

Final Report on

# **Study on Feasibility and Market Identification of Densified Biomass Briquettes**

Submitted to  
**Alternative Energy Promotion Center (AEPC)**  
Khumaltar, Lalitpur,  
Nepal



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**Chairman and Team Leader**

**Centre for Energy and Environment Nepal (CEEN)**

## **Abbreviations**

AEPC	Alternative Energy Promotion Center
CBS	Central Bureau of Statistics
CEEN	Center for Energy and Environment Nepal
CFUG	Community Forest Users' Group
GDP	Gross Domestic Product
GIS	Geographic Information System
GJ	Gega Joules
ha	Hectare
HH	Household
kg	Kilogram
kW	Kilo Watt
kWh	Kilo Watt Hour
m	Meter
Max	Maximum
Min	Minimum
NGO	Non Governmental Organization
NPC	National Planning Commission
RI	Residue Index
RPR	Residue to Product Ratio
RET	Renewable Energy Technology
TCN	Timber Corporation of Nepal
VDC	Village Development Committee
WD	Women Development
WECS	Water and Energy Commission Secretariat

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## **1. Introduction**

Biomass refers to all forms of organic matter produced as products of photosynthesis. Biomass has long served as one of the primary energy forms utilized by human being for essential activities aside from nutrition [1-4]. Different forms of biomass are

- Forest based products
  - Timber, fuel wood, wood chips/shavings, saw dust, milling residue, forest waste like leaves, twigs, shrubs, herbs, herbal products, etc.
- Agriculture based products
  - Agricultural products, agro-residues, by-products of agro-based industries such as rice husk, rice straw, rice bran, wheat husk, wheat straw, wheat bran, maize cobs, maize stalks, sugarcane bagasse, sugarcane leaves, coffee husk, tobacco waste, tea waste, waste from herb processing and herb production, coir pith, jute sticks, groundnut shells, mustard stalks, cotton stalks, etc.
- Aquatic plants
- Animal dung and human waste.

Direct burning of loose biomass is inefficient and cause extensive pollution to the environment. Apart from the problems of transportation, storage, and handling, the direct burning of loose biomass is associated with very low thermal efficiency and widespread air pollution. The conversion efficiencies are as low as 40% with particulate emissions in the flue gases. In addition, a large percentage of unburnt carbonaceous ash has to be disposed off. To overcome these drawbacks of loose biomass raw materials briquetting technology is often used[5].

Briquetting is used basically to produce high-density fuel by compacting combustible raw materials such as charcoal, agricultural residue, forest waste, industrial and municipal waste to increase the net calorific value per unit volume, to improve combustion efficiency, to reduce pollution and to ease handling, transportation, storage, etc[3, 6].

### **Biomass briquetting**

Biobriquetting is a densification process of loose biomass or charred biomass by compaction in a die or mold, turning it into a solid fuel of different shape and size. In this technology, loose biomass or charcoal powder is densified or changed into a solid form of particular shape and size through the application of pressure, heat and/or binding material[1, 6]. The densification of biomass or charred biomass (charcoal) can be achieved by any one of the following methods (Fig 1)[7] .

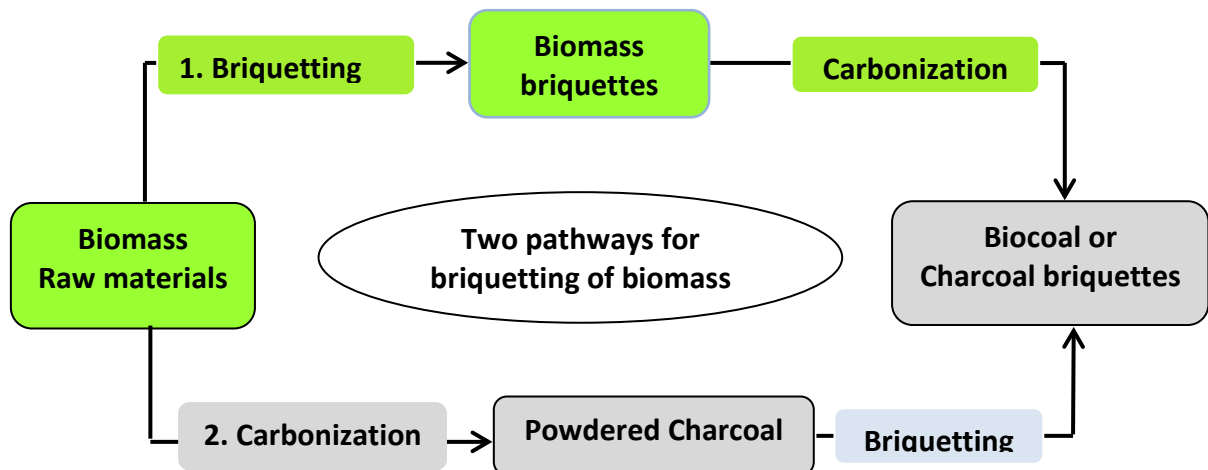


Figure 1. Different processes for briquetting

Densification of charred biomass using a binder (lower path in the Fig 1)- where the biomass is first charred to obtain charcoal powder, which is then treated and mixed with a binder and then densified.

Direct densification of biomass materials (upper path) - where the processed or non-processed biomass is mixed with a binder and other additives is then densified using pressure or heat. This densified product can either be used in the form of non-charred briquettes or be carbonized to get charcoal briquettes.

In this given background, proper information on potential of different biobriquettes and its market is highly essential to encourage the briquette producers as well as promotion and utilization of the densified products for reducing raw fuel wood use at household level as well as replacement of imported coal and petroleum products in commercial and industrial sector.

Assessing the current situation and practices in briquetting as well as lessons from neighboring countries, a comprehensive package of different biomass briquetting systems have been proposed for three levels namely-**producers, traders and users.**

For the successful promotion and marketing of briquettes it is very important to develop a sound and efficient marketing mechanisms and network, that is reliable and can continuously supply the goods to the consumers/users. Thus, it is important to look into the existing marketing mechanism and the distributing network, from the producers to the end users. The common exiting marketing network is expressed in figure 2.

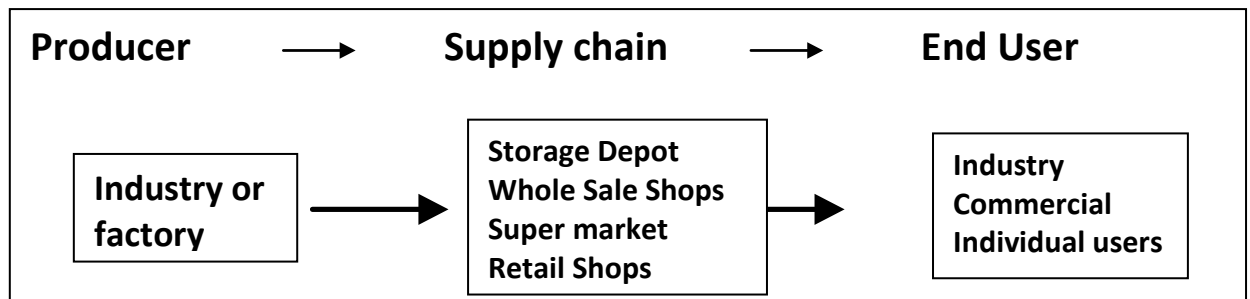


Figure 2. Supply chain

### 1.1. Objectives

The main objective of this task is to conduct a study on feasibility and market identification of densified biomass briquettes in Nepalese context.

Specific objectives are;

- To identify type, source (eg. forest waste, agricultural by-products, industrial by-products etc.) and potential quantity of biomass raw materials appropriate for various types of briquette production.
- To identify existing and potential end users for various types of biomass briquette.
- To develop case studies based on existing entrepreneurs producing different types of briquettes and supply chain management in practice.

### 1.2. Activities

To conduct a study on feasibility and market identification of densified biomass briquettes in Nepalese context, following activities have been performed:

- Interaction with BESC to better understand activity goals.
- Desk study and review relevant literatures have been collected. Most of the important reports, books, articles, etc were collected and studied. Besides, planning documents, documents related to feasibility and marketing were also studied.
- Developed data collection tools (formats, checklist etc.) for the collection of information.
- Identified key areas adjoining with high potential for users (households, brick kilns, boiler operating industries, community cooking, etc.) & manufacturers of biomass briquette in Nepal.
- Interact with relevant stakeholders, potential users (households, brick kilns, boiler operating industries, etc.) as outlined from desk study for necessary information.

## 2. Methodology

### Approach to deal with the TOR requirements

Following are the work program approach to deal with the TOR requirements:



- a. Review and identification of relevant literature on biomass briquetting, relevant data on the availability of raw materials, policy guidelines, marketing strategy and other preparatory works.
- b. Parameter identification
- c. Interaction with NRREP/AEPC and other stake holders.
- d. Field visits, assessment of the availability of resources and its applicability and market potential
- e. Collection of technical data on the resources of biomass residues for briquetting and their market potential
- f. Data Analysis

After the interpretation of the results on the availability of the biomass resources and the business opportunities for the densified briquettes with possible markets, the team prepared a draft report. The report was presented in the stakeholder consultation workshop in consultation with AEPC. Final report was produced incorporating as far as possible all the suggestions made in the consultation workshop.

## **2.2. Work program and its methodology**

Details on the work programme and its methodology is given as follows:

### **Planning Phase / Desk Study**

After awarding the project, the contract agreement was signed with AEPC. The team for the study with their assignments was quickly mobilized. Some literature and other secondary data were collected and proper planning for the relevant project documents, feasibility study reports with regards to biomass briquetting was carried out. On consultation with NRREP/AEPC relevant stakeholders like NGOs/INGOs, FNCCI, FECOFUN, Biomass Briquette Industries and others was consulted for collecting relevant information.

### **Field visit and Data Collection**

In this phase, the team in consultation with NRREP/AEPC finalized the potential areas for collection of information on raw materials for biomass briquetting and their marketing potential.

During the field visit, the team interacted with relevant stakeholders, potential users (household, brick kilns and boiler operating industries) as well as briquette industries for necessary information. Due to time and resource constraints the field visits focused only on randomly selected industries, markets and users for the collection of data. Hence, primary data was managed through visits, interviews and questionnaires to producers, researchers, markets, users, etc. Detailed information was collected through interviews, questionnaire survey and focus group discussion (FGD) with the

stakeholders. Secondary data was collected through literatures. Based on the information collected, the data was analyzed for the assessment of the availability of biomass resources for briquette production as well as their market potential for end use diversification. The methodology of the aforesaid work programme is presented in Table 1 below.

**Table 1: Work Plan with methodology**

No	Activities	Objectives	Methodology	Assumptions	Responsibility
1	<b>Desk Study and Review of Literature</b>	<i>Compilation of the existing information on biomass briquetting</i>	<ul style="list-style-type: none"> <li>• Identification of possible biomass product in high altitudes and plain lands and its distribution pattern</li> <li>• Study production standard of raw material with reference to specification on direct briquetting technologies</li> <li>• Appraisal on various types of briquette and end users in neighboring countries</li> <li>• Assessment on current use practice</li> </ul>	Reports, books, journals, published documents, other relevant literatures available from dept of forest, agriculture, small cottage industry, NARC, Bureau of statistics , internet, etc.	<b>Overall task supervisor:</b> Project Leader
2	<b>Data collection</b>	<i>To collect/receive information on viability &amp; market identification of densified biomass briquettes from producers, stakeholders involved in briquette supply chain in Nepal</i>	<ul style="list-style-type: none"> <li>• Preparation of document for scheduled interview and interaction</li> <li>• Transcript analysis</li> <li>• Random Field visits and Interaction with Producers, Traders, suppliers, marketing, users to validate the information collected and prepare case study</li> <li>• Industry, current market analysis, anticipated future market potential, potential buyers.</li> </ul>	<ul style="list-style-type: none"> <li>• Visits on the basis of available information</li> <li>• Scheduled inquiry through accessible communication medium.</li> </ul>	<b>Supervisor:</b> Project Leader <b>Preparation of detail methodology and data collection:</b> Statistician with socio-economist and support staffs

3	<b>Data analysis</b>	<i>Interpretation of received data/information</i>	<ul style="list-style-type: none"> <li>• Statistical tools analysis</li> <li>• Optimization technique</li> </ul>	<ul style="list-style-type: none"> <li>• Linear programming method</li> </ul>	Statistician and socio-economist
4	<b>Preparation of draft</b>	<i>Preparation of draft report</i>		<ul style="list-style-type: none"> <li>• Draft report</li> </ul>	Project Leader and team
5	<b>Stakeholders Consultation Workshop</b>	<i>To obtain the remarks of each stakeholder on the report of the given assignment</i>	A stake holder consultation workshop will be held in consultation with AEPC	The relevant suggestions/ comments of the stakeholders will be collected, incorporated while finalizing the final report	Project team and AEPC
6	<b>Submission of Final report</b>	<i>Finalization of report</i>	Final report will be produced in consultation with AEPC incorporating as far as possible all the suggestions.	sources of raw materials for densification, potential users and their case study will be the final product	Project Leader and team

## Activity Schedule

The proposed Activity schedule is presented in table 2.

**Table 2- Activity Schedule**

No	Name	1	2			3	4	5	6	7	8	9	10	11	12
1	Signing Contract				Work delayed due to constitutional Election in Nepal										
2	Desk Study and Review of Literature														
3	Preparation and Submission of Inception Report														
4	Field Visit for Interaction, case study and validation														
5	Information analysis														
6	Preparation and Submission of Draft Report														
7	Stake Holder Consultation Workshop **														
8	Preparation of Final Report**														
9	Submission of Final Report**														

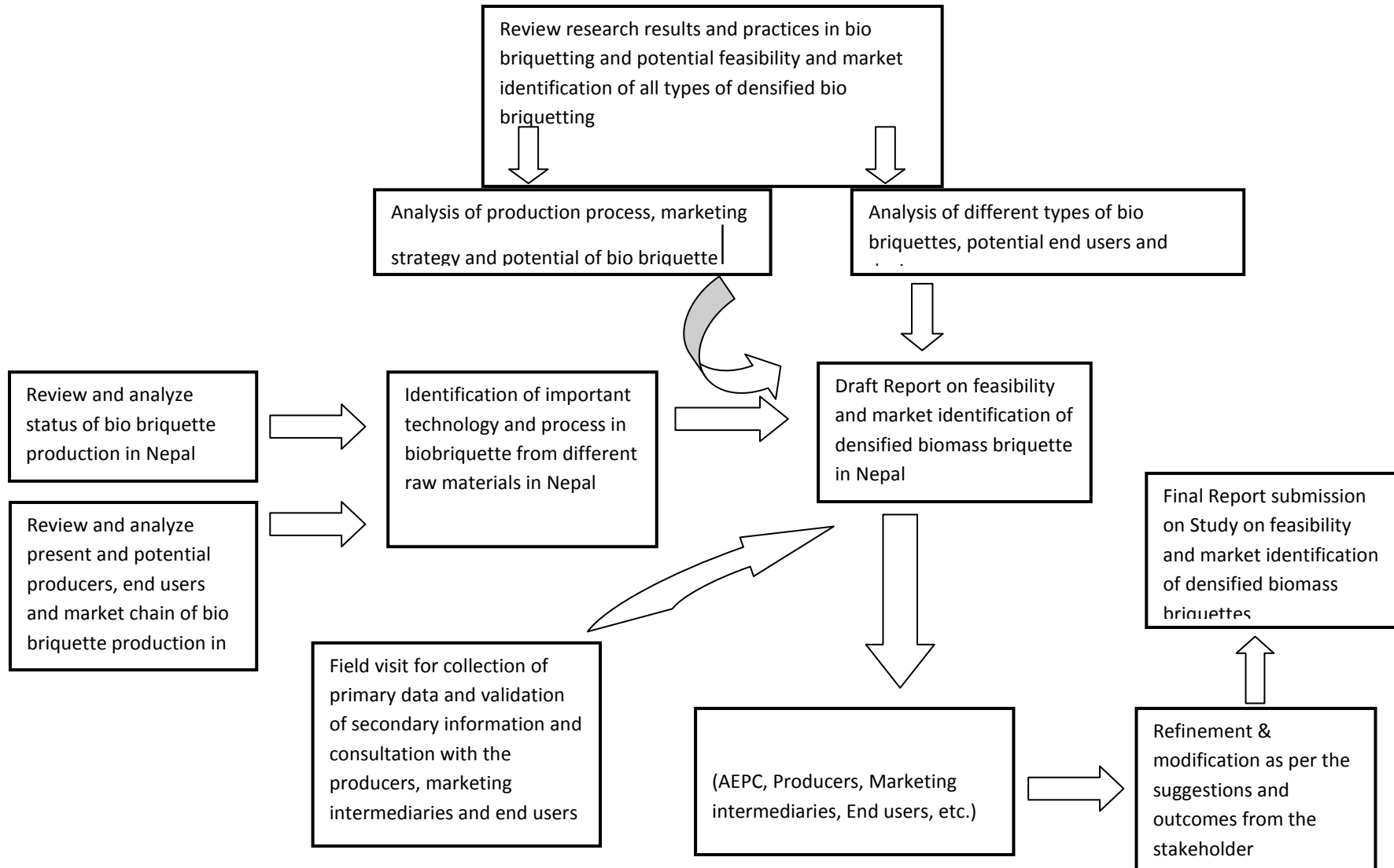


Figure 3. Frame work for the study

### **3. Limitations**

There are various direct densified briquetting technologies available in the market. All these technologies are not being well practiced in the context of Nepal. As per the knowledge and experience of CEEN, two types of biomass briquetting technologies, namely piston press briquetting and screw extruder rice husk briquetting, have so far been well established and seen wide promotion in the country. The screw extruder briquetting technology has been in operation since the early 1990ies[8-9].

Besides these technologies beehive briquette technology and to some extent briquetting of waste materials such as paper and biomass is also being practiced by Foundation for Sustainable Technology (FoST)[10].

Thus this study will be limited to:

- i) The identification, source and potential quantity of the biomass raw materials will be done through primary data and secondary data available from authentic organization considering the limited time and finance.
- ii) The study will be confined in the three briquetting technologies: screw press, piston press and compression technology.
- iii) Since this assignment requires getting into privacy of manufacturers i.e. supply chain management and end users, the task seems to be dependent on the level of response provided by them. So, here in this circumstance, the role of AEPC in comforting those manufactures seems to be very vital and the assignment can be completed efficiently only in that situation.

### **Schedules/Logistics**

The schedule for the study was prepared in accordance with activity schedule proposed in table 2 above. Field studies were carried out in the identified potential areas with availability of biomass resources, market potential and end use diversification. Also some briquetting industries (old as well as new) were visited to learn about their operational status and marketing aspects.

Field study was conducted to some selected areas and industries. Some newly established biomass briquette industries in Bhairawa, Nawalparasi and Kathmandu districts were visited to collect information on their technical details for production of briquettes, marketing mechanism and distribution of the products to the users. Some biomass assessment study was done to collect

information on the availability of Forests wastes as well as industrial waste, which could be used for briquetting.

### **3. Analysis of objectives and components of the study**

Analytical assessment and study the objectives of the proposal and TOR reveal that the study consists of two important parts:

- Feasibility of densified biomass briquettes and
- Market identification of biomass briquettes.

The feasibility of a project or technology consists of several aspects such as technical, economics, market, legal, etc aspects of the technology or the product. Such feasibility goes beyond the scope of this study. Therefore, this study will look into only technical aspects of the technology being used in the country, technological capability (technical manpower, fabrication, repair and maintenance ability) of the country for briquetting and the cost of the technology and the product itself.

Market identification will depend on upon the type of fuel used in different sectors and the possibilities of substitution of the used fuels by briquettes. Whether briquettes can fulfill the heat requirements of the production process will also determine the promotion of briquettes.

