Development Alternatives

Designing Sustainable Rural Energy Solutions in the Terai Arc Landscape

Final Report

2012

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Report citation: Vijaya Lakshmi K, Mathur S,Nagrath K, Ray R 2012. Designing Sustainable Rural Energy Solutions in the Terai Arc Landscape report to WWF India, June 2012. Development Alternatives Group, New Delhi.

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ACKNOWLEDGEMENTS

This study is based on a research project funded by WWF India. We thank WWF India for their support and co-operation through the duration of the study. The project was led by the Development Alternatives Group. We confirm that the views expressed in this document are those of the authors alone.

We thank Mr. Abhishek Nath – Associate Director, Energy Policy and Practice, WWF India and the rest of the involved team at WWF, India- Delhi and Pilibhit offices for their extended support and help during the field visits and report preparation.

Many Government institutes and publication houses contributed to the research and provided valuable inputs for the study. These are the Economic and Political Weekly, the Central Institute of Rural Electrification, the Planning Commission and the Press Information Bureau.

Support for the research was also widespread with engagement across the industry and civil society, including Technology Action for Rural Advancement (TARA) and the Vasudha Foundation. We thank all of them for their time and valuable insight.

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EXECUTIVE SUMMARY

India is heading towards the 12th five-year plan where the focus has been given on clean development mechanisms. Keeping this in mind, the development process needs to be sustainable and environment friendly. As a part of a clean development process, the access to energy also needs to be clean with more focus on low carbon growth and renewable energy resources.

With this objective in mind, Development Alternatives (DA) with assistance from WWF-India conducted a study in the Terai Arc Landscape in Pilibhit district of Uttar Pradesh to provide technically and commercially feasible sustainable rural energy solutions leading to low carbon growth. The micro study area (Madho Tanda and Dhuria Palia Panchayats) was selected on the basis of wildlife-human conflict, backwardness and proximity to the forest cover.

The study focused on four identified sectors: agriculture, transport, commercial cooking and brick making. The sectors are energy intensive and are interdependent on each other. Additionally, they have forward and backward linkages with local employment and the regional economy. This report contains an energy and GHG inventory of these identified sectors. Further, an analysis of the energy use patterns was done. Based on this understanding, a roadmap for carbon resilient growth of the study area was prepared. The report also explores policy recommendations required for promotion of sustainable rural energy solutions in the region.

The study produced a wide consortium of learnings which formed the basis for the recommendations. For instance, brick kilns and agriculture were found to be the most energy intensive sectors consuming approximately 96% of the total energy consumption in the identified sectors in the study area. As seen from the 10 brick kilns included in the study area, brick making primarily involves energy input during preparation of the premix for green bricks, drying and firing them. The total energy consumption and total GHG emissions per year by the brick sector in the study area are 125 TJ and 12,300 tCO_2, respectively. 83% of the energy comes from coal and 17% from fuel wood. To reduce these emissions promotion of cleaner brick technologies such as mechanization for hollow bricks and use of internal fuel, among other technologies, has been recommended. Such promotion would require work on different aspects such as awareness generation amongst entrepreneurs, innovative financing mechanisms, links to technology providers, etc..

Additionally, the study revealed that the energy consumption in agriculture is mainly in irrigation and mechanization of agriculture i.e. use of tractors and combines. The total annual energy consumption in agriculture for the study area is approximately 18 TJ and GHG emissions for the sector are 1300 tCO_2. The emissions for small, large and medium farmers are not homogeneous. To reduce these emissions energy efficient technologies and technologies based on using cleaner fuel such as solar based irrigation systems and mobile biomass gasifiers have been suggested. Innovative approaches, particularly in financing and implementation models, would be required for encouraging a fuel shift.

Further, it was observed that commercial cooking is the lowest CO_2 emitting sector. However, since the sector consumes large quantities of fuel wood yearly, it becomes important to consider the existing problems of the sector and ensuring reduced consumption of fuel wood by the sector. Improved cook stoves have been recommended as they will sufficiently address the existing issues.

It is important to note that in the area of transportation, the study only focused on various types of public transportation. This sector is dominated by Jugaads which are energy inefficient, locally made vehicles requiring low initial investments. The total consumption by the transport sector in the study area is 5.02 TJ per year with emissions of 373 tCO_2 yearly. To achieve sustainable development for the entire study area it is required to restrict Jugaad operation by providing alternative cost-effective as well as fuel efficient modes which can act as intermediate modes of transport. Promotion of public transport in the study area is recommended to meet the growing rural transport demands of the region.

The identification of policy gaps at both the local and State level were also undertaken as a part of the study activities. Policy recommendations have been made based on these findings. Policies addressing financial and regulatory mechanisms for cleaner brick production, replacement of energy inefficient pumps and related infrastructure, promotion of irrigation powered by a clean fuel, promotion of improved cook stoves along with promotion of public and green transport have been recommended. Their expected outcomes include decreased total GHG emission in the study area along with improved efficiencies in operation in identified sectors of the study area.

This in-depth look into the rural energy systems of the study location in Pilibhit has provided an exclusive understanding of the energy needs and constraints of the study area. The recommendations for not only local Government but also civil society are intended to steer action and policy towards low-carbon growth and development of the study area. The methodology and practices were successful in obtaining relevant information, and can be used further for extending understanding energy needs in the surrounding regions and developing a roadmap for their low carbon growth.

1 INTRODUCTION

1.1 SCOPE AND OBJECTIVES OF THE STUDY

The aim of the study was to develop an understanding of energy use patterns in the four priority sectors of agriculture, transport, brick making, and commercial cooking as well as to explore opportunities for a low carbon growth path at a Panchayat level. The study focused on two Panchayats of the Pilibhit district located in the Terai Arc Landscape region. The specific objectives under the study were:

- To develop an inventory for energy intensive sectors in the two selected Panchayats
- To prepare a roadmap for energy intensive sectors at a Panchayat level providing them with techno-commercially viable sustainable energy solutions to meet their energy needs
- To provide policy recommendations for replication of these sustainable energy solutions

1.2 METHODOLOGY

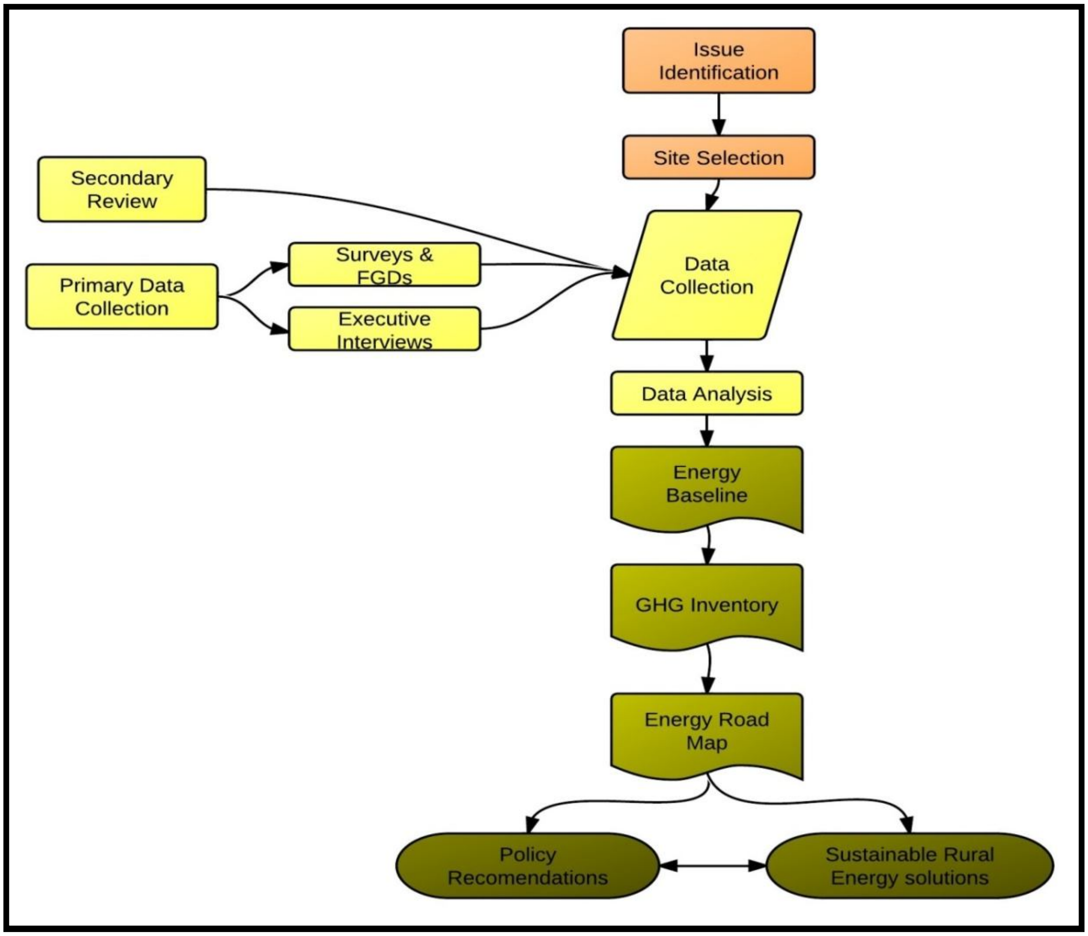
The methodology of the study consisted of issue and site identification, data collection, data analysis and preparation of inventory and roadmap.

The site and issue identification was done in consultation with WWF to ensure that the local needs of the study area were addressed while keeping in mind the priority and focus areas of WWF. A joint visit of the Development Alternatives (DA) and WWF team was conducted. Alongside, secondary data was collected and desk research and policy review of the rural energy scenario for the study location was performed.

Based on desk research and profile of the study location, a survey and methodology for problem analysis was designed. A survey questionnaire was prepared for each of the focus sectors. Primary data was collected from the field based on these surveys as well as informal interactions with important stakeholders. Focus group discussions (FGDs) were held with interest groups and Panchayati Raj Institution (PRI) members. This part of the study was very crucial in terms of basic understanding of the study area and energy related issues.

The primary and secondary data obtained was analyzed using standard United Nations Framework Convention on Climate Change (UNFCCC) protocols to prepare energy and Greenhouse Gas (GHG) baselines for the focus sectors. Based on secondary desk research, interactions with stakeholders and sectoral experts and the baselines prepared, the energy roadmap and policy recommendations were drafted. The flow chart for the methodology is described in Figure 1 below.

Figure 1: Methodology

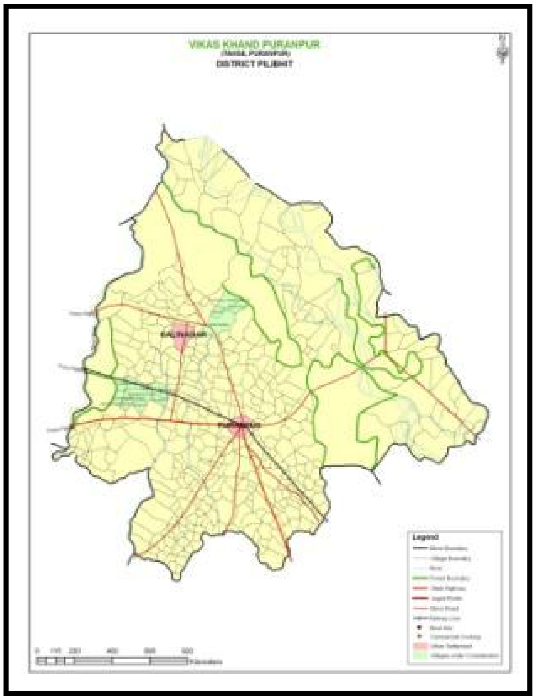


1.3 PROFILE OF THE STUDY AREA

Physiography and Climate Profile: The site of study consists of two Panchayats named Madho Tanda and Dhuria Palia located in Pilibhit district, Uttar Pradesh (UP), which is geographically located in the Terai Arc region of India. Details of the Panchayats are given in Annexure 1. The location of the villages and Panchayats is given in the maps below (Figures 2, 3 and 4)[1]. The Panchayats under study lie in the northern part of the district and hence have a terai arc landscape. The area is relatively flat plain with shallow river valleys. The soils are mainly sandy, loamy and clayey. Soils are deep and water table is high hence the study area has good features for agriculture. The climate is dry sub-humid to semi-arid, with an average of 41 rainy days.

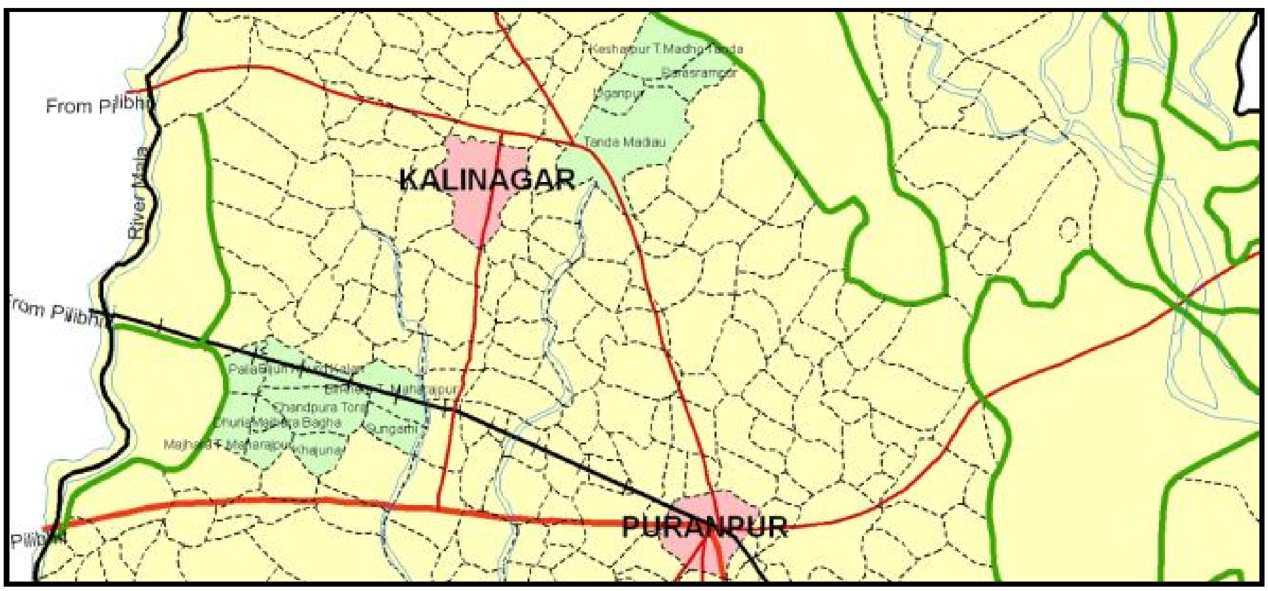
1 Base line survey in the minority concentrated districts of Uttar Pradesh (report of district Pilibhit), Ministry of Minority Affairs Government of India-G.S. Mehta

Figure 2: Puranpur block in Pilibhit district



Source: Geographic Information System, Development Alternatives

Figure 3: Study Area (Dhuria Palia & Madho Tanda



Source: Geographic Information System, Development Alternatives

Figure 4: Pilibhit District Map

Source: G.S. Mehta, M. o. (2008). Base line survey in the minority concentrated districts of Uttar Pradesh (report of district Pilibhit).

