost of Fuel: NPR 15/kg

Annual expenses on fuel: NPR 4,950,000

Specific Energy Consumption per kiloliter: 243,660 kCal.

2.1.3 Cost Comparison for Potential Fuel Switching

Cost Comparison between Pellet and Firewood:

1 Ton of pellet	1.5 cords of firewood	(1 cord=128 cu.ft.=5000 lbs=2267 kgs)
1 kg of pellet	3.4	kg of firewood
Cost of pellet	30	per kg
Cost of firewood	15	per kg
Cost of firewood equivalent to 1 kg of pellet	51	NPR
Cost savings (NPR)	**21**	NPR

It is clear from table that with the current price of firewood i.e NPR 15 per kg, pellet is cost effective fuel than firewood. Hence, it is financially feasible to replace firewood with pellet until the cost of firewood goes down and make economic sense.

Cost Comparison between Pellet and Diesel:

GCV[9] of Diesel	10000	kcal
GCV of pellet	4500	kcal
1 litre of Diesel	2.22	kg of pellet
Cost of diesel	172	NPR/litre

[9] Gross Calorific Value.

Cost of pellet	30	NPR/kg
Cost of pellet equivalent to 1 litre of Diesel	66.67	NPR
Cost Savings (NPR)	**105**	

It is clear from table that with the current price of diesel, pellet is cheaper fuel than diesel. So, it is financially attractive to replace diesel with pellet.

2.2 Paper

2.2.1 Process Description

The waste paper, consistent out of white cuttings, copy paper, books and newspaper, is mixed with water in the pulper machine. V-Belt is used to move the agitator to receive a homogeneous mixture of pulp. The pulp is then pumped into a High-Density Cleaner that removes all foreign particles such as staples, stones screws, nails, pebbles and other debris. After this process the pulp is forwarded to the primary turbo separator, which separates the unwanted materials. Rejected mixture from primary Turbo Separator is sent to the secondary turbo separator which is further refined. The rejected mixture from secondary turbo separator is passed via vibrating flat screen where the final selection of mixture is done whether to send it back to the process through high density cleaner or to send for waste management practices.

The accepted pulp from both the turbo separator is then moved through a Thickener that decreases the water content and improves the consistency of the pulp, before going to the Potcher. Before it is ready for manufacturing, the pulp is pumped maintaining a constant weight at the production line. Surplus pulp will flow back in the storage tank. The pulp suspension then passes through the Approach Flow, a 3 stage centric cleaner system that separates the heavier unwanted particles from the pulp and maintains a desired quality level. It is then forwarded to the head box of the production line through the pressure screen. The head box distributes the pulp solution on the wire section, where the water content is constantly reduced through different stages (1st Press followed up by 2nd Press). The drying process is done with the injection of steam, followed by a vacuum pump that sucks out the water by the pressure.

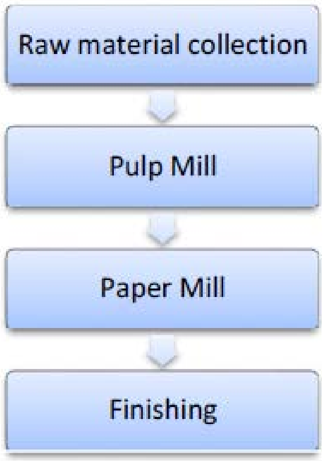
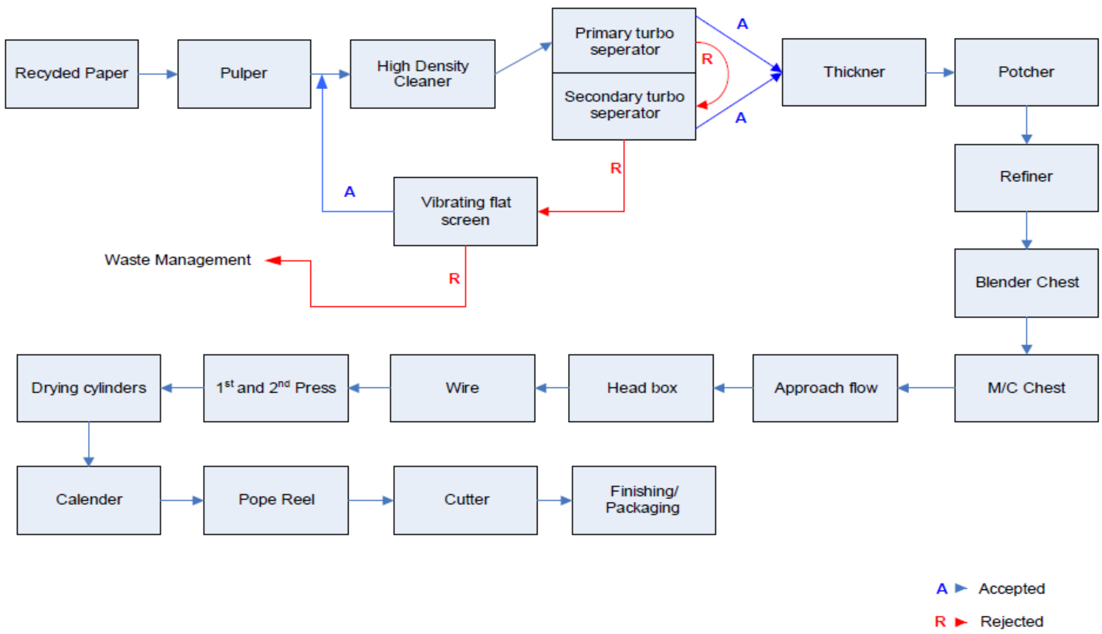
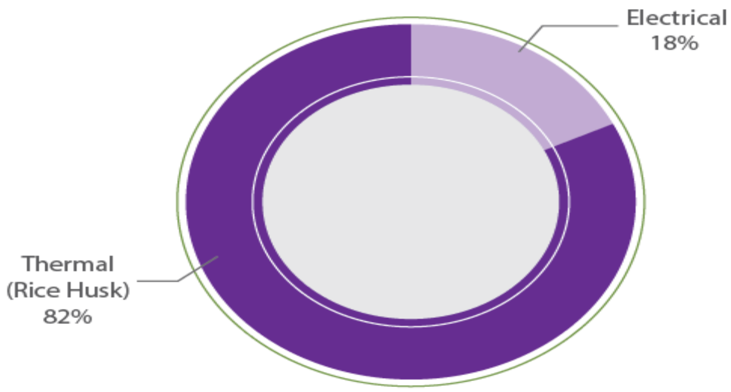


Fig: General Process Overview



2.2.2 Existing Energy Use Pattern

Paper industries consume electrical as well as thermal energy in their production processes. The larger units are installed with boiler for steam generation. These units use rice husk as fuel for boiler. Electrical energy is mainly used for the drives and lighting.



Example:

Name of the Industry: XXX

Capacity: 20 TPD

Annual Production: 3,057 Ton

Type of fuel used: Rice Husk

Quantity of fuel used: 2,950 Ton/year

Annual expenses on fuel: NPR 20,650,000 (2950000*7)

2.2.3 Cost Comparison for Potential Fuel Switching

Cost Comparison between Rice Husk and Pellet:

GCV of rice husk	2800	kcal/kg
GCV of pellet	4500	kcal/kg
1 kg of rice husk	0.62	kg of pellet
Cost of rice husk	7	NPR/kg
Cost of pellet	30	NPR/kg
Cost of pellet equivalent to 1 kg rice husk	18.66667	NPR
Cost Savings	**-11.6667**	NPR

It is clear from table that with the current price of rice husk, pellet is expensive fuel than rice husk. So, it is not financially feasible to replace rice husk with pellet.

2.3 Brick Kiln

2.3.1 Process Description

Manufacturing of bricks constitutes four stages i.e., preparation of soil, molding, drying and burning.

Preparation of Soil

The removal of top soil involves the loose materials present at the top of the soil for a depth of about 200 mm. These materials should be removed as they contain a lot of **impurities** and are not used in the preparation of bricks.After digging the soil for about 200 mm, the soil is spread on the level ground, and the heaps of clay are about 600 to 1200 mm.After spreading the soil on the ground, it should be cleaned of stones, vegetable matter, pebbles, etc. If excess non-clay materials are present, the clay should be washed and screened. This whole process will become expensive and clumsy. The lumps in soil should be crushed into a powder form. The soil is then exposed to the atmosphere for softening for a few weeks depending on the nature of the soil, which imparts plasticity and strength to the soil. To increase the quality of soil, additionally, sandy or calcareous clays may be added in suitable proportions along with coal, ash, etc. and the whole mass is mixed uniformly with water. After adding the sufficient quantity of water, the soil is kneaded under the feet of men or cattle to make it stiff and homogeneous. In general, for handmade bricks, the soft plastic clay could be prepared by using about 25 to 30 per cent water. For making superior bricks on a large scale of about 20,000, the earth is tempered in a pug mill.

Molding of Bricks

Bricks are made in metric sizes called modular bricks, as prescribed by the Bureau of Indian Standards. Nominal size of the bricks is 20cm X 10cm X 10cm, which include the thickness of the mortar and the actual size of modular brick is 19cm X 9cm X 9cm.A brick mould is a rectangular box of steel or wood, which is open at the top and bottom of the box and inside dimensions of the mould are 20cm X 10cm X 10cm.Moulding of bricks can be done using either hand or machine.

Drying of Bricks

Moulded bricks cannot be burnt directly, as they may get damaged. So before burning they should be dried either naturally or artificially for about two weeks.

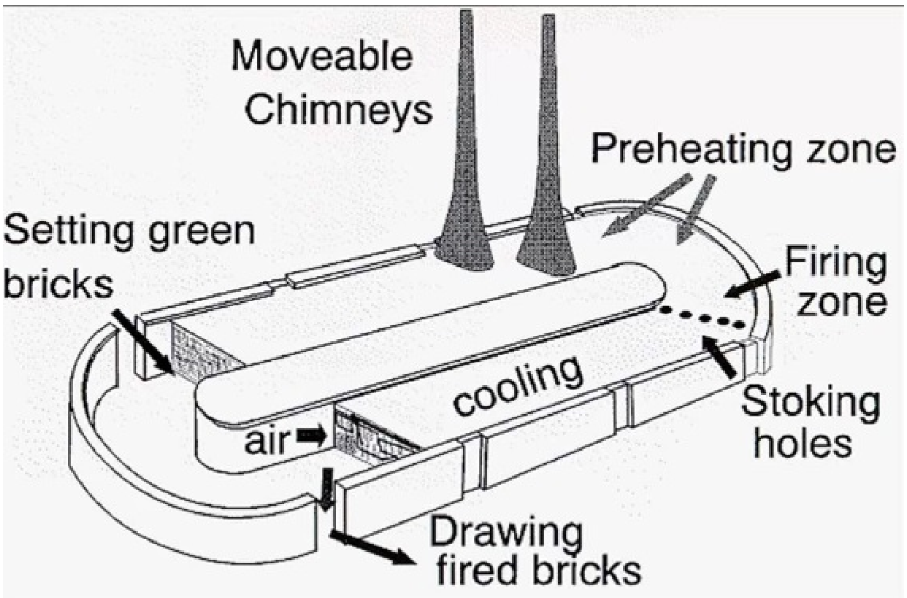
Natural Drying: It is also called hack drying, which comprises placing moulded bricks in rows on their edges, slightly above the ground called a hack. These bricks are air and sun-dried that is strong enough to use for the construction of small structures.

Artificial Drying: When bricks are needed to dry on a large scale, then this artificial drying is preferred. They are dried in special dryers which receive heat from specially made furnaces for artificial drying.

Burning of Bricks

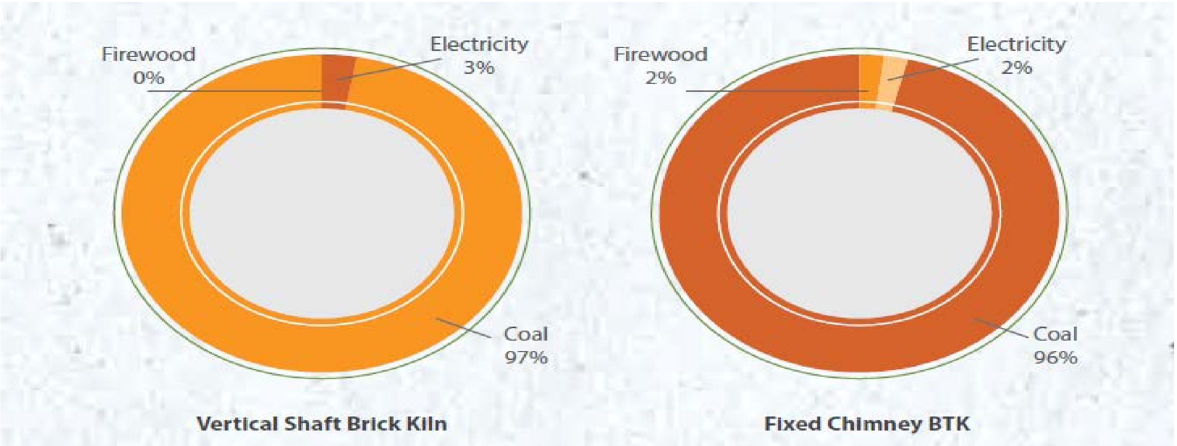
After the process of moulding and drying, bricks are burnt in kilns to impart hardness, strength and to increase the density of the brick. Some physical and chemical changes take place in the burning of bricks. Heating brick to about 640°C produces only physical changes. If a brick is heated up to 700-1,000°C, it undergoes chemical changes. During this reaction, the materials present in brick alumina and silica fuse together to make the brick strong and stable to prevent from cracking and crumbling.

The types of Kilns used for burning purposes are: Clamp or Open Kiln, Intermittent Kiln and Continuous Kiln.



2.3.2 Existing Energy Use Pattern

Coal is the main fuel used which is mainly imported from Assam in India. Apart from coal, a small fraction of sawdust/fire-wood bagasse is also used as fuel in these kilns. The energy cost on product value is 32% for the Fixed Chimney BTK, whereas 14% for Vertical Shaft Brick Kiln. The efficiency margin or simply energy saving potential on thermal energy usage is estimated to be 34% and 4% respectively for FCBTK and VSBK respectively. (GIZ/NEEP, 2012)



2.3.3 Cost Comparison for Potential Fuel Switching

Cost Comparison between Coal and Pellet:

GCV[10] of Coal	6500	kcal/kg
GCV of pellet	4500	kcal/kg
1 kg of coal	1.44	kg of pellet
Cost of coal	45	NPR/kg
Cost of pellet	30	NPR/kg
Cost of pellet equivalent to 1 kg of coal	43.33	NPR

[10] Gross Calorific Value

Cost Savings	1.67	NPR

From above table, it is clear that with the current price of coal and pellet; pellet seems to be cheaper than coal. But, if price of coal is NPR 43/kg or lower, coal is cheaper than the pellet.

3. Financial Analysis

Replacing pellet with diesel seems to be financially attractive, so financial calculation of diesel replacement has been conducted with some assumption listed below:

Assumptions:

1. Boiler capacity: 1000 kgs/hour
2. Monthly plant operation days: 30 days
3. Daily plant operation: 8 hours
4. Fuel consumption by Diesel boiler: 64 liters/hour

S.N.	Particular	Unit	Diesel Boiler	Unit	Pellet Boiler
1	Boiler Capacity	kg/hr	1000	kg/hr	1000
2	Annual Plant operation	hours/yr	2880	hours/yr	2880
3	Fuel consumption	litre/hr	64	kg/hr	142.22
4	Fuel consumption per year	litre/yr	184320	kg/yr	409600
5	Cost of Fuel	NPR/litre	172	NPR/kg	30
6	Annual fuel cost	NPR/yr	**31,703,040.00**	NPR/yr	**12,288,000**

Annual Savings from fuel switching: NPR 19,415,040.

Capital Investment required for boiler replacement: NPR 7,000,000

Simple payback period: 4.32 months.

4. Conclusion

From above calculation, it is evident that pellet is expensive than rice husk and firewood, marginally cheaper than coal and very much cheaper than the diesel. So, replacing pellet with diesel seems to be financial attractive. With 1000 kg/hour boiler capacity case, payback period is only 4.32 months. Therefore, NREP should target those industries which are using diesel as a primary fuel from fuel switching perspective.