In both the issues mentioned above, it will be very important to look into the past experiences of different countries (especially India and Bangladesh) as well as Nepal. The past experience and the current situation of biomass briquetting in Nepal will be analyzed in the light of these components.

As the specific objectives of the proposal mentions

- To identify type, source (eg. forest waste, agricultural by-products, industrial by-products etc.) and potential quantity of biomass raw materials appropriate for various types of briquette production.
- To identify existing and potential end users for various types of biomass briquette.
- To develop case studies based on existing entrepreneurs producing different types of briquettes and supply chain management in practice.

This report will be structured in line to fulfill the above mentioned objectives.



#### **4. Past experience of biomass briquetting in Nepal**

##### **4.1. Screw extruder briquetting of Pyrolyzed products**

The first biomass briquetting plant Nepal Bio-Extruder Industry Pvt Ltd in Nepal was established in 1982 in Thapathali, Kathmandu, which followed with similar factories in Butwal (1984) and a third one followed in Dharan (1984). They used the rice husk pyrolyzing technology, which were very much polluting and having many technical problems during operation. A list of the industries is provided in Table 3. [11]. All these plants could not operate for a long time due to problems underlined below.

**Table 3 : Some Pyrolyzing Plants**

No	Name and Location of factory	Year of estd.	Origin of tech./capacity	Status
1.	Nepal Bio Extruder Industry, Kathmandu	1982	India, 900 ton/yr.	Closed
2.	Nepcoal Pvt. Ltd. , Butwal	1984	India, 1200 ton/yr.	Closed
3.	Kosi Briquette Fuel Industry, Dharan	1984	PECo, Nepal, 600 ton/yr.	Sold as scrap
4.	Trishakti Husk Coal Briquette, Narayanghat	1990	PECo, Nepal, 600 ton/yr.	Sold as scrap
5.	R.S. Briquette Factory, Kathmandu	1990	PECo, Nepal, 600 ton/yr.	Sold as scrap

PECO – Pradhan Engineering Company, Narayanghat

There were many problems related with the pyrolyzing technology that led to their closure. Some of them are:

- High cost of technology

The briquetting technology and briquetting plants are not available in the country and have to be imported; therefore the cost of machinery equipment was high. Briquette production cost as well as repair and maintenance cost is also high. To address this problem, machinery equipment has to be fabricated in the country with assurance of quality.

- Manufacturing plant maintenance

The plant had a pyrolyzer, made from low quality of steel, and had to be repaired once a month. This problem is further aggravated by the production of tar

(pyrolytic oil) inside the pyrolyzer. Tar is very viscous and difficult to control. Because of its high oxygen and moisture content it is also corrosive to mild steel.

- Wearing of the screw/worm feeder and die

In addition to the wearing caused by the abrasive nature of the rice husk alone, addition of different binders such as clay and molasses to the charred material cause additional wear of the screw and the die. Repair and maintenance ability in the country was very much lacking and frequent repairs were costly. Besides technology duplication/fabrication, capability of plant repair and maintenance also has to be developed.

- High cost and seasonal availability of the raw material

The cost of the raw material (rice husk) was high and seasonal availability was a problem for the briquetting plants. In addition during pyrolysis of rice husk a lot of volatile matter, which is a major contributor to the heat value of the fuel, is also lost, reducing the heat content and quality of the briquette product.

- Problems of drying (raw material & product)

The rice husk has to be dried for the Pyrolysis process and this increases the cost. Also high moisture content accelerates corrosion of the pyrolyzer. Charcoal and charred briquettes are very susceptible to moisture so they have to be well dried and stored properly. This increases the cost per unit of energy produced. Also the briquettes were very friable and difficult to handle.

- Pollution and environmental degradation

During the process of Pyrolysis, burnt carbon in the form of carbon monoxide and dioxide (CO, CO<sub>2</sub>) and sulfur compounds are released into the atmosphere. In the extrusion of briquettes, a lot of smoke, burnt carbon and sulfur compounds, are also released.

The experience of the pyrolysing briquetting plants can be summarized below:

1. The cost of imported machinery/equipment was high and repair/maintenance of the pyrolyzer, screw and other components were frequent and costly.
2. Plant operation and repair/maintenance was difficult due to shortage of technical manpower.
3. The Pyrolysis plant and formation of coal tar in the process was very polluting to the environment.

4. Raw material (rice husk) was very abrasive and costly.
5. Drying the raw material and product was costly.
6. The product was not of high quality as the heat content was low (<4000 kcal/kg) and the ash content was high (>20%).
7. Appropriate cooking/heating devices were lacking and marketing of briquette product was difficult.

For promotion of the above technology and the product, the above mentioned problems were not addressed successfully.

#### **4.2. Screw extruder briquetting**

Many screw extruder rice husk briquetting industries were registered with the Department of industries after a demonstration program of Fuji conveyor screw extrusion technology to produce rice husk briquettes in Khumaltar Agricultural Complex supported by Japanese Embassy in 1986. Many could not be established at all. In 1987/88 four extrusion type briquetting machinery were imported from Sun Chan Company of Taiwan and briquetting factories were established in Simara, Hetauda, Chitwan and Parwanipur[9, 11]. Information about these industries and their problems are also given in table 4 below.

The problems of these industries can be summarized as follows:

##### **1. High cost of the imported technology**

The cost of the machinery/equipment was very high demanding huge financial investments through NIDC loans. Without good sales of the product paying banks loans could not be on time. Because of high cost of imported technology, simple briquetting units were even fabricated in Nepal and two industries using similar but simple type technology started operation with comparatively low investments - one in Chitwan and another one in Nepalgunj.

##### **2. Wearing of the screw**

The biggest problem of this type of industry was wearing of the screw due because of the high ash content in the rice husk. Repair of the screw and die were big problems as hard surfacing welding rods were not easily available. Repair and changing of screw made production process slow and high cost.

##### **3. Lack of skilled labour**

Operation and repair/maintenance was a serious due to lack of skilled labour. Originally screw propeller had to be taken to Raxaul for repair and was costly

because skilled labour, especially for welding, was not easy to find in the local market.

#### 4. Lack of technical support and R&D

Besides skilled labour, there was no R&D support and technical backstopping to cater to the needs of briquetting industries. Very few R&D institutions were involved in briquetting.

#### 5. Market and marketing

Briquette was a new product and public were not aware of the benefits as there was no publicity and promotional programs. Therefore, the market for briquettes was not established and marketing of the product was always not secure as the product had to compete with cheaper fuel wood. Marketing was done on personal contacts only. Also heating and cooking devices for the use of briquettes were not available. Individual case studies of problems of industries in briquette marketing and sales will be reported later.

#### 6. Lack of policies, programs and conducive environment

No policies and programs existed in the government documents for the support and promotion of briquetting industries. Hence, there were neither concessions, subsidies, tax incentives nor motivation to these briquetting industries.

#### 7. Raw material problem

Rice husk as raw material was originally free of cost. But once cost grew, other raw materials were not easily available as the supply was seasonal. From the above table it can be seen that, some industries ventured using other types of raw materials like saw dust, Banmara, biomass waste under the high tension lines and to produce charcoal.

**Table 4 : Briquetting industries that were in operation till 1995**

<b>Name of Factory (Location)</b>	<b>Chitwan Briquette Koila Udyog Pvt Ltd., Narayanghat</b>	<b>Xan Coal Industry Pvt Ltd, Simara</b>	<b>Quality Wood &amp; Fuel Industry, Hetauda</b>	<b>Mhaipi Briquette Udyog Pvt Ltd, Nawalparasi</b>	<b>Himalayan Briquette Udyog, Narayanghat</b>	<b>Bageswari Briquette Industry, Nepalgunj</b>	<b>Remarks</b>
Owner	Mr. Prabhat Joshi	Mr. Jiwan Basnet	Mr. Chandi Karjit	Mr .Surendra Gorkhali	Mr. Ram Prasad Nepal	Mr. Amrit Karmacharya	
Production capacity	Closed	Sold out as scarp	Closed	About 4 tons per shift average	Closed	Closed	They never worked at full capacity
Origin of machinery	Made in Taiwan	Made in Taiwan	Made in Taiwan	Made in Nepal and Taiwan	Made in Nepal	Made in Nepal	
No of extruders	4	4	4	8	2	1	
Factory cost	60,000/- US\$	60,000/- US\$	60,000/- US\$	NRs125,000/ Taiwan – NRs375,000/	NRs 250,000/-	NRs 125,000/-	Imported technology very expensive, but local very cheap
Raw material	Rice husk	Rice husk & saw dust	Rice husk and saw dust	Rice husk	Rice husk	Rice husk	Rice husk abrasive and costly
Technical Manpower	Skilled labour –3 including one welder	NA	Skilled labour-5	Skilled labour-2,	Skilled labour-1,	NA	Very much lacking, especially welders
Heating of die	Rice husk briquettes	Electric	Electric	Electric/ briquettes	Briquettes	Briquettes	High cost of electricity increases product cost

Major technical problems	Damage of screw & die every 2-3 hrs	Damage of screw and die	Damage of screw & die every 5-7 hrs	Regular damage of screw and muff	Screw and die damage every 2-3hrs	Damage of screw and die set	Lack of skilled welders. No hard surfacing welding rods. No technical back stopping (No R&D).
Major consumers	Army canteen, paper factory and others	Army canteen and others	Restaurants, grill bars and others	Army canteen, carpet & pashmina, brick industry, etc.	NA	NA	No product promotion and protection policy from government
Marketing	Personal contact	Personal contact	Personal contact	Developed network and sales outlets	Personal contact	Personal contact	Except for Mhepi, marketing was thru personal contacts
Bank loan	NIDC , loan payback problem	NIDC , loan payback problem	NIDC , loan payback problem	No loan, self investment	NA	NA	No subsidy, no preferential treatment and no incentives

These briquetting industries were in operation till 1995. Despite the struggle and effort of these industries, most of them had to close down due to technical, market and bank loan problems. Nevertheless, the survival of Mhepi Briquette Udyog till today shows that the rice husk briquetting industries are economically viable.

The experience of the above industries show that for promotion of these industries the following factors have to be undertaken

1. Imported technology is costly, requiring bank loans, whereas locally produced ones are cheaper. Tax incentives on imported machinery equipment are required and local technological capability of mechanical and engineering workshops should be developed.
2. Technical manpower and technical support for repair/maintenances as well as supply of materials (hard surfacing rods) have to be ensured at reasonable prices.
3. Policies and programs consisting of incentives from the side of the governments are required for the promotion of briquette industries and briquette products.
4. Preferential treatment for briquettes with market protection should be guaranteed.
5. Promotional and awareness programs about briquettes are necessary and important.

#### **4.3. Experience and case studies of different industries**

##### **4.3.1. Chitwan Briquette Koila Udyog Pvt Ltd., Narayanghat**

Wearing of the screw was one of the biggest technical problems of these industries. Solution to this was hard facing of the screw surface using very stable and hard types of Eutectic welding rods. With the cooperation of (RO)NAST a whole set of experiments using different types of hard surfacing (Eutectic)welding rods from Japan were used to increase the life of the screw during briquetting. Thin coatings of these materials were applied on the screw during welding and the screw life increased from 3 hours to 6-7 hours, which was more than double. This was an eye opener for these industries to bring such hard surfacing welding rods from India.

##### ***Brikutti Kagaj Karkhana- potential users of briquettes***

The ***Brikutti Kagaj Karkhana*** during the economic blockade of Nepal by India in 1989-90, decide to shift to briquette fuel for its boilers as no coal and petroleum products were imported and fuel wood supply was short. Chitwan Briquette Koila

factory operated only one 8 hours shift in a day. The demand of the paper factory was so big that 3 shifts were needed to keep the paper factory in operation. The rice husk briquette factory till that day had never operated even two shifts a day. Nevertheless, the factory did fulfill the demand of the paper mill throughout the economic blockade. The government afterwards made an assessment of the economic blockade period and the performance of the industries. The General Manager of the Brikuti Paper Factory was rewarded for running the factory smoothly. But the Briquette factory never got any attention, recognition or any kind of support for its contribution.

This is an illustrative example of not only of a potential user of briquettes but also an effective way to save fuel wood or fossil fuel and curtail greenhouse gases. Preferential treatment for promotion of briquettes from the government side in such industries has to be made compulsory.

#### ***Market problem of Chitwan Briquette Koila Udyog Pvt Ltd***

The factory owner Mr. Prabhat Joshi had established good relations with the procurement officer in Royal Nepal Army for the supply of rice husk briquette as fuel for cooking. It even signed an agreement for three years for the supply of briquettes. After two years the contact person in the army got transferred and the agreement was terminated unilaterally from the army side. This led to a big problem and the factory went at a loss and closed down. (Source: Mr. Prabhat Joshi).

This is another illustration of potential users of rice husk briquettes for cooking. If government could issue directives to use briquettes for cooking in army and police canteens alone, imagine the savings in kerosene and fuel wood.

#### **4.3.2. Xan coal Pvt Ltd, Simara**

##### ***Approach to Raw material problem***

Mr. Jeevan Basnet was another entrepreneur with high hopes to promote briquetting and briquette products. Originally rice husk was available free of cost, so paying back the NIDC loan for the industry could have been quick. However, a price tag of Rs 2/kg came to rice husk as industrial boilers and the poultry farms started using also. Hence, the rice husk suddenly became costly for the industry. Banmara a problematic weed, which was freely available in the forest and non forest areas, was an alternative material. Xan Coal tested Banmara from



Sagarnath Forestry Project for briquette production. The cost involved was collection, transportation and grinding of the Banmara.

Another more promising raw material was the massive amounts of biomass under the high tension lines along the highway from Hetauda to Birgunj. Every year the government calls a tender for the cutting of the biomass under the high tension lines. Biomass on the right-of row (about 3- 5 meters left and right) from the high tension lines have to cut/cleared of biomass growth, to protect the high tension lines causing accidents. The contractor cuts the biomass and leaves it to decay. A study of NIDC even suggests that this raw material be handed to briquetting industries[12]. Mr. Jeevan Basnet had approached the contracting office, awarding the tender with a proposal to cut the biomass under the high tension lines as per the requirement of the government, asking the ownership of the cut biomass to use as the raw material for briquetting. But the concerned authorities turned a deaf ear to his proposal. The payment of the loans was also difficult; hence the factory went for auction (Source Mr. Jeevan Basnet). This shows that raw material is not a problem and only support is needed from the side of the government.

#### **4.3.3. Mhepi Briquette Udyog Pvt Ltd**

Mhepi Briquette Udyog survived all the ups and downs faced by the rice husk briquetting industry and is the only industry still in operation. Financially, the factory had an upper hand as it did not take any bank loan, so it was free from this burden. The General Manager, Mr. Surendra Gorkhali, was successful in establishing a small marketing network by appointing distributors for its product to the general public and maintained cordial relations with the local suppliers. Advertising a product is an important aspect of product promotion. Probably, Mhepi briquette industry was the only industry, which has printed materials for the promotion of its product and also initiated some awareness and promotional programs through demonstrations and participation in national seminars and exhibitions.

The marketing strategy with different price structure of the briquettes adopted by the factory played a crucial role in its existence. Price for old regular customers like carpet industries was low (about Rs8/ kg) with marginal profit only. Seasonal users such as five star hotels require briquettes during the winter season only. The price for them is high (~ Rs 20 per kg). All these untiring efforts have contributed to the survival of this industry (Source: Mr Surendra Gorkhali).

Past experiences of the briquette industries indicate the following prerequisites for establishment and promotion of biomass briquetting.

- Briquetting technology should be easily available in reasonable affordable price.
- Technological capability to undertake fabrication and repair/maintenance works with skilled manpower has to be developed.
- Continuous availability of cheap raw material for briquette production and facilitation from government and concerned agencies for making available the materials.
- Government support through policies and programs to facilitate establishment and promotion of briquetting industries.
- Preferential treatment to briquetting industries and fuel briquettes with market protection and guarantee.

#### **4.3.4. Roller press briquetting in Jhapa**

The Bhutanese refugee camp in Jhapa used about 6 crores rupees worth of compressed coal dust briquettes (CCDB) from India annually as cooking fuel. These briquettes are of low quality, difficult to ignite producing a lot of smoke and pollution. The study conducted by LWF to evaluate the impact of CCD briquettes showed negative impacts on the environment and health[13]. Introduction of roller press briquetting in Jhapa to produce biobriquettes from coal and biomass to replace CCDB as cooking fuel in the refugee camps was very appropriate. But the concerned authorities (UNHCR and LWF) and the Ministry of Home Affairs did not pay any attention to the person who installed such a unit to this matter. The roller press briquetting unit is still lying there (Source: LWF). This is another potential user of briquettes, where briquettes can be promoted if the government could intervene to replace compressed coal dust briquettes.



**Roller press briquetting machine and**



**biocoal briquettes in Jhapa**

## **5. Experiences of neighboring countries**

### **5.1. Bangladesh experience**

Briquetting Technology in Bangladesh is mainly the heated screw press type. The screw extruder briquetting was first started (around 1992) in Sheikh Ghat, Sylhet by importing machines from Taiwan. These machines were from the same company (Sun Chan, Taiwan) which Nepal had also imported. Because of the high cost of imported technology, similar types of machine were fabricated locally which gave continuity to the work. Gradually the technology was spread to Khulna, Chittagong, Rajshahi, Barisal, Dinajpur, Rangpur, Bogra, Jessore, Satkhira and several places of Bangladesh (table 5).

**Table 5 : Briquetting machine distribution in different region in Bangladesh**

Region (Greater District)	Total No. of Briquetting Machine	No. of Foreign machine	Total
Sylhet	233	15	248
Khulna	174	2	102
Chittagong	135	-	103
Rajshahi	268	-	60
Barisal	32	-	23
Dhaka	47	-	04
Total	889	17	906

In Bangladesh rice husk is the main raw material used for making briquettes as the country produces 3 crops of paddy annually, generating huge amounts of rice husk. Total rice husk available for densification only is estimated at 1.0462 million metric. Total production of rice husk briquette fuel (Table 6) was estimated as 0.942 million metric ton equivalent to 0.493million ton of coal which is 2.34 times of imported coal (0.211 million ton) in the year 2002-2003 in Bangladesh [14].

Analysis of the wide spread promotion and distribution of rice husk briquetting business in Bangladesh reveals that various factors played very important role in the success of rice husk briquetting.

**Table 6: Total estimated production of rice husk briquettes in Bangladesh (2005)**

No	Rice production, husk and rice husk briquette	Amount in million tons
1.	Total rice production in 2004-2005	39.33
2.	Total rice husk available for densification at present situation of rice processing system	1.0462
3.	Total potential production of densified briquettes at present situation (90% conversion efficiency)	$1.0462 \times 0.90 = 0.941580$

### **Cost of Technology, Technological capability and Technical Issues**

Initially the average cost of a briquetting machine (imported technology) was about US\$ 2,500. R&D efforts of KUET in improving design and fabrication methods brought down the cost of briquetting machine of similar production capacity to about US\$ 800. Local availability of materials (base metal and welding electrode) in fabricating and repairing the screws contributed to a further reduction in operating costs.

In addition to cost reductions, KUET also developed a new mechanism for changing the worn out screws in a shorter time, thus reducing the machine downtime during screw replacement significantly. To support the dissemination of briquetting technology, KUET also developed and distributed over 400 briquette burning domestic stoves to the local village community[15].

There are many Engineering workshops for fabricating briquetting units as well as screw and die sets at cheap and affordable rates in major cities, where briquetting is popular. There are similar mechanical workshops in most of cities where briquetting is popular [16-17]. Some photos are shown below.