Area and Population: The total area under the study is approximately 4,600 sq.km. with a population of 10,776[2]. Table 1 highlights the demographics of the study site[3]:

Table 1: Demographics of the Study Area

Items	Study Area
Total area	≈ 4,600 sq. km.
Total population	10,776
Size of households	6.81
Total number of households	1,582
Total number of males	5,604
Total number of females	5,712
Literacy Rate (%)	39.68
Worker Population Ratio (%)	25.85

Source: Census of India, 2001

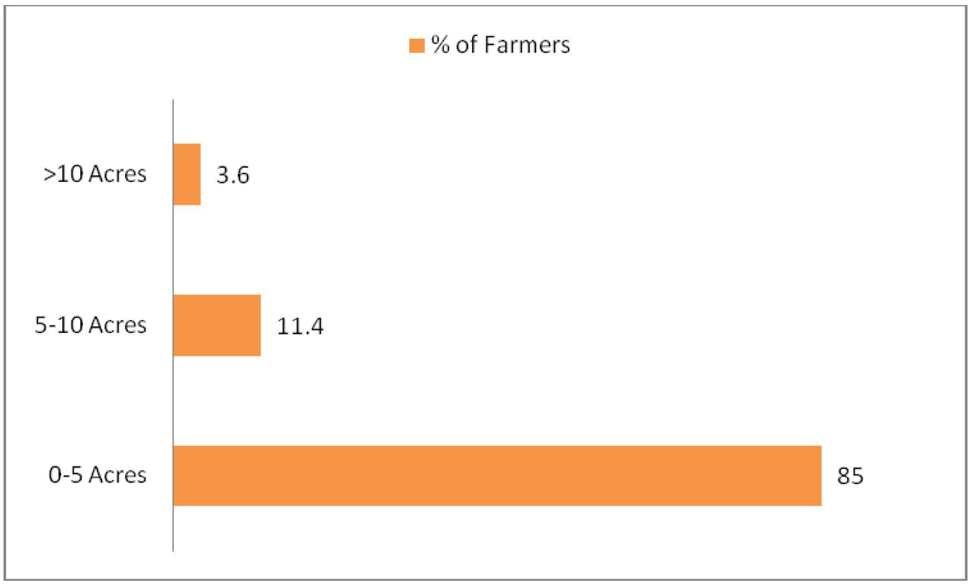
Socio-Economic Profile: The study area has inhabitants of a historically migrated population. Post the Green Revolution, substantial migration occurred from Punjab due to cheaper availability of farm lands. It also observed influx of a migratory Bengali population from the neighbouring country of Bangladesh.

2 Census of India 2001
3 Census of India, 2001

The migratory population as a whole makes the study area socio-economically distinct from other regions of UP.

The number of agricultural cultivators in the two Panchayats is approximately 907 and the number of agricultural labourers is approximately 372. The total main workers in the Panchayats are approximately 1,852. Hence, about 49% of the total working population depends on agriculture as a primary source of income. The land holding pattern, represented in the graph below, shows unequal distribution of land as 85% of the farmers have small land holdings i.e. 0-5 acres[4].

Figure 5: Land Holding Pattern of the Study Area



Source: Census of India, 2001

There exists inequality in the distribution pattern of arable land for cultivation among households from different communities. There is a domination of Hindu and Muslim population but the arable land has been largely owned by Sikh communities which has been forcing other communities to get engaged in low paid occupations available largely in their farm level in the district[5].

Besides agriculture, the other sources of income are brick kilns, agro processing industries, dhabas, shops, etc. The proportion of population actively employed in different economic activities constituted only a little over 28.5%. However the work participation rate of women is very low at 16.4%.

Land use pattern: A high proportion of 56% of the study area was under cultivation in 2004-05 which increased to 62.25% in 2008-09. This increase can be attributed to increasing population pressure and availability of adequate irrigation facilities. The percentage of area under forest cover in the district is quite large i.e. 21%[6].

4 District level data for land holding pattern has been extrapolated to the Panchayat level, as data for the same was unavailable at the Panchayat level.
5 G.S. Mehta, 2008
6 District Statistical Bulletin, 2006, district Pilibhit

Table 2: Land Use Pattern of the Study Area

Items	% of Study Area
Net area sown	56.06
Forest	21.15
Land put to non-agricultural uses	11.11
Barren and uncultivable Land	1.8
Current fallows and other fallow land	1.87
Pasture and other land under trees, plants, etc.	1.05
Culturable waste land	0.73

Source: District Statistical Bulletin, 2006, district Pilibhit

Cropping Pattern: The main crops of the study area are paddy, wheat and sugarcane along with jowar, bajra and maize. 85% of the total area is used for cultivation of food crops while the area used for different high-value commercial crops such as of oilseeds, pulses, potato, etc is extremely low[7]. The percentage of the total area under the cultivation of sugarcane is relatively higher in the study area. Most farmers of the study area practice multi-cropping. Wheat and paddy are grown in Kharif and Rabi seasons, respectively, mostly on the same land, which forms a major portion of the produce. The primary survey revealed that a very high percentage of medium and large farmers grew sugarcane along with wheat and paddy, however the smaller farmers mostly grew wheat and paddy only.

7 Statistical Bulletin, 2006, District Pilibhit

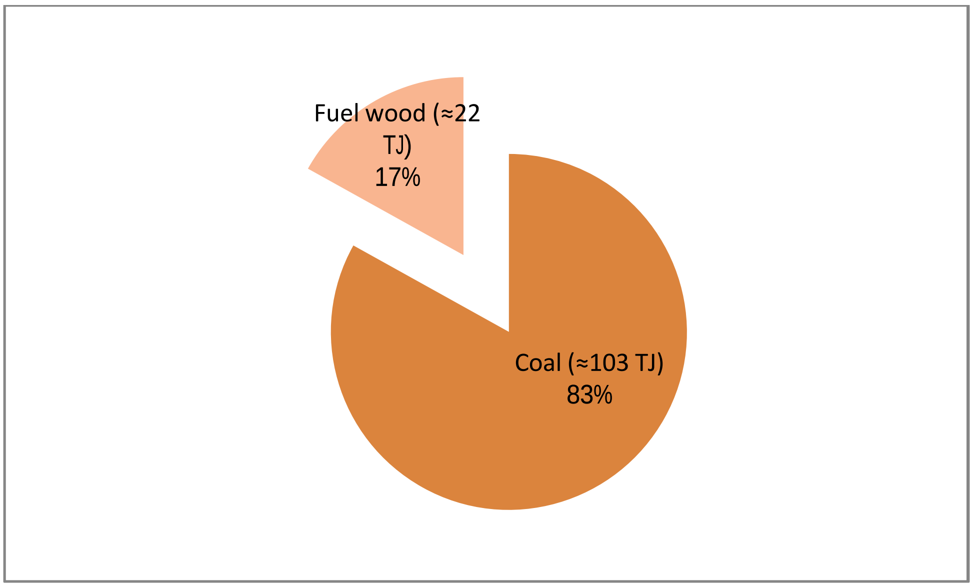
2 Energy and GHG Inventorization

This section details the energy consumption and the total GHG emissions produced by each of the four priority sectors i.e. brick kilns, agriculture, commercial cooking and transportation per year.

2.1 Brick Kilns

The total energy consumption by brick kilns in the study area is 125 TJ per year (103 from coal and 22 from fuel wood as a 70-30 mix of coal and fuel wood is used). On an average, each brick kiln uses 18 tonnes of coal and 5.4 tonnes of fuel wood per 1 lakh bricks fired.

Figure 6: Brick Kiln Annual Energy Consumption (Break-up by Fuel Source)



Source: Primary Survey, n=2 brick kilns

The total GHG emission from the bricks sector is 12,300 tCO2 (9,950 tCO2 from coal and approximately 2,340 tCO2 from fuel wood).

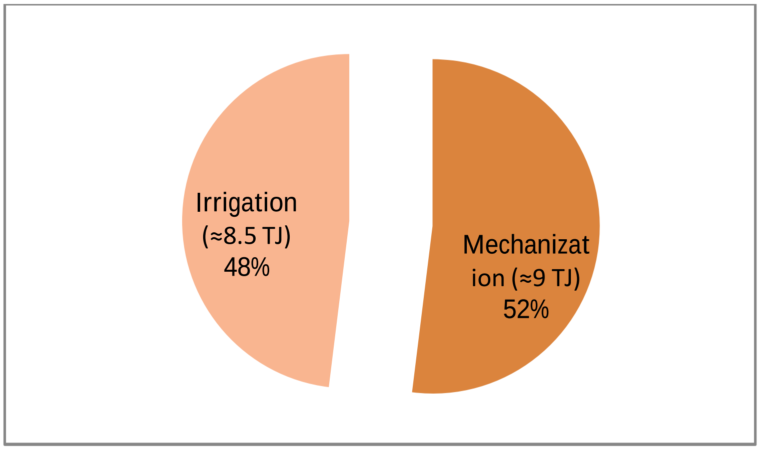
2.2 Agriculture

Agriculture requires an energy input at all stages of agricultural production right from pre-harvesting activities like water management, irrigation and cultivation to harvesting and post-harvesting activities. Post-harvesting energy use includes energy for food processing, storage and transport to markets. In addition, there are many indirect or sequestered energy inputs used in agriculture in the form of mineral fertilizers and chemical pesticides, insecticides and herbicides. This study, however, considers energy use in agriculture only for the following activities as they are highly energy intensive:

- Irrigation
- Transportation of agricultural produce and agricultural inputs
- Mechanization of agriculture i.e. use of tractors and combines (for activities like cultivation, threshing, harvesting, etc.)

The energy consumption in agriculture is mainly in irrigation and mechanization of agriculture i.e. use of tractors and combines. The total annual energy consumption for the study area is approximately 18 TJ. It can be seen that the energy consumption in mechanization (52%) is slightly higher than irrigation (48%). Thus, the total GHG emission due to the agricultural sector is approximately 1620 tCO2 per year.

Figure 7: Agriculture Annual Energy Consumption (Break-up by Activity)



Source: Primary Survey, n=30 farmers

The source of fuel for energy use in irrigation is diesel and electricity, but the electricity scenario in the study area is erratic and unreliable. Thus the energy consumption due to diesel pumps is 6-7 TJ per year while for electric pumps is 2-2.5 TJ per year. On the other hand, the source of energy use in mechanization is diesel alone.

The energy consumption pattern by large, medium and small farmers is not homogenous as seen in Table 3 below:

Table 3: Energy Consumption and GHG Estimation for Different Farmer Groups

Category	Irrigation		Mechanization	
	Energy Consumption (TJ) per year	**GHG Emissions (tCO2) per year**	**Energy Consumption (TJ) per year**	**GHG Emissions (tCO2) per year**
Large farmers (>10 acres)	1.13	80	1.85	136.72
Medium farmers (5-10 acres)	2.07	244.2	4.20	311.34
Small (0-5 acres)	5.25	620	3.10	229.41

Source: Primary Survey, n=30 farmers

2.3 Commercial Cooking

Road-side dhabas dot all major and minor roads catering to transporters, travellers and passer-bys. The main source of fuel used in these is fuel wood. Traditional cook stoves or chullahs, which have efficiencies less than 10%[8] and are known to be a source of large quantities of pollutants, are used by most dhabas. The total number of dhabas in the study area is 10.

The total annual energy consumption by the dhabas is 1.3 TJ, while the total annual GHG emissions are 147.5tCO2.

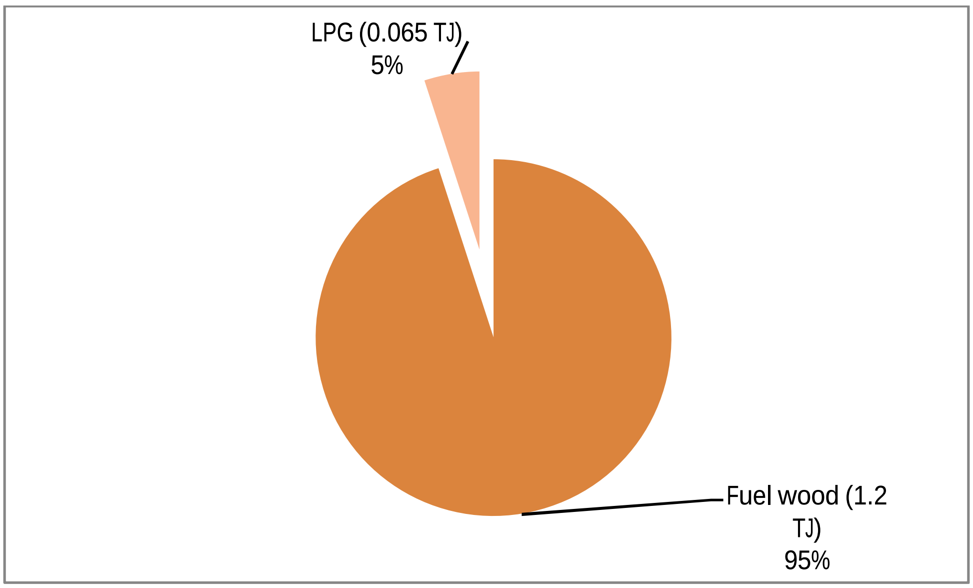
The main source of energy in the dhabas is fuel wood and LPG. The use of LPG is, however, restricted to preparation of tea, and mostly fuel wood is used for for major purposes.

Table 4: Energy Consumption Pattern for Different Fuel Sources in Commercial Cooking

Source	Energy Consumption (TJ) per year	GHG Emissions (tCO2) per year
Fuel wood	1.2	141.6
LPG	0.065	5.9

Source: Primary Survey, n=8 dhaba owners

Figure 8: Commercial Cooking Annual Energy Consumption (Break-up by Fuel Source)



Source: Primary Survey, n=8 dhaba owners

The main problems associated with the traditional chullahs are their low efficiency and their inability to vent smoke out of a room, which causes significant levels of indoor air pollution. They have efficiencies less than 10% and are known to be sources of large quantities of pollutants. The cooking efficiency of the chullah is a function of its design, the number of pots and pans placed upon it, and the type of food that is cooked. Standardized tests for estimating thermal efficiency of wood-fuelled stoves indicate that traditional chullahs operate at only one-half the efficiency of standard improved stoves. Dung cakes yield even lower efficiency ratings because they have lower heat intensity, and the greater distance from the low flame to the pot or pan may result in heat loss.

8 The open *chullah* efficiency is estimated to be less than 10%. The same has been documented in Parikh, Jyoti, and Vijay Laxmi. 2001. "Biofuels, Pollution and Health Linkages: A Survey of Rural Tamil Nadu." Economic and Political Weekly, Vol. 36 and among other studies (Parikh, Jyoti, & Laxmi, Biofuels, Pollution and Health Linkages: A Survey of Rural Tamil Nadu., 2001) (Parikh, Jyoti, Smith, & Laxmi, 1999).

2.4 TRANSPORT

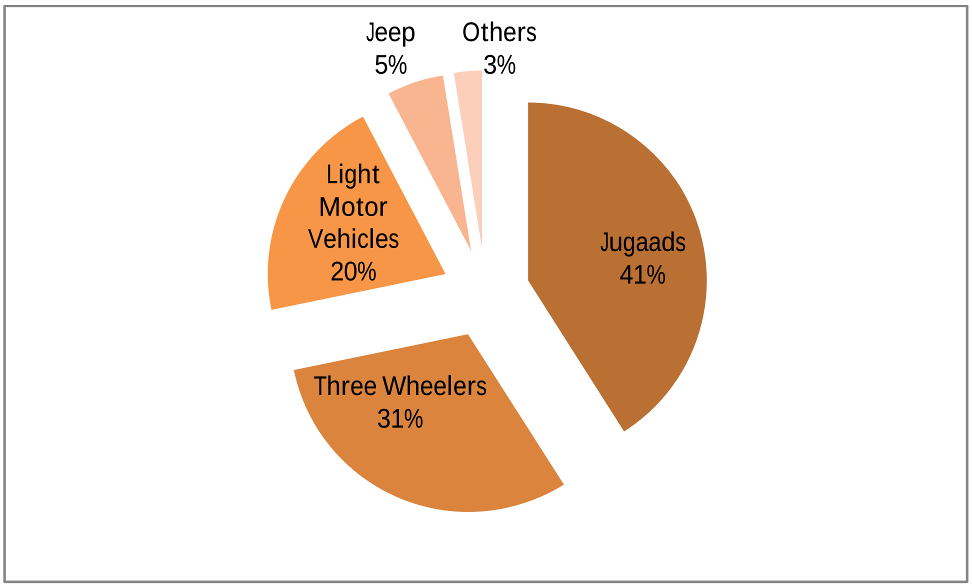
The total number of vehicles considered in the study area is approximately 50. The total energy consumption in the transport sector under the boundaries of the study is 5.02 TJ per annum. The total GHG emission due to the transport sector is 375 tCO2 per annum.

Table 5: Energy Consumption Pattern in Different Vehicle Types

Vehicle Type	Energy Consumption (TJ) per year	GHG Emissions (tCO2) per year
Jugaads	2	153
Three wheelers	1.5	115
Light motor vehicles	1	77
Jeep	0.25	20
Others	0.13	10

Source: Primary Survey, n=12 vehicle owners

Figure 9: Transport Annual Energy Consumption (Break-up by Vehicle Type)



Source: Primary Survey, n=12 vehicle owners

2.5 TOTAL FOR ALL FOUR IDENTIFIED SECTORS

The total energy consumption in the four identified sectors in the two Panchayats is 150 TJ and the total GHG emission for these sectors is 13,990 tCO2 (as per boundary conditions defined in the study).

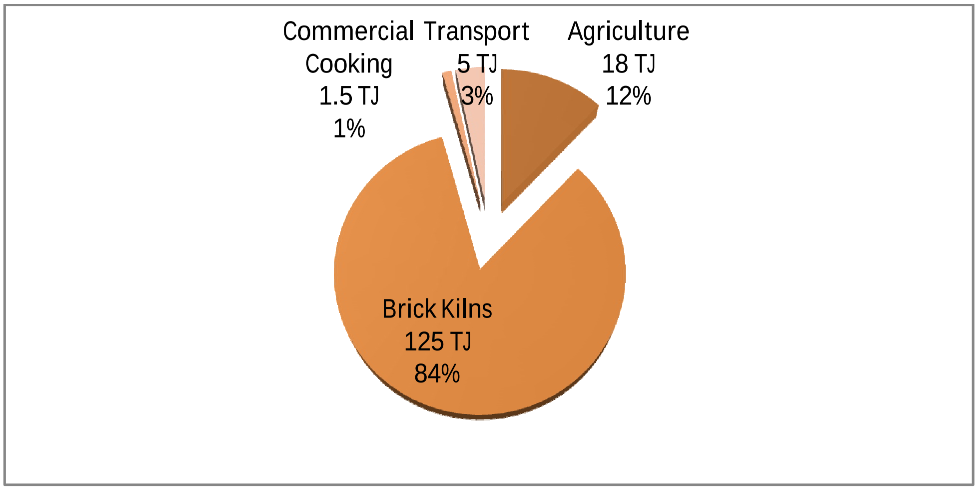
Table 6: Total Energy Consumption and GHG Emissions in Each Sector

Sector	Total Energy Consumption (TJ)	Total GHG emission (tCO2)
Agriculture	18	1,620
Brick Kilns	125	12,300
Commercial Cooking	1.3	147.5
Transport	5	375

Source: Primary Survey

It can be seen that the two sectors in the study area which consume more than 95% of the total energy are brick kilns and agriculture, while transport and commercial cooking consume only 4% of the total energy. However, while making this comparison it is extremely essential to keep the frame of reference in the background i.e. the sample size[9], scope and boundary of the study.

Figure 10: Energy Scenario of Identified Sectors (by Activity)

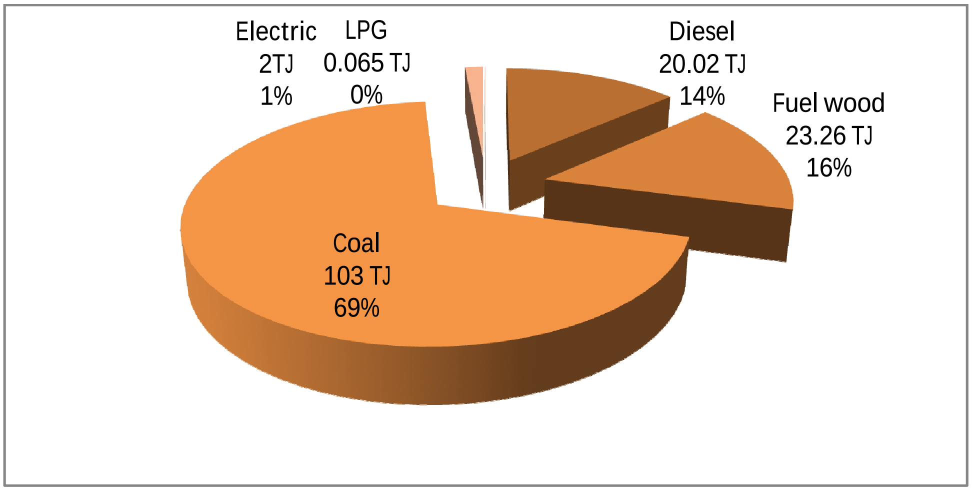


Source: Primary Survey

The energy mix of the study area for the four sectors is mainly coal: diesel: fuel wood in the ratio of 69:14:16 as given in the graph below.

9 The sample size is as follows: Agriculture n~900 farmers (3,300 acres of cultivated land) , Brick kilns n~10 kilns, Commercial cooking n~10, Transport n~ 40 vehicles.

Figure 11: Energy Scenario of Identified Sectors (by Fuel Source)



Source: Primary Survey

3 MAPPING OPPORTUNITIES

This section explores the possible sustainable energy solutions which can be adopted for each sector to ensure a low carbon growth in the future.

3.1 BRICK KILNS

3.1.1 RETROFITTING EXISTING KILNS: MECHANISATION FOR HOLLOW BRICKS

Hollow bricks are resource and energy efficient bricks. By virtue of being hollow they use less fertile agricultural soil, and subsequently less energy is used to fire them. Hollow bricks result in savings of 25% soil. This leads to an incremental energy saving of up to 40%. Thus resulting in a GHG reduction of over 500 tCO2 per year per kiln.

Mechanisation is a pre-requisite to moulding hollow bricks. The mechanized brick making technology combines the art of mechanized mixing and moulding for producing consistent quality green bricks. It ensures high energy saving through reduced coal usage and low breakage due to improved quality. The most important advantage is the reduced dependence on skilled workers thereby creating local jobs.

Brick moulding machines require an investment of Rs. 5, 50,000 – 6, 50,000. It results in superior quality of finished brick, higher strength, consistent size and sharp corners. It also expands the brick season for entrepreneurs as green brick production continues into the rainy season. The machine operation is easily managed with training of local manpower.

3.1.2 RETROFITTING EXISTING KILNS: USE OF INTERNAL FUEL

Use of internal fuel in brick making is based on the premise that substituting wastes into brick making process either as fuels, pore opening or anti shrinkage materials can improve the profitability of brick making enterprises, reduce the working hazards and also reduce the environmental impact of brick making.

Use of internal fuel reduces total energy consumption by 25%, improving environmental efficiencies by more than 50-70%. Subsequently it also reduces energy costs by 25%. Thus resulting in a GHG reduction of over 300 tCO2 per year per kiln. In addition, it reduces dependency on skilled moulders and promotes local unskilled employment generation.

Many types of domestic, agricultural and industrial wastes have an acceptable heat value and therefore have a potential for use in domestic or industrial processes that require heat. In the study area, the two options that show best potential are:

- Pulverized coal
- Waste boiler ash from sugar mills in the vicinity

For any type of internal fuel use in soil, manual mixing process is not followed if desired quality is to be achieved. Uniform mixing is the key to achieving consistency. Experiences from other States in India and various countries show that uniform mixing cannot be achieved through manual mixing. Thus a combination of mechanized mixing and right proportion of internal fuel gives the desired results. Mechanized mixing can be done using either a pug mill or via Tractor mixing.

This is a low cost technology that can be used in any firing technology. It can be easily integrated into existing brick production systems. A simple pug mill requires an investment of between Rs. 40,000 to 80,000 depending on quality and capacity.

3.1.3 Introducing New Technologies: Vertical Shaft Brick Kiln

The Vertical Shaft Brick Kiln (VSBK) is the most energy efficient and environment friendly burnt brick production technology available globally. Benchmark operation of the VSBK can save more than 40% energy consumed with reduction in environmental emission by more than 80% compared to traditional firing technologies available in India and most Asian countries. Functional VSBK can be found across India with concentration in Eastern and Central India, as well as in many Asian and African countries.

Invented and developed in China in the 1970's as a rural brick producing enterprise, it essentially consists of one or more rectangular, vertical shafts within a kiln structure. Rectangular arrays of dried green bricks and crushed, pre-sized fuel (coal) are carefully stacked into batches, which are continuously loaded into the top of the shaft. At the bottom of the shaft, batches of fired clay bricks are continuously removed at pre-determined intervals. As the procession of batches gradually passes through the shaft, the green bricks encounter pre-heating, firing and cooling zones before they reach the shaft exit.

The VSBK relies on the principle of a counter current heat exchanger in order to achieve high thermal efficiency, while economizing on fuel costs and subsequently carbon emissions. Compared to fixed chimney Bull's Trench Kiln (BTK), the savings are around 40%. Compared to all firing technologies globally, the VSBK has the lowest specific energy consumption.

Brick production using VSBK technology is a profitable business. It requires an initial investment of Rs. 25, 00,000 in order to construct the kiln. It can be operated all year round. Weather factors have only a minor influence because a roof protects the kilns. Temporary low cost sheds can also store dried green bricks.

Table 7: Specifications of Vertical Shaft Brick Kilns

Shaft size (meters)	1.00 x 2.00 and 1.25 x 2.00
Daily production per shaft (bricks) @ 12 batch shaft height	8000-9000
Specific Energy Consumption	0.72 to 0.95 MJ/kg of fired bricks
Emissions from stack (mg/Nm3)	22 to 37 (SPM) 38 to 51 (SO2)
Construction costs including equipments	Between Rs. 15-20 lakh for a twin shaft kiln
Compressive strength of bricks (kg/cm2)	70 to 100 (hand moulded bricks) 100 to 200 (machine made bricks)
Construction time	Approximately 4 - 6 weeks
Kiln commissioning and stabilization time	Approximately 15 days

3.1.4 Introducing New Products: Cement Cured Boiler Ash Blocks

Given the availability of alternate raw material, another option is to explore the possibility of manufacturing cement cured boiler ash blocks. This is a process of converting industrial waste materials into quality building materials. Boiler ash from sugar mills is an ideal raw material. On mixing with sand or stone dust, the ash has a potential to form building blocks that can replace clay bricks. The blocks are cement cured for 21 days to obtain the desired strength. Strength of the bricks can be engineered by varying compositions. Equipment used can be manual or mechanized. Mechanized machines deploy hydraulic compaction to produce a variety of bricks and can be operated through electric or diesel power.

This technology offers a potential of over 90% energy saving as there is no firing involved. Thus resulting in a GHG reduction of over 1,130 tCO2 per year per kiln. The only energy expended is on the moulding of the blocks. However, further research is needed into determining the exact mix for the blocks based on the local raw material.

3.2 AGRICULTURE

There are a number of ways in which electricity and diesel consumption in agriculture can be reduced. These include:

- Reduce energy use for irrigation. Irrigation often requires considerable amounts of fuel. Reducing energy consumption for irrigation while providing the desired service may be accomplished through use of more efficient pump sets and water-frugal farming methods.
- Switch to lower-carbon energy sources. Options in this category include photovoltaic(PV)-powered pumps, enhanced solar drying and use of biomass instead of fossil fuels.

The technical recommendations have been focused on reducing the energy consumption due to irrigation by promoting energy efficient technologies and by switching to carbon intensive energy sources.

Large farmers are higher consumers of diesel due to their large land holdings of more than 20 acres of land. They also have capacity to invest higher capital. Thus by addressing their energy needs, the energy consumption of the study area can be reduced in the short term. Due to lower paying capacities of smaller farmers it becomes difficult for them to shift to a new technology. However long term interventions coupled with community mobilization can be planned successfully.

3.2.1 SOLAR PUMP IRRIGATION

Technology and Specifications

A solar PV water pumping system consists of a PV array, motor pump and power conditioning equipment, if needed. For Alternating Current (AC) pumping systems an inverter is required.

Depending on the total dynamic head and the required flow rate of water, the pumping system can either be on the surface or submersible[10] and the motor can run on either AC or Direct Current (DC).

The main advantages of the system are its low operation and maintenance costs. Besides that it has flexibility of use. The panels can be placed up to 20 meters from the source of water. Water provided by the pump can be used for irrigation by more than one farmer in the vicinity. With storage systems in place, water can be easily distributed amongst farmers having land adjacent to each other. Batteries can be used with the solar pump, however they increase the overall cost and maintenance of the system.

10 A submersible pump (or electric submersible pump [ESP]) is a device that has a hermetically sealed motor close-coupled to the pump body. The whole assembly is submerged in the fluid to be pumped. Submersible pumps push water to the surface as opposed to jet pumps, which have to pull water. Submersibles are more efficient than jet pumps.

A solar system is harmonious with nature and provides energy in the hot and dry season when it is most required, particularly for irrigation. It also has a longer life - the solar plates have a life of almost 20 years and the pump, if maintained properly, can operate for 10 to 12 years.

The disadvantages of the system are mainly its high investment and replacement cost and its low and variable output. It cannot be used where the output requirement is very high. However, the output of a 2 HP solar based pump is equivalent to a 4 HP diesel pump. Also theft of plates or their damage by animals can be issues to be considered.

Techno-Commercial Viability

A solar pump runs with sunlight, and there is plenty of sunlight available in the study area. The rate of solar radiation in the study area is 5 Kwh/m2/day.

For a large farmer with an average land holding of 15 acres a solar pump with a specification of 2HP, Water output @ 10m head=1,40,000 L/day, surface centrifugal pump powered by 1800Wp solar photovoltaic cells is sufficient to replace his/her diesel pump. The cost of this pump system is approximately Rs. 4,00,000, out of which a subsidy of Rs. 1,20,000 can be availed from the Government. The operating and maintenance costs of a solar pump are negligible. The farmer is able to save approximately 75-80 litres of diesel per acre per year, i.e. Rs. 45,000- 50,000 on the fuel cost by replacing a diesel pump with a solar pump.

Similarly, a medium farmer in the study area, with an average land holding of 8 acres, can replace his/her diesel pump with a solar pump of 0.75 HP, Water output @ 10m head=50,000L/day, submersible pump powered by 1200 Wp solar PV cells, the cost for which is approximately Rs. 2,50,000. Out of this, a subsidy of Rs. 75,000 can be availed from the Government. The farmer is able to save approximately 50-70 litres of diesel per acre per year, i.e. Rs. 35,000- 40,000 on the fuel cost.

Opportunities for funding of these solar pumps can be explored further. This pump has a simple payback of approximately 5-7 years. However, if the farmer makes an initial investment of Rs. 50,000- 1 lakh, his/her payback period reduces to 1-3 years. This varies depending on the specifications of the system and the landholding size of the farmer.

If 80% of the large farmers (≈30) covering more than 20% of the cultivable area replace their diesel pumps with solar pumps, 50 tCO_2 will be saved per year. If 50% medium farmers (≈50) covering more than 15% of the cultivable area replace their diesel pumps with solar pumps 58 tCO_2 will be saved per year[11].

Thus by replacing diesel pumps of 80 farmers (≈9% of the total farmers) covering more than 30% of the cultivable area GHG emissions due to irrigation in agriculture can be reduced by almost 23%.

11 As per general observations, a high percentageof the large farmers have origins in the northern adjacent State of Punjab. These farmers are interested in shifting to a new technology because of their existing knowledge and exposure to these methods which are practiced in their native Punjab, particularly solar based irrigation. Alternately, the medium farmers are apprehensive to adopt new technology due to high cost and lack of information about the same.

Table 8: Techno Commercial Viability of Solar Pump Irrigation

Technology	**Solar Pump Irrigation**		
Specifications of the system	0.75 HP, Water output @ 10m head=50,000L/day, submersible pump	1 HP, Water output @ 10m head=75,000L/day, surface centrifugal pump	2HP, Water output @ 10m head=1,40,000 L/day, surface centrifugal pump
Wp of solar system	1200 Wp	900 Wp	1800Wp
Finance			
Initial investment Cost (Rs.)	2,50,000	1,90,000	4,00,000
	The cost of the system varies as per requirements of the farmer and the specifications of the pump, but the whole system costs approximately between Rs. 2.5 lakh to Rs. 4.5 lakh.		
Funding Mechanism	The benchmark price for photovoltaic systems which do not use storage battery (water pumping systems) the installed PV system cost is considered as a maximum of Rs. 210 per Wp. Capital subsidy of 30% of the total investment with a maximum of Rs. 70/Wp will be provided for the system up to a maximum capacity of 5 kWp. An interest subsidy will be provided - soft loan @ 5% per annum, on the amount of project cost - promoter's contribution - capital subsidy amount.[12]		
Capital subsidy	75,000	57,000	1,20,000
Interest subsidy	1,75,000@ 5% per annum	1,33,000@ 5% per annum	2,80,000@ 5% per annum
Manufacturer supplier	Please see Annexure 8 for the list.		

Source: MNRE, Govt of India

The following table presents a case study on the use of solar irrigation pumps in the Kutch region of Gujarat.

12 Ministry of New and Renewable Energy, Guidelines for Off-Grid and Decentralised Solar Application, dated 16.06.2010

Table 9: Case Study on Irrigation Pump System at Chandroda, Anjar

Location: Chandroda, Anjar, Kutch district, Gujarat

Geographical context: In Kutch region, there are two zones with varied situations in the water table. In the wet zone or green zone the water table is higher (within 10 to 20 meters) and in the dry zone the water tables goes down to 50 to 100 meters.
Technology: To meet the requirements of the users in these zones, two types of solar based pumps (centrifugal and submersible) were selected. The centrifugal pump consisted of an 1800 Wp solar array, 2 HP DC centrifugal pumps, manually operated tracking structure, electrical connections, pipes, fittings and civil works. The submersible pump consisted of an 1800 Wp solar array, 0.75 HP AC submersible pump, 1500 watt inverter, manual tracking structure, electrical connections, pipes, fittings and civil works.
Cost: Under the Ministry of Non-Conventional Energy Sources (MNES) programme, Sahjeevan, collaborated with Auroville Renewable Energy (AuroRE) to bring solar pumps to Kutch. A financial package was arranged to leverage the subsidy and soft loans available from the Indian Renewable Energy Development Agency (IREDA) through a leasing company. The cost of the system was reduced from Rs. 3, 92,000/- to Rs. 1, 20,000/-.
Implementation model: Since farmers were hesitant to pay the subsidized price of Rs. 1,20,000 for a centrifugal pump and Rs. 1,65,000 for a submersible pump and there were no credit packages from financial institutions in the region, a rental system for the solar pumps was developed. Eight farmers were identified to pilot test the solar system and the rental model. Interactions revealed that these eight farmers were expending approximately Rs. 20,000 to Rs. 36,000 for the fuel on the operation and maintenance of 5 HP Diesel Engine to irrigate 5 to 7 acres of land per year. The rent was decided on the basis of the subsidized cost of the system, replacement/repairing of parts and insurance for ten years. The rent was Rs. 6600/four months and Rs. 9200/four months for the surface pump and submersible pump, respectively. Through this approach it took about a year to convince the farmers about the technical and financial viability of the system.
In 2005 farmers were offered to make a **one-**time payment and transfer the system in their own name. 90% of the farmers opted for this scheme and paid for the balance cost of the pump and got the systems transferred in their name. **S**ahjeevan was able to recover half its investment over 2 years (approx.) of the project period.

Source: Sahjeevan's Renewable Energy Programme- A learning Document

An approach similar to the model implemented in the above case study in Kutch, Gujarat can be employed for implementation of solar pumps in the study area. This would include development of a business model for a rental scheme to ensure sustainability of the project. Through this the general perception amongst farmers on the financial and technology viability of the pumps can be established.

3.2.2 Mobile Biomass Gasifier for Irrigation

A mobile gasifier unit turns biomass into producer gas. This can then be used to fuel an engine that can produce electricity to power irrigation on fields. The unit can be fuelled using crop residues. The unit is mobile and has several modifications which make it possible for more than one farmer to use the unit at the same time.

Techno-Commercial Viability

The biomass gasifier is mobile, has a high initial and operational cost with regular supply of easily available raw material and hence it would be most effectively run by a group of farmers rather than a single farmer. Thus it is essential to form a Common Interest Group (CIG) of farmers which shares the costs and benefits of the gasifier. The CIG can collectively purchase and own a biomass gasifier worth Rs. 7,00,000 - Rs. 8,00,000. The members can then use it on a fixed rental basis. The business plan for the CIG can be developed for ensuring sustainability.

The raw material for the biomass gasifier will mainly be crop residues. The per hour requirement for a 12 KW biomass gasifier is 15-20 kg. An assessment of biomass available has been attached as Annexure

7. However a detailed assessment of available and required biomass as per the technology, relevant business models and the financial viability (cost of equipment, operational costs for running the gasifier, cost of obtaining crop residues as currently they are burnt and there is additional labour cost to retrieve the burnt crop residue, the cost of an operator, maintenance costs, transmission and distribution costs and indirect costs) is required to be done before further pursuing this option.

Table 10: Techno-Commercial Viability of Mobile Biomass Gasifier

Technology	
Specifications of the system	Gasifier Type: Downdraft 12 KW (9HP) in 100% producer gas
Finance	
Initial investment Cost (Rs.)	7-8 lakh (excluding transportation, civil construction, T&D, etc) The cost of the system varies as per requirements of the farmer and the specifications of the equipment.
Funding Mechanism	MNRE offers a central financial assistance of Rs. 15,000 per KW i.e. for a 12 KW biomass gasifier, approximately Rs. 1,80,00.

Source: Field Study

By replacing diesel pumps of 200 farmers covering more than 25% of the cultivable area, the GHG emission due to irrigation in agriculture can be reduced by almost 20%.

3.2.3 Energy Efficient Irrigation

There can be a potential energy saving of 20% to 50% by retrofitting and improving efficiency of electric pump sets[13] [14]. This saving will depend on the kind of modifications performed. To improve the efficiency of irrigation pump sets, a number of technical measures are available (Table 11)[15].

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13 A study conducted by TERI on Demand Side Management in the agriculture sector of Uttar Pradesh-investment strategies and pilot design. 1996. TERI report code: 1995em52 states that a saving potential in the range of 30% to 35% through major and minor retrofitting measures is achievable as cited here. (TERI, 1996)

14 Several pump set initiatives have been initiated by the Government. Such a pilot programme was initiated in Gujarat by the Gujarat Electricity Board (GEB) in the year 1978-85. Under this, replacement of suction pipes and foot-valves implemented by GEB resulted in an estimated average 21.7% energy conservation. In the same study, complete replacement of pumps, piping and foot-valves resulted in an estimated 51% energy conservation. The same was stated in Monitoring Results of REC's Pilot Projects, a report of the Central Institute for Rural Electrification, (Central Institute for Rural Electrification, 2005).

15The same includes the following substitution of high friction GI / MS pipes by low friction PVC pipes, use of low-resistance foot-valves, improving the efficiency of the pump and the prime mover, replacement of undersized pipes and fittings, proper sizing of motors and pumps, and use of efficient couplings between motors and pumps. Other methods include: use foot valves that have low-flow resistance; replace undersized pipes and reduce number of elbows and other fittings that cause frictional losses; use high-efficiency pumps; select pumps better matched to the required lift characteristics; use rigid PVC pipes for suction and delivery; operate pumps at the recommended RPM; select prime mover for the pump (i.e., electric motor or diesel engine) matched to the load; select an efficient diesel engine or motor for the application; schedule and perform recommended maintenance of the pump and the prime mover; and ensure efficient transmission of mechanical power from the prime mover to the pump.

Table 11: Saving Potential in Agriculture through Retrofitting

Scope of rectification	Reduction in energy consumption (%) (kWh per pump per year)
Low resistance foot-valve and low friction suction pipe of proper diameter	20%-25%
Low friction delivery pipe	10% - 15%
Replace pump by one of higher efficiency	10% - 15%
Replace motor by one of lower rating	15%-20%

Source: TERI, 2003

The efficiency of diesel irrigation pumps is abysmal by itself. Similar retrofitting of diesel pumps can lead to reduction in fuel consumption by 25 - 50%[16].

A farmer in Madho Tanda carried out modifications on his pump to get better efficiency. The modified pump consumed 0.6 litres of diesel per hour as compared to 1 litre before the modifications. Hence, the efficiency improved by a factor of 0.4. The average cost of these modifications was Rs. 2500-5000 as this was implemented by the farmer himself. Further study, however, is essential to analyse the complete potential of this.

Techno-Commercial Viability

There are three different sets of energy efficiency measures for electrical pumps— (1) purchasing an energy efficient pump set instead of a conventional one at the end of the pump life, (2) rectification (retrofitting) of the existing agricultural pump set by replacing pipes and the foot valve, and (3) replacement of the existing pump with an energy efficient pump.

16 The efficiency of such diesel irrigation pumps is abysmal by itself. Bom et al. (2001) report states that during field studies suitable modifications reduced fuel consumption by 25 - 50%. (Duali, Bom, Raalten, & Majundar, September 2001)

Table 12: Cost and Potential of Energy Efficiency

	New pump purchase		Pump rectification		Pump replacement	
Measure/ technology	Conventional new pump	Efficient new pump	Existing pump	Pump after rectification	Existing pump	Efficient new pump
Power requirement (W/ Unit)	5 HP	5 HP	5 HP	5 HP	5 HP	5 HP
Retail market price (Rs./Unit)	15,000	20,000	0	5,000	0	20,000
Potential kWh saving (kWh/ year)		400[17]		430[18]		400

Source: Field Study

Cost effectiveness of these measures varies depending on the situation. For e.g., if the existing pump is not that old and is of a standard brand (hence, likely to be more efficient) then pump replacement may not be cost effective. Other measures such as pipe and foot valve replacement may result in greater efficiency improvement at a lower cost. In some cases, the efficiency of an existing pump is so low that it is worth replacing it with a new energy efficient one. Due to flat rate charges of irrigation, it is difficult to obtain any cost benefit for the farmer by improving energy efficiency of the electric pump. However this is an issue to be looked at particularly from the policy level by the Government.

In case of diesel pumps, if efficiency is improved by 30%, the diesel consumption per year will reduce proportionately. This will result in a saving of 20-25 litres for a typical small or medium farmer per year per acre. This will result in a cost saving of approximately Rs. 2,000 per year for a small farmer for a land holding of 2 acres and Rs. 7500 per year for a medium farmer holding 8 acres. The payback periods depend on the scenario of the farmer as defined earlier.

If 50% of the small farmers replace existing diesel inefficient pumps with efficient new pumps, it will lead to a GHG emission reduction of 23%. Since the investment per farmer is up to Rs. 20,000 a model can be developed, to obtain a part of this amount from the farmers itself. The payback for a small farmer is 2-5 years if an initial investment of Rs. 10,000 is made on the pump. A subsidy or reduction in cost would be required in the same for reducing the pay back for small farmers.

Leveraging from existing programmes such as the Agricultural Demand Side Management programme[19] and tying up with corporate houses for the same is essential. This will help to reduce the initial investment to be borne by the farmer.

17 This measure applies to new purchases. Appropriately selected (sized) standard quality pumps can save between 30 to 40% of the used energy (Patel & Pandhya, 1993) We assume a conservative 25% efficiency improvement. Pumps that meet the ISI mark (such as Kirloskar) cost 30 to 50% more than substandard quality pumps. Use of an efficient pump can decrease electricity consumption by 400 kWh / year.

18 It has been seen in several studies that undersized pipes are used by farmers (Patel & Pandhya, 1993). This greatly increases the frictional losses as frictional resistance is inversely proportional to the square of the diameter. In many cases, high friction foot valves are used. Replacing the existing undersized pipes with appropriate size pipes and replacing high-friction with low-friction foot values can improve efficiency of agricultural pump sets by 30-40%, (Sant, Sant, & Dixit, 1996) (Patel & Pandhya, 1993). We assume an efficiency improvement of 30%. The cost of such rectification is around INR. 2500; this cost is very sensitive to the length of the piping. Our estimate is for a replacement of a 50 meter pipe which results in a saving of 30% for a 5 hp pump. Rectification can decrease electricity consumption by 430 kWh / year.

19 BEE has prepared an Agricultural Demand Side Management (AG-DSM) programme in which pump set efficiency upgradation could be carried out by an Energy Service Company (ESCOs) or the distribution company. The Ag-DSM programme for preparation of Detailed Project Reports (DPRs) has already been initiated by BEE as pilot projects in 5 states, viz, Maharashtra, Gujarat, Haryana, Punjab & Rajasthan.

The following case studies elaborate energy efficient irrigation practices followed in from Tamil Nadu and Karnataka.

Table 13: Energy Efficient Irrigation Case Studies

Tamil Nadu: (TNEB/REC) Pump-Set Rectification (with sample monitoring), 1980s

Replacement of suction and delivery piping (GI to RPVC) and foot valves was completed by the Tamil Nadu Electricity Board (TNEB) on 3,125 pump sets of 5 HP rating each, as per REC guidelines (CIRE, 2005). 500 cases were evaluated by the National Productivity Council (NPC), Hyderabad in 4 distribution areas -- Madurai, Periyar, Thiruvannamalai, and Vellore. NPC reported the energy reduction as 10% - 30% in about 70% of the sample, and about 19% for the entire sample. Replacement of GI pipes on both suction and delivery sides by the recommended RPVC led to, both, reduction in energy consumption and higher discharge rate of water. While energy use increased by 11.7% due to increase in the flow of water, the impact on the energy index was beneficial. NPC also reported that the energy saving by rectification of suction and delivery pipes alone was 8% 6 14% of the overall saving of 19%.

Karnataka (WENEXA): Pilot Pump Set Project (and related research), Doddaballapur sub-division, Bangalore district 2006-08

The use of energy efficient, right-sized pump sets, in conjunction with drip irrigation systems resulted in an overall 70% reduction in energy consumption and a 60% reduction in water consumption. The pumps in use were replaced with new efficient and correctly sized pumps, in return for the farms shifting at least 1 acre of flood-irrigated crop-land to drip irrigation. (Pump rectification was considered, but because of the depth of groundwater in the area, this option – involving removal and re-insertion of the pump -- is at least as expensive as replacement).

With pump replacement, the average capacity was reduced by 2 HP, the average number of pump-set stages was increased from 18 to 21, and the average depth where pumps were seated in the wells declined from 156.3m to 152.1m—all factors contributing to reduced energy use.

The Water and Energy Nexus Project (WENEXA) Project is under the Indo-US Bilateral Agreement on Energy Conservation and Commercialization, between the Governments of India and the United States, with the Ministry of Power as the Indian Government's authorized nodal agency.

Source: (PRAYAS, IEI, 2005-06)

3.3 Commercial Cooking

3.3.1 Promoting Use of Improved Chullahs

Improved cook stoves are more efficient than open cook stoves, and have 20-40% higher efficiencies. A list with the improved cook stove manufacturers and their specifications are attached in Annexure 10.

The quantity of fuel wood used in a chullah depends on the efficiency of the chullah involved. The fuel wood thus saved can be up to 30 tonnes of fuel wood for the dhabas of the study area per year. The GHG emissions thus saved per year per are up to 35 tCO2 per year. Cost saving due to reduction of use of fuel wood can be up to Rs. 9,000 per year per dhaba. However very often it can be seen that the fuel wood is obtained from nearby forested areas, without paying for it, hence the cost savings depend on the fuel wood consumption patterns.

The cost of an improved cook stoves varies and is approximately between Rs. 2,000 and Rs. 12,000 depending on the chosen model. So the payback period also varies and is over a year or two for a dhaba owner.

The following table provides a case study on energy efficient cook stoves promoted in dhabas of Karnataka.

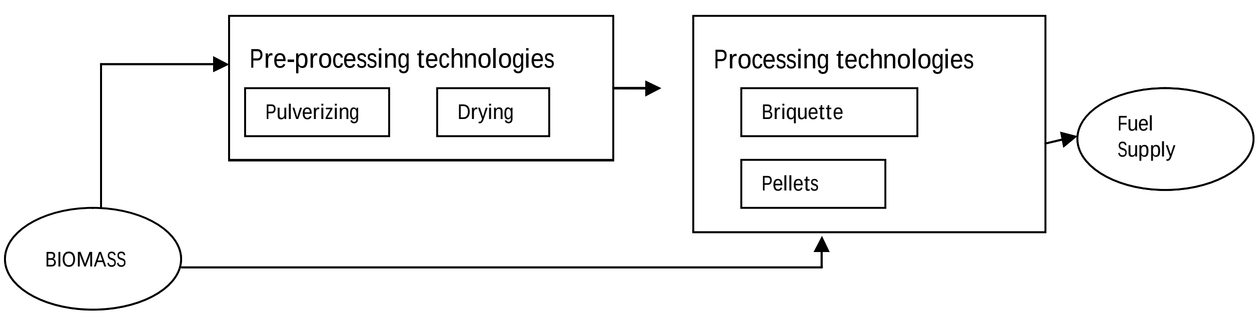
Table 14: Environment Friendly Cook Stoves by WII

Winrock International India (WII) modified the improved cook stoves designs to suit the requirements of users maintaining the same basic design of the earlier stove. The improved cook stove is a 2 pan stove based on the combustion technology. In this design the volume of the combustion chamber has a uniform 1:6 fuel, air mix capacity, i.e. one kilogram of fuel requires six kilograms of air for better combustion. A top metal plate which is mounted on the stove body is filled with fire crate (castable) refractory to retain heat (it retains heat up to 1,200°C). A Priming Hole is provided near the chimney for heating the chimney when the stove is started for the first time and for removal of the soot that gets deposited on the inner side of the chimney walls at regular intervals. It was noted that the improved stoves showed 20 to 22% improvement in efficiency in comparison to the traditional stoves which had only 8 to 10% efficiency. Fuel consumption was reduced by almost 50%. Carbon monoxide emissions were noted to be around 480 $\mu g/m^3$ in comparison to 4,260 $\mu g/m^3$ recorded by older model stoves. Shifting from conventional stoves to improved cook stoves involved, both, one-time and recurring costs. Hotel owners had to invest Rs. 12,000/- to Rs. 15,000/- as one-time cost depending on the model of the stove installed. Recurring costs were around Rs. 1,500 which had to be spent once every 12 to 18 months to replace the grate and fire crate cement. On an average, 75 to 100 kg of firewood was saved daily by each improved stove installed amounting to a total saving of about 3,600 tons of firewood per year for 100 stoves, which is equivalent to reduction in 3,402 tons of carbon dioxide emissions per year. In financial terms, the hotel owners could save about Rs. 72,000 per year on fuel expenses.

3.3.2 Promoting Use of Improved Chullahs with Use of Processed Fuel

A number of improved cook stove models are used in different parts of the country. These models are classified into two broad categories (i) natural draft, and (ii) forced draft (new generation). It has been observed that in order to achieve the best performance from improved cook stoves, both, in terms of combustion efficiency and reduced emissions, the use of processed fuels is essential, especially in forced draft cook stoves.

Figure 12: Flowchart for Pre-processing and Processing of Biomass



Processing of biomass either requires compacting of loose biomass into pellets/briquettes or downsizing of bigger sized woody biomass, like pruned branches of trees or agro-residues like stalks using a simple cutter. The sizing of biomass is essential and amongst the most important components of a supply system of processed fuel. Due to the scattered nature of the biomass, their harvesting, collection and transportation present a major challenge in establishing a biomass supply chain.

In India, the most common biomass residue processing technology being practiced is briquetting, in which a ram and piston press is used to manufacture briquettes of 40 mm diameter and above. The process of briquettes manufacture includes screening, drying and pulverizing, depending upon the type and quality of raw material. The cost of briquetted fuels for large-scale use is well justified in industrial and commercial sectors as replacement of coal or other commercial fuels. However, due to their size and high cost, briquettes are not an effective solution for household-level applications.

The other biomass processing technology is pelletizing, where biomass is converted into pellets using smaller dies (less than 30 mm diameter). Biomass pellets can directly be used in the improved cook stoves or chullahs. Pelletizing technology is very popular in Europe, but the Indian experience on pelletizing of agro-residues is very limited.

3.3.3 USE OF CROP RESIDUE AS A FUEL FOR COOK STOVES

Based on the approximate biomass assessment, the energy required by the chullahs can easily be provided by the crop residues, which are burnt by the farmers in the study area, as discussed in Annexure 7. The energy potential of the crop residues is 35-55 TJ per year, whereas the energy requirement of the dhabas in the study area is less than 1-1.2 TJ (for improved cook stoves with an energy efficiency of 20%). Hence, this demand can be met by use of crop residues as fuel for the improved cook stoves. However, processing of the crop residues is essential before they can be used. This requires a fuel supply chain to be established.

Replacement of use of fuel wood by use of processed agro residues as fuels in improved chullahs will lead to a potential saving of approximately 80 tonnes of fuel wood per year for the dhabas of the study area. The GHG reduction would be approximately 140 tCO_2. The costs involved would be of processing the residue, transporting it to the dhabas and of the improved chullah itself. By development of a proper supply chain and establishment of entrepreneurs in this business, this model can be made financially viable. The following table gives a case study of Nishant Bioenergy Pvt Ltd a biomass cookstove which works on biomass briquettes mainly.

Table 15: Nishant Bioenergy Pvt. Ltd: Cook Stove with a Difference

Nishant Bioenergy Pvt. Ltd. is renowned for its patented and largest range of community cooking stoves. Their unique Sanjha Chullah (community cook stove) has transformed the waste agricultural product of little economic value into a cash income for the farmers. Briquettes are a good source of fuel for cooking because they are cheaper than liquid petroleum gas (LPG) and their maximum attainable temperature (1,000° C) is more than adequate for cooking purposes. The community cook stoves not only provide the briquetting industry with a more sustainable and high-priced market but also gives institutional scale cooking a much cheaper option. Each stove saves almost 10 tons of carbon dioxide per year.

There are two options for these stoves:

- The Micro Entrepreneurs' Stove for making fried snacks (namkeen) is an automated powdered biomass stove (Surya stove) with a temperature controlling facility. Fuel feed can be controlled on the basis of the heat requirement of the food being cooked (or fried). This stove saves up to 50% fuel when it replaces a diesel fired stove.
- The Restaurants and Road Side Dhabas' Stoves come in two models -ES2 and ES3 - and save up to 70% of fuel when they replace the LPG stoves. These models come with briquette fired, earth stoves operated with a DC powered blower.

The cost of one stove is approximately Rs. 1,51,750. The total expenditure on briquettes per month was found to be Rs. 27,000 .

3.3.4 Promoting Use of Biogas for Cooking

Plants ranging from 15-35 cubic meter/day/dhaba are required in these dhabas for fulfilling the cooking requirements of the dhaba. This requires 75 to 175 cows which will produce approximately 750-1750 kgs of cow dung. Assuming that a part of the cow dung is used for other purposes, the collected cow dung would be approximately 50% of the total cow dung i.e. 375-875 kgs of cow dung. This resource is readily available and can be utilized. Kitchen waste might be able to replace 20-25% of the cow dung. However before implementing the same a detailed study is required for economic feasibility of such a plant.

If dairy farms are present in the study area, the same can be used to develop a value chain which will make the plant economically viable. This may also require formation of cow dung collection centres, transporting the gas to be the dhaba, etc. Biogas bottling is an option that can be looked at.

3.4 Transport

The most effective solution to the rural transport problem will involve a combination of policies and measures designed to address the wide range of constraints that are commonly experienced in rural areas of developing countries like India. Basic infrastructure is a major problem in terms of the rural transport in the study area. Inefficient transport practices increase the GHG emission of the area.

Among the existing public transport systems, the Jugaad is the most inefficient in terms of energy use due to low fuel efficiency. But simultaneously it has a high accessibility index because of higher passenger capacity, cost effectiveness and suitability in terms of all types of road conditions.

3.4.1 PROMOTION OF INTERMEDIATE MEANS OF TRANSPORT (IMT)

Promotion of IMT in terms of cost-effective modes of transportation like bicycles, single axle tractors and motorcycle driven vehicles will decrease the dependency on Jugaads. The State Government is going to bring policy restrictions on Jugaads due to their high polluting effect. The necessary modal shift will be possible by providing cost effective alternative options. The IMTs can be categorized according to varying distances covered.

Table 16: Comparison of Different IMTs

IMT Mode	Distance Covered	Passenger Capacity	Initial Investment	Fare/Passenger
Bicycle	5 km.	1	Rs. 2500	-
Single Axle Tractor	15-20 km.	8-10	Rs. 2-3 lakh	Rs. 10
Motorcycle driven Vehicle	20-25 km.	4-5	Rs. 1 lakh	Rs. 10

Source: Field study

For shorter distance travels individual bicycling needs to be further promoted. This requires zero energy consumption.

For moderate distances single axle tractors and motorcycle driven vans can be efficient. The advantage of single axle tractor is its multipurpose use in terms agricultural use, agricultural products transportation and as a means of public transportation. The fuel efficiency of this mode is about 20% better than a Jugaad whereas the cost effectiveness is similar to a Jugaad. The disadvantages of this mode are the high initial investment and low speed.

Motorcycle driven vehicles are 30% more fuel efficient than the Jugaads. The advantages are lower initial investments, high speed and suitability in all road conditions. The only disadvantage of this mode is its low passenger carrying capacity.

3.4.2 PROMOTING USE OF SOLAR AND ELECTRIC VEHICLES

There is a lot of ongoing research on low cost solar and electric powered vehicles currently in the market. A lot of these vehicles are in their prototype phase or under development and can be modified as per the needs of the terrain. A few of these vehicles which may be useful in this study area are mentioned below:

Soleckshaw

A Soleckshaw (Solar Rickshaw) is an eco-friendly tricycle. It is driven partly by pedal and partly by electric power supplied by a battery that is charged from solar energy. The Soleckshaw was developed by a partnership between CSIR-CMERI[20]. The details of the manufacturers of the vehicle have been attached in Annexure 9.

[20] Council of Scientific and Industrial Research (CSIR) and Central mechanical Engineering Research Institute (CMERI)

Table 17: Soleckshaw Specifications

Power source	Solar and human
Drive	Motor-assisted pedal-driven
Transmission	BLDC hub motor: 240-350 W, 36 V with regenerative capabilities
Electric motor	Chain drive with differential and two ratios
Brake	Three-wheel braking
Seating capacity	Two passengers
Payload	200 kg (excluding driver)
Speed limit	15 kmph

Each Soleckshaw currently costs Rs. 22,000 (in mass production). However, the Government is in talks with NGOs, banks, environment-conscious corporate houses and manufacturing organizations to reduce this cost.

The main difference between the two vehicles is that a jugaad is powered by diesel whereas a Soleckshaw is powered by solar energy. Hence the fuel cost can be saved in the Soleckshaw. However the carrying capacity of a jugaad is much higher. Also durability of the soleckshaw is questionable under adverse rural road conditions, particularly monsoons. These aspects have to be further studied for a better understanding before the soleckshaw can be proposed as an alternative to a jugaad.

3.4.3 Integrated Transport Planning

An effective rural transport policy is required which takes an integrated approach; where roads are considered in conjunction with vehicle services and the location of essential facilities like medical services. Currently, Government policies focus on development of roads without development of transport facilities. Good rural planning can provide an appropriate solution for accessibility to important facilities such as hospitals, clinics, etc.

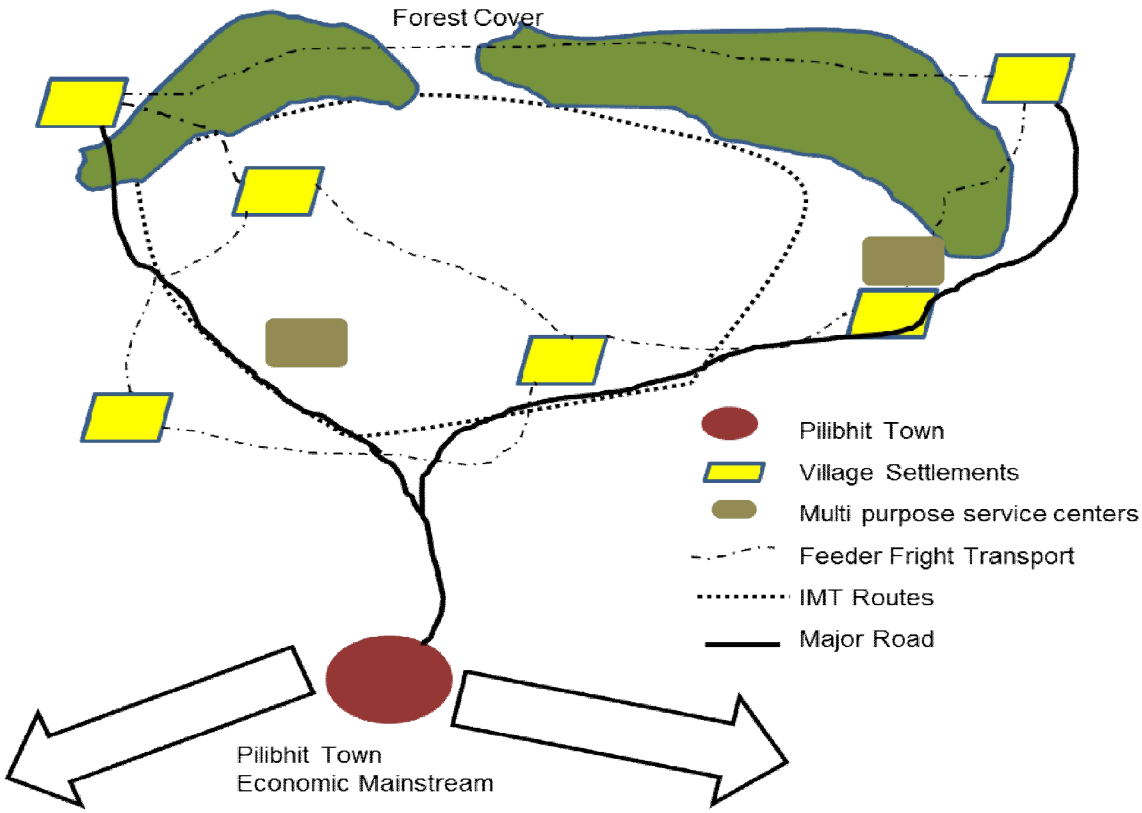
To reduce the travel distance, provision of basic services in a cluster model needs to be adopted. 2-3 village settlements can be part of a cluster. Each of the clusters can be serviced by one multi-purpose service centre which can include an educational resource centre, agro processing unit and a periodic market. This will reduce the travel distance which will further contribute to the reduction of GHG emissions.

There can also be a hierarchy of road networks which can include a feeder freight transport route, IMT routes and major roads. The feeder freight route is to be used only for cycles. The purpose of this route is to increase inter-settlement connectivity in a sustainable manner. The next level of road network is the IMT route (covering distances of 20-25 km). This will be a secondary route to access basic services. It will be an inter-cluster connectivity route. At a primary stage motorcycle driven vehicles and single axle tractors can operate on this route. At a later stage these can be replaced by soleckshaws. The third level of road network will be the major road which can serve as the connecting road for major towns and economic centres. The mode of transport operating through this route can be a mini bus. This will cover a distance of 40-50 km with a passenger capacity of 20-25. This service needs to be promoted in a Public-Private Partnership (PPP) model.

Collectively, these interventions can reduce GHG emissions by 25-30%.

Figure 13 provides a sample Integrated Transport Plan for Pilibhit and the surrounding villages.

Figure 13: Integrated Transport Plan



4 POLICY RECOMMENDATIONS

Any kind of breakthrough technology cannot have a far-reaching, long term, sustainable impact unless supported at the Policy level. For the same recommendations at a policy level have been provided below. These are high level recommendations impacting not just the study area, which is a representative sample but also the entire State.

4.1 PROMOTION OF CLEANER BRICK PRODUCTION

The brick sector contributes substantially to the energy and GHG baseline of the study area. However, UNFCCC has also identified the sector as one of the cheapest avenue for GHG mitigation. This requires a shift from current energy and resource intensive practices and technologies to cleaner firing technologies and products. While there are technologies available, there is a gap in the uptake of these technologies in terms of lack of favourable policies and inadequate enforcement of existing regulations, lack of information on cleaner alternate technology options among entrepreneurs, regulators and consumers and lack of easy access to finance for entrepreneurs.

The incentives proposed in order to accelerate the acceptance of eco-friendly technologies include:

- Establishment of a preferential compliance regime
- Waiver for Pollution NOC for eco-friendly technologies especially those which do not cause emissions (fly ash, CEB, etc.) and relax the renewable time period from 1 year to 5 years
- Preferential siting criteria or relaxation of siting criteria for eco-friendly technologies
- Single technology neutral emission standards for the brick sector
- Inclusion of clean brick production in the thrust areas in industrial policies
- Facilitation of easy access to finance for technology upgradation and setting up new enterprises
- Simplified guidelines to avail bank loans
- Dedicated fund for offering subsidies to clean production technology
- Single window systems for Government subsidies
- Generation of awareness among key stakeholders:
  - Consumers – both private and institutional (CPWD, PWD, Line departments)
  - Entrepreneurs – about existing rules and regulations
- Capacity building of regulatory staff at a regional level with respect to technical and legal provisions applicable to the brick sector

4.2 PROMOTION OF ENERGY EFFICIENT AND SUSTAINABLE IRRIGATION

The Indian power sector provides significant opportunities for reducing energy consumption by addressing existing inefficiencies of technical, operational and economic nature. Replacement of inefficient agricultural pump sets has been identified as one of the key policy initiatives, which, till date, has been limited to a few pilot projects. This is mainly due to the fact that the higher price of efficient pumping and HP-based flat electricity tariff leads farmers to buy cheaper but inefficient pumps. This highlights financing to be the most important barrier for implementing the policy. Due to the flat tariff, farmers do not perceive the value of the incremental cost of inefficient pumps.

The policy objectives are thus to: replace inefficient pump sets, improve distribution grids and provide metering. Adequate readdressing of economic inefficiencies, in terms of electricity pricing, remains a long-term objective.

The policy recommendation is to implement a joint programme for replacement of inefficient agricultural pump sets (including motor/engine and pump assemblies, piping, foot valves, etc.) along with mandatory electronic metering.

Large policy shifts are required in order to promote reliable supply of power for agricultural and domestic purposes in rural areas. The following need to be promoted for the same:

- Feeders supplying agricultural connections are bifurcated from those supplying to commercial and residential connections at the sub-station itself.
- Meters on distribution transformer centres are installed on both sides of the feeders to improve the accuracy of energy accounting.
- Consumers are charged tariffs based on metered usage and without deviating from earlier tariff schemes.
- Investments are made in ground water recharging structures.

Such measures will indirectly promote use of energy efficient agriculture amongst the farmer communities. A few Governments have already implemented such schemes such as the Jyotigram Yojana of the Gujarat Government and seen visible effects.

Other aspects to look at are promotion of irrigation powered by a cleaner fuel such as a renewable energy source, particularly solar pumps. The current subsidies by the MNRE for solar based pump irrigation reduces the price for farmers, however, it does not make it financially feasible for farmers, particularly the small farmers. Thus, there is a need to promote better financing mechanisms for solar based pump irrigation. Several State Governments such as the Haryana and Punjab Governments promote solar pumps by further incentivising use of solar pumps and creating financially sustainable models around the same. Similarly, biomass based mobile gasifiers need to be promoted to the rural population to cater to their energy needs by favourable financing schemes and institutional processes.

4.3 Promotion of Cleaner Cook Stoves

Large quantities of fuel wood currently consumed by dhabas on a daily basis can be considerably reduced by use of improved cook stoves. In order to disseminate improved cook stoves, the value chain and financing mechanism for these needs to be strengthened. Measures to do the same will require policy changes as follows

- New value chains for cook stove dissemination can be created by:
    - PPP amongst various stakeholders
    - Collaboration with companies and programs that have existing delivery networks
    - Linking cook stove dissemination with existing Government programs
- Improving financial mechanism for purchasing improved cook stoves through:
    - Provision of micro-credit loans to micro, small, and medium enterprises (MSMEs), entrepreneurs, and/or self-help groups (SHGs) for working capital to sell cook stoves
    - Establishment of connections by the MNRE with nationalized banks, commercial banks, and microfinance institutions
    - Provision of subsidy on the interest of the micro-credit loan

4.4 Promotion of Sustainable Transport

There are several policies to control the fuel efficiency of vehicles and atmospheric pollution regulations in India. However despite these their penetration in rural transport is low and implementation of the same is not done satisfactorily due to several issues such as sale of adulterated fuels (which cause high pollution) and use of old vehicles (which are more polluting than their counterparts). Adoption of transport related instruments such as high taxation of in-service vehicles can help to control pollution.

Public transportation is an efficient mode of transport, occupying much less road space and using less fuel per passenger thereby generating less pollution per passenger kilometre. The following are required to promote public transport:

- Fiscal incentives from the Central Government. To promote the much-needed investment in the road public transport system there is urgent need to strengthen it with following (a) Availability of adequate funds towards fleet modernization of State Road Transport Undertakings (SRTUs) so as to create world-class public bus transport systems; (b) Upgraded bus infrastructure – bus terminals, stops, etc.; (c) Identification of routes for plying of stage carriages based on comprehensive route surveys; (d) Promotion of road safety and; (e) Co-ordination with other modes of transport
- PPP models for development of alternative transport services. For e.g., in Kerala, private buses are operating efficiently and meeting the requirements of the villagers and rural transport. Kerala has 34,000 buses which connect each village, but of these only 2000 buses are SRTU owned. The rest are private buses. This shows the importance given by the Government to private road transport.
- Livelihood and economic analysis as this sector has several forward and backward linkages. The modal shift needs to more participatory rather than regulatory.

To increase energy efficiency of transport in the region the following aspects need to be considered:

- Jugaads are highly polluting and are frequently used in the study area. Thus regulations on Jugaad use are required to restrict the unsustainable transport services.
- Licensing and regular emission check-up of the existing vehicles is required. Even though rules and regulations for the same exist they are commonly flouted.
- There is a lot of ongoing research on low cost solar and electric powered vehicles currently in the market. A lot of these vehicles are in their prototype phase or under development. The same can be modified as per the needs of the terrain.

Road conditions need to be improved for better fuel efficiency. Maintenance of roads and development of new roads play an important part in the rural transport sector. Poor quality roads are the primary cause of use of inefficient vehicles such as Jugaads, which are the only vehicles which can operate on these badly maintained roads in the monsoon season. Besides this, poor road conditions damage vehicles and reduce their fuel efficiency. The following are important in this context:

- The Panchayats of the study area can take substantial initiative in this area
- The share for maintenance of existing roads should be increased in public sector transport development funds
- Low cost construction or pavement materials and technologies should be introduced as they are easily available locally

- Strong governance measures should be taken to restrain corruption in public works departments due to which crores of rupees meant for transportation and road construction are siphoned off

5 THE WAY FORWARD

From the earlier analysis it has been established that the maximum GHG emissions i.e. 90% of the total GHG emissions in the study area is in the two sectors of agriculture and brick kilns. Therefore, the main technological recommendations focus primarily on these two sectors.

5.1 BRICK KILNS

Table 18 provides the short term and long term interventions which can be made in the brick kiln sector of Pilibhit.

Table 18: Short term and long term interventions in brick kilns

Intervention type	Nature of intervention	Investment required (Rs.)	GHG Emission Reduction (tCO2) /year /kiln
Short term	Hollow bricks	5,50,000-6,50,000	500
	Internal fuel	40,000- 80,000	300
Long term	VSBK	25,00,000	500
	Introduction of new products	-	1130

5.1.1 PROMOTION OF CLEANER BRICK PRODUCTION TECHNOLOGIES

Awareness workshops and demonstrations need to be organized to introduce entrepreneurs to new technologies as well as options of retrofitting their existing kilns. Exposure visits to other kilns in neighbouring areas can help in bringing about a mindset change among the entrepreneurs. Links to technology service providers and innovative finance mechanisms are needed to initiate uptake of these technologies.

5.1.2 R & D FOR INTRODUCING NEW PRODUCTS

Further research is required in characterization of the available boiler ash in the study area. Based on the characterization, studies should be undertaken in determining the correct mix for a product that meets BIS standards.

Subsequently, it is recommended that a few pilots are implemented in the study area to seed change among the entrepreneurs to encourage a shift away from clay bricks.

5.2 AGRICULTURE

Table 19 provides the short term and long term interventions which can be made in the agriculture sector of Pilibhit.

Table 19: Short term and long term interventions in agriculture

Intervention type	Per Large farmer (>10 acres) per year	Per Medium farmer (5-10 acres) per year	Per Small farmer (0-5 acres) per year
Short term	Solar pump GHG emission reduction: 5 tCO2 Initial Investment: Rs. 2.80,000	Solar pump GHG emission reduction: 3 tCO2 Initial Investment: Rs. 1,75,000	Energy Efficiency in electric pumps GHG emission reduction: 0.36 tCO2 Initial Investment: ≈Rs. 10,000-20,000
Long term			Mobile Biomass Gasifiers (promotion in CIG mode) GHG emission reduction: ≈10-11 tCO2 Initial Investment: Rs. 5,00,000- 6,00,000

5.2.1 PROMOTION OF SOLAR PUMPS IN THE LARGE AND MEDIUM FARMERS

A short term intervention can be made with large and medium farmers to promote solar based irrigation. Before doing the same it would be important to create awareness amongst the farmers, particularly the medium farmers due to their lack of knowledge about the technology. A market assessment study needs to be carried out to determine technology specifications of the equipment along with the suppliers for different needs of farmers. An appropriate financing model in consultation with banks and other financing institutions like NABARD, UP Non-Conventional Energy Development Agency (NEDA) etc. needs to be developed. Options such as renting of the pump need to be studied in greater detail and developed for long term sustainability.

5.2.2 PROMOTION OF MOBILE BIOMASS GASIFIER IN THE SMALL AND MEDIUM FARMER CIGS

A long term intervention can be made with small and medium farmer CIGs to promote the mobile biomass gasifier. Before doing the same it would be important to carry out a study on economic feasibility assessment of the technology and a resource assessment of the study area. Besides these a business plan for the CIG model of owning, operating and maintaining a mobile gasifier unit is essential while considering all the direct and indirect input and output costs.

5.3 COMMERCIAL COOKING

5.3.1 PROMOTION OF IMPROVED COOK STOVES IN DHABAS

Suitable models of improved cook stoves for dhabas need to be shortlisted based on the energy requirements of the dhaba owners and their payment capacities. Mobilizing the dhaba community through demonstration of technology and exposure visits is essential to increase the technology acceptance amongst the community. Innovative financing options for the same need to be explored, especially through micro credits.

5.4 TRANSPORT

5.4.1 PROMOTION OF IMT AS AN ALTERNATIVE TRANSPORT MODE

With restrictions on Jugaads, IMTs including bicycles, single axle tractor and motor cycle driven vehicles need to be promoted instead of Jugaads. This intervention also includes distance specific transport modes. For shorter distances bicycles along with Soleckshaws can be promoted whereas as for relatively longer distances (20-25 km.) motor cycle driven vehicles can be promoted. Since their ownership will lie in the private domain, efforts will be required to create awareness generation and to find suitable financing mechanisms.

5.4.2 PROMOTION OF PUBLIC TRANSPORT

A system for public transport in the form of buses is important for the study area. The same can be done through PPP models. Such initiatives need to be started after consultations with the local government and authorities.

5.5 PROMOTION OF BIOMASS PROCESSED FUELS

For promotion of biomass processed fuels such as briquettes and pellets which can be used in different sectors such as brick kilns, agriculture, commercial cooking, etc. an assessment study should be carried out for biomass and charcoal availability in the study area. A feasibility assessment of briquetting and pelletizing as a commercial venture in the study area is essential. Feasibility of the same will only be proved, if briquettes are used as an integrated solution for energy requirements of agriculture, commercial cooking and the brick sector, as well as other sectors not covered in this report. A study of the fuel supply chain is important to ensure sustainability of commercial ventures.

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Annexure 1. Demographic Data of Panchayats

Table 20: Demographic Data of Panchayats

Name of Village	Number of households	Total Population	Total Male Population	Total Female Population	Total Literate Population	Total Worker Population	Total Main Worker Population	Total Main Cultivator Population	Total Main Agri Labour Population
Panchayat 1- Dhuria Palia									
Bijauri Khurd Kalan	7	39	22	17	12	9	8	7	1
Palia	50	273	154	119	124	92	91	73	18
Dhuria	175	1053	571	482	453	351	302	118	144
Majhara Bagha	60	415	226	189	186	121	114	76	37
Majhara T.Maharajpur	164	1082	586	496	472	273	258	166	75
Khajuria	120	805	435	370	290	272	201	121	71
Panchayat 2- Madhao Tanda									
Keshpur T. Madhotanda	63	412	199	213	220	117	106	98	4
Parasrampur	19	113	60	53	56	29	23	18	5
Uganpur	5	28	16	12	8	10	6	5	0
Tanda Madiau	1495	10223	5329	4894	3992	2630	1717	786	363
Total	**1582**	**10776**	**5604**	**5172**	**4276**	**2786**	**1852**	**907**	**372**

Source: Census of India, 2001

Annexure 2. ENERGY USE PATTERN IN BRICK KILNS

A2.1 SOURCES OF ENERGY USE

There are two fuels which are primarily used in the brick kilns in this study area namely coal and fuel wood. Across the country, coal is the predominate fuel used for firing of bricks. This is also true for the study area with 70% of the energy requirement of brick kilns being met by coal from the Jharia coal fields, in the neighbouring State of Jharkhand. However, this is becoming a major stress point for kiln owners due to the escalating prices of coal each year. The increasing cost is due to, both, rise in cost of coal and transportation with increase in diesel prices. Since prices of these two commodities will continue to increase, fuel cost in the study area will also continuously be on the rise in the coming future.

The remaining 30% of the energy requirement is met by fuel wood. Fuel wood is mainly used during the start of the kiln. Easy availability and low costs of fuel wood (illegally cut from nearby forests), contrasted with the high coal prices promote the extensive use of the same.

Generally fuel wood is used during the start of the brick season. Traditionally, the Terai region has high rainfall and a consequent high water table. Additionally, during the start of the brick season, due to winter and fog, inherent moisture content is high in the atmosphere (ranging between 80-90%). Moreover the kiln body has absorbed high moisture during the rainy season. Thus, during the initial two firing cycles (about a month and a half) substantial amount of energy is used to dry out the kiln. Therefore, in addition to excess coal, wooden logs (as fuel wood) are used especially at the outer periphery of the kiln to drive out moisture and compensate for heat loss, therefore maintaining uniformity in the quality of the fired products.

In few of the kilns, bagasse (organic waste from sugarcane processing) is also used as a fuel. Since sugarcane is grown in abundance in the area, bagasse is easily available. However, kiln owners claim that the bricks don’t bake completely and it increases the breakage. This is due to low heating value and high volatility of the fuel. It cannot be used in the same firing pattern as coal and requires a different brick setting pattern.

A2.2 ENERGY CONSUMPTION AND CALCULATION

The energy consumption in any brick kiln primarily depends on the firing technology used and the quality of fuel used. Other contributing factors include climatic conditions of the study area (energy requirements in warmer temperatures are lesser than in colder temperatures), soil type, capacity of the brick kiln, skill of the fire masters, heat losses, etc. An exact measurement of the energy consumed in the kilns requires an audit of the brick kiln. A typical energy balance profile of a fixed chimney kiln using similar soil is given in the table below.

Table 21: Energy balance profile of a fixed chimney kiln

Dry flue gas loss	7%
Heat loss due to CO in flue gas	1%
Heat loss due to moisture in air	1%
Heat for free moisture removal	12%
Surface heat loss	41%
Residual heat loss	2%
Heat for chemical reactions	26%
Unaccounted loss	9%
Others	1%

It can be seen that in “above the ground” fixed chimney kilns most of the input energy is lost as surface heat loss from the side walls, top insulation and bottom.

Given time and resource constraints, a typical energy audit could not be carried out. Thus estimates based on primary data collected from the field were used to arrive at the energy figures. Universally accepted default values for emission factors (2006 IPCC GHG guidelines for National Greenhouse Gas Inventories) were used to determine the carbon dioxide emissions.

The total energy consumption is the sum of the calorific values of the coal and fuel wood used. For the study area, with a 70-30 energy mix for coal and wood, it is estimated at 125 TJ / year. This leads to carbon dioxide emissions of 12,301 tCO2 per year.

A2.3 Energy Efficiency

The calculated specific energy consumption of the kilns in the study area is quite high at 1.78 MJ/kg. This is mainly due to inefficient firing practices, extremely high heat loss due to moisture removal and the wet and humid climate of the study area. Industry best practices[21] for producing red clay fired bricks have pegged the specific energy consumption benchmark at 0.75 MJ/kg for the VSBK.

A2.3.1. Costs of Energy Use in Brick Kilns

On an average, each brick kiln uses 18 tonnes of coal and 5.4 tonnes of fuel wood per lakh of fired bricks. Energy costs contribute towards almost 60% of the cost of a brick. Coal costs have increased by over 20% in the last one year alone to Rs. 11,000 per tonne. Thus the share of fuel cost alone has proportionately increased to 70% of the total energy cost of the kiln at Rs. 5.3 million per kiln.

Though this calculation accounts for cost of the entire fuel wood used, this is rarely the case. On an average, 80% of the fuel wood is bought from local markets or vendors while the remaining 20% is sourced directly from the nearby forests.

A2.3.2. Challenges

The major challenges faced by most of the brick makers are mainly as follows:

- Rising energy costs
- Availability of skilled labour
- Increased awareness on pollution amongst the local residents

21 UNIDO, Global Industrial Energy Efficiency Benchmarking - An Energy Policy Tool, Working Paper , November 2010

The increasing energy cost is one of the major issues faced by the kiln owners. Due to the distance from the coal fields (coal is being brought from Jharkhand, a distance of more than 1000 kms), the prices of coal are substantially high. Each year the coal prices keep rising while the price of the brick is not increasing at the same rate. Thus, each year profitability decreases. Another major concern is the availability of labour. Traditionally, the brick industry is a seasonal one driven by migrant labour. Social protection schemes (e.g. MGNREGA) are one of the primary reasons for the shortage, as they are provided with employment and / or food in their villages reducing migration.

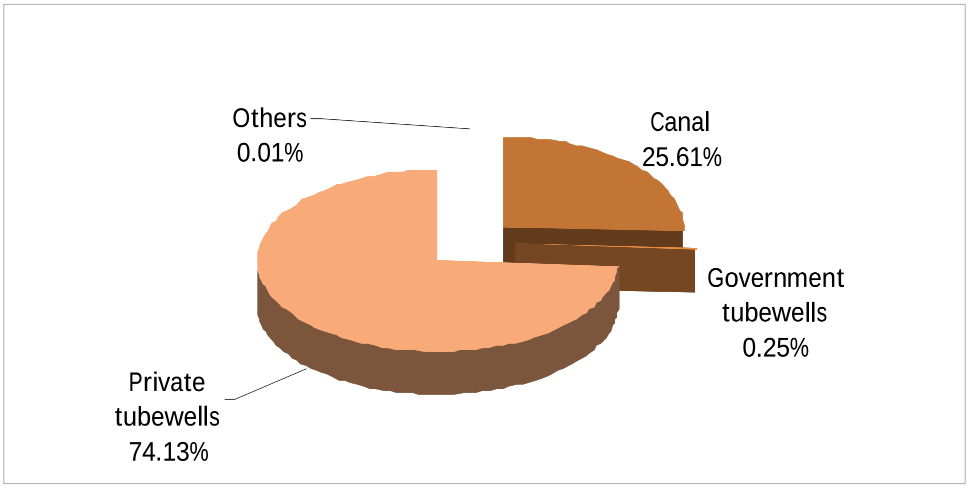
On the other hand, there is reluctance among kiln owners to adopt new (cleaner) production technologies. This is due to a lack of knowledge about technology options as well as a lack of service providers in the study area. Even if there is a will, graduation to improved technology cannot happen due to lack of financial support, both, from the Government and the banks.

Annexure 3. ENERGY USE PATTERN IN AGRICULTURE

A3.1 IRRIGATION

96% land area of the study location is under irrigation. Two methods of irrigation are commonly used in this area - ground water irrigation and canal irrigation - due to better control over water availability. Tube wells irrigate over 74% and canals irrigate over 25% of the irrigated area.

Figure 14: % of Net Irrigated Area to Total Net Irrigated Area in Pilibhit, 2008-2009



Source: District Wise Development Indicators 2010, Uttar Pradesh

A3.2 MECHANIZATION OF AGRICULTURE

Mechanized agriculture is the process of using agricultural machinery to mechanize the work of agriculture, massively increasing farm output and farm worker productivity. Tractors and combines are widely used in this study area. Also, implements such as reapers, harvesters, threshers, etc. are used with the tractor and for performing various agricultural operations.

A3.2.1. Methodology

Ground water irrigation through tube wells, private or Government owned, requires high energy use. These depend on the water requirement of a particular crop for irrigation, crop pattern and area irrigated. Energy estimations for irrigation have been based on primary data collected from the field and secondary data about the Panchayats under consideration. Universally accepted default values for emission factors (2006 IPCC GHG guidelines for National Greenhouse Gas Inventories) were used to determine the carbon dioxide emissions.

A3.2.2. Energy Consumption and Calculation

75-80% of energy for irrigation is supplied through electricity and 25-20% is supplied through diesel pumps. This assumption can be arrived from primary surveys performed in the region.[22]

22 Also secondary research proves the same. A paper written by Niranjan Pant, 2004, International Water Management Institute based on research done in four districts of Uttar Pradesh, two each in the western and eastern regions on "Trends in Groundwater Irrigation in Eastern and Western UP" indicates that there has been a significant increase in the proportion of diesel pumps to

Our surveys indicated that electricity for the pumps was irregular, and the time for which it was provided in the villages varied from 5-6 hours. However the villagers also complained that there were spells for long periods of time where the villages did not receive electricity, which could vary from 2 days to a week or more[23].

Under the survey it was observed that almost 60% of the farmers used tractors. It was found that most large farmers owned tractors whereas most small farmers did not own them. However they used tractors on rent when required. This increases cost of farming for small farmers. It was also determined that 83% of energy in a tractor is used for carrying out agricultural practices and 17% was used for transportation. Based on this, the total energy consumed in a tractor and the corresponding GHG emissions were calcuated.

The usage of combines was on a smaller scale. Approximately 8-10% of farmers used combines in agriculture - mainly the large and medium farmers. Of these only 0.25-0.5% owned the combines.

The cost of diesel based irrigation varies from Rs. 1300-1700 per acre per year. And for electricity based irrigation it is fixed at ≈ Rs. 700-1400 per acre per year. It turns out to be even cheaper for the large farmers sometimes as irrigation of land through electric pumps has lower costs than diesel pump irrigation. This is mainly due to the low cost of power and flat rate charges irrespective of actual consumption (in some areas the supply of power is free for agriculture). Thus, small and large areas of land can be irrigated by electric pumps at the same cost.

The cost for using a tractor and combine vary. The same depends on whether the machine is owned by the farmer or on rent. Combines are usually used on a rental basis by farmers. The cost of using a combine per acre on rent is approximately between Rs. 700-900. The cost for the same if owned would be approximately between Rs. 350-600. This cost varies with the kind of crop, as different quantities of diesel are required for the same. The cost of buying a combine is Rs. 14.5 lakh and hence is mostly owned only by large farmers in the study area.

The total energy consumption in irrigation is 8.5 TJ and in mechanization (tractors and combines for agricultural purposes) it is 9.1 TJ.

The energy consumption in tractors and combines per year per farmer are given in the table below.

Table 22: Energy Consumption in Agriculture per Year

	Energy consumed by per small farmer per year (GJ)	Energy consumed by per medium farmer per year (GJ)	Energy consumed by per large farmer per year (GJ)
Irrigation	7	20	30
Mechanization	4	40	50

Source: Primary Survey, n=30 farmers

A3.3 AGRICULTURAL TRANSPORT

As per the surveys and general observation almost, 55% to 60% farmers use tractors in the study area for agricultural transport, which they own themselves or rent. Some of them also use trucks, however

electric pumps in the study area. The proportion of diesel pumps in total pumpsets was also always higher in the western region. It increased from 59.3% in 1980 to 64.5% in 1985 and then to 78. 6% in 1994, after which it registered a marginal decline of 0.7% up till the year 1999-2000, after which this percentage has not had a large deviation.

23 Under the same study as mentioned above, surveys conducted in 2002 survey found that power supply was available for 6.3 hours per day in the villages of the western regions (Niranjan Pant, 2004).

this is a small percentage as this is done by large farmers only. The rest mostly use bullock carts for transport.

However this travel is mostly seasonal. For e.g., since sugarcane is harvested during August to November, there is increased transportation of sugarcane from fields to sugar factories during November to January in trucks, tractors and bullock carts. The farmers have to travel large distances to obtain diesel, which they buy in bulk to prevent frequent trips.

The energy consumption by trucks for agricultural transport is variable as it depends on various aspects such as seasonality, distance of farm from market or industry, quantity of produce, land holding of the farmer, etc. Thus it has not been considered in the study.

Annexure 4. ENERGY USE PATTERN IN COMMERCIAL COOKING

The occupancy of dhabas increases during the season, and decreases during the off-season. As November to February is the festive season, the demand for sweets in the area increases. The same period being the sugarcane harvesting season, a large number of trucks transport the sugarcane, hence increasing the influx of customers and sales of these roadside dhabas.

July to August is the monsoon season in the study area. Every year this region gets heavy rainfall. As the infrastructural facilities are not up to the mark, the roads are not in good condition during the monsoons, thus making travel for the rural community difficult. This decreases the dhaba sales in the monsoon season by almost half. March to May and September, October have medium level sales.

A4.1 SOURCES OF ENERGY USE

Dhabas have a traditional chullah which used for all the cooking. Besides this they also use a stove, which they use with LPG. Of all the dhabas, 66% use LPG and open chullahs while the remaining 34% use only chullahs throughout the year.

LPG availability is scarce and registration to get LPG is also a problem. Often the villagers have to travel and carry the cylinders for large distances. And most importantly, use of LPG in dhabas for cooking, turns out to be expensive for the dhaba owners and hence a financially unviable option in their perception.

A4.2 ENERGY CONSUMPTION AND CALCULATION

Each dhaba in this area uses an average of 23 kg of wood daily. However this value is not applicable throughout the year. In the busy season, the average wood used in a dhaba is 30 kg per day. The same is approximately 15 kg per day in the low demand season, and 20 kg per day in the medium demand season.

The total energy consumption per year by the dhabas of the study area is approximately 1.3 TJ. Thus the total wood consumption per dhaba per year is 8,105 kg and 122 tonne per year for all the dhabas in the study area.

In the 66% dhabas where LPG cylinders are used, the total LPG consumption per dhaba per year is approximately 200 kg 3 tonne per year for all the dhabas is the study area.

A4.3 COST OF ENERGY USE

It was established that the cost of fuel wood was approximately Rs. 3 per kg. The money spent by the dhaba owners on fuel wood is approximately Rs. 90, 60 and 45 per day and Rs. 2775, Rs. 1865 and Rs. 1345 per month in the high, medium and low demand seasons, respectively. However, in some cases the dhaba owner procures his/her own fuel wood without paying for it, by collecting it directly from the forest.

The average amount of money spent on fuel wood per year per dhaba is Rs. 24,315. This value varies depending on the location and the practices followed by the dhaba owners. Most dhaba owners purchase fuel wood from local vendors while some also go to the forest and obtain this wood free of cost.

The fuel cost for LPG is approximately Rs. 6413 per year per dhaba and approximately Rs. 534 per month per dhaba. The share of LPG and fuel wood in a dhaba is 79% and 21%, respectively.

A4.4 CHALLENGES

One of the other issues faced by the dhabas is the limited clientele they are currently catering to. As these dhabas are not located on the main road or highways, their clientele is limited to mostly the rural community and not the truck community. Hence their incomes are lesser than that of a dhaba on the highway. Besides this, due to unavailability of electricity in the area, the dhabas are generally forced to run only in the day time, and cannot run after dark, thus decreasing the time period of its operation further.

Annexure 5. ENERGY USE PATTERN IN TRANSPORT

A5.1 SOURCES AND COST OF ENERGY

The main modes of transport in the study area are Jugaads, Three Wheelers, Light Motor Vehicles (Passenger, Tata Magic, etc.), Jeeps and others. All the vehicles use diesel as a fuel. There is one fuel station at Puranpur to cater to the fuel demands.

The costs incurred by the vehicles are fuel cost and several other costs such as a fee to the union for tempos, operation and maintenance cost, helper costs, charges to be paid to the local police of the area, etc. The fuel cost is the same for all vehicles and stands at Rs. 43.5 per litre of diesel (at the time of the study). The operation and maintenance cost varies for all vehicles. The same has been obtained by surveying the owners. This cost is incurred mainly to replace damaged parts, repair the vehicle and ensure its proper working. In Three Wheelers and Tata Magic vehicles, helpers are used to gather passengers, to stop the driver for passengers, to collect the fare, etc.

The following table denotes the average distance travelled per day, the mileage of the different vehicle types, and the total fuel consumption by different vehicles.

Table 23: Different Vehicle Type Specifications

Vehicle type	Average distance travelled per day (Km)	Mileage (Km/L)	Approximate fuel consumption in L per day	Total cost of fuel used per day (Rs./ day)
Jugaads	46	7.6	6	265
Three Wheelers	250	25	10	435
Light Motor Vehicles	250	15	17	725
Jeep	50	9	6	240
Others	50	12	4	180

Source: Primary Survey, n=12 vehicle owners

A5.2 ENERGY CONSUMPTION AND CALCULATION

Energy consumption by different vehicles depends on the fuel consumption and hence efficiency of the vehicle. Calculating energy consumption per passenger km, considers the number of passengers transported over certain distance, thereby providing for the overall efficiency of the system.

Table 24: Energy and Cost Comparisons for Different Vehicle Types

Vehicle type	Pass-km / L	MJ/ pass-km	Cost pass-km
Jugaads	152	0.282895	0.30
Three Wheelers	250	0.172	0.179
Light motor vehicles (passenger, Tata Magic)	225	0.191111	0.196
Jeep	90	0.477778	0.508
Others	240	0.179167	0.192

Source: Primary Survey, n=12 vehicle owners

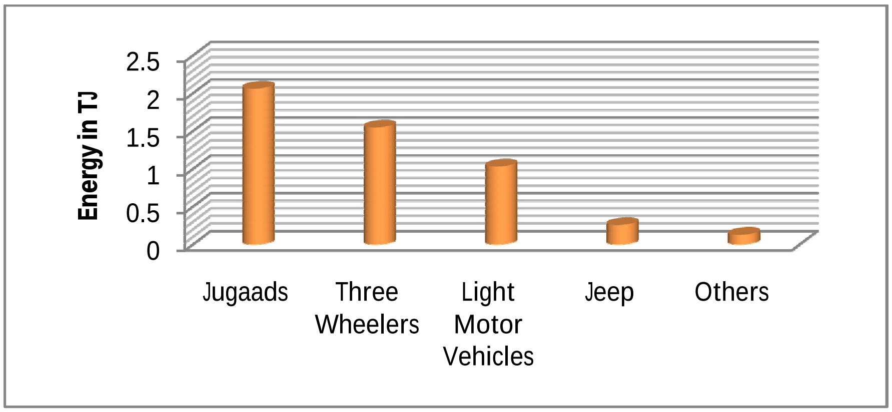
From the table above it can be seen that:

Three Wheelers use 0.2172 MJ/pass-km. They use the least amount of energy in any of the transportation modes analyzed. While jeeps use 0.4778 MJ/pass-km and are the most energy intensive.

Cost per passenger km is the cost incurred by a vehicle per passenger km travelled. As this cost increases, the profit values go down. It is the lowest for three wheelers and highest for jeeps.

The total energy consumption in the transport sector under the boundaries of the study is 5.02 TJ per annum. In Figure 15, the energy consumption by each vehicle type per year is provided. It can be seen that the energy consumption was maximum by Jugaads, and minimum by the Others category, which is mainly the school bus.

Figure 15: Energy Consumption per year by Different Vehicle Types



Source: Primary Survey, n= 12 vehicle owners

Annexure 6. EXISTING RELEVANT GOVERNMENT POLICIES

A6.1 ENERGY USE IN AGRICULTURE

In the 70s and 80s the Government promoted small boreholes and mechanized diesel and electric pumps for agricultural irrigation through provision of institutional credit, a variety of subsidy schemes on borings and pumps, support to farm electrification and electricity subsidies. However this raised new concerns about the threat of groundwater depletion and the adverse impacts of electricity subsidies on the viability of the electricity industry. These policies in turn resulted in the following outcomes: (a) progressive reduction in the quantity and quality of power supplied by power utilities to agriculture as a desperate means to contain farm power subsidies; (b) growing difficulty and rising capital cost of acquiring new electricity connections for tube wells; and (c) an eight-fold increase in the nominal price of diesel during 1990-2007 (a period during which the nominal rice price rose by less than 50%)[24].

In this study, while interviewing farmers, it was observed that 'energy cost and availability' was the top challenge they faced. And increase in diesel prices was a growing concern amongst the community.

A6.2 ENERGY USE IN BRICK KILNS

The brick sector is one of the most polluting industries in India and recognising this, the Government of India has undertaken certain steps in influencing better practices in the sector. The moving CBT Kiln, one of the more polluting technologies, has been banned across the country. Emission standards have been established for different firing technologies. These standards include those for cleaner production technologies like VSBK. They have mandated the use of a pollution control system, called gravity settling chamber in brick kilns. In addition, a rigorous siting criteria has been established by the Central Pollution Control Board mandating set distances from settlements, roads and orchards among others. While the Government does encourage adoption of cleaner production technologies, policies are silent on the fuel use.

A6.3 ENERGY USE IN COMMERCIAL COOKING

The national biomass policy has two decades of history, emanating with the rural energy policies. In the mid-seventies, a rural energy crisis manifested as a fallout of high oil price, population growth and depletion of wood fuel resources. Import of oil was resorted to as a short-term supply-side solution. But this was unviable in the long run. India's oil imports rose rapidly in the 1970s, rising from 8% of total imports in 1970 to 24% in 1975 and 46% in 1980. High oil imports led to growing trade deficit and balance of payment crisis. At household level, a vast section of rural poor had little disposable income to spend on commercial fuels. Policy makers perceived biomass as an energy alternative that could alleviate the crisis.

The biomass strategy was multi-pronged. It focused on improving efficiency of traditional technologies, enhancing supply of biomass, introducing modern biomass technologies to provide reliable energy services at competitive prices and establishing institutional support. The DNES, established in 1982, implemented the programme for biogas and improved cook stoves with moderate success.

The National Programme on Improved Chullahs (NPIC) was implemented during 1983-84 to 2002-03. About 35.2 million improved cook stoves were disseminated under this programme as against an

24 (Tushaar Shah)

estimated potential of 120 million in the country. Despite potential this programme was unable to meet its desired objectives and targets mainly due to lack of awareness, availability and thrust on use of biomass improved cook stoves in the development plans at the local level.

Further National Biomass Cook stoves Initiative (NBCI) was launched by MNRE with an emphasis on enhancement of technical capacity in the country by setting up state-of-the-art testing, certification and monitoring facilities and strengthening R&D programmes in key technical institutions. Under this initiative, the MNRE has taken up pilot scale projects for demonstration of community cook stoves in eight identified States for mid-day meals, anganwadi schemes in schools and dhabas, etc. The Special Project on Cook stove (SPC) launched by MNRE during 2009-10 conducted a process of consultations to review the status of various types of biomass improved cook stoves developed and promoted in the country.

Liberalization of LPG in 2000 has been a significant policy intervention by the Indian Government. The LPG market has been opened to private retailers who have been authorised to sell imported LPG. The commission given to retailers has been increased to ensure better consumer service, quality product supply and improved safety measures. Private retailers have been also allowed to produce LPG cylinders, the shortage of which has been a perennial problem in increasing LPG supplies.

A special scheme has been launched to extend LPG connections to the rural sector with associated reduction in the quota of subsidized kerosene, by opening extension counters in rural areas falling within a 15 km radius of the normal trading area of urban distributors. Some of the State Governments are providing grants to poor people to meet the initial cost of buying gas stoves, etc. In Himachal Pradesh, a strong financial incentive is provided to use LPG in an effort to slow deforestation.

Though the Government makes some adjustments through subsidies to partly offset the increase in international prices of LPG, the price of LPG has risen over the years in India from about Rs. 62 in 1985 to Rs. 220 in the year 2000 and Rs. 430 in the year 2012.This increase in prices has resulted in low penetration of LPG in rural areas.

A6.4 ENERGY USE IN TRANSPORT

Rural transport is a highly neglected area by the Government of India. Though emphasis has been laid on building of all weather roads and infrastructure especially in rural parts of the country under various schemes, such as the Pradhan Mantri Gram Sadak Yojana (PMGSY) amongst others, access and mobility of the rural people continue to be major issues.

However, if we look at transport from a different lens i.e. looking at the link between transport and energy, it can be seen that the Government has taken considerable policy measures to influence the same. The key strategies[25] which are emphasized in transport policy documents are:

25 In the transport policy post 1992 economic fuel efficiency in vehicles was promoted by economic liberalization of the licensing regime for automobiles. This led to introduction of small and fuel-efficient vehicles. The policy ensured tightening of vehicular emissions standards and norms. Each vehicle now requires a mandatory certificate of pollution under control (PUC) every three months. The Auto Fuel Policy in 2003 addressed issues of vehicular emissions, vehicular technologies and the provision of cleaner auto fuels in a cost-efficient manner while ensuring the security of fuel supply. The policy included a roadmap for reduction in emissions levels of the new vehicles. Besides proposing the enhanced quality of liquid fuels, the policy also encouraged the use of CNG (compressed natural gas)/LNG (liquefied natural gas) in the cities. Thus in the transport policies LPG, battery operated and electric vehicles are being promoted to reduce carbon emissions through vehicular pollution. The same norms lead to phasing out of lead in gasoline, reduction of benzene and sulphur content in diesel. However due to inferior vehicle technology, vehicular emissions particularly in diesel vehicles are high. Also use of two stroke engines in two wheelers causes high pollution. Decrease in use of the railways and increased use of road transport has been mainly due to contradictory policies which on one hand want to arrest the decline of the railways share while on the other have liberalized and promoted road transport. The Government also has a

- Increasing the share of electric traction in railways and the share of railways in the transport sector
- Promotion of other modes of transport like coastal shipping and inland waterways
- Increasing the share of public transport in the sector
- Introducing efficient vehicle technology to reduce the energy and environmental implications

However, an emphasis on rural needs has not been place under these policies. For e.g., energy efficient technologies are expensive and are not affordable by rural populations. For widespread use in rural areasthe Government would be required to incentivize their use. Also, in case of promoting a fuel shift for rural India, it is essential that Government provides infrastructure for the same and incentivizes the conversion to a cleaner fuel.

policy to increase biofuel use in the transportation sector to 20% ethanol-blended petrol and diesel across the country by 2017. The 11th Five-year plan (2007-2012) endorses policies for improving the efficiency of new vehicles and advocates inter-modalism and better integration of urban land-use with transportation (Planning Commission, GoI, 2007-2012).

Annexure 7. WASTE GENERATION TRENDS

The study area has a large biomass potential. The same needs to be completely assessed, to know the potential of using biomass as a clean resource. Biomass includes mainly crop residues and fuel wood. Fuel wood is currently being used in brick kilns and dhabas.

Agricultural burning is the practice of using fire to reduce or dispose off crop residue from an agricultural activity to control crop diseases, weeds or pests, or to maintain crop yields. Agricultural burning can produce a large amount of smoke in a short amount of time. Concerns over impacts to public health, safety and the environment arise from this practice. Crop residue burning is now banned, mainly due to the threat of a forest fire or fire in the neighbouring fields.

After harvesting, often the crop residue remains in the fields. This is approximately 20% of the total produce. Farmers prefer burning the crop residue after harvesting because removing this residue by hand requires labour, which is expensive and hard to find. With MGNREGA which has been implemented by the Central Government, the wages of the labourers have increased, thus making it harder to find farm labour for agricultural work.

The available biomass is given in the table below, based on estimations.

Table 25: Biomass Assessment

Type of residue	Quantity of residue (tonnes)	Energy Content (TJ)
Rice husk	800-1100	9-13
Wheat stalk	800-1100	2-4
Sugarcane leaves, stalks, etc.	250-350	9-13
Total	**1,800-2,700**	**35-55**

Source: Field Study

From the survey it was established that there was a good population of livestock in the study area. Based on extrapolations, the population of the livestock in the study area is estimated to be 5,000, most of which is buffalos and cows. The cow dung produced is approximately 25,000 kg[26]. Even if only 50% of the available cow dung produced is considered, the energy potential of the dung is over 700 kwh of electricity per day and it produces more than 500 cum of gas. Thus there is high potential to use biogas for cooking purposes as well as for irrigation.

26 Gujarat Energy Development Authority

Annexure 8. Solar Water Pump Manufacturers

Name	Contact Details
Premier Solar Systems Pvt. Ltd	3rd Floor, V Towers, Main Road, Karkhana, SECUNDERABAD-500009 AP INDIA Phone: +91 4027744415/27744416 Fax: +91 4027744417 Mobile: +91 9490167793/9490167791 Email: marketing@premiersolarsystems.com
Vimal Electronics	Plot No. E-49, G. I. D. C. Estate, Sector - 26, Gandhinagar - 382 044 Gujarat. (India) Phone : +91 79 23287573. TeleFax : +91 79 23287571. Email : vimal@vimalelectronics.com, mktg@vimalelectronics.com
Tata BP Solar	78, Electronic City Hosur Road Bengaluru 560 100. Phone: +91 804070 2000. Fax: +91 802852 0116. Email: tatabp@tatabp.com
Auroville Renewable Energy (AuroRE)	CSR office, Auroshilpam, Auroville- 605101, Tamil Nadu Phone: +91 413262749/168/277 Email: aurore@aurooville.org.in
Aspes Solar	Address : 46, Matiyala Industrial Area, City : New Delhi State : Delhi-110059, India Phone : +91-92123-32405 Email Address : allsunpower@gmail.com, aspessolarindia@gmail.com Web Site : http://www.aspessolarproducts.com
Ritika Systems Private Limited	C-22/18, Sector - 57 NOIDA - 201 301 Phone: 0120-2586610

Annexure 9. SOLECKSHAW MANUFACTURERS

Name	Contact Details
M/s Modular Machines	16/2, Karkhana Bagh, Mathura Road, Faridabad (Haryana) 121 002 Fax No: 0129-2227079 Mobile No: 09810829404 E-mail: modularmachines@gmail.com / avbhatnagar@yahoo.com
M/s HBL Power Systems Limited	8-2-601, Road No 10, Banjara Hills, Hyderabad-500 034 Mobile No: 09958798546 E-mail: anilsahoo@hbl.in
M/s DEAN Systems	New Green Park, Narendrapur Kolkata 700103 Telephone: 033-24773375 Fax No: 033-24770627 Mobile No: 09331841091/ 9432745125 E-mail: dean01@vsnl.net / deansystems01@gmail.com
M/s Stilam Automobiles Pvt. Ltd.	475, Udyog Vihar, Phase-V Gurgaon, Haryana Mobile No: +91-9871027084, +91-9717030095 Phone No: +91 124 6768600 E-mail: sales@stilam.net , info@stilam.net Works: Plot No 16, Sector 27C, Industrial Area Faridabad, Haryana, India +91-0129-413 5200,413 6200, 412 8300 info@stilam.net

Annexure 10. COOK STOVE MODELS

The specifications of the stove models developed by organizations/ NGOs are summarized below.

Organization	Model Type	Specifications
Philips	Forced & Natural draft stoves	Optimal wood size: 20X30x100 mm Heat output: 2-5 kW for forced draft and 1.6-3 kW for natural draft Charging time: 1x 8 hours Combustion efficiency: 98-99%
Appropriate Rural Technological Institute (ARTI)	Vivek, Sampada and Agni.	Vivek runs on loose, powdery biomass. It can operate continuously for 1.5 to 2 hrs. Sampada requires dry woody biomass, wood chips, shavings etc. It is a low power stove, whereas Agni is a gasifier stove that runs on briquettes/ pellets. Once filled give high heat for 20-25 minutes.
First Energy Pvt. Ltd.	Oorja Stove	Stove is provided with mini fan with rechargeable batteries and regulator Runs on pellets made up of agricultural waste. Cost of cook stove Rs. 675 & Oorja fuel costing Rs. 7/kg
Envirofit India Pvt. Ltd.	5 models	50% less fuel consumption HxWxD of cook stove: 27x24x24 Cost of cook stove between Rs. 500 and Rs. 2000.
Indian Institute of Science	SWOSTHEE, pulverized fuel stove, Gasifier stove for pellets and tiny sticks	Increased thermal efficiency: 25-35% Power consumption 3-50 kWt Continuously burn for 2 to 5 hrs Cost between Rs. 200/3 kW to Rs. 600/ 3 kW for SWOSTHEE and Gasifier stove respectively

Annexure 11. Manufacturers and Suppliers for Biomass Processing Machines

Manufacturers	Briquette size (dia in mm)	Output capacity (kg/hr)	Power requirement (HP)	Other information
Lehra Fuel Tech Pvt. Ltd, Ludhiana	30, 40, 50, 60, 70, 90 & 100	150-2600	13 to 89	Required granulated material, vertical feeder, gear box and motor
Hi Tech Agro, Delhi	40 to 90	250 -2000	15 to 60	
Radhe Engineering, Kota	60 & 90	500 -750	75 to 90	Super -60 & Jumbo -90 models; require biomass of proper size and moisture content less than 10%.
Harsad Engineering, Rajkot	60 & 90	600-1500		HBP -60 & HBP -90 models; require biomass with moisture less than 10% and must be powdery or up to 25 mm sized.
Enerware Engineering Enterprises, TN	50 to 65	400-600		Requires high power for motors and mould heaters.
M/s Agni Engg & Industries	50 to 90	400-1400	25-85	

The above tabulated information on briquette manufacturing machineries, capacity, power requirement, and method of production, it appears that briquetting technology is not suitable for fuel processing in rural areas as the machines require high power input and also production capacity is huge as compared for a small community necessitate. The briquette processing technology is mainly for the large-scale production and be used for commercial purposes. Moreover, for the new generation stoves with the requirement of specific-sized fuels, the available briquette sizes are generally unmatched.

Annexure 12. INDIAN MANUFACTURERS IN PELLET MANUFACTURING TECHNOLOGY

Hi Tech agro, Delhi supplies pellet presses in few models which produce pellets of size 8-25 mm in diameter. The output capacity of pellet plant is 500 to 5000 kg/hr (with different models), which is huge production for household or village utilization.

Radhe Engineering also has pelletizing machines, which produces pellets of 8 to 20 mm in diameter, and production capacity is 1 metric tonnes/ hr.

First Energy has gained experience with development of biomass pellets fuel processing system based on both Indian fodder pellets machine and Imported fuel palletizing machine. They have set up two local fodder pellets machines having capacity 25-30 tpd modified for fuel pellets applications. In addition they have set up one imported fuel palletizing machine having 2 ton per hour capacity. As part of their cook stove dissemination work the company is able to supply the processed fuel at Rs. 7/kg to the end-users. These machines are mainly used with saw dust and a few agricultural residues as feedstocks. Based on the discussion, it was clear there is need to develop/adapt these machines on widely available agricultural residues and to reduce the overall operation and maintenance costs of these machines.

Abellon Clean Energy, a company based in Gujarat also has gained experience with Pelletizing machines and produces pellets based on locally available residues in the State of Gujarat. The pellets are used in their captive biomass power plant and also sold for Industries as boiler fuel.