Final Report

Project Code 2010BE11

"To convert tender coconut husk into convenient form of fuel for clean combustion"

Prepared for

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The Energy and Resources Institute

...towards global sustainable development

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To convert tender coconut husk in to convenient form of fuel for clean combustion"

1. Introduction

Kerala, being a land of coconut cultivation, has a large area under coconut farming. A major portion of the coconut grown is used as tender coconut. Currently the tender coconut husk is not utilised in effective manner. As such the tender coconut husk is not usable for coir industry. Since the tender coconut husk is in soft form but with high moisture, with adequate fuel processing the tender coconut husk can be converted in to a valuable clean combustion fuel.

In order to prevent the environmental degradation and to meet the ever-growing energy demand it is essential to develop new processes/ technology to convert this waste to energy. In its available form tender coconut husk is having high moisture content and need to be cut in to pieces and dried for using it as a convenient biomass fuel. The processed tender coconut husk will be used as fuel for cook stoves.

2. Project Objectives

To develop suitable fuel processing equipment for "Tender Coconut husk" to be used as a value added fuel for cooking applications, with clean combustion.

3. Purpose of this research work

The purpose of this proposed research work is to convert the Tender coconut husk in to value added clean combustion fuel. This will replace the conventional fossil fuel and also will contribute towards environmental protection.

The main objectives of the proposal are as follows:

- To have an effective usage of "Tender Coconut husk"
- Adding value to the "Tender Coconut husk" by introducing appropriate fuel processing technology
- To create a market potential for "Tender Coconut husk" to use as fuel in domestic and community cooking applications
- To demonstrate usage of "Tender Coconut husk" as clean combustion fuel in selected applications line cooking/ banana chip making.
- To create appropriate business model for effective use of "Tender Coconut husk"

4. Proposed methodology

A detailed proximate analysis of "Tender Coconut husk" will be carried out for best use of "Tender Coconut husk" as clean combustion fuel. A shredder will be procured for chipping the "Tender Coconut husk" in to small pieces, to dry and use it as fuel. Inherently the

"Tender Coconut husk" has high moisture content and it is essential to make the husk in to smaller pieces to enhance the drying process. A suitable biomass dryer will be designed to dry the "Tender Coconut husk" which is currently available with high moisture content. Dried "Tender Coconut husk" will be used in specially designed gasifier based stove for cooking applications in domestic and community cooking applications. An appropriate business model will be developed for collection of "Tender Coconut husk" and processing it at a centralized place. The processed "Tender Coconut husk" can be packed in to bag s of 20 kg and sold in to market for usage as fuel for cooking applications.

5. Activities of the project

The activities include the following components to meet the objective and their status is given in the following table.

Table 1: The key activities of the project, along with status

Sl.No	Work component	Status
1	Detailed analysis of tender coconut husk in its available form.	Completed and results are discussed
2	Design and development of a tender Coconut husk chipper for size reduction.	Completed and results are discussed
3	Design and development of a moisture remover cum drying system (mechanical and thermal based).	Completed and results are discussed
4	Detailed analysis of processed tender coconut husk as biomass fuel.	On-going activity
5	Testing the fuel for cooking applications in turbo stoves.	To be carried out

6. Sampling methodology

Fresh sample has been processed for different sets of experiments. The methodology followed for performing the experiments is explained in the following figure given bellow.

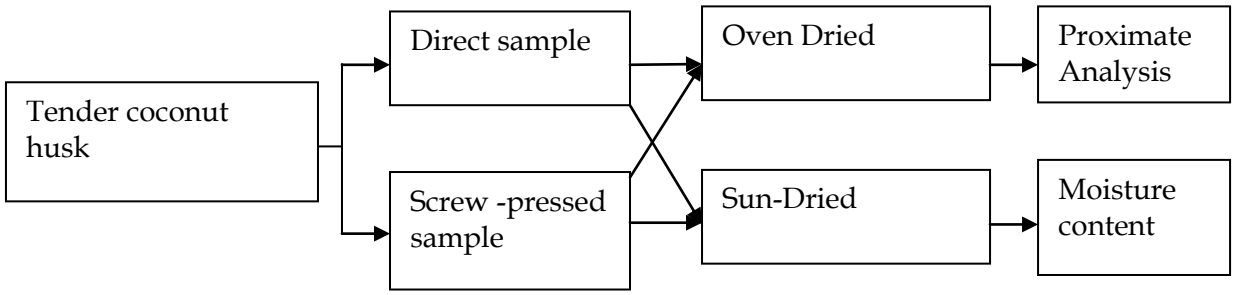


Figure 1: Methodology followed for performing experiments

a) Direct sample- The 1" sized fresh tender coconut husk sample was taken and analyzed to determine moisture content.
b) Screw press sample- The 1" sized fresh sample was tightly pressed in a screw machine. The amount of water obtained after pressing the tender coconut was collected and then, pressed sample was analyzed for moisture content.