**Rupali Engineering works,**



**Khulna Ayub Ali Engineering works, Khulna**

### **Building Local Capability and trained manpower**

Junior researchers of KUET participated in several academic and training programmes on briquetting technology in particular at AIT. Two researchers from KUET followed advanced courses in biomass energy and participated in briquetting research at AIT. The training resulted in the development of improved biomass briquetting systems and efficient briquette-fueled stoves. A biomass briquetting laboratory with fabricating and testing facilities was established at KUET.

Training programmes and workshops were conducted as part of the capacity building and technology transfer activities. KUET also developed one month-long intensive training program on briquetting technology for local personnel, and 68 local technicians were trained in fabricating, operating and repairing of briquetting systems.

### **Community Participation and Including Local Stakeholders**

The improved biomass briquetting technology in Bangladesh was developed by local partner with sufficient know how, experience and capacity for local fabrication of low cost and more efficient briquetting systems.

### **Achieving Co-Benefits**

The impacts of improved briquetting machine is multi-prolonged, including the generation of rural employment and income, elimination of disposal problems of large quantities of rice husk residues, efficient utilization of energy resources and reduced use of fuel wood and consequent conservation of forests.

Research has also shown that potential benefits of using rice husk briquettes in Bangladesh include time saving (for collecting rice husk briquette over firewood) to be 24 man-days/year; generation of 3.73 man-days of direct employment through the production of each ton of briquettes; and saving of 1.81 kg of CO<sub>2</sub> per each kg rice husk briquette fuel use over each kg of non-sustainable firewood.

The activities related to briquette production such as briquette machine and components fabrication, screw repairing, transportation, and marketing of rice husk and briquettes, have contribute in instituting a small industrial and service sector in Bangladesh. Country-wide survey showed that there were over 900 briquette machines in use and 98% of them were manufactured in Bangladesh.

### **Market and users of briquettes Target Group**

The marketing of rice husk briquettes in Bangladesh is complex. A complex market channel exists in most of the areas/cities where briquette fuel is getting popular. The marketing mechanism of briquette consisted of four different channels:

Channel 1: Producer → Consumer

Channel 2: Producer → Retailer → Consumer

Channel 3: Producer → Wholesaler → Consumer

Channel 4: Producer → Wholesaler → Retailer → Consumer

In Bangladesh the densified rice husk briquettes are mainly used for cooking purposes. Tea stalls, small retailers and poor household were the users of rice

husk briquette in some urban areas of the country. The main reason for this shift is that firewood has been reducing alarmingly and briquette is smokeless and provides higher temperature more quickly than that of coal and wood. Also interesting results obtained from some tests show that 1 kg of densified biofuel is equivalent to 1.21 kg of wood fuel[18]. With technology getting mature there was growing acceptance of briquettes as replacement for fuel wood in the residential and for small and cottage industries sector, especially in the food processing business.

User group can be divided into mainly two sectors - household and commercial. Major consumer of densified briquette fuel is the commercial sector consuming about 60%. These are restaurants and sweetmeat shops. About 25% is used in tea stalls around the city and 15% is consumed by different street food stalls. The households who could not avail the gas grid connection are using densified biofuel. It is used as an alternative fuel for cooking food in parties and group cooking. It is also used in road construction to melt the bitumen and asphalt. Industrial boilers also use it boiler fuel[16]. However, the densified biofuel is still not be well accepted by small industries such as bakery because the present system was not suitable for firing this fuel. However, briquette fuel is slowly finding use some industries such as brick kilns, rice mills, etc).

### **Stove market**

What is very unique in Bangladesh is the stove market for rice husk briquettes. One such is situated on the Shere-e-Bangla road in Khulna. This market (Basupara market) is a unique type of markets which has all kinds of locally produced stoves for use of rice husk briquettes. There are many kinds of clay stove, metal casing stove with clay linings ranging from 150 to 400 Takas. Some stoves have smoke removal systems. Some photos of the stove market are given below.



Different types of stoves on display for sale



**Some photos of Rice husk briquetting in Bangladesh**



A wholesale briquette shop in Sylhet



A tea stall in KUET



Using briquettes in sweetmeat shop



In restaurant in Mymensingh town



Institutional briquette stoves in Sylhet



A whole sale shop in Rajshahi



Briquetting industry in Khulna



Briquetting unit in KUET



A food stall in Khulna



Transporting briquettes in Khulna

### **Conclusions drawn**

As per the assessment of KUET, some important points which made rice husk briquetting successful in Bangladesh even without any support from the government[16-17].

1. Cheap and abundant raw material (rice husk) is available everywhere because rice production is very high. Cost of rice husk is 5 takas per kg.
2. Cheap and simple technology – One unit will cost Takas 50 to 60,000.00
3. Fabrication of technology and Repair and maintenance capability has been well developed.
4. Cheap and wide variety of heating and cooking devices
5. Technical support (Technological backstopping) from Research Institutions like KUET
6. Availability of skilled and trained manpower
7. Easy access to hard facing materials and hard facing technology



8. Reliable power supply to industries
9. Cheap and economical life style of rural people

## **5.2. Indian experience**

### **A brief history of briquetting in India**

Since the beginning of the 1980s there have been three different types of briquetting technologies introduced into India – PARU, Screw Extruder and Piston Press. Between 1982 and 1986 seventy entrepreneurs bought the PARU (Korean company) technology. All but six or seven of these plants became non functional within 3 months to 2 years of start up, and there are now none in operation. The high failure rate was attributed to the licensees' using inferior materials in the construction of the equipment (to increase their profit margins) and altering design without consulting the developer. Entrepreneurs in South India imported twenty screw extruders from Taiwan. Although the briquettes were well accepted by the customers, there was excessive wear in the press due to the use of rice husk (a particularly abrasive material) as the feedstock[19].

The Screw Extruder is considered to be more appropriate to the Indian power supply situation since the down time associated with power disruption is significantly less than that for a piston press (half our compared to four hours). The disadvantage of this type of press is the higher investment costs compared to the piston press and the need for skilled welding to repair the screw.

The piston press is the technology that has been most widely used on commercial basis in India with any degree of success. The technology was first introduced in India in 1981 from a Swiss company, Fred Haussmann Corporation, but later no major imports was noticed since the costs were very high. So a number of some manufacturers started producing the piston presses as it had a good market potential. In 1993, thirty five plants were identified using this indigenously manufactured equipment[19]. Some of the frequent problems of briquetting plants in India which has resulted in underutilization of this technology for rural development are given in Figure 4.

<b>Raw Materials</b>
<ul style="list-style-type: none"> <li>• Poor Availability</li> <li>• Cost</li> <li>• Vulnerability of stored material</li> <li>• High moisture content of biomass</li> </ul>
<b>Technology</b>
<ul style="list-style-type: none"> <li>• Wear in press</li> <li>• Space required for drying and storage</li> <li>• High maintenance costs</li> <li>• Jamming of ram in die holder</li> <li>• Non-standard parts</li> </ul>
<b>Markets</b>
<ul style="list-style-type: none"> <li>• Dependency on one client</li> <li>• Lack of Market awareness and Stimulation</li> <li>• Cost of briquettes as compared to other fuels</li> <li>• Intermittent production causes marketing problems</li> <li>• Clients with different specifications</li> </ul>
<b>Other Problems</b>
<ul style="list-style-type: none"> <li>• Poor communication between stakeholders</li> <li>• Poor after sales service of equipment manufacturers</li> <li>• Electricity supply disruption</li> <li>• High electricity costs</li> <li>• Distance to repair facility</li> <li>• Spare part availability</li> <li>• Poor product quality</li> <li>• Mismatch between press and auxiliary equipment</li> <li>• Seasonal labour shortages.</li> </ul>

Figure 4: Common Problems in Briquetting Plants

According to estimates by the All Gujarat Biomass Briquette Association (AGBBA), there are at least 500 briquette manufacturers across the country, giving direct and indirect employment to 100,000 people. About 200 of these are in Gujarat; the other major producers are in Maharashtra and Rajasthan, along with other northern states.

Biomass Briquettes are made from the Agricultural waste, Forest Waste and Industrial Waste. The major residues are Rice Husk, Coffee Husk, Coir Pitch, Jute Sticks, Sugarcane Bagasse, Groundnut Shell, Mustard Stalks, Cotton Stalks, Sawdust, Caster Seed Shells / Stalk, Wood Chips, Bamboo Dust, Tobacco Waste, Tea Waste, Paddy Straw, Wheat Straw, Sunflower Stalk, Palm Husk, Soyabean Husk, Veneer Residues, Barks and Straws, Forestry waste, Seeds Cases etc.

Raw materials such as rice-residues which were once takeaways are not free anymore. If the rice husks wastes are used for briquetting, the rice-mills charge up to 250 INR/ton (20 US\$/t) though a more usual price is 100 - 150 INR/ ton. Food processing industries, distilleries and agro product developers can harness this potential opportunity and one can expect that the price of biomass waste feedstock will be on uphill.

Briquetting plants in India are using saw dust, bamboo dust, bagasse, cotton stalk, coffee husk, groundnut shell, mustard husk/stalk, pine needles, rice husk, sugar mill waste, jute waste, coir pith and other wastes. Also, residues like castor shell, red gram stalk, tobacco stem, tea waste, sander dust, tree bark, wild grasses and shrubs and sander dust etc. can be also be briquetted individually or in combination without using any binders.

### **Advantages of fuel briquettes**

There are many advantages which make briquettes a better fuel in comparison to coal, fuel wood, etc. A Briquette is an Ideal Fuel because it is

- Eco friendly and Renewable Energy Fuel.
- Economical and Cheaper than other solid fuels i.e. Coal and Wood.
- Higher Thermal calorific value around 4000 Kcal/Kg.
- Pollution free because there is no sulphur or any hazardous materials.
- Lower ash content 2 to 5%. There is no fly ash when burnt.
- Consistent high burning efficiency due to the low moisture.
- Contain High Density and Higher Fix Carbon Value.
- Easy for Transportation, feeding & combustion due to unique shape.
- Combustion is more uniform compared to other fuels.
- Good Market due to rise in price of Fossil Fuels.

### **Applications for Biomass Briquettes**

Briquettes can be used in any appliances meant for burning wood or coal. Briquettes have a density twice that of common fuel wood. Porosity is very low and, accordingly, char produced during combustion is denser than wood or biomass charcoal. Moreover, screw pressed briquettes with a central hole have better combustibility than ram pressed solid briquettes and are considered to be better fuel than coal, wood and solid briquettes.

### **Combustion in Stoves**

Solid briquettes (SB) are considered unsuitable for cook stoves and give excessive smoke unless broken into small pieces of 1-2 cm in thickness. Screw pressed

briquettes (SPB) are easy to burn and give better combustion than wood. Moreover, SPB should be placed in a vertical position as far as possible so that the air can easily pass through the central holes. These can be broken into suitable sizes so as to fit well in the combustion chamber.

### **Combustion in Furnaces**

Both types of briquette are suitable for industrial furnaces which are meant for burning coal/wood but SPB fuels because of their homogeneous structure and configuration give much better performance than SB and other fuels. The power density is at least twice that of coal, provided secondary and primary air are properly distributed and the installed blowers supplying air have the requisite capacity.

### **Applications**

The briquettes are extensively used in the following sectors for different purposes like steam generation, drying, baking, dyeing, cooking, etc. (table 7).

**Table 7 : Major users of briquette in India**

<b>Sectors</b>	<b>Purpose</b>	<b>Remarks</b>
Boilers	For steam generation	SB and SPB
Food processing industries	Distilleries, bakeries, canteens, restaurants & drying	SB and SPB
Textile process houses	Dyeing, bleaching etc.	SB and SPB
Agro-products	Tobacco curing, tea drying, oil milling etc.	SB and SPB
Clay products	Brick kilns, tile making, pot firing etc	SB and SPB
Domestic	Cooking and water heating	SB and SPB
Gasification	Fuel for gasifiers	SB and SPB
Charcoal	Suitable for making charcoal in kilns	SPB only

### **Briquette Use - Present and Future Perspectives**

The current major users of briquettes in various regions are shown in Table 8. The survey revealed that there are no major problems at present as far as marketing of briquettes is concerned. In fact, the demand for briquettes far exceeds the supply at present, either due to high prices or due to shortage of commercial fuels. However, usage of briquettes is not without its problems. The equipment used to burn biomass briquettes is not designed for such use.

Table 8: Potential users of briquettes

State	Type of industry	Briquettes used as replacement for
Uttar Pradesh	Leather industry, Brick kiln	Coal
Punjab	Solvent extraction oil mill, Brick kiln	Coal
Gujarat	Textile, Dye and chemical industry	Coal
Tamil Nadu/Kerala/ Karnataka	Tea factories Rubber factories Pharmaceutical industries	Wood, Leco Leco Coal
Madhya Pradesh/ Maharashtra	Textile industry, Pharmaceutical industries, Brick kiln	Coal

Some industries that have converted their boilers to briquette fuels are given below. They consist of a wide range of industries, which mostly use fuel wood and coal, ranging from paper mills to textile processing. A list of industries that have converted to briquette fuel is given below in table 9.

**Table 9: List of Installations, where Boiler is converted to Briquette Fired**

Company	Boiler capacity(TPH)
M/s. Cadbury India Ltd, Thane (Turnkey Supply)	04
M/s. Novartis India Limited, Mahad ( Turnkey Supply)	12
M/S. Golden Chemicals Ltd., Borivali	10
M/s. Three M Paper, Chiplun	20
M/S. Clarisis Ltd., Baroda	06
M/s. Lactose India Ltd., Baroda	03
M/s. Skol Breweries Ltd, Uran	05
M/s. Garware Polyster, Aurangabad	09
M/s. Toshniwal, Tarapur	04
M/s. Sadguru Gums, Tarapur	0.3
M/s. Gharda Chemicals, Lote	12
M/s. Perstorp Aegies Ltd., Vapi	8
M/s. Pidilite Ind. Ltd., Vapi	2
M/s. Hindustan Braveries & Bottling Ltd., Thane	10
M/s. Colourchem Ltd., Thane	16
M/s. Bayer (I) Ltd., Thane	10
M/s. Pfizer (I) Ltd., Turbhe	12
M/s. Zydu cedilla (German Remedies) Ltd., Patalganga	2
M/s. M/s. Colourchem Ltd., Roha	16

### Incentives for briquetting industries

For the promotion of briquetting in India there are several financial incentives that have been sanctioned by the government agencies (IREDA) to different industries. The government gives a capital subsidy of 10-25% depending on the location of the industry in backwards areas. In addition the government provides incentive on Income tax, Sales tax, VAT and Excise duty[3] (table 10).

**Table 10: Incentives for briquetting sector project and equipment**

	INCENTIVES ->	Existing	Proposed
	<b>CENTRAL GOVT. INCENTIVES</b>		
1	Accelerated Depreciation (100% in the 1st year)	Yes	Yes
2	Income Tax Holiday for Power/Energy Generation (First 5 year - Nil) (Next 5 year - 70%)	N.A.	Yes
3	Concessional Customs Duty	40%	10%
4	Auxiliary Duty	Nil	Nil
5	Excise Duty	Nil	Nil
6	Central Sales Tax	*	Nil
7	Priority Sector Status (For priority lending)	N.A	Yes
	<b>STATE GOVT. INCENTIVES</b>		
1	Sales Tax Concession	Nil	Yes
2	Sales Tax Benefit (Deferment/exempn/transfer)	N.A	Yes
3	Octroi	*	Nil
4	Capital Subsidy	Yes	Yes

N.A. - Not available \* - Information available

However, briquetting industries say they need more support for raw materials and marketing. Some of the demands are:

“The government should make some arrangement to collect agricultural waste on a large scale, so that it would be helpful for us and also for farmers,” said Rakesh K Chhatbur, owner of Ramit BioCoal.

AGBBA also wants the government to make it compulsory for all those buying above 100 tons of coal to use at least five per cent white coal. It is also demanding tax sops from regional governments, as the fuel is pollution-free.”

## **Service Opportunities**

Briquetting being a relatively new area of business that is receiving increased attention, the need for consulting is of paramount importance. Companies have come up which aids in the facilitation of the production of fuel briquettes for fuel wood and other end uses. They assist entrepreneurs in the development of briquetting projects using various types of wastes. In addition, they assist fuel briquette entrepreneurs in developing local and export markets for their briquettes. Other Service Opportunities exist in the following areas:

- Design, installation, operation and maintenance of a briquette machineries and auxiliary units.
- Market research and feasibility studies for using the appropriate feedstock and research on the end user market segments.
- Developing energy production estimates for the process and feedstock.
- Assisting briquette entrepreneurs in developing export markets for their briquettes.
- Logistics support for briquette manufacturers.
- Due diligence and expert witness services
- Financial and insurance services.

## **Marketing**

The main problem associated with marketing is the seasonal requirements of briquettes by the end users like brick kiln and tea industries. The local market for biomass briquettes includes industrial users most of which are processing plants that have boilers. Briquettes sold in supermarkets are usually used for household purposes like barbecuing and roasting. It is reported that the volume of supply of biomass briquettes nationwide is still very small. Apparently, there is a low demand for the product due to: (a) low level of awareness about the product and (b) lower price and abundant supply of fuel wood and charcoal. The industry faces problems due to non-availability of sufficient working capital necessary to store the briquettes and sell it in periods of fuel shortage. With the price of petroleum products sky rocketing, this appears to be a profitable and eco-friendly venture. Also, the briquettes have to meet users' requirements based on which the market for briquettes have to be developed.

## **6. Identification of biomass resources for biomass briquetting**

### **6.1. Types of biomass residues in Nepal**

Biomass residues as energy feed stocks are more environment friendly than fossil fuels. Utilization of biomass energy recycles the carbon and does not add carbon

dioxide to the environment, in contrast to fossil fuels. Furthermore, the biomass residues are also fire hazards during the dry season. The use of biomass feed stocks in energy generation essentially promotes the development of healthy and sustainable local economies[4].

People have been using agricultural residues derived after harvesting crops like straw, stalks of plants, etc or after industrial processing of the crops like rice husk, bagasse, coffee husk, etc. for different purposes as well as energy. Besides agricultural residues people have also been using forest wastes as fuel for cooking, animal bedding and compost preparation. But forest waste does not seem to draw the attention as much as agricultural residues, although these resources are also plentiful. Forest residues are fire hazardous during the dry season and proper measures to utilize these resources and to control forest fires have to be introduced. Briquetting of these residues could be one option.

Nepal is rich in biodiversity and has many herbs and medicinal plants that are being processed in herb processing plants. After processing the herbs more than 90% of the remaining weight is residual biomass (Source: HPPCL). These residues also are potential raw materials for briquetting.

With growing urbanization Municipal solid waste is increasing daily. The combustible portion of the MSW is not being utilized yet for energy recovery in Nepal. This portion of the MSW is also a reliable source of energy which is being utilized in many different forms in other countries around the world[20].

Biomass, though abundant in the country, is a scattered resource and information regarding its availability is not well established except for some agricultural residues. The total biomass materials which can be available for Biobriquetting [4]can be categorized as

- Agricultural crop residue,
- Forest residue materials
- Residues from medicinal and herbal plant processing
- Municipal solid waste (MSW)
- Other biomass residues

## **6.2. Agricultural Crop Residue**

Residual biomass is the weight of all the remaining biomass except the grain. For the estimation of the residual biomass available for energy, different researchers use different but similar indicators. Some use the factor indicating the ratio of



weight of the residual biomass to weight of the total biomass. Total biomass here means the weight of the grain and the entire residue. The relationship between them is called the Residue Index (RI). The Residue Index could be defined as follows: Residue Index (RI) = Weight of the Residue (Wt)/Weight of the Total Biomass (wt)[21].

On the other hand many researchers use a similar indicator called the Residue to Product Ratio (RPR) of Crops. The yield of the crops has a definite relationship with the residue that is left after extracting the produce. The RPR is defined as the gravimetric ratio of the residue to the actual produce of the crop. The near accuracy of the RPR value of a particular crop leads to the realistic estimates of the total residue generated. Quantity of crop residue generated (tones) = RPR x Y Where, RPR = Residue to Product Ratio and Y is the Crop Yield (tones). Hence, this approach has been used here for the estimation of agricultural residues[22].

For the estimation of the agricultural crop residues some major cereal and cash crops have been taken into consideration [23]. Time limitations do not allow us for the assessment of all of the crops. The cereal crops include paddy, maize, millet wheat and barley, while the cash crops include oilseed, sugarcane, jute, soya bean and black gram. These crops have been selected as representative examples to show only some of the raw material potentials of the country. The residue estimates of the cereal crops are given in Table 11.

The residues of paddy are the largest source of agricultural residue at nearly 8,521,376MT. Considering the RPR value for rice husk to be 0.267 (Bhattacharya, et al 1993) the residue in the form of rice husk alone come to 1,354,290MT. Following paddy, maize, wheat and Barley also generate considerably large quantities of residues. The total residue of maize including stalk, cob and husk comes to 5,389,691MT, whereas for Millet, wheat, Barley and Buckwheat the residue generated 340272, 3230748, 60952 and 10021MT respectively, indicating their potential for briquetting.

**Table 11: Area, production and available residue from cereal crops**

Crop type	Area [Ha]	Crop Production [MT]	Residue type	RPR*	Total Residue Production [MT]
Paddy	1,531,493	5,072,248	Total residue	1.68	8,521,376
			Husk	0.267	1,354,290
Maize	871387	2179414	Total residue		5,389,691
			stalk	2	4,358,828

			cob	0.273	594,980
			husk	0.2	435,883
Millet	278030	315067	stalk	1.08	340,272
Wheat	765317	1846142	straw	1.75	3,230,748
Buckwheat	10339	10021	Straw	1	10,021
Barley	27966	34829.8	straw	1.75	60,952

Source: Statistical information on Nepalese Agricultural 2011/2012

\*RPR- (Bhattacharya, et el 1993)

Besides cereal crops, there are a large number of cash crops, which yield huge amounts of residues directly after harvesting of the crops. Industrial processing of these crops also yields additional residues as in the case of sugarcane which gives bagasse. The total residue generated from sugarcane including bagasse and leaves and tops alone comes to 1,728,728MT. The residue production of some of these crops is given in Table 12. Besides these crops there are many other crops like coffee, tea, cardamom, cotton, etc which also generate a lot of residues, which can be used for the purpose of briquetting.

**Table 12: Area, production and available residue from cash crops**

Crop type	Area [Ha]	Crop Production [MT]	Residue type	RPR	Total Residue Production [MT]
Oil Seed	214835	179145	Stalk	4.01	71,837
Sugarcane	64472	2930047	Bagasse	0.29	849,714
			tops/leaves	0.3	879,014
			Total		1,728,728
Jute	10540	14424	Stick	2	28,848
Soybean	29281.8	28269.8	Total		98,944.3
			Straw	2.5	70,674.5
			Pods	1	28,269.8
Black Gram	27496.2	22482.4	Straw/stick	1.66	37,320
Cotton	135	133	Sticks	2.75	365.75
Coconut			Husk	0.419	NA
			Shell	0.12	NA
Coffee	1780	425000	Husk	2.1	892,500
Ground nut	2736	3869	Husk	0.477	1,845
			Straw	2.30	8,899

Source: Statistical information on Nepalese Agricultural 2011/2012

## **6.2. Forest Based Biomass Resources:**

### **6.2.1. Wood based resources**

Forest and shrubs cover 39.6% of the total land area (including protected areas) of Nepal. According to a study conducted by Forest Resources Survey Department the potential assessment of total growing stock (i.e. total biomass of stems, branches, leaves of tree from ground level to the top) is nearly 285 million cubic meters while the available volume per hectare is about 131 cubic meter[24].

Forest based residues can be mainly classified into residues coming from wood processing plants, management of perennial crop plantation and waste generated from the forest itself. Wood processing plants include wood residues from logging and wood-processing such as saw-milling and manufacturing of plywood and particle board. Logging residues consist of branches, leaves, lops, tops, damaged or unwanted stem wood. After receiving the logs, about 12% is waste in the form of bark. Slabs, edgings and trimmings amount to about 34% while sawdust constitutes another 12% of the log input. After kiln- drying the wood, further processing may take place resulting in another 8% waste (of log input) in the form of sawdust and trim end (2%) and planer shavings (6%). For calculation purposes a yield factor of 50% has been used (38% solid wood waste and 12% sawdust). [2, 25]. This indicates the amount of waste generated from wood processing.

### **6.2.2. Saw dust**

The Timber Corporation of Nepal does not have the exact number of saw mills existing in the country, but gave some estimates of the saw dust that is produced by the saw mills. It is assumed that about 9-11% of sawdust is obtained during the processing of timber. Taking the average as 10%, the volume of sawdust obtained is shown in table below in Table13.

**Table13: Timber used & sawdust obtained in different fiscal years**

S No.	Year	Timber used (ft <sup>3</sup> )	Volume of sawdust & wood waste obtained (ft <sup>3</sup> )
1.	2061/62	1227739.62	122773.96
2.	2062/63	924843.11	92484.31
3.	2063/64	1266008.80	126600
4.	2064/65	1271515.62	127151.56
5.	2065/66	1359099	135909.9
6.	2066/67	673275.07	67327.50

Source: TCN and Department of Forest, 2066

There are many saw mills, private as well as government owned under the Timber Corporation of Nepal, located in different places throughout the country. A study report conducted in early 1980ies had established that the TCN in Hetauda was generating annually 14,800 tons of wood wastes (saw dust, bask, trim-ends, etc) including daily 10 tons of saw dust alone. Based on this raw material a piston press briquetting plant of daily 8 ton production capacity had already been proposed to establish there during the early 70ies [26]. This already indicated that saw dust and wood waste had big potential as raw material for briquetting.

Similarly substantial amounts of waste are generated from Veneer, Plywood production and Particle board production. The assessment of the residues generated from wood processing plants is also required to be established as the raw material base for briquetting undertaking separate studies. The case of waste generated from Veneer Industries will be dealt later as an example of a good source of raw material for briquetting industries. The case of particle board and plywood industries too has to be studied in future if briquetting is to be promoted in large scale.

On the other hand during processing of timber substantial amount of the biomass such as twigs and branches are also obtained. The volume of this biomass is given in Table 14.

**Table 14 : Twigs & branches obtained in different fiscal years.**

S No.	Year	Twigs and branches obtained (ft <sup>3</sup> )
1.	2061/62	21650.46
2.	2062/63	1464.19
3.	2063/64	1870.57
4.	2064/65	1713.07
5.	2065/66	1938.70
6.	2066/67	892.66

Source: TCN and Department of Forest, 2066

Despite having such big biomass resources briquette production from sawdust and wood waste has not been a priority. This is due to lack of interest as well as genuine knowhow about briquetting technology coupled with ignorance which tempts the villagers and sawmill owners to simply burn the obtained residue without briquetting.

### **6.2.3. Pruning of trees**

Wood residues generated by management of perennial crop plantations such as pruning and replanting of trees (rubber, coconut, palm oil); perennial crop

plantations such as for coconut and rubber generate considerable amounts of wood residues from pruning and replanting activities. This is another potential area where forest based biomass residues are generated and the amount of waste generated should be established through separate studies.

#### **6.2.4. Biomass under the high tension lines**

Another important resource which is also neglected and being wasted is the biomass under the high tension lines which is cut annually so that they are not destroyed by climbers and trees. The Sub sector report of NIDC on Fuel briquetting [12] clearly mentions the huge amount of biomass under the high tension lines which is cut annually and wasted. It even recommends it as a very good raw material which should be distributed freely to the existing briquetting industries. Quantification and utilization of this resource is also important.

Data and information regarding these forest based waste resources are very scanty and have not been quantified properly. Hence, it is necessary to undertake separate assessment studies for the quantification of forest based waste resources in view of establishing and promoting briquetting industries in the future.

In the absence of established data base, for the purpose of giving some indicative figures for some waste biomass, some rough estimates of some waste biomass found while studying various reports and literature have been given here.

#### **6.2.5. Different Forest waste**

Waste generated from forest itself, such as leaves falling from the different trees, weeds and invasive plants, etc. can also be used for briquetting. A lot of trees (Sal) shed leaves regularly during the winter season to give a thick bed of leaves. Likewise, where there are pine forests a thick layer of pine needles as well as pine cones are found in huge amounts. All these resources are plentiful and are very fire hazardous during the dry seasons and cause tremendous amount of damage [4]. Then there are a lot of alien invasive species of biomass such as Banmara, Lantana camara, Mikania macrantha, etc, which have invaded the forest as well as grassland and are destroying the forest as well as the habitat of many protected areas. Some assessment of these resources is also necessary as there is no established data on these waste resources. Some estimates of these resources are given below to indicate the large amounts of forest based biomass that can be available for briquetting.

### 6.2.6. Banmara

Banmara (the forest killer) or *Adenophorum Eupatorium* is an invasive seasonal plant which came from Latin America, can be seen everywhere throughout the country in forest areas, agricultural land and on the sides of roads and highways. There are many species of this plant. Photos of different species from different areas are given below. It not only destroys the forest but also destroys all other plants around it. During the dry season it is very fire hazard and the seed of this plant can be carried to long distance during forest fires.

During 1994, Sagarnath Forestry Development project, which spread over 11,000 hectares, had undertaken some preliminary study and reported that an average yield of 0.8 tons of Banmara can be collected from one hectare. An estimated amount of 8800 tons could be generated from the project area and the collection cost came to Rs 40 for 70 kg per person.



White Banmara



White and Kalo Banmara together



A recent assessment study (February 2014) of availability of Banmara in different parts of the country showed that the amount of dry matter that can be obtained is about 17 tons/ha annually (Table 15). The total area of coverage of Banmara

has not yet been established, but the visibility of Banmara along the highways (East West Highway and other roads) and degraded forest areas, especially the areas under the high tension electricity lines, show huge amounts of Banmara. Once the exact coverage area by Banmara is established then the total amount available can be determined.

**Table15: Amount of Banmara from different places**

S.N	Site location	Biomass species	Wt of wet biomass(kg)	Area	Wt of dry Biomass (kg/m <sup>2</sup> )	Average wt of dried matter
1	Makwanpur (Bhaise)	Banmara	10	1 m2	2.5	
		Banmara	11	1 m2	2.75	
2	Nawalparasi	Banmara	6	1 m2	1.5	1.78 kg/m2 (17 tons/ha)
		Banmara	6	1 m2	1.5	
3	Dhading	Banmara	6	1 m2	1.5	
		Banmara	3.5	1 m2	0.85	
			7.5	1 m2	1.85	

Field survey February 2014:CEEN

### 6.2.7. Pine needles

Chir pine (*Pinus roxburghii*) is an important native conifer tree species in Nepal. It has dominated the coniferous forests of the country, which comprise 17% of the total area. In 1981 and 1982, 57% of all trees planted by the Community Forestry Development Project were chir pine. Out of the seventy-five districts, forty-eight districts have contributed to the pine forest in Nepal. Western regions of Nepal show higher percentage of pine forest. Achham, Baitadi, Doti, Salyan, Dailekh, Jajarkot, and Pyuthan have crossed the twenty percent level.

The total Chir pine forest area in Nepal is reported to be 382,944.80 hectares (table 16). The average number of pine trees having stem diameter greater than 30 cm is 50 per hectare.

**Table 16: Chir Pine Availability in Nepal**

S.N.	District	Total Forest Area(Ha)	Chir Pine Forest Area(Ha)	Percent Availability of Chir Pine (%)
1	Achham	88,097.90	22,122.80	25.11
2	Baitadi	78,720.90	31,708.90	40.28
3	Bajhang	113,179.20	8,813.40	7.79
4	Bajura	98,646.10	2,506.30	2.54
5	Dadeldhura	115,891.10	21,620.20	18.66

6	Darchula	97,537.70	2,713.60	2.78
7	Doti	144,689.20	35,573.20	24.59
8	Kailali	231,092.70	15,761.10	6.82
9	Bardia	127,682.20	295.00	0.23
10	Dailekh	78,136.50	18,495.50	23.67
11	Dang	197,272.80	5,252.50	2.66
12	Jajarkot	135,615.00	36,459.90	26.88
13	Mugu	111,098.90	1,776.50	1.60
14	Pyuthan	72,694.30	16,373.40	22.52
15	Rolpa	94,096.80	15,219.10	16.17
16	Rukum	136,452.00	4,795.80	3.51
17	Salyan	79,597.90	52,539.40	66.01
18	Surkhet	177,854.70	31,045.70	17.46
19	Argakhache	73,133.40	6,247.30	8.54
20	Baglung	98,045.70	1,841.20	1.88
21	Gorkha	112,534.70	344.90	0.31
22	Gulmi	40,663.30	5,973.20	14.69
23	Kaski	89,943.20	400.00	0.44
24	Myagdi	84,452.10	1,056.40	1.25
25	Nawalparasi	12,274.70	91.60	0.75
26	Palpa	71,172.00	1,313.60	1.85
27	Parbat	19,997.20	1,039.60	5.20
28	Syangja	31,690.60	32.60	0.10
29	Bhaktapur	1,947.20	32.30	1.66
30	Dhading	92,855.40	3,495.20	3.76
31	Dolakha	94,477.80	3,660.30	3.87
32	Kathmandu	13,752.40	741.10	5.39
33	Kavre	72,949.60	3,342.70	4.58
34	Lalitpur	20,727.50	161.20	0.78
35	Makwanpur	167,453.30	5,879.20	3.51
36	Nuwakot	49,654.40	1,056.00	2.13
37	Ramechhap	66,151.90	4,525.30	6.84
38	Rasuwa	52,290.40	118.50	0.23
39	Sindhupalchok	162,543.20	724.90	0.45
40	Sindhuli	62,043.00	6,158.90	9.93
41	Bhojpur	77,887.60	542.80	0.70
42	Dhankuta	36,385.20	601.30	1.65
43	Khotang	79,553.70	2,912.50	3.66
44	Okhaldhunga	47,346.70	3,746.20	7.91
45	Panchthar	57,706.60	1,390.70	2.41
46	Taplejung	139,167.20	96.70	0.07
47	Tehrathum	24,627.60	160.50	0.65
48	Udayapur	138,916.70	2,185.80	1.57
		4,270,700.20	382,944.80	8.96

Source: (Land Utilization report Appendix One (1986), Land Resource Mapping Project)

Pine tree is a major source of timber used for making furniture and plywood. Resin from chir pine trees is used to manufacture turpentine, rosin and other products. The only wastage of pine tree is being the pine needle, so the appropriate use of pine needle as energy source will enhance the community



people for greater plantation of the pine tree. As pine needle being loose forest residue which is slow decaying and totally wastage material is also a major cause of forest fire. The collection of pine needles ensures that the chances of forest fires are minimal. Usually, the accumulating carpet of needles on the forest floor under these trees makes it unsuitable for many common plants and trees to grow. Every autumn, the dried needles of this tree form a dense carpet on the forest floor, which the locals gather in large bundles to serve as bedding for their cattle, for the year round. Pine-needle collection will generate employment opportunities for the villagers. It is estimated that one family can collect up to 100–200 kg of pine needles in a day depending upon the time they spend in collection. A pine forest area of 1 m<sup>2</sup> will yield 1.19kg of pine needles and 115 ha of cleared forest every year will give 1350 tons of pine needles per year. So considering the pine forest area in Nepal to be 382,944.80ha then around 4.5million tons of pine needles will be available as raw material.

Pine needles as raw material is being used for different purposes like biomass gasification for electricity generation, briquetting and pellet production. In Berinag, Uttarakhand, India, it is used for gasification and villagers get Rs 1,000 for every ton of needles collected. Hence, the material itself will be free of cost requiring only collection cost[27].

An equal amount of pine cones also can be expected from these forests. This resource can prove to be a potential raw material base for biobriquetting in the areas where pine forests exist.

#### **6.2.8. Besarmi jhar**

Besarmi jhar is abundantly found in the Terai region. It grows wildy in water logged areas along the highways and roadsides. A sample survey of the plant shows that from an area of 2 sq meters about 8-10kgs of wet biomass can be collected. This yields about 5-6 kgs of dried biomass which can be used for briquetting. So far the area of coverage by this plant is not known. Hence if a survey is conducted in future the total amount of biomass can be known.



Photos of sample survey of Besarmi Jhar in Nawalparasi

### **6.2.9. Saal leaves**

Saal forest in Nepal is a source of hard wood used for housing and construction purposes. Sal is moderate to slow growing, and can attain heights of 30 to 35 m and a trunk diameter of up to 2-2.5 m. The leaves are 10–25 cm long and 5–15 cm broad. In wetter areas, it is evergreen; in drier areas, it is dry-season deciduous, shedding most of the leaves in between February to April, leafing out again in April and May, giving a bed/carpet of leaves of around 8-12 inches thick. Timely disposal of this material is important as it can induce forest fires that can destroy forest area.

An estimate has shown that a total of 3654 million ha of forest area is available for improved management. Out of which saal forest occupies area of 1,320,000 ha in Nepal [28].

There is considerable amount of litter fall annually in tropical dry deciduous forests. According to Burges [29] the total litter fall in tropical forest may reach to 1.53 thousands kg/ha/yr. Taking this figure into consideration and the saal forest area of Nepal as 1,320,000 ha, the amount of saal litter i.e. leaves that will be available will be around 2,019,600 tons of leaf litter per year[30].

Earlier if fresh green leaves of saal found limited use traditionally for making Tapari, recently Saal leaves are used as raw materials for the production of traditional plates or bowls (tapari) in certain industries. These industries consume large amounts of leaves in the process of making tapari, etc. One such industry alone has around 5 tons of waste materials (Source AEPC), which do not find any use. As these leaves have better heating values and low ash content they can be used as raw materials for briquetting. Ghimire has shown that these leaves

have higher calorific values of about 4880 kcal/kg than other waste biomass and a lower ash content.



**Saal leaf litter**



**Collection of leaf litter**

#### **6.2.10. Mikania micrantha**

*Mikania macrantha*, also known as mile a minute, is one of the many invasive species of biomass, which is showing severe damaging effects on young trees, shrubs, grasses in mostly mixed and reverine forests and grass lands. It has reduced food availability of wildlife species found in Koshi Tappu and Parsa Wildlife Reserve and Chitwan National Park areas. It is threatening the rhino-habitat including the grassland. Its present infestation is estimated to have over 30 % of the entire Chitwan national park area. If it is spread widely it will reduce the productivity, destroy regeneration and degrade the forest condition.

It is neither a good feed for the animals nor does it have any other value of biomass. One of the methods of utilizing it would be for briquetting. Poudel M. S. has successfully shown that the invasive plant *Mikania* can be used to produce different types of briquettes – biomass briquettes, beehive briquettes and charcoal pellets. A survey conducted jointly by NTNC, TCN and NAST in Chitwan National Park has shown that 91,088 tons of dried *Mikania* or 34,158 tons of Charcoal from *Mikania* respectively[31] is available for briquetting purposes annually (Table 17).

*Mikania* has infested many other places such as the Koshi Tappu, Parsa Wild life Reserve, etc. It has been established that more than 20 districts in the Terai region has been infested with *Mikania* [32]. Therefore, the potentials of *Mikania* as one raw material for briquetting in these areas are quite large and assessment of its available quantity should be established if briquetting is going to be promoted in future.

**Table 17: Estimates of Mikania as raw material for briquetting**

No	Parameter	Amount	Unit
1	Average fresh weight of Mikania from a plot		30.39 Kg/25m <sup>2</sup>
2	Total area of Chitwan national park		932 Km <sup>2</sup>
3	Mikania coverage**		30%
4	Effective Mikania coverage with reference to column 3		279.6 Km <sup>2</sup>
5	Total weight biomass of Mikania in 279.6 Km <sup>2</sup>		339881760 kg
6	No of times Mikania can be collected in a year		2
7	Total biomass yield from 2 collection phases in a year		679763520 Kg
8	Moisture content with reference to thesis		86.6%
9	Recovery of dried Mikania for direct densification	91088312 kg	~91088 tons
10	Recovery of Mikania after charring***		34158117 kg
11	Recovery of Mikania for charcoal briquetting	34158.117	~34158tons

Since it does not find much use and does not have any economic value, simply using it as renewable biomass could be an option to tap and use this as a raw material for briquetting. Considering the infestation of about 20 district of Terai by Mikania, approximately 600,000 tons of dried Mikania will be available as raw material for briquetting.

#### **6.2.11. Other agro and forest waste**

There is many more such waste that does not find much use and they are also creating problems. Lantana Camara and Mugwort are invasive biomass like Banmara Water hyacinth is creating problem in many water bodies including Fewa Taal. Many more such waste biomass exists in different parts of the country but the amount of coverage and the yield per hector has yet to be established.

Then there are also many agro wastes that are found available in abundant quantities but to use them as raw material some assessment studies have to be conducted to know the exact amount that will be available. The list of waste biomass is in exhaustive. To mention a few, they are

- |                      |                                      |
|----------------------|--------------------------------------|
| 1. Cotton stalks     | 6. Lantana Camera –Dhugri Phool      |
| 2. Coffee waste      | 7. Mugwort - Tite pati               |
| 3. Tobacco waste     | 8. Water Hyacinth                    |
| 4. Tea waste         | 9. Banana waste                      |
| 5. Ground nut shells | 10. Eucalyptus forest Waste (leaves) |

For the assessment of the available quantity of these waste separate studies have to be commissioned by AEPC and concern authorities.

### **6.2.12. Municipal Solid waste**

The combustible portion of the Municipal Solid Waste from cities is another reliable raw material for briquetting. The five municipalities in the Kathmandu Valley generate daily approximately 435 tons of solid waste of which more than 70% comes from Kathmandu Metropolitan City alone [33]. The most recent data suggests that the five municipalities in Kathmandu valley generate around 468.25 tons of solid waste daily [20]. This increase in the amount of solid waste by 7.64% in a span of four years can be attributed to the increasing population in Kathmandu valley. The average composition of MSW of Kathmandu valley, which consists of compostable waste (decaying organic matter), combustibles (paper, plastics, textiles) and inorganic matter such as glass and metal from different years are given in Table 18.

**Table 18 : Composition of waste in past years Kathmandu (% wt)**

No.	Type of waste	1976	1981	1985	1988	1995	1999	2000	2004	2008
1	<b>Organic</b>	67.8	60.0	67.5	58.1	65.0	67.5	69.84	67	68.0
2	<b>Paper</b>	6.5	19.3	6.0	6.2	4.0	8.8	8.5	10	10.0
3	<b>Rubber</b>	0.0	0.0	0.0	0.4	1.0	0.3	0.54	0.24	mix1
4	<b>Leather</b>	-	-	-	-	-	-	0.12	-	-
5	<b>Wood</b>	2.7	1.6	0.0	0.5	3.0	0.6	0.73	-	-
6	<b>Plastic</b>	0.3	3.6	2.6	2.0	5.0	11.4	9.17	16	13.0
7	<b>Bone</b>	-	-	-	-	-	-	0.23	-	-
8	<b>Textile</b>	6.5	5.3	2.7	2.0	3.0	3.6	3.02	4	2.0
9	<b>Ferrous metal</b>	4.9	3.4	2.2	0.4	1.0	0.9	0.87	1	-
10	<b>Aluminium</b>	-	-	-	-	-	-	0.05	-	-
11	<b>Metal</b>	-	-	-	-	-	-	-	-	1.0
12	<b>Sand dust</b>	-	-	-	-	-	-	-	-	1.0
12	<b>Glass</b>	1.3	3.4	4.0	1.6	1.0	1.6	2.5	1	4.0
13	<b>Construction debris/Others</b>	10.0	3.4	15.0	28.9	17.0	5.3	4.33	1.24	1.0

(Source: Various JICA survey reports, and SWMRMC 2008)

The recent trend towards MSW in many countries is to look at it as a resource and not waste. It has been practiced worldwide to use MSW for power generation, compost, recycling and recycled products. Waste to energy conversion can be an economical and eco friendly way for waste utilization and reduction as well as

source of fuel alternative at the same time. This technology has long been in practice in many cities of Japan in the form of MSW briquette fuel use for the purpose of heating. Likewise, the municipal waste of Kathmandu could be best recovered and reused by transformation into solid waste fuel briquettes in the form of Refuse Derived Fuel (RDF). In Nepalese context, such type of fuel material can be a substitute for the imported Indian coal in industries like Brick Kiln, industrial boilers, etc. With this concept NESS also had undertaken some research works to produce fuels briquettes in 1995. As plastic is an integral component of RDF the heat content was high and the fuel was easy to ignite, so the test results of NESS had shown very promising results[34].

There are 58 municipalities in Nepal and the amount of waste generated by these municipalities per day comes to 2813.13 tons. Out of this amount of generated waste, 2164.49 tons are collected. The average composition of this waste, considering the combustible portion only, is 8.36% - plastics, 8.59% -paper, 1.66%- textiles and 0.68% by weight – woody matter [20]. From simple calculations, this gives about 181 tons of plastics, 186 tons of paper, 36 tons of textiles and 15 tons of woody matter on a daily basis which are good raw materials for producing RDF. All these waste resources open up big avenues for briquetting of these combustible matters to produce fuel briquettes for industrial use.

#### **6.2.13. Waste from veneer industries**

There are many veneer and plywood industries established all over Nepal. In Birtamod alone there are around 38 veneer industries (table No19), which are using Utis, Malato and Mauwa logs from Ilam and Panchthar for the production of veneer. The logs cost about Rs 150 per cubic feet. One such industry - Shree Hari Om Veneer Udyog in Ataarmani, Jhapa – processes an average amount of 400 cu. ft. of logs per day. Along with the veneer product the industry generates a huge amount of different types of waste starting from bark of the tree logs to saw dust.

Mainly five different types of waste were found in the factory. These waste materials have found limited use only. Some of it is being sold to a tea factory, which uses about 8 tons/per week as fuel for a Gasifier to dry tea leaves. Some selected waste is sold to the local people as fuel for cooking.

These wastes from the veneer industry could be a potential raw material for briquetting. Since the wood used is mainly soft wood, they are good raw materials



for producing wood pellets. The different types of waste in the factory are shown in the pictures below.

**Table 19: Different types of waste and cost**

No	Different waste	Cost (Rs/kg)	Users	Purpose
1	Bark	2	Locals	Making alcohol
2	Gollia or golla	6-7	Locals	Cooking/tea factory
3	Saw dust	1	Locals	Cooking food
4	Small strips	3-4	Locals	Cooking food and animal feed
5	Very small pieces	1	Locals	Cooking/tea factory

Source: Shree Hari Om Veneer Udyog in Ataarmani, Jhapa

**Waste No 1 - the bark of the logs**



**Waste No 2 – the remaining central part called golla or gollia**





**Waste No 3 – saw dust**



**Waste No 4 - Small chunks/pieces of wood, sold to local people at Rs 3/kg.**



**Waste No 5- Small pieces/straps of unusable veneer**







### **Discussions in Sri Hari Om Veneer Udyog**

About 20 industries are situated in Morang districts. According to the Nepal Veneer Producers Association there are 54 members in the association. Not all industries are members. Altogether all over Nepal there are about 200 such industries in operation.

According to Ms Shri Om Veneer Udyog, the estimate of waste generated in the factory comes to about 30% of the processed wood. However, visual on sight observation indicate more. According to Nepal Veneer Producers Association, currently 25% of the waste from the industries is being consumed locally as fuel for cooking and boilers and 75 % is unused. (Source: Mr Ek Raj Karki, President, Nepal Veneer Producers Association)

For these industries, Koopmans and Koppejan [22] mentions that from the log input, the main forms of waste are log ends and trims (7%), bark (5%), log cores (10%), green veneer waste (12%), dry veneer waste (8%), trimmings (4%) and rejected plywood (1%). These form the largest amount of waste while sanding the plywood sheets results in another loss of 5% in the form of sander dust [3]. For calculation purposes a yield factor of 50% has been used, with 45% solid wood residues and 5% in the form of dust[22].

# नेपाल भेनियर उत्पादक संघ

केन्द्रीय कार्यालय, अनारमनी-६, भापा  
मेची अञ्चल (नेपाल)

फा.वि.प्र.का.द.नं. १७४१/०६७

फोन : ०२३-

प. सं.

च. नं.

स्थापित : २०६७

मिति : .....

भापा जिल्लाका यस संघ संग आवद्ध भेनियर उद्योग व्यवसायीहरूको विवरण २०६८ माघ २७ गते सनिवारबाट

क्र.सं.	नाम	पद	भेनियर उद्योगको नाम	ठेगाना	कार्यालय नम्बर	मोबाइल नम्बर
१.	श्री एकराज कार्की	अध्यक्ष	सुजन भोनायक उद्योग	अजुनाधारा-५	०२३-५४५३४३	९८५२६०१५८०
२.	सुभास कुमार मुरारक	वरिष्ठ उपाध्यक्ष	जगदम्बा भेनियर उद्योग	मेची न. -२	०२३-५४१२६०	९८५२६०३३१८
३.	श्री राधेश्याम गौयल	उपाध्यक्ष	गायत्री भेनियर उद्योग	दुवागढी-८	०२३-५४१८५६	९८५२६०४०८२१
४.	श्री गोपाल तुलस्यान	महासचिव	वैष्णवी भेनियर उद्योग	चारपाने-१	०२३-५४११६१	९८५२६०४०८३
५.	श्री मुरारी लाल चौधरी	सचिव	ओम शिव भोनायक उद्योग	चारपाने-१	०२३-५४०५१२	९८५२६०४२१३
६.	श्री विकास गौयन्का	कोषाध्यक्ष	राज इन्स्ट्रुज	दुवागढी-३	०२३-६८०८६२	९८५२६०४८२६
७.	श्री दुर्गा प्रसाद भण्डारी	सदस्य	श्री पशुपती भेनियर उद्योग	चारपाने-३	०२३-५४१८५६	९८५२६०४८८८
८.	श्री सुरेश अग्रवाल	"	पशुपति भेनियर उद्योग	अनारमनी-६		९८५२६०४२३०
९.	श्री विरबहादुर कुरुवाड	"	श्री गजुरमुखि भेनियर उद्योग	मेची नं. - ११		९८५२६०४३८५
१०.	श्री टंक गौतम	"	जानकी भोनायक उद्योग	अनारमनी -६	०२३-५४२१२१	९८५२६३३१२१
११.	श्री दिपेश प्रधान	"	जय श्री हलेशी भेनियर उद्योग	मेची न. -२	०२३-५४१८५६	९८५२६०४३११
१२.	श्री विशाल अग्रवाल	"	बालाजी भेनियर उद्योग	चारपाने -५	०२३-५४४१६०	९८५२६०४००२८
१३.	श्री नन्द किशोर सरावगी	सल्लाहकार स. अध्यक्ष	दुर्गा टिचेस्ट	दुवागढी -४ चारआली	०२३-५२१११५	९८५२६०४१८५
१४.	श्री विमल प्रधान	स. च. उपाध्यक्ष	मेची भेनियर उद्योग	मेची न. -१	०२३-५४२३४५	९८५२६०४०६७
१५.	श्री रामेश्वर बंशज	" " "	प्रेम गुरु भोनायक उद्योग	चारपाने-३	०२३-५४२४०५	९८५२६०४३०२
१६.	श्री अजय गौयल	सा.स.स.	श्री जय वज्रभंग भेनियर उ.	चारपाने-१	०२३-५४२४०५	९८५२६०४०२५०
१७.	श्री विजय केडीमा	" " "	श्री पुजा भेनियर उद्योग	चारपाने-५		९८५२६०४४४१
१८.	श्री मुकेश अग्रवाल	" " "	श्री साई भेनियर उद्योग	मेची न. -२	०२३-५६१५२५	९८५२६१८३३८
१९.	श्री विनोद गुप्ता	" " "	हरी ओम भोनायक उद्योग	अनारमनी-६	९८५२०५५८८०	९८०५८२५०८८
२०.	श्री अमित कु. अग्रवाल	" " "	शाकम्बरी भेनियर उद्योग	अनारमनी -६		९८५२६०४८८०
२१.	श्री संजय चौधरी	" " "	गणपति भेनियर उद्योग	अनारमनी -६	०२३-५४३०६५	९८५२०३१०८८
२२.	श्री बासुदेव साह	" " "	सर्वांग भेनियर उद्योग	चारपाने - ३	५२०८६३.५४०५८	९८५२६०४०८८८
२३.	श्री महेश कुचितलंगिया	" " "	जय अम्बे फ्लाईउड ई. उद्योग	चारपाने -५	०२३-५४४१३५	९८५२०२०२८८
२४.	श्री रोहन मुरारक	" " "	मनकामना भोनायक उद्योग	दुवागढी -८	०२३-५६०८८५	९८५२४०८३३२
२५.	श्री मोहन मुरारक	" " "	विहारी जो भोनायक उद्योग	अनारमनी-६		९८५४६४२८२५
२६.	श्री दिनेश कु. चापगाई	" " "	पाथिभरा भोनायक उद्योग	चारपाने-८	०२३-५४३८८८	९८५२६०४००८४
२७.	श्री राज कुमार जैन	" " "	नमस्ते फ्लाईउड उद्योग	चारपाने-५		९८५२६०४१०८
२८.	श्री अनुप साह	" " "	अन्नपूर्ण भोनायक उद्योग	अनारमनी-६		९८००४०४८८८
२९.	श्री विमल प्रधान	" " "	मेची भोनायक उद्योग	मेची न. -११		९८५२६०३१०५
३०.	श्री देवराज घिमिरे	" " "	हलेशी भोनायक उद्योग	शनश्चरे -८	९८५२६०४४११	९८५२०२५४८६
३१.	श्री अरुण अग्रवाल	" " "	रिद्धिसिद्धी भोनायक उद्योग	अनारमनी-६		९८५२६०४८८०
३२.	श्री धेराज प्र. राजवंशी	" " "	मिताञ्जली	चारपाने -३	०२३-५४४२०२	९८५२०१२०४०
३३.	श्री नरेन्द्र खड्का	" " "	सिद्धी विनायक प्रा.लि.	मेची न. -२		९८५२०११८८५
३४.	श्री बासुदेव शाह	" " "	अम्बे भोनायक उद्योग	ज्यामिरगढी	०२३-५६१५३१	९८५२६०४०८८८
३५.	श्री अरविन्द्र अग्रवाल	" " "	मिताल फ्लाईउड उद्योग	गरामनी -३	०२३-५४६०२१	९८५२६०४५३५
३६.	श्री दिपेन्द्र पोखरेल	" " "	सिद्धी विनायक फ्लाईउड	अनारमनी -८		९८५२६०४८८५
३७.	श्री अच्युत प्र. घिमिरे	कार्यालय सचिव	नेपाल भोनायक उत्पादक संघ	अनारमनी -६	०२३-५४१८५८	९८५४६१०१३१

Members of the Nepal Veneer Producers Association of Jhapa district

**Table 20: Waste generated by Veneer Industries in Nepal**

Subject	Amount in Cu.ft. processed per day	Waste per day (taking 50%)	Density of soft wood	Total Amount waste per day
Waste from Sri Om Veneer	400 cft. (300-500cft)	200 cft. = 5.66 m <sup>3</sup>	53lb/cft* (670kg/m <sup>3</sup> )	3792kg or 3.8 tons
Total Amount of waste generated from 200 industries from all over Nepal				758440 tons
Current use by local people and boilers and tea drying = 25%				189610 tons
Unutilized waste that can be used for briquetting = 75%				568830 tons

\*<http://www.engineeringtoolbox.com>

Taking 50% as the waste factor and the average processing capacity of each factory to be 400 cft per day, an estimate of 200 cft of waste is generated daily. Therefore, in Jhapa alone, some 7600 cft of waste is generated daily. Currently, only 25% of the waste is being utilized by the locals and some industries as boiler fuel and tea drying. Seventy five per cent is still not used and wasted. Simple calculations using the density of soft wood as 670kg/m<sup>3</sup>, around 568,830 tons of wood waste (Table 20) is being generated in a day and this waste can be a good starting raw material for biomass briquetting.

#### **6.2.14. Other wood processing industries**

Similarly there are many other wood processing industries factories such as furniture, handicraft (wooden frames), etc. These factories also generate huge amounts of wood waste of different nature. An example of such factories can be Bira Furniture in Patan Industrial District (PID). It processes around 3 trucks of wood (about 30 tons) every month to produce different furniture, which give some 10-15 tons of wood waste per month (Source: Mr Padam Bahadur Shrestha). This waste can be a potential raw material for briquetting.

Waste from another factory also in PID, Lalitkaltmak Kastha Udyog, which make different wooden frames also generate wood waste in the form of saw dust and small cut pieces during production. About one truck (~0.5 tons) of Saw dust and 1-1.5 tons of wooden strips are generated per week. (Source: Mr. Simha Bahadur Baharai).

There are many such furniture, handicraft, parquet and other industries spread all over Nepal that process huge amounts of wood. Undoubtedly huge amounts of



wood waste are generated from them, which have to be quantified by conducting some studies.

**Some photos of different wood wastes in Bira Furniture (Source: R. M.Singh)**



Bakal and wood strips



Wood chips, plywood strips, wood strips, etc



Saw dust and wood strips

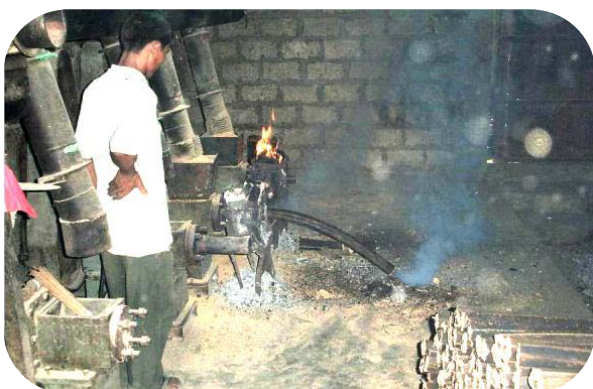
### **6.3. Other raw materials in the country**

If previously only rice husk was use as raw material for briquetting, now the scope of briquetting has widen because research and development has shown that many new raw materials can be used for briquetting. Some of them are Tite pati, Dhungri Phool, banana waste, bamboo waste, water hyacinth, etc. They are available free of cost and also found to be a problem for agricultural activities and forestry propagation. There are many more such waste biomasses, which can be potential raw materials for briquette production. The cost involvement is only the labor cost for collection. It can be seen from the above chapter on biomass situation that the list of waste biomass is in exhaustive.

## **7. Status of existing briquette industries and their markets**

### **7.1. Mhepi briquette and its supply chain**

Mhepi Briquette Udyog is the oldest existing briquette industry in Nepal. It was originally established as Chawosoti Briquette Udyog near Birgunj. It was later transferred to Kawosoti in Nawalparasi. Initially it used 4 Screw extruder units from Taiwan. Later 4 more such units were fabricated in Raxaul. Currently in 2012, it sold out 2 of its briquetting units to Namuna Briquette Industry in Chitwan. The details of the industry are given in table 22. Mhepi briquette Udyog has come a long way over coming all the technical difficulties as well as market problems.



Screw extruder briquetting



Rice husk briquettes

In 2012, it introduced another technology from China to produce pellets from rice husk. The rice husk pellets are 20mm square shape and are around 3-6cm in length. Trial production was conducted, however technical difficulties were faced and production could not be smooth and the pellets have not come to the market yet. The cost of the pelletizer alone was about US \$12,000/-.





Chinese Pelletizer

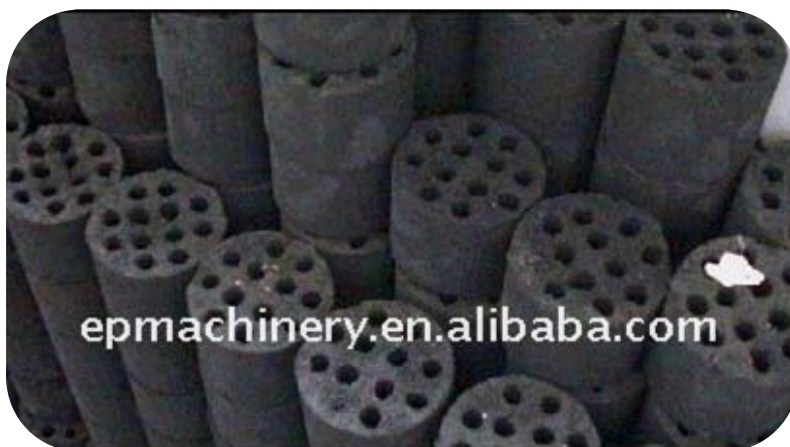


Square type rice husk pellets

Recently in 2013, Mhepi has again ventured into beehive briquetting and introduced a hydraulic briquetting machine, which can produce about 40 pieces of beehive briquettes in one minute. The production process is smooth but the product has yet to come to the market.



Briquetting press



Beehive briquettes

Mhepi Briquette Udyog has survived all the ups and downs faced by the rice husk briquetting industry. During the course of its operation for several decades, it has developed various strategies and capabilities which could be an example for other briquetting industries.

Mhepi briquette has developed its own market mechanism. Initially it also did marketing of briquettes through personal contacts and personal relations to army barracks and carpet industries. But this was not very reliable as the contact persons changed in due course of time. As the market developed it developed its

own network by establishing a distribution depot as a marketing outlet by appointing distributors for its product to the general public. In Katmandu alone he has several outlets.

Probably, the marketing strategy adopted by the factory played a crucial role in its existence. Price structure of the briquettes is also unique in the sense that the same product has different prices according to the customers. Price for old customers including carpet industries is about Rs 8/kg with marginal profit only. As they are regular customers who continuously require fuels for their industries, they get a special price. Seasonal users such as five star hotels and international offices require some briquette for space heating during the winter season only. The price for them is over Rs 20 per kg (Price during the late 1990ies). As fuel wood substitute and environment consciousness is predominant in these users group, they can afford it and are willing to pay this price. The distribution network is illustrated in the diagram below (Fig 5).

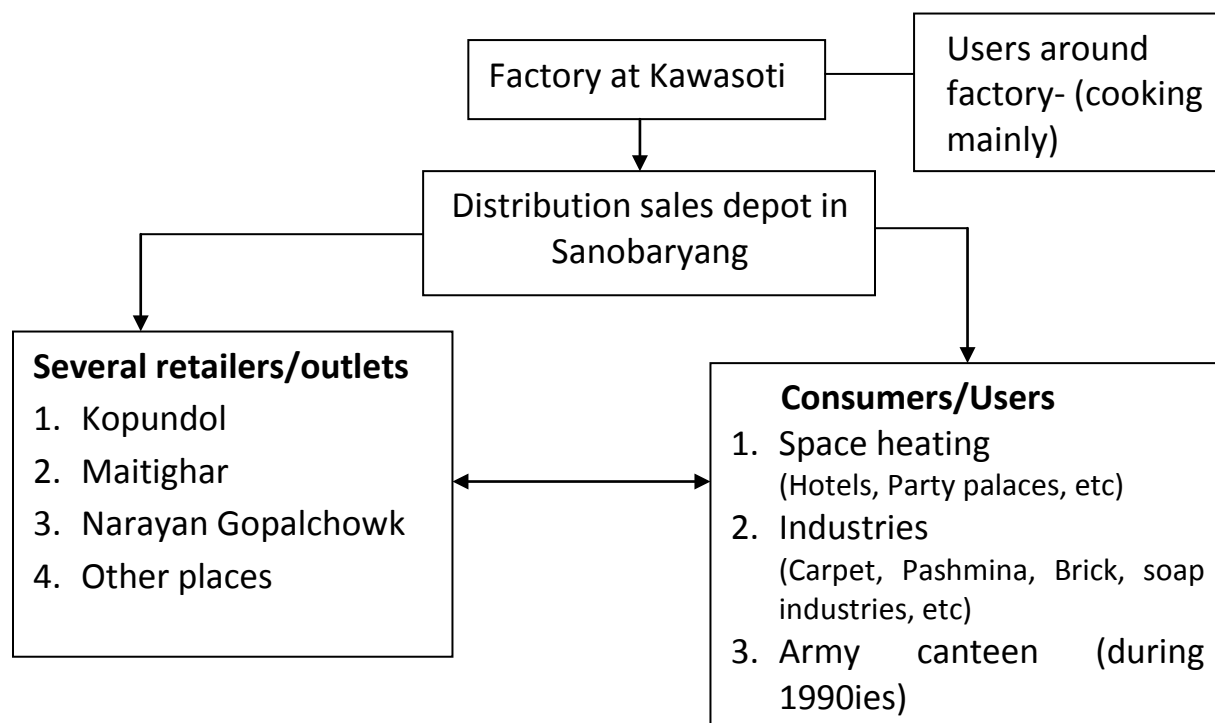


Figure 5. Distribution network of Mhepi briquette Industry

Mhepi also initiated some awareness and promotional programs through demonstrations and participation in national seminars and exhibitions. Advertising a product is an important aspect of product promotion. Probably, Mhepi briquette industry is the only industry, which has printed materials for the

promotion of its product. The industry has been able to bring and keep highly skilled technical staff required for the repair and maintenance works of the screw and the die either from local market or from India even with special allowance.

Recently, Mhepi briquette has initiated two more briquette production systems: Production of rice husk pellets and mechanized beehive briquettes using hydraulic compression technology as a drive for diversification of briquette products, which are already described in above chapter.



Participation in exhibitions



Participation in seminar and promotional programs

The industry has been able to bring and keep highly skilled technical staff required for the repair and maintenance works of the screw and the die either from local market or from Bangladesh even with special allowance.

Research interest was also a good quality possessed by Mr. Gorkhali, which made him join RenewableNepal project PD-172 of KU on Biomass Briquetting as an



Industrial partner. Through RENP project he gained exposure to industries in Bangladesh and learnt many small but critical things which helped him to make production process more efficient.

## **7.2. Shubha Biomass Pvt Ltd**

Shubha Biomass Pvt Ltd is an industry which was dismantled and transferred from Budhanilkantha in Kathmandu (Watabaran Biofuel Ptv Ltd 2011) to Chitwan in 2012 due to political interference involving some environmental issues. It was established in Mangalpur VDC, Ward-1, Chitwan, Nepal and started production in 1 February 2013. It is a piston press briquetting technology from Shree Engineering of India. The production capacity is 450-500kg/hr with running capacity of 3-4hrs daily because of the loading shedding schedule. The cost of the briquetting unit alone is around Rs 30,00,000. Cost of other machinery (dryer, pulverizer (grinder), etc, is about Rs 40 lacs. Actual production capacity is 75 tons/month.

Although Shubha Biomass is a recently established industry, it has come to limelight because of the open minded management attitude. It already has a website of its own (<http://www.shubhabiomass.com.np/kontakt/>), which serves as an advertisement of its products and production process. It has started using new raw materials like Banmara, bagasse, etc as substitutes for rice husk which is very abrasive in nature, causing wear of the piston and die. It has analyzed its briquette products (proximate analysis and calorific values) for the benefits of its clients. The results of the analysis are available in its website and people now know industry and the parameters of the briquettes. It is now in the process of introducing cook stove for institutional (large scale) cooking and displacing fuel wood and other fossil fuels.

This is the only industry which has a complete piston press briquetting system, including a hammer mill, biomass dryer and transportation system. Other similar industries do not have complete system.

Due to severe load shedding, it has even installed a 125 KVA generator for smooth production. Jamming of the screw feeder and wear of the piston and die are the big problems for the industry, so in future it plans to establish repair and maintenance unit within the industry.

The prime target of the industry is to replace firewood and fossil fuels in Nepal. These fuels are both expensive and unreliable. Frequent strikes and rising prices

are the causes for such insecure supply of energy source. They are producing briquettes are made from sawdust/forest waste and agro waste for industrial use. They have successfully tried production using Banmara from local vicinity. One surprising observation was the unawareness of the industrialist about the abundant availability of Banmara and other forest residues.

### **Market and marketing of products**

Shubha Biomass is promoting its product exclusively to industrial clients even at a lower price Rs 15-19/kg than the market price (Rs 25/kg) to establish good relations with clients on long term basis and promotion of its product. Currently they are supplying briquettes to some pashmina, carpet industry and bakery units. They have plan to supply to Distillery, dairy industry, Clay and brick industries in future. One of the future targets is supply briquettes to industrial boilers and to replace LPG with briquettes.

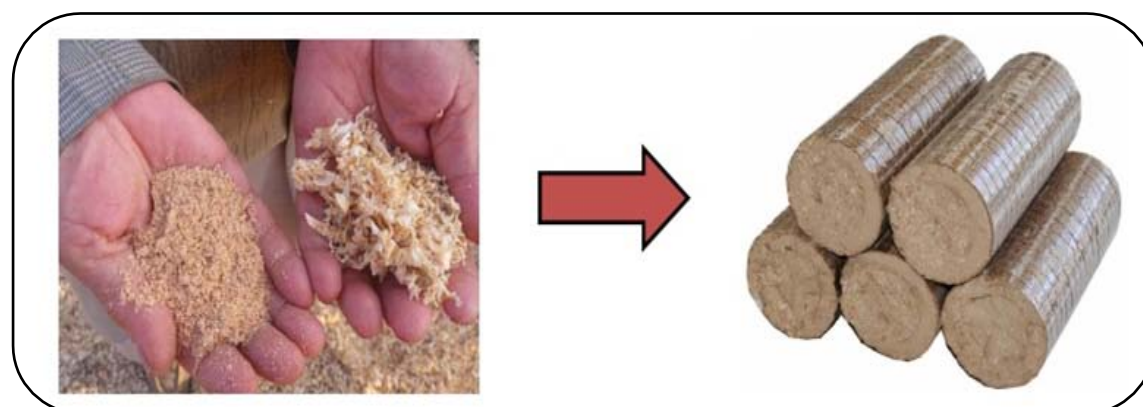
Marketing is done on individual basis through personal contacts and through the factory itself. Neither marketing outlet nor networking has been developed yet.



Piston press briquetting unit



Problem of Piston and die



Raw material and product

The main problems the factory is facing are

- Irregular electricity supply (load shedding)
- Low quality of electricity (low voltage lower than 300volts) cause jamming of the screw feeder
- High cost of technology requiring huge investments
- High cost of spare parts (especially the stainless steel piston and the die) – one unit cost more than Rs 10,000.

#### **Suggestion from the industry**

- There should be regular supply of good quality (full voltage 340-360 volts) electricity without interruption for industry.
- Reduction in electricity tariff for this type of industry
- Since technology is expensive, government should give tax incentives on machinery hardware and spare parts (minimum import duties and tax reduction or tax holiday for certain years) and soft loan.
- Support in the promotion of briquette fuel through preferential treatment, market protection and subsidies on product.

#### **7.3. Jaibik Urja Nepal and its supply chain**

Jaibik Urja Nepal Company was established in 2010 with a screw extruder briquetting unit from Bangladesh to produce rice husk briquettes. The screw extruder is a very simple machine with a gear box transmission of power from the electric motor. The cost of the machinery equipment was about Rs 350,000/ including all taxes and transportation. Importing the machine and getting it across the border was the biggest problem for the company. Besides the briquetting unit, it has some spare parts for the heating element. All the repair and maintenance work especially if the screw is done locally.

Marketing of the product is done on a personal relationship and contacts. There is no network and there are no dealers. The briquette product is mainly being used in the local market in Bhairawa and surrounding places for cooking (domestic and restaurants, tandoors) and other space heating purposes. A market exploration was done once in Kathmandu, where the owner himself sold on truck load of briquettes. So there is no problem of market for briquettes. The industry however is closed and has not run for over a year due to several reasons like load shedding, raw materials problem, labour problems, etc.



Briquetting unit



Discussion with owner

The industry has been successful in promoting briquette products to local market displace fuel wood and coal. The products of this factory are mainly being used in the local market in Bhairawa and surrounding places for cooking. It has an advantage over other industries as the cost of the machinery/equipment from Bangladesh was cheaper.

It has done some marketing and market studies personally outside Bhairawa including Kathmandu. The owner, after establishment of the industry has gained wide knowledge about the technology, its critical components, but has not been able to run it smoothly for more than a year for unseen reasons.

The problems the industry is facing are

- Irregular supply of electricity (Load shedding)
- Shortage of technical manpower
- Non availability of spare parts (for spare parts have to Delhi)
- Problem of wear of screw and die
- Problems of the heater

### **Suggestions**

- Provision for continuous electricity supply
- Provision of soft loans for machinery and hardware, reduction in custom duties and taxes
- Provision of some subsidy on product

### **7.4. Majgaon briquette Udyog**

Majgaon briquette Udyog is going to be a community based briquette industry, which will be run by the local community in Majgaon. The fuel briquettes from

the industry will be consumed by the local community for cooking and other purposes. The briquetting unit is from Rajkumar Agro Engineers Pvt Ltd in India and finance by IRDC and costs Rs. 1,150,000. The community is now going to construct a shed to house the machinery.

The locally available raw materials such as rice husk, wheat stalks, rice straw, oil seed stalks, lentil stalks, etc from the agricultural fields will be used for briquette production. Local people will exchange raw materials from their fields for briquettes. Any extra briquettes will be sold to the local road side tea shops and restaurants as fuel. In future briquettes will also be sold to neighbouring GaBiSas like Bairghat, Bogadhi, Maryadpur, Rajpur, Bakuiya, etc.



Hammer mill



Briquetting unit

Specification of unit	
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Model	RKJ – II
Output kg/h	120 – 150
Motor Power	20HP
Electric heater (kw)	3*1.5
Size of products (mm)	Ø55

They were unable to run the machine properly during the trial production and could not operate well. The big worry of the industry is the operation of the briquetting unit as they do not have knowledgeable and trained personnel with them.

### 7.5. Indira Sugar Mills

Indira Sugar mills established a piston press briquetting unit in 2069/70. It initiated briquette production using piston press briquetting unit from Radhe Engineering Co of India. It produced piston press briquettes of 90mm diameter from sugar cane bagasse. It has tested the briquette fuel in CEEN for fuel characteristics and calorific values and has plans to supply the fuel to industries as boiler fuel. Currently the factory is distributing the briquette fuel to the local factory workers on a subsidy basis for cooking purposes. The feedback received from them shows that it can be very easily promoted as a cooking fuel in the local market. Also it has plans to promote the briquettes to local industries as fuel. The



production capacity is 8-10 tons per day, but during the trail production only 4 tons were produced.

As seen from the pictures below the briquetting unit has not been installed properly in a shed. Also normally for piston press for smooth operation of the industry, a single piston press is not enough. A whole set of machinery such as grinder, dryer, raw material transportation system is required. It seems a simple one time trial production was conducted. The specification of the unit is given below (table 21). The marketing of the product has not started. As per the discussion with factory people, marketing will be done initially on personal contact basis.

The Sugar mill also has a bagasse baling machine (virtually also a briquetting machine) which is used to produce brick shaped bales from sugar cane bagasse which will be used as boiler fuel.

**Table 21: Specification of the Briquetting Plant**

Input Raw Material Form	Up to 20mm Size
Production Capacity	1500 Kg / Hr *
Finished Product Size	90mm diameter
Finished Product Shape	Cylindrical
Production Capacity depends on the Bulk Density of Raw Materials	



Bagasse baling machine



Piston press unit

Sugarcane bagasse has high moisture content and without drying briquetting is not possible. Production will start only after installation of a dryer. The briquettes are costlier than fuel wood, so they can be popularized if there is some subsidy on

the product. Spare parts are not available in the Nepalese market. They are expensive and have to come from the parent company.

### **7.6. Green City Briquette Udyog**

Green City Briquette Industry was established in Nayapati, Bhumisthali on the way to Sundarijal in 2011. The industry has a fixed capital of Rs 2,500,000/-. The industry has one screw extruder briquetting unit, one hammer mill, a charcoal making chamber and a drying system from mainland China. The production capacity of the briquetting unit is 220kg/hr and the running capacity is about 150kg/hr. The industry operated for one year produced with difficulty about 2 tons of briquettes, but could not operate smoothly due to moisture and die problem. Till today it is closed and has not been able to operate in a regular basis.

The main clients of the briquette industry has been some party palaces which use the briquette both for cooking and space heating during parties, especially during the winter seasons. Marketing and marketing network has not been developed. Marketing is done mainly on personal contact basis.



Chinese Briquetting unit



Dryer



Briquettes



Screw and tapered die

The main problem is with the heated die, which has a tapered path in the beginning of the die. Also the moisture content of the rice husk has to be controlled for smooth briquetting. The high cost of machinery has made the investment very high without any returns till today making difficult to pay back the loan. The plant was imported and installed locally without any support from the manufactures as after sales service was costly. Poor response to get technical service from the technology provider was also a setback.

### **Suggestions**

- Uninterrupted supply of electric power should be made available at special prices
- Subsidy and tax incentives should be provided on machinery and hardware
- Technical support should be available for the operation
- Spare parts and materials (hard surfacing material) should be available
- Repair and maintenance facilities have to be developed

### **7.7. Namuna Briquette Industry**

Namuna Briquette Industry was recently established in 2012. It has two screw extruder briquetting units from Mhepi Briquette Udyog, a biomass drying unit designed and made in Nepal by Narayani Engineering works. Its fixed capital is around Rs 3,500,000/. The briquetting units alone cost about Rs 600,000/each.

The industry is now running trial production and is facing problems of the heater for the die. It has already produced some briquette which is being tested in different places. The owner of the industry has a restaurant which uses mainly LPG as cooking fuel. It has plans to substitute as least 50% of the LPG with briquettes for cooking in near future. The target of the industry is to introduce and substitute cooking fuel in Chitwan area.

The main raw material used is now rice husk. As one member of the team is a student who undertook briquetting as his thesis work, it has been easy to understand the mechanism of briquetting and problems and issues related with briquetting. One unique feature of this industry is that, it has been established almost totally with the knowledge and experience of the local people, which shows that the local capability in briquetting business has enhanced largely.

Each unit can produce around 100kg/hr of briquettes only, which is not sufficient to meet the demand for large scale industries; however they are planning to



purchase 2 more units in future. In future they are planning to produce briquettes in large scale. They are planning to use different raw materials like pine needle, saw dust also. They are also planning to develop different types of stoves for briquettes.



Briquetting units



Dryer for biomass



Sieving of rice husk



Rice husk transportation

Some qualitative market analysis was done which showed that there is large potential to substitute cooking fuel in Chitwan alone. Initially the marketing will be done through personal relations and contact. Once the market is established then only other means will be explored. It is presently focusing on local customers through personal contacts. Their main customers are small industries like noodles, bakery, milk dairy, restaurants, campfires, catering and party palace. Since there is no continuous production they have not supplied their products to big industries as they cannot produce briquettes in large scale.

**Problems they are facing:**

1. Wear and tear of machines is high in winter as moisture content in raw materials is high.
2. Heat management of heat in die.

3. Wear and tear of blower
4. Market establishment and Marketing challenges
5. Screw wear and hard surfacing of machines.

### **Suggestions**

- Government should provide subsidy on electricity like agro industry
- Government should make Tax and Vat exemption on machinery and product
- Government should provide soft bank loans,

### **7.8. Mahakali Sugar Mills**

Mahakali Sugar mill is a newly established sugar industry in Dhangadi, Kanchanpur is of West Nepal which started to produce 90mm diameter briquettes using sugarcane bagasse with a press press. The factory is said to have the capacity of crushing 1,200 tons of sugarcane daily. Not all the bagasse is used by the factory so it plans to produce briquettes using piston press technology. During the field visit and attempt was made to visit the factory to get first hand information by visiting the factory's briquetting unit. However, the factory did not give a positive response till the last minute so the visit could not be accomplished. It is believed that the factory has plans to market its product not only in Nepal but also in neighboring India. Poor response from the factory people did not allow study team to collect any information at all.

### **7.9. Annapurna Sugar Mills**

Annapurna sugar mill is established in Sarlahi district. As per literature search it was found that this factory also has plans to produce briquette from sugar cane bagasse using a piston press.

Besides these, there are other briquetting industries and briquetting units in the country as well. However poor response and unwillingness to communicate with the study team did not allow us to produce authentic information here. The above reporting shows that there are several briquetting industries operating in across the country as of January 2014. Some if these industries have had successful beginnings (Mhepi and Shubha Biomass) and experiences which may serve as lesson for others. Some information about existing rice husk briquetting industries and their products are given below in table 22.

**Table 22 - Rice husk briquetting factories in Nepal**

Name of company	Mhepi Briquette industry Pvt. Ltd.	Jaibik Urja Nepal Company	Namuna Briquette Industry
<b>Company information</b>			
Address	Shiva mandir-3, Kawasoti, Nawalparasi	Mayadevi Falful tatha Bajar (Putali bazar), Bhairawa	Bhratpur-4, Chitwan Nepal
Chief Executive	Surendra Gorkhali, Managing Director	Ganga Bahadur B. K., Director/ Proprietor	Chandra Mani Bhattarai
Company Established	2050 B.S.	2066-04-18 B.S.	2069
Total Staff	7 (2 technical)	2	10
no. of technical person	2	1	2
<b>Technology</b>			
Technology type	Screw Extruder	Screw Extruder	Screw extruder
Origin of Technology	Taiwan	Bangladesh	Mhepi Briquette Udyog (Taiwan)
Specification	NA	NA	NA
Major Components	2 units in operation (4 not in operation) - 4 machines from Taiwan, 4 made in Nepal Screening Feeder, Pre-heating, Conveyer Cyclonic dust separator, Screw Extruder, Muff	1 set of machinery imported from Bangladesh Hopper, Screw extruder, Muff Gear transmission system	2 units purchased and has plans for 2 more units Drying system and conveying system made in Nepal by Narayani engineering
<b>Biomass raw material</b>			
Biomass	Rice husk	Rice husk (Dhuto, sawdust, etc)	Rice husk (saw dust and pine needle in future)
Particle Size	<5mm	< 6mm	
Moisture entering the factory	10%	5-10%	
Moisture after drying	almost zero, 2-5%	zero???	
<b>Technological process</b>			
Briquetting technique	Screw Extruder briquetting	Screw extruder briquetting	Screw extruder briquetting

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Drying system of biomass	Drying with hot air	No drying (sun drying)	Drying with hot air
Feeding system	Automatic feeding with cyclone separator	Manual feeding hopper	Automatic feeding with cyclone separator
Briquetting Temp	250 - 300oC	200-300 oC (not measured) 300 (1/2 hr heating)	250 - 300oC
Heating of die	Collar Heaters in 1st Machine 2100 W	4500 W coil (electric)	Collar heater
Grinder	not used, not necessary for rice husk	not used, not necessary for rice husk	not used, not necessary for rice husk
<b>Production and Product Information</b>			
Production shifts	according to load shedding schedule	1 shift (load shedding schedule)	Trial production only
production rate	NA	production rate 1 ton/day	100kg/hr

## **8. Potential users of biomass briquettes**

### **8.1. Past experience of Nepal**

Although there was no support of any kind neither from the government (policies or program) or technical institutes (technical backstopping and research), the past experiences of briquetting in the country show that initially it was difficult to sell the product market and establish the market. It was solely the business of the private industries to produce and search the market for their products. Despite the difficulties they faced, some industries did make some achievements and breakthroughs in some industries and community cooking to displace fuel wood and fossil fuels. With some support from the government and R&D institutions, they could have made remarkable progress. The main users briquettes earlier in the country [35]are given in Table 23.

Table23: The main user of briquettes

<b>Name of Industry</b>	<b>Client/User</b>	<b>Purpose</b>	<b>Remarks</b>
<b>Chitwan Briquette Koila Udyog</b>	Nepal Army Brick Industry Carpet industry Others Bhrikuti Paper factory	Cooking food Baking bricks Wool dyeing Barbecue Boiler fuel – running three shifts (24 hrs round the clock)	3 years contract  During economic blockade from India
<b>Himalayan Briquette Udyog</b>	Nepal Army Brick Industry Carpet industry	Cooking food Baking bricks Wool dyeing	
<b>Quality Wood &amp;Fuel Industry</b>	Nepal Army Hotels Others	Cooking food Space Heating Barbecue & tandoori	Saw dust briquettes and charcoal from saw dust briquettes
<b>Mhepi Briquette Udyog</b>	Nepal Army Brick Industry Carpet industry Five star hotels Others	Cooking food Baking bricks Wool dyeing Space Heating Campfire	Factory is still operation. It has even diversified its products – pellets and beehive briquettes

Source: Elite Consultant P. Ltd 1995

### **8.2. Experiences of neighboring countries**

#### **Bangladesh**

The experience of Bangladesh shows that even without but any support from the government in terms of policies and programs, the briquetting of rice husk succeeded well because of the

1. Scarcity of fuel wood and environment benefits of briquettes
2. Availability of cheap, abundant raw material and reliable power supply
3. Developed technological capability for briquetting in terms fabrication, repair and maintenance of technology
4. Simple life style and simple and cheap technology
5. Wide variety of locally produced cheap heating and cooking devices
6. Technical support from Research Institutions and availability of trained manpower
7. Easy access to hard facing materials and hard facing technology

In Bangladesh rice husk briquettes are used mainly for cooking food for domestic and commercial purposes. As show earlier in chapter 5 it is used in

- Domestic use for cooking food
- Commercial cooking
  - Road side tea stalls
  - Restaurants
  - Sweetmeat shops (Mithai shops)
  - Street food stalls
  - Community cooking and parties

***Probably two important and critical issues that led to the success story of briquetting in Bangladesh stand out prominently. One was development of technological capability in the country to fabricate cheap briquetting units along with the ability to carry out repair and maintenance works and tangible technical support from KUET and other institutions. These issues will also play a deciding role for the promotion of biomass briquetting in Nepal.***

## **India**

Indian experience shows that briquetting is a big business and receives adequate support from the government. There are special organizations (IREDA) which give financial support as well as technical consultations. Briquettes are used mainly as industrial fuel and as a substitute for fuel wood and fossil fuels. They are used in small amounts as domestic fuel for cooking. Some of the principle users of briquettes are given in table 24.

Table 24: Main users of briquettes

State	Type of industry	Briquettes used as replacement for
Uttar Pradesh	Leather industry, Brick kiln	Coal
Punjab	Solvent extraction oil mill, Brick kiln	Coal
Gujarat	Textile, Dye and chemical industry	Coal
Tamil Nadu/Kerala/Karnataka	Tea factories Rubber factories Pharmaceutical industries	Wood, Leco Leco Coal
Madhya Pradesh/Maharashtra	Textile industry, Pharmaceutical industries, Brick kiln	Coal

The briquettes are particularly recommended for steam generation in industrial boilers, heating, cooking, etc as given in table 25. A separate column shows that status of briquette use in Nepal as well.

Table 25: Use of briquettes in different purposes

Sector/Industry	Purpose /process	Scope of use in Nepal
Boilers	For steam generation	Was already used
Food processing industries	Distilleries, bakeries, canteens, restaurants & drying	Some are using already
Textile process houses	Dyeing, bleaching etc.	Already in use
Agro-products	Tobacco curing, tea drying, oil milling etc.	Very good scope
Clay products	Brick kilns, tile making, pot firing etc.	Brick kilns did use
Domestic	Cooking and water heating	Some are using
Gasification	Fuel for gasifiers	Future scope
Charcoal	Suitable for making charcoal in kilns (Screw press briquettes)	Attempts were made

## **9. Some important issues/lessons from Bangladesh and India**

### **9.1. Technology capability and cost of technology**

If in 1990ies the briquetting technology was just being introduced and people did not know about it. Establishing an industry was very difficult as there was no technical information about the machinery equipment, any fabrication capability and technical knowhow. Everything had to be imported, including manpower. Hard surfacing materials and techniques to address the wear of the briquetting screw were not known nor were available in the country. Even for small repair works industries had to go Raxaul [7].

Now the situation has changed. Technology fabrication along with repair maintenance capabilities has developed in the country with several engineering workshops already producing briquetting units. Some of them which are located in Kathmandu valley are given below in table 26. Similarly, there are many other workshops which have developed technological capabilities in fabrication and repair and maintenance in other part so the country like Chitwan, Bhairawa, Kwasoti, etc.

**Table 26: Technological capability of engineering workshops**

Name	Technological Capability	Repair and maintenance	Remarks
Powertech Nepal, Patan	Fabrication of briquetting unit Fabrication of screw and die	Screw and die and welding for hard surfacing	Fabrication of screw extruder briquetting for NAST
General Engineering, Khumaltar, Patan	Fabrication of briquetting unit Fabrication of screw and die	Screw and die and welding for hard surfacing. Eutectic welding capability for hard surfacing	Fabrication of screw extruder briquetting for NAST. Fabrication of several portable briquetting units for AEPC project and RENP project
Absolute Engineering, Swayambhu,	Fabrication of briquetting unit Fabrication of screw and die		Fabrication of briquetting unit for RENP project
Valley Engineering, Teku	Fabrication of briquetting unit Fabrication of screw and die	Screw and die and welding for hard surfacing.	Fabrication of briquetting unit for RENP project
Balaju Yantra Shala	Fabrication of		Screw propeller for



	briquetting unit and screw propeller		NAST
Purna Metal, Patan	Fabrication of screw		Fabrication of screw for NAST
Narayani Engineering works	Fabrication of screw and die. Fabrication of biomass dryer and transport system.	Screw and die and welding for hard surfacing.	Screw and die and biomass drying system for Namuna Briquette industry.

### **Briquetting units in NAST**



Powertech Nepal  
RETs in ASIA



General Engg workshop



Valley Engineering  
RENP project

### **RENP project briquetting units made in Nepal**



Briquetting unit In RECAST,  
Absolute Engineering



Unit in CEEN



Unit in Gen Engg

### **Screw repair**



General engineering Workshop



Valley Engineering

### **Fabrication of drying system, screws and die (Narayani Engineering, Chitwan)**



Cost comparison of technologies of different briquetting units are given in table 27 below. From the table it is obvious that the imported machinery equipment are very costly hence will raise the question of feasibility of briquettes produced by such industries. Even second hand equipment is very costly.

**Table 27: Cost of technology**

No	Industry/Organization/project	Type of technology	Origin of technology	Cost	Remarks
1	Mhepi Briquette Udyog				
	Screw Extruder briquetting technology	Screw Extruder	Sun Chan, Taiwan	US\$ 60,000/ In 1993-4	Very High cost
	Pelletizer	Pellet press	Rep of China	US 12,000/	High cost
	Hydraulic Beehive briquette press	Hydraulic press	Rep of China	~US 10,000/	High cost
2	Shubha biomass – piston press	Piston press	Shree Engineering, India	Rs 30,00,000/	High cost
3	Jiabik Urja Nepal- screw extruder	Screw Extruder	Bangladesh	Rs 600,000/	Reasonable
4	Green City briquette industry – screw extruder	Screw Extruder	Rep of China	Rs 800,000/	High cost
	Biomass Drying unit		Rep of China	Rs 18 lac?	
5	Namuna Briquette Industry – screw extruder	Screw Extruder	Taiwan/Mhepi	Rs 600,000/ Per unit?	High cost
	Biomass drying unit		Narayani Engineering	Rs 12 lac	
6	Indira Sugar mills – Piston press	Piston press	Radhe Engineering, India		
7	Majgaon briquette industry – screw extruder	Screw Extruder	Raj Kumar. India	Rs 11,50,000/ New	High cost
8	JDA Apparals – screw extruder	Screw Extruder	Rep of China	Rs 600,000/ 2 <sup>nd</sup> hand	High cost
9	Ganesh trading Concern- screw extruder	Screw Extruder	Rep of China	NA New	
11	NAST – screw extruder (big)	Screw Extruder	Powertech Nepal (2001)	Rs 200,000/20HP motor	Reasonable
	Screw extruder (small)	Screw Extruder	General Engg Nepal	Rs 50,000/	Cheap

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12	RENP project Unit in NAST – screw extruder	Screw Extruder	Valley Engineering Nepal	Rs 400,000/20HP motor	Reasonable
	Unit in RECAST – screw extruder	Screw Extruder	Absolute Engineering Nepal	Rs 400,000/20HP motor	Reasonable
	Unit in CEEN – screw extruder	Screw Extruder Small	General Engineering Nepal	Rs 2lacs 5hp motor	Reasonable
13	Chitwan (AEPC) – screw extruder	Screw Extruder Small	General engineering	Rs 1 lac 3hp motor	Cheap

## **9.2. Research and development capabilities**

If during 1992-95, there were no other institutions working in the research and development of briquetting except NAST, now many institutions are undertaking different research and development project and activities in biomass briquetting. NAST had extended some support to local rice husk briquetting industries since 1993 introducing new techniques of using hard surfacing welding rods. Welding rods were brought from Japan and tested and the screw life was extended to more than 8 hours. This solved one of the major problems faced by the rice husk briquetting industries. Later, cheaper welding rods from India, Bangladesh were also introduced which made briquetting easier.

The concept of eutectic welding for hard facing of the screw was also introduced by NAST to the briquetting industries. In fact, a screw from Himalayan briquette Udyog was prepared using this technique. Later, many projects were launched to extend support for promotion of briquetting. Hence, ability to provide technical assistance and guidance for promotion of briquetting industries does now exist. Some of the institutions and projects on briquetting are given in table 28.

**Table 28: Institutions and projects**

No	Projects	Institutions involved	Contribution to industry
1	Alternative Energy Development project 1992-1995	NAST, JICA	Introduction of hard surfacing welding rods and Spray welding technology, Introduction of coal beehive briquette, biocoal briquettes, charcoal briquettes, Identification of new raw materials (Banmara, pine needles) for briquetting
2	Establishment of experimental and demonstration unit for production of Biocoal, 2000-2004	IHC (Japan), NAST, NESS	Introduction of roller press briquetting and biocoal briquettes
3	RETs in ASIA project on renewable energy	AIT, NAST, and many Asian	Introduction of and fabrication of simple rice husk briquetting technology from Bangladesh along with hard surfacing

	1999-2003	countries and SIDA	materials, heating elements for die, etc
4	Technical Cooperation in the Dissemination of Alternative Energy Technologies in Nepal (2009-2012)	JICA, NEPA, NAST, CEEN	Quality improvement of beehive briquettes, different molds, binders and stoves
5	Production of Biomass Briquetted Fuel Based on Agro- Forestry Wastes as Substitute for Fuel Wood in Domestic and Industrial Sector of Nepal (2010-2013)	CEEN, NAST, Mhepi briquette industry and NORAD (RENP-10-06-172)	Fabrication of low cost briquetting units, introduction of hard surfacing welding rods, identification of new raw materials

### **Financial Incentives and support**

Supports in terms of financial incentives are also necessary for the promotion of biomass briquetting. The Indian experience shows the government not only gives tax incentives but IREDA support in financing of briquetting projects. Hence, if biomass briquetting is to be promoted in Nepal these experiences have to be taken into consideration and concerned agencies should act in such manner.

## **10. Current users and clients of briquette**

### **10.1. Cooking food**

Cooking, domestic as well as institutional, is one area where a huge amount of fuel is used. These fuels are used not only for cooking but also cooking animal feed and hot water. Jiabik Urja Nepal had promoted rice husk briquettes for cooking as well Tandoori around Bhairawa market area. Namuna Briquette Udyog is distributing briquettes in Narayanghat city for cooking in different food stalls. Similarly, Mhepi had launched a campaign around its factory to use rice husk briquettes at a subsidized rate along with stoves. It has also developed large institutional stoves for community use. Indira Sugar Mills has also distributes piston press bagasse briquettes to its factory workers for domestic cooking. But it has still not reached the scale as in Bangladesh. Green City Briquette and some

others have supplied to party palaces and catering services, which use briquettes for large scale cooking.

### **10.2. Space heating**

Currently, briquettes are used for space heating during the winter season in major functions (wedding parties, dinners and other social gatherings) that take place in hotels, party halls, gardens and other open venues, where catering services are provided. Numerous numbers of Party palaces that have opened across big cities also use briquettes for space heating and cooking as well. Briquettes are also used for campfires as well.

### **10.3. Industrial users**

Mhepi Briquette Udyog has been continuously supplying its briquettes to several carpet (wool) dyeing industries since a long time back. It is now also supplying its product to Pashmina Industry. Earlier it had supplied briquettes to brick industries as well.

Shubha Biomass regularly supplies its briquettes to carpet and pashmina industry as well. Occasionally it sells out briquettes to industrial boilers but not regularly, because the production capacity is still low. It has now started to supply its product to some bakeries as well.

Most of the briquetting industries do not want to supply their products to industries for use in boilers as the briquette production capacity is low due to various reasons as industries using boilers require huge amounts of fuel briquettes. For example Shubha Biomass would first like to improve productivity and establish smooth production before going for supply to industries with boilers. This is their future target.

**N.B. most of the Industries are very reluctant to share their information, so it is very difficult to extract the exact information. They are reluctant to say how many and to which (names) industries they are supplying their products.**

## **11. Fuel price in the country**

The fuels price in the country has been changing drastically. If in the 1990ies the cost of one liter of kerosene was Rs 4, it has now gone up to Rs 103. Whereas the price of rice husk briquettes during this period has reached only Rs 25. Already in 2005 the price of kerosene was almost double that of rice husk briquettes Table

29. Hence this opportunity cost has also favored the promotion and use of briquettes. Because of this changed situation in the fuels prices as well as the environmental degradation factors such as global warming, climate change, etc, people and industries are growing more and more conscious about the replacing fossil fuels by using biomass fuels. Hence, the opportunities for the promotion of biomass briquettes and industries are ideal provide the government is ready to provide some economic concessions in the technology as well as the products.

**Table 29: Cost of different fuels**

<b>Fuel</b>	<b>Cost 1990ies</b>	<b>Cost in 2005</b>	<b>Cost 2014</b>
Fuelwood	*Rs 2-4/kg	*Rs 6-8/kg	*Rs 10-15/kg
Kerosene	Rs 4 liter	Rs 26/liter	Rs 103/liter
Rice husk briquette	Rs 5/kg	Rs 8-15/kg	Rs 25-30/kg
Beehive briquette	NA	Rs 15/	Rs 25/pc

\*Cost of fuel wood is just the collections cost. Actual cost will include cost from the time of plantation, nurturing, etc which is almost double the collection cost.

## **12. Potential users of fuel briquettes**

### **12.1. Institutional and commercial cooking**

Institutional cooking using rice husk briquettes were introduced by Chitwan Briquette Koila Udyog and Mhepi Briquette Udyog during the 1993-95 in army barracks for cooking food for the army men. Especially, where large scale cooking or cooking for community is required, there is potential for promotion briquettes, which are a good substitute for fuel wood and fossil fuels. Some of these users can be listed below.

- Army and Police canteens
- Hospitals, Bridhasrams, Orphanages
- School and college hostels
- Prisons and refugee camps
- Tourist and trekking areas
- Road side restaurants, food and tea stalls in cities and highways
- Sweet meat shops, Dalmoth factory, etc
- Curd making (Dahi), momo shops, etc



Although these areas, like army, police canteens, hospitals, etc are potential places for substitution of other fuels, continuity is not possible without support from the government. Promotion and use of briquettes in the private sector will depend upon the government policies and programs relating to fuel briquettes. Appropriate policies and program along with efficient heating and cooking devices will be required for successful promotion. Few institutions and projects have already developed them. Some of them are given below.



RENP Low cost tin stove for cooking



Stove for institutional cooking

## **12.2. Space heating**

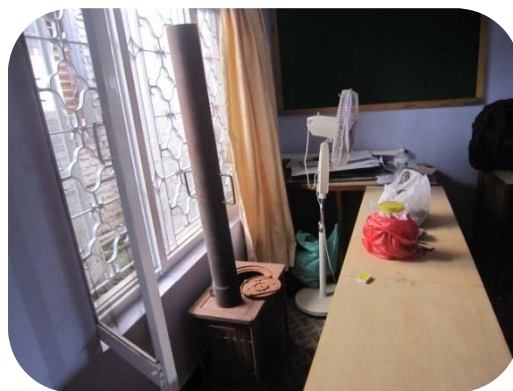
Space heating is another area where large amounts of fuel and energy are spent annually. Large amounts of fuel briquettes are already being used in many social and ceremonial functions that are taking place in party palaces, hotels and catering services. This will continue to be a potential area for the use of briquettes.

In the hilly and mountainous regions of the country the temperature falls drastically during the winter season. Besides cooking, heat is required to keep rooms warm. This phenomenon is more severe especially in the high altitude area. These areas will be very appropriate to use briquettes for space heating. Some of them are:

- Party palaces and catering services
- Office rooms and buildings
- Hotels, guest houses and lodges
- Tourist and trekking routes
- Social, religious and community centers

As for institutional/commercial cooking, support from the government side will again be required in terms of policies and program for space heating as well. Likewise appropriate heating devices will also be required. Some space heating stoves are already being tested for commercialization.

Beehive briquettes although popular have certain limitations of duration and space for heating. Heating for longer duration (more than 2 hrs) and larger space require different devices. Space heating stove using rice husk briquette has already been demonstrated by CEEN. Such stoves of different capacities and size could very well serve the purpose of space heating.



Space heating stove

### **12.3. Industrial use of briquettes**

Past experience has already show that fuel briquettes were successfully used in Bhrikuti Paper Factory during the economic blockade impose by India and some brick industries. Some briquette industries (Mhepi and Shubha biomass) are already supplying briquettes to carpet, pashmina, baleries, etc. Therefore, there is a high scope of using fuel briquettes in many industries. Also from the experience of India, briquettes can replace fuel wood and fossil fuels in boilers.

Potential industries where briquette can be promoted are given in table 30.

Table 30: Industrial users of briquettes

Sector/Industry	Purpose /process
Industries with Boilers (paper industry, rosin and turpentine, )	For steam generation and hot water
Food processing industries	Distilleries, Bakeries, Dairy products, Curd (dahi) making, Dalmoth, Sweetmeat (Mithai), etc
Textile process houses	Carpet, pashmina, Dyeing, bleaching etc.
Agro-products	Tobacco curing, tea drying, coffee roasting/drying, cardamom drying, oil milling, etc.
Clay products	Brick kilns, tile making, pot firing etc.
Gasification	Fuel for gasifiers
Charcoal	Suitable for making charcoal in kilns

#### 12.4. Market arrangements for briquette promotion

Based on the past experiences on briquetting of Nepal (especially Mhepi Briquette Udyog) and neighboring countries (Bangladesh) it is proposed that the market and marketing mechanism should be developed in the following manner as shown in the chart.

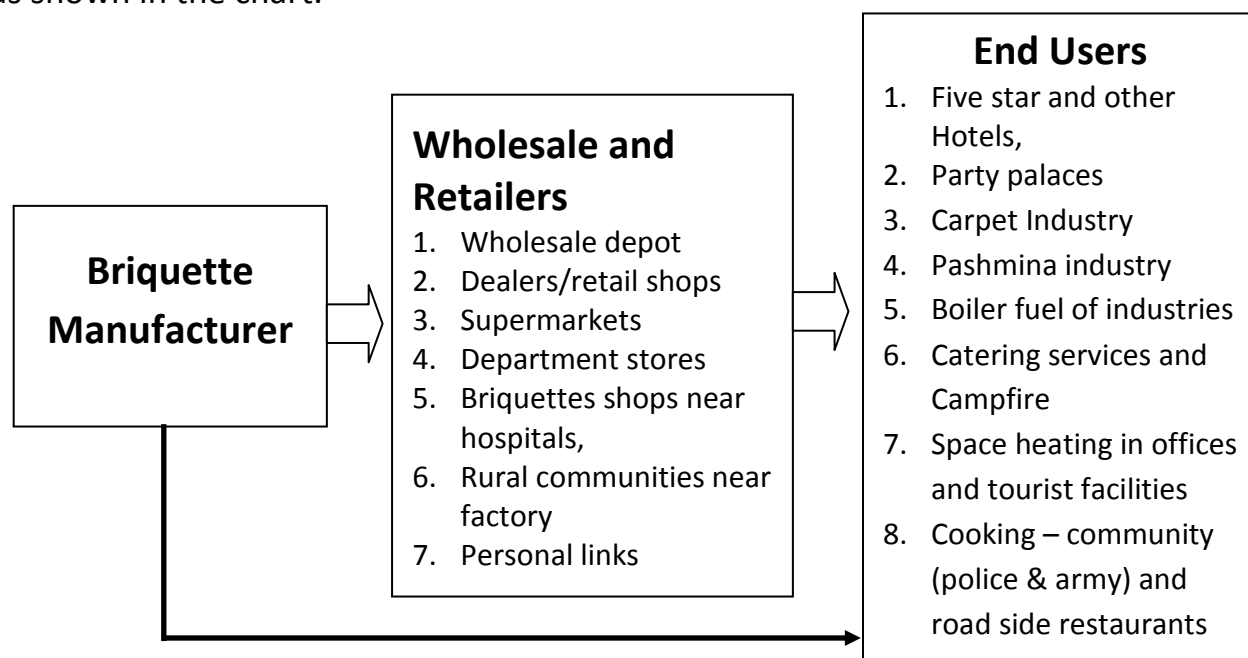


Fig.6. Market supply chain of Biobriquettes

### **13. Conclusions**

- Most of the briquetting industries in the past and present have used or are using imported technologies mainly from India and China. They are very expensive, and make briquetting unfeasible and lead to local adaptation and fabrication, reducing the capital costs. Locally fabricated machinery/equipment is comparatively cheap making briquetting business more feasible. The past experiences of Nepal and neighboring countries (Bangladesh and India) also clearly indicate this issue. Therefore, locally made, cheap technologies need to be promoted rather than imported ones. This will make briquetting business more feasible.
- Earlier in the 1990ies the capabilities of local engineering workshops were low, however, now they have slowly improved. Policies and program for support and upgrading local engineering workshops have to be implemented by the government as well as other concerned agencies if briquetting is to be promoted.
- Imported technologies are complicated and require special skills to operate. Repair maintenance works also require special skills and training. Skill development programs and special training program like that conducted by KUET (Bangladesh) should be organized for stakeholders to enhance the capabilities of technical manpower.
- Spare parts (like a screw propeller or piston and tapered die) from China or India are expensive. The same parts can be fabricated locally and this should be encouraged. In case spare parts for briquetting industries have to be imported, special facilities and incentive have to be provided in making them available.
- Earlier rice husk was the only raw material for briquetting, now many new raw materials such as agro-forest wastes such as bagasse, saw dust, saal leaves, Banmara, pine needles, Mikania micrantha, wastes from wood proceeding industries (Veneer Udyog, furniture, handicraft, industries, etc) have been identified and can be used for briquetting. Proper initiatives should be taken by concerned agencies to make these materials available for briquetting.

- The data on the forest residues (dhugri phool, tite paati, besrami jhar, etc) are not well established. The biomass resources coming from the forest areas should be assessed to establish a data base, not only Biobriquetting but also Biomass energy technology (BETs) programs.
- These raw materials are free of cost but require collection only. Especially the biomass which is cut under the high tension lines every year should be made available to briquetting industries. The concerned agencies should make arrangements so that these raw materials are made available to industries at reasonable rates.
- In the 1990ies the price of fuel wood, kerosene, etc were low, briquette price was high, now the situation has changed and it is vice versa. Considering environmental degradation from use of fossil fuels and fuel wood, and realizing the current fuel costs advantage of briquettes there is a need to prioritize briquette promotion like other renewable energy solar, wind, micro hydro, biogas etc.
- Learning from the experiences of neighboring India, financial incentive packages (tax as well as subsidy) for the establishment of briquetting industries has to be formulated and implemented in the future.
- Promotional and awareness programs related to briquettes, their benefits and use are very much lacking. Therefore these awareness and promotional programs are very important and have to be launched in the future by all concerned agencies.
- Biomass Briquetting should be incorporated/integrated in the agricultural, forestry and energy sector policies of the government.
- Some industries (Mhepi, Indira Sugar Mills, Jaibik Urja) were found to have encouraged locals to use briquettes for domestic as well roadside cooking. They are some potential consumers of briquettes. Learning from Bangladesh experience, briquettes should be promoted not only for domestic cooking but also for commercial cooking in road side restaurants, hotels, tea stall, food stalls, etc in rural areas, the cities and highways. For this subsidies will be required to make briquette cheaper than fuel wood. Also briquettes should be

encouraged for use for commercial cooking in sweetmeat shops, dalmoth, dahi making, etc.

- Past experiences show that briquettes were successfully used for large scale cooking (in army and police canteens). These programs have to be revived with the support of the government and concerned agencies and expanded to other such areas such as hospitals, prison wards, bridhasrams, schools, hostels, orphanages, etc.
- Hotels, party palaces, catering services, etc. are using briquettes extensively for space heating and cooking. This should be further expanded to tourist and trekking areas in the hill and mountain areas.
- Use of fuel wood and fossil fuels should be discouraged in industrial boilers and briquettes should be used as substitutes. Fuel briquettes should be promoted in agro processing industries, distilleries, textile dyeing, etc. Use of briquettes in clay and ceramic industries (brick kilns, pottery), carpet, pashmina industries should be revived and further expanded.
- Mhepi Briquette has a functional market network and a good promotional strategy using brochures; flex charts, etc. for dissemination of product information through participation in exhibitions and seminars. This should be encouraged with other industries for promotion and marketing of briquettes.
- Technical backstopping and R&D are important factors learnt from Bangladesh experience. Financial and technical Support should be extended to strengthen R&D and training institutions for fruitful cooperation and interaction with briquetting industries.

## **14. Recommendations**

- The government should formulate and bring about policies and programs for the promotion of biomass briquetting as in the case of other renewable energies. These should be targeted to industries, R&D institutions and other concerned organizations.
- Financial and tax incentives packages (as in the case of India) related to briquetting industry, technology (hardware) and spare parts should be

formulated and implemented as soon as possible by concerned agencies (government, financial institutions, etc)

- Market development, protection and preferential treatment should be given to fuel briquettes, discouraging the use of fuel wood and fossil fuels wherever possible. It is recommended to use briquettes for cooking with improved stoves under a special program such as “Go Green” in organizations under government control such as army, police, hospitals, prisons, orphanages, bridhasrams, etc.
- Briquettes should also be recommended for space heating in office buildings, rooms, hotels and wherever possible. Government should launch programs with subsidies to replace current space heating fuels with briquettes through introduction of appropriate heating devices.
- Government should discourage the use of fuel wood and fossil fuels in all kinds of industries, commercial cooking, etc. replacing them with fuel briquettes.
- Concerned agencies (government and non-government) should establish a unit within AEPC to look after biomass briquetting and commission studies related with briquetting industries
  - To make an inventory of industries, their activities and problems and ways to help them out. Past experience shows many industries collapsed due to negligence and lot of resources were wasted.
  - To commission studies for assessment of raw materials for briquetting and establish a data base.
  - The unit will establish/compile data base on various briquetting technologies to assist and guide entrepreneurs.
- Also the carbon credit program (like biogas) through utilization of all forms of briquettes should be initiated and the benefit from these programs should be used for further promotion and diversification of briquetting activities in the country.



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## 16.ANNEXES

### Survey questionnaire

The Government of Nepal (AEPC) is in the process of establishing the **Study on Feasibility and Market Identification of Densified Biomass Briquette** and for promotion of briquetting technologies in Nepal. Therefore, it is appropriate to collect valuable suggestions and opinions of **users/industries involved in using of Rice husk Biobriquettes**, which will facilitate the promotion of quality briquettes in Nepal. We shall appreciate very much your kind cooperation by giving us your valuable opinion/suggestion through the short questionnaire given below.

### Biobriquette Questionnaire for users/industries

(Tick or Circle whichever is applicable)

#### A. General Information

1. Name and address of users/industry/company (postal address, email and telephone)

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2. Name and post of Chief Executive or Officer

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3. When \_\_\_\_\_ was \_\_\_\_\_ your \_\_\_\_\_ company \_\_\_\_\_ established?  
Date/year \_\_\_\_\_

4. Number \_\_\_\_\_ of \_\_\_\_\_ persons \_\_\_\_\_ working \_\_\_\_\_ in \_\_\_\_\_ the \_\_\_\_\_ company?

5. Since \_\_\_\_\_ when \_\_\_\_\_ have \_\_\_\_\_ you \_\_\_\_\_ been \_\_\_\_\_ using \_\_\_\_\_ briquettes?

#### Product information

6. How quality of product is determined?

7. % \_\_\_\_\_ Breakage \_\_\_\_\_ when \_\_\_\_\_ product \_\_\_\_\_ is \_\_\_\_\_ delivered?

8. Storage during usage? Condition of Storage place? How and where stored?

---

9. Problems encountered during usage?

Combustion

\_\_\_\_\_

Ignition

\_\_\_\_\_

Smoke

\_\_\_\_\_

Smell

\_\_\_\_\_

Clinker

\_\_\_\_\_ problem

10. What are your complains/demands?

\_\_\_\_\_  
\_\_\_\_\_

11. Any other inputs that contributes to the enhancement of the quality of briquettes

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

12. Any suggestions from traders for the improvement of quality of beehive briquettes.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

13. What purpose do you use it for?

\_\_\_\_\_  
\_\_\_\_\_

14. Is it easy to ignite?

\_\_\_\_\_

15. What purpose do you use for?

\_\_\_\_\_



16.Does it cost effective than other energy sources?

\_\_\_\_\_

17.How do you feel its flame than other energy sources?

a. Fire \_\_\_\_\_ wood

b. Heater \_\_\_\_\_

c. Gas heater \_\_\_\_\_

18.Cost of biomass briquette paid per Kg.? Rs.-

\_\_\_\_\_

Date of information collection \_\_\_\_\_

Name of person collecting information \_\_\_\_\_

**Biobriquette Questionnaire for Marketing and Trading Companies**

**(Tick whichever is applicable)**

**A. General Information**

19. Name and address of company (postal address, email and telephone)

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20. Name and post of Chief Executive or Officer

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21. When was your company established? Date/year.....

22. Number of persons working in the company? \_\_\_\_\_

**B. Information on Feasibility of biomass briquette**

1. What types of biobriquettes are collected? \_\_\_\_\_

2. Number of collection centers/producers \_\_\_\_\_

3. **Major** producers/suppliers-how many? \_\_\_\_\_

4. **Minor** producers/suppliers- how many? \_\_\_\_\_

5. Total briquettes collected in one season \_\_\_\_\_

6. Inputs for feasibility of bio briquettes

a. Trainings on briquetting Y N

b. Equipment/hardware support (screw extruder machine, screw extruder, etc) Y N

c. Demand of bio briquette in the market. Y N

d. Financial support (loan or grant to be deducted) Y N

e. Other incentives/motivation. Y N

f. If yes, what are they?

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---

7. Product delivery system

a. Producers delivers product to traders

i. Packed (means of packing) \_\_\_\_\_

ii. Unpacked \_\_\_\_\_

b. Trading company goes to collect

i. How? Means of transportation \_\_\_\_\_

ii. Cost of collection \_\_\_\_\_

iii. Best way of collection \_\_\_\_\_

iv. How many at a time? \_\_\_\_\_

8. Means of transportation of briquettes
  - a. Vehicle \_\_\_\_\_
  - b. Cycle \_\_\_\_\_
  - c. Manual carry \_\_\_\_\_
9. Packing of product
  - a. Means of packing (carton boxes, sacks) \_\_\_\_\_
  - b. Tools/materials for packing \_\_\_\_\_
10. Handling techniques/methods during load/unload \_\_\_\_\_
11. How are the stored system?
  - a. In piles .....
  - b. Racks with aeration .....
  - c. Any other.....
12. How is the store/place before delivery to market?
  - a. Dry.....
  - b. Moist.....
  - c. Air circulation/supply \_\_\_\_\_
13. How it is handled during delivery to market?
  - a. Load-unload .....
  - b. Careful/rough.....
14. Transportation means of Briquette.....
15. Percentage of breakage from producers to suppliers \_\_\_\_\_
16. Percentage of breakage during delivery to market \_\_\_\_\_
17. Any other inputs that contributes to the enhancement of the quality of briquettes  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
18. Any suggestions from the trading/marketing house for the improvement of quality of beehive briquettes. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Date of information collection \_\_\_\_\_

Information Collectors name \_\_\_\_\_

**Biobriquette Questionnaire for Briquette Producers**

**(Tick whichever is applicable)**

**A. General Information**

23. Name and address of company (postal address, email and telephone)

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24. Name and post of Chief Executive or Officer

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25. When was your company established? Date/year.....

26. Number of persons working in the company? \_\_\_\_\_

**B. Biomass collection**

1. From where did you collect the raw materials? \_\_\_\_\_

2. Cost of saw dust per Kg.? \_\_\_\_\_

3. Cost of rice husk briquette per Kg.? \_\_\_\_\_

4. Demand of biomass is increasing?      Yes                                      No

5. For what purpose consumer/trader purchase it? \_\_\_\_\_

6. Production per day? \_\_\_\_\_

7. How many dealers do you have? \_\_\_\_\_

Name & add:      a.                                      b.  
                         c.                                      d.  
                         f.                                      g.

**C. Information on making briquette**

**Biomass production**

1. Name of biomass used for  
briquetting \_\_\_\_\_

2. Volume of raw material used  
\_\_\_\_\_

3. What is the temperature of making briquette?  
\_\_\_\_\_

4. Is there any size of Biomass briquette?      Yes                                      No

5. If yes, what is it?  
\_\_\_\_\_

6. Local cost of Screw extruder machine  
\_\_\_\_\_

7. Time for one cycle

---

8. How many briquettes do you produce from a screw?

9. Is it cost effective than other energy uses?

1. What types of briquette are consumers prefers? (BHB, Rice husk-pellet, big or small size)

2. Are consumers satisfied with your products?

3. Any suggestions from consumers and traders?

4. Which is the major target group?

5. Is it feasible for both health and financial?