The moisture content of the sample was checked by both oven- drying and sun- drying methods.

Further, the oven-dried, direct and screw- pressed samples were analyzed for volatile matter, ash content, bulk density and calorific value estimation.

Procedure:

a) **Screw pressing of tender coconut husk**: 1000 grams of tender coconut husk was taken and tightly pressed in a screw machine. The amount of water squeezed out from coconut sample and final weight of the pressed sample was taken to calculate moisture content
b) **Moisture content (MC):** Moisture content of both, direct and screw pressed sample was measured by using Oven-drying method and sun- drying method

Oven-drying method: The moisture content was determined by overnight drying the weighed amount of sample at 105^{o}C in an oven.

Sun-drying method: The moisture content was determined by putting the weighed amount of sample under the sun in the morning and then took the weight of sample during evening time. Total number of days was noticed. The procedure was repeated till the constant weight of sample obtained, i.e. for the weight of sample, kept in sun will be equal to the weight of sample, taken in the evening.

The moisture content of the sample taken as =

$$\frac{\{\text{Wt of sample} - \text{wt of sample after drying}\} \times 100}{\text{Wt of sample}}$$

c) Volatile matter (VM): Volatile matter was estimated by heating a known amount of oven-dried sample in an open and pre-weighed silica crucible at 950 ± 25 ^{o}C for 7 minutes in a muffle furnace. The amount of weight loss in the sample gives the volatile matter.

% Volatile matter (dry basis) =

$$\frac{\{\text{Wt. of oven dried sample} - \text{Wt. of sample after heating at 950 } ^{o}\text{C}\} \times 100}{\text{Wt. of oven dried sample}}$$

d) **Ash Content:** Ash Content of samples was estimated by combusting a known amount of oven-dried biomass sample in a pre-weighed and closed silica crucible at 750 ± 25 ^{o}C for a minimum of 4 hours in a muffle furnace. The amount was estimated using the formula given below:

% Ash (dry basis) =

$$\frac{\{\text{Wt of sample after heating at 750 }^{o}\text{C} - \text{Wt of oven-dried sample}) \times 100}{\text{Weight of oven-dried sample}}$$

e) **Fixed Carbon:** The fixed carbon was estimated on material balance basis using the following formula.

% Fixed Carbon (dry basis) = 100 – (% volatile matter + % ash content)

f) **Calorific value:** The heating value of sample was estimated using bomb calorimeter.

7. Results obtained based on average of test results of experiments

6.1.1 Analysis of coconut husk samples after removal of moisture using mechanical press

Table 2: Analysis of coconut husk sample

Sample Wt (gms)	Wt after pressing (gms)	Squeezed water (mL)	Moisture removed
1000	580	310	31%

From the above table it may be observed 31% of moisture can be removed instantly by mechanical press. The mechanical press will be further improved to remove the moisture at least by 50%.

6.1.2 Moisture analysis

The results of moisture reduction by direct sun dried and oven dried samples are shown in the following table given below.

Table 3: Results of moisture reduction

Direct sample	
Oven- dried	Sun- dried
81.9	83.2

From the above table it may be noted that total solid content of Tender coconut husk in its available form is 18.1 % which indicates approximately 5 kg of wet husk can produce one kg of sun-dried tender coconut husk, which can be used as fuel for cooking applications. The above results also conclude that oven drying can be used as alternative to sun drying in monsoon seasons. This will ensure sustainable availability of cooking fuel derived from Tender coconut husk, round the year.

8. Proximate analysis of Tender coconut husk

Proximate analysis was carried out various parameters to estimate the value of processed fuel produced from raw tender coconut husk.

Table 4: Proximate analysis

Sample	Volatile Matter (% of TS)	Ash content (% of TS)	Fixed carbon (% of TS)	Calorific value (Kcal/kg)
Oven dried direct	90.7	2.6	6.7	3800
Oven-dried screw pressed	90.2	2.9	6.9	4300

It may be noted the calorific value of tender coconut husk from screw press is found to be higher than the non-processed oven dried coconut husk. This is due to residual moisture remains in direct drying process. Screw press effectively removes the moisture and increases the useful heat content. The calorific value of the processed tender coconut husk is in the range of 84 to 95 % of fuel wood heat content.

8.1 Ultimate analysis of tender coconut husk

The ultimate analysis of the processed tender coconut husk was carried out. The tender coconut husk was processed as per the methodology proposed in this report. The tender coconut husk (TCH) was, chipped in to small pieces, de-watered using screw press and sundried. The sun dried TCH was having only 7.34 % of moisture content. Carbon and hydrogen contributes the heating value of the TCH. The carbon content in TCH was 60.09% and the hydrogen content was 3.84%, on moisture free basis.

A comparative table of proximate analysis of TCH along with fuel wood and coconut shell is given in table. It may be noted though the ash content is more in tender coconut husk its oxygen content is much less than fuel wood and Coconut shell. This is the reason that the carbon content is high in tender coconut husk.

Table 5: Results of the comparison of the ultimate analysis of tender coconut husk with fuel wood and coconut shell

S. No.	Components	Unit	Biomass Fuels		
			Processed Tender Coconut Husk TCH)	Fuel wood	Coconut shell
1	Carbon	%	60.09	47.16	52.29
2	Hydrogen	%	3.84	9.07	5.80
3	Oxygen	%	31.83	40.62	37.16
4	Nitrogen	%	0.29	1.39	0.66
5	Ash	%	3.95	1.76	4.09
6	Energy content	Kcal/kg	4300	4500	4700

9. Processing of tender coconut husk

9.1 Drying profile

Drying profile of Tender coconut husk was obtained for raw tender coconut husk and Screw Pressed Tender coconut husk. It may be noted that drying time required for direct sample is 4 days where as Screw Pressed Tender coconut husk can be sun dried with in 3 days. Further work will be carried out to get improved response of drying. Design of biomass fired dryer is under design finalization stage. Dryer design includes all the results obtained by analyzing the tender coconut husk. The processed coconut husk will be tested for its performance in turbo stoves shown in annexure III.

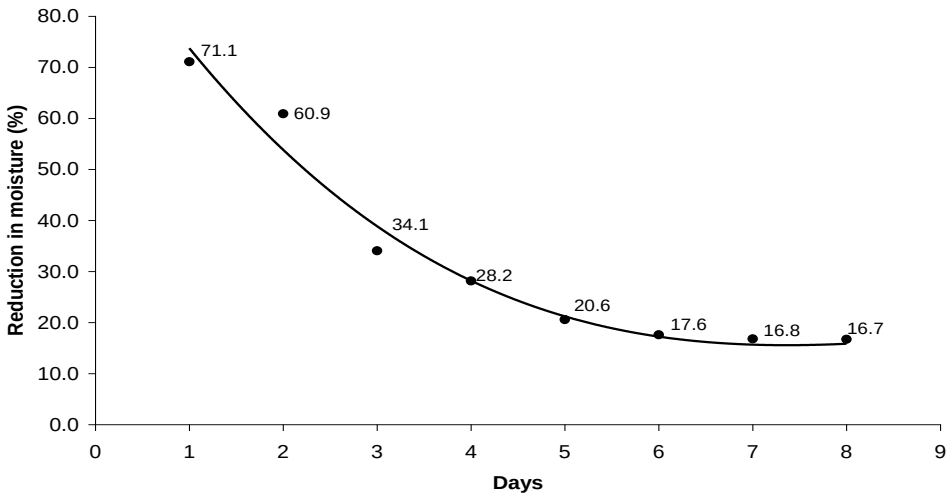


Figure 2: Sun drying – direct sample

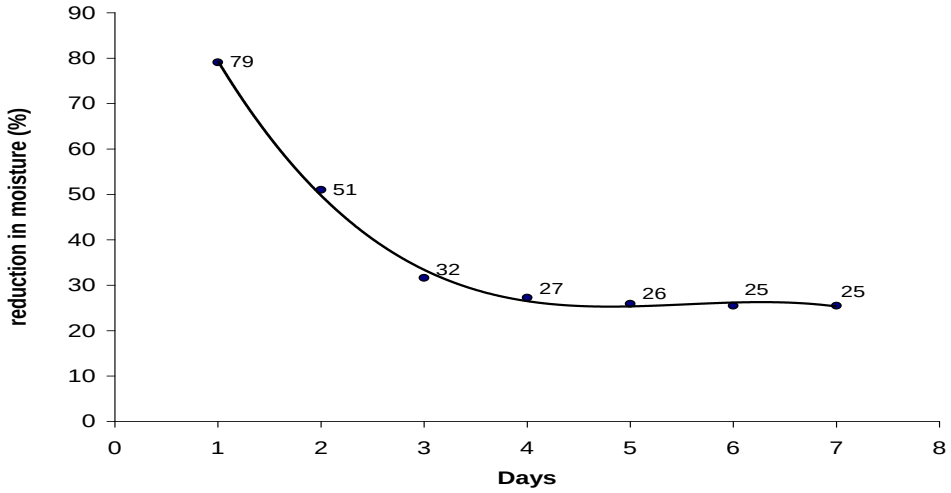


Figure 3: Sun drying – screw pressed sample

9.2 Size reduction of Tender coconut husk for fast drying and convenient usage

Fuel chipper equipment for size reduction is procured and modified for chipping of the Tender coconut husk at for size reduction and efficient drying.

9.3Chipper for Tender Coconut Husk

Initial trial runs were taken for cutting the tender coconut husk into small pieces to convert as value added fuel. Based on the observation and the results obtained, technical specification were finalized for designing of a suitable shredder which produces Tender coconut husk chips in the rage of 1 to 1 ½ inch size. A view of the tender coconut husk samples chipped and kept for sun-drying is shown in Figure (1). It may be seen that these chips can be conveniently dried and packed for marketing for using it as a clean fuel for cooking applications. Key specification of the tender coconut chipper is given in table 1.

Table 6: Technical specification for the tender coconut husk chipper

Sl. No.	Details	Technical specification
1	Material to be chipped	Tender coconut husk with 80% moisture
2	Size of the tender coconut husk chips	4cm* 4cm*2cm
3	Type of chipper	Rotating disc with swinging knives
4	Production rate	100-200kg/hr
5	RPM	3500
6	Prime mover	A/C motor

Sl. No.	Details	Technical specification
7	Input material size	4 inch by 4 inch
8	Feeder	Iron sleeve
9	Output material-chipped	Collectable in bag

Figure 4: Sun-drying of tender coconut husk

9.4 Biomass dryer for Tender Coconut Husk

A biomass stove based drier is developed and fabricated for drying the tender coconut husk. The dryer is currently under modification process based on the initial test run. This dryer will be useful at places that receive monsoon for longer periods, like Kerala. The biomass drier can be used to dry high moisture content tender coconut husk even in cloudy monsoon days. The drier will use a fraction of dried tender coconut husk for drying the wet husk. A sketch of the biomass drier designed and fabricated for drying the tender coconut husk.

9.5 Drying Tender Coconut Husk in sunlight

Tender coconut husk is chipped into pieces for easy and quick drying. The wet husk is chipped instead of dry tender coconut husk to have high productive and improved efficiency of chipping. Aimed chipping rate is 100 to 200 kg of wet tender coconut husk per hour. A drying profile of tender coconut husk by sun-drying for a period of 10 days is given

in Figure (3). A profile having the percentage of moisture removal rate of tender coconut husk by sun-drying for a period of 10 days is given in Figure (4). The data observed is for cumulative weight loss of tender coconut husk is given in Table (2). The data obtained with percentage of moisture reduction of tender coconut husk is given in Table (3) above. Similar tests will be conducted with biomass drier also in combination of drying through sunlight.

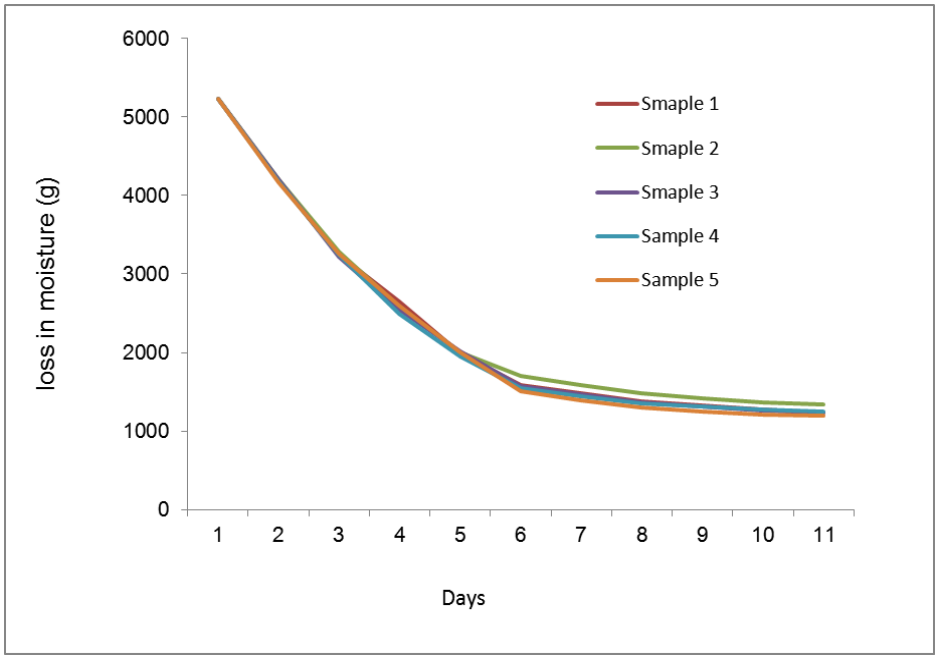


Figure 5: Profile of Cumulative weight loss due to moisture reduction of tender coconut husk by sun drying

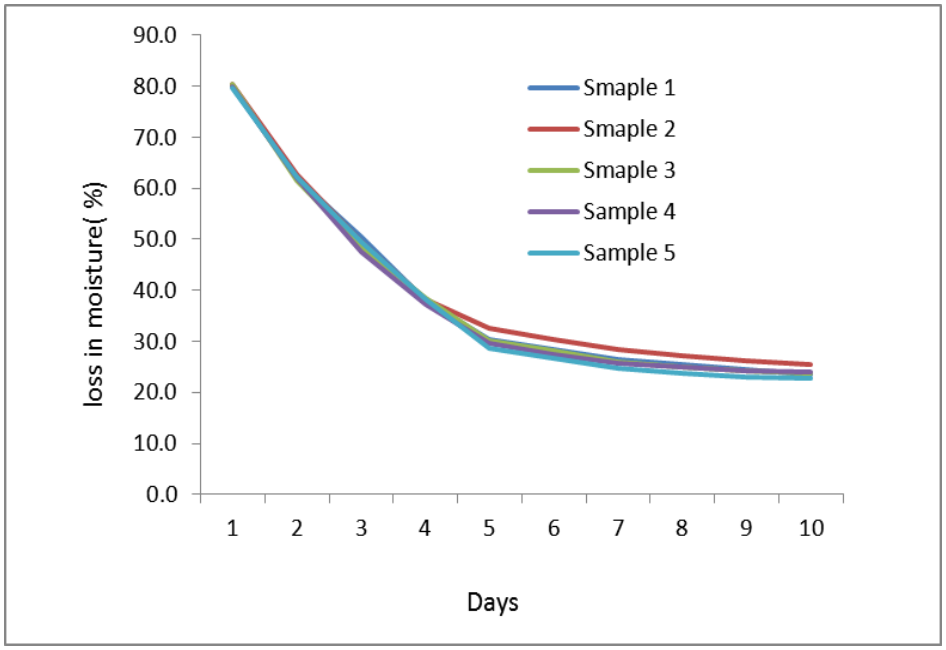


Figure 6: Profile of percentage of moisture reduction of tender coconut husk by sun drying

Table 7: Cumulative weight reduction due to moisture reduction in tender coconut husk by sun-drying

Days	Cumulative weight reduction due to moisture reduction				
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
1	5230	5230	5230	5230	5230
2	4189	4203	4204	4179	4170
3	3247	3282	3217	3250	3258
4	2645	2589	2544	2490	2593
5	1990	2003	2014	1946	2001
6	1586	1700	1576	1545	1504
7	1481	1585	1469	1438	1391
8	1380	1485	1359	1349	1298
9	1326	1417	1311	1309	1246
10	1279	1367	1263	1270	1205
11	1235	1336	1237	1252	1196

Table 8: Percentage of moisture reduction of tender coconut husk by sun-drying

Days	Moisture reduction in percentage				
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
1	80.1	80.3	80.4	79.9	79.7
2	62.1	62.7	61.5	62.1	62.3
3	50.6	49.5	48.6	47.6	49.6
4	38.0	38.3	38.5	37.2	38.3
5	30.3	32.5	30.1	29.5	28.8
6	28.3	30.3	28.1	27.5	26.6
7	26.4	28.4	26.0	25.8	24.8
8	25.3	27.1	25.1	25.0	23.8
9	24.5	26.1	24.1	24.3	23.0
10	23.6	25.5	23.6	23.9	22.9

9.6 Different combination of moisture removal methods

From the results obtained by sun drying the tender coconut husk, it may be noted that sun drying is required for a minimum of 5 days to bring down the moisture level from 80% to 20%. Using the screw press the moisture level can be brought down from 80% to 50%. Due to this advantage of the screw press method, a combination of drying process will be developed to improve the efficiency of tender coconut husk drying. Tender coconut husk

drying combination will be arrived for monsoon and non-monsoon seasons. Drying duration will be estimated to match the combination of drying matrix for tender coconut husk as shown in table 4. It may be noted from table 4. There are three methods of moisture removal will be arrived at the completion of the project. Moisture removal data related with all the three methods will be arrived based on experiments with tender coconut husk.

Table 9: Drying combination matrix adopting different methods according to seasonal requirement.

Sl.No	Weather Scenario	First stage	Second Stage
1	Non-monsoon season	Screw press for removal initial moisture from 80% to 50%	Second phase removal of moisture from 50% to 20% by sun drying
2	Monsoon season	Screw press for removal initial moisture from 80% to 50%	Second phase removal of moisture from 50% to 20% by biomass dryer

As the solar energy is available abundant, the preference is given for sun drying. Drying of tender coconut husk in its available form will be time consuming process. Chipping and screw press will reduce the moisture to a large extent. A minimum portion of the moisture is being removed in the drying phase. During monsoon season the biomass dryer is proposed for drying the pre-processed tender coconut husk.

9.7 Proposed methodology for processing the tender coconut husk as a value added fuel source

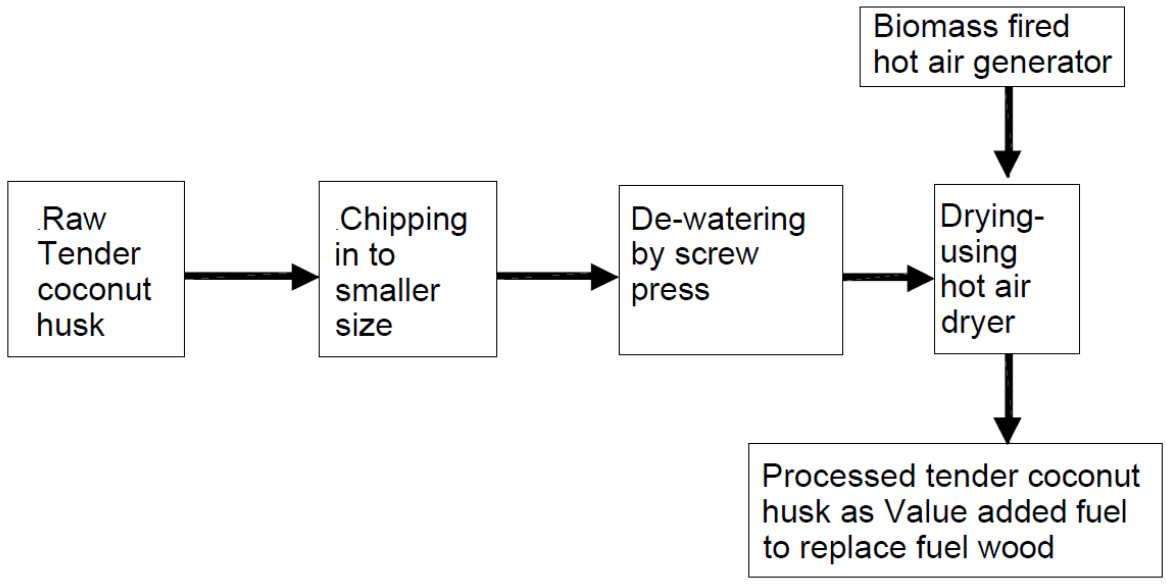


Figure 7: The proposed methodology for processing of tender coconut husk

Table 10: Optimized drying scheme for tender coconut husk

Sl.No	Weather Scenario	First stage	Second Stage
1	Non-monsoon season	Screw press for removal initial moisture from 80% to 40%	Second phase removal of moisture from 50% to 20% by sun drying
2	Monsoon season	Screw press for removal initial moisture from 80% to 40%	Second phase removal of moisture from 50% to 20% by biomass dryer

The project identified a sequence of process for drying coconut husk. The sequence varies as per the season and required production capacity.

10. Business model

Based on discussion with the manufacturers, dealers and users a business model is proposed as a way forward for successful use of the project outcome.

A business model is proposed along with a supply chain network. The business model consists of partners at five layers.

i. Location of the raw material; where the raw tender coconut husk is thrown as waste. This location is the place where the tender coconut is sold or the place where the tender coconut husk is dumped.
ii. Intermediate suppliers; who collect the raw tender coconut husk and supply it to the tender coconut processing center.
iii. Processing center for tender coconut husk to convert it into value added fuel to use in cooking applications.
iv. Intermediate dealers to transport and supply the processed tender coconut husk to the fuel wood selling markets.
v. Fuel wood markets can be used as source for marketing the processed tender coconut husk as they are used for same application and by the same user group.

A flow diagram depicting the proposed business model is presented in Figure.

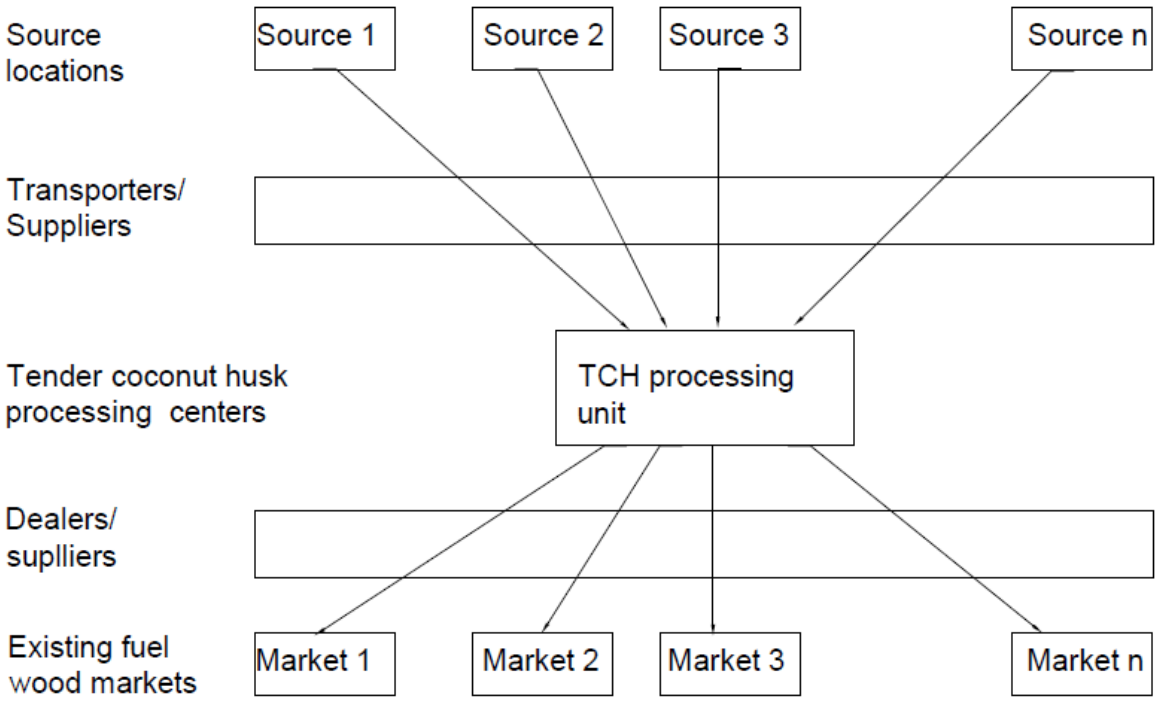


Figure 8: Proposed business model

10.1 Economics

Due to the high moisture content, the tender coconut husk is currently not used and thrown as waste. So for converting the tender coconut husk the following cost will be involved.

i. Collection and transportation cost of unprocessed green tender coconut husk
ii. Processing cost for tender coconut husk which include chipping, dewatering and drying.
iii. Transportation cost to the dealers who sell fuel wood and coconut husk as fuel for cook stove
iv. Marketer's profit for marketing the value added, processed tender coconut husk.

A tender processing unit with a capacity of handling 200 kg/h (The raw and wet coconut husk in the available form) will cost about Rs. 200 000/- as capital investment, for procuring the chipper and dryer. The return on investment, expenditure related to operation and maintenance is considered as Rs. 40,000/- per annum, for economic calculation. A skilled worker is required to operate the equipment for processing the tender coconut husk. Rs. 60,000/- per annum was considered for the operator who process the tender coconut husk. The collection transport cost for the raw tender coconut husk as 45,000 per year. With these entire configuration the total expenditure for processing of tender coconut husk works out to be 1, 45,000/- per year.

The processing plant can operate 6 hr. a day at 200 kg/h for 300 days in a year. The plant can produce about 72 tonne of processed, dried tender coconut husk , which can be used as a value added furl for cooking. Currently the fuel wood, coconut shell etc. are being sold for Rs. 4.50 per kg. Even at the selling rate of Rs. 4.00 per kg of the processed tender coconut husk the industry can be able to generate a gross income of Rs. 2,88,000/- per year. With this income a net profit of 1, 43,000/- can be realized with a single chipper and dryer. When the production capacity is increased the economics will work out even better than the smaller scale. With these numbers, the payback period to recover the capital investment works out to be two years. The profit can be increased by the production capacity of the tender coconut husk processing unit.

As a part of the study to understand the scope for up scaling processing and usage of tender coconut husk, a market survey was conducted. The potential users shown interest for tender coconut processing and usage are categorized in three categories as given bellow.

i. Potential manufacturers to manufacture the equipment related to processing of tender coconut husk.
ii. Potential dealers for marketing of the equipment related to processing of tender coconut husk.
iii. Potential users showing interest for using processed tender coconut husk, as a value added fuel for cooking applications.

The details of the manufacturers, dealers and users shown interest on the project objective are provided in annexure IV.

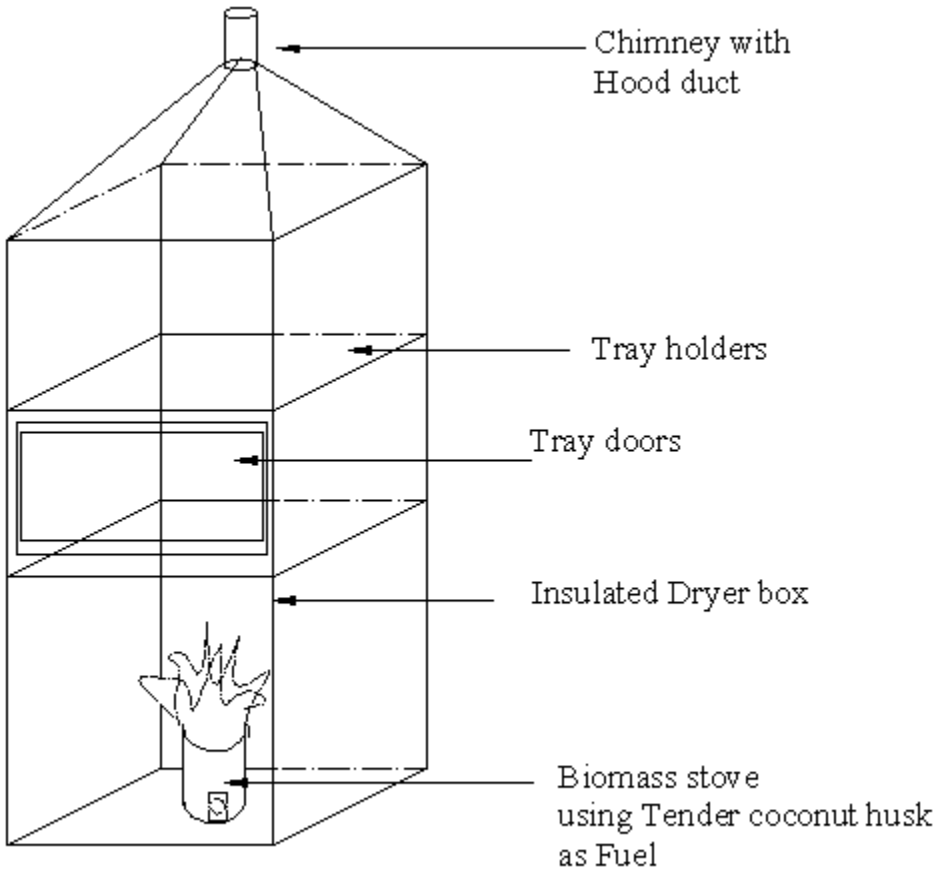
11. Conclusions

The preliminary tests and outcome of the project indicates that the processed fuel from fresh tender coconut is having energy content about 10 times of the raw material before chipping and drying. Processed tender coconut husk is having a heating value of 4300 kcal/kg on dry basis. The calorific value of the processed tender coconut husk is comparable with fuel wood or coconut shell. Tender coconut is chipped into one inch by one inch pieces using a shredder. The screw press designed for de-watering the tender coconut husk works effectively and removes more than 40% of the moisture by mechanical pressure itself. This reduces the energy requirement and duration for drying. Thus the project results are promising and will meet the objective of the project to add value to the tender coconut husk for using in cook stoves as good quality biomass fuel. The processing of tender coconut and marketing can be done either at individual level or at industrial level depending on the financial resources available for capital investment. A suitable business model is proposed in the report. A net profit of about Rs.1.5 lakhs is possible by establishing a small unit for processing of tender coconut husk. The payback period of the investment made on equipment is less than two years. The key finding of the project is tender coconut husk can be converted into value added fuel source which can replace fuel wood, used for cooking applications.

Annexure I

Tender coconut husk drier to be used in non-sunny and rainy days

Concept and components of biomass fired coconut husk drier is shown in the following diagram. The dryer will use part of the dried tender coconut husk itself for drying purpose using specially designed high efficient turbo stove and drying chamber.



A sketch of the coconut husk dryer with components

Figure 9: A view of the tender coconut husk dryer

Features:

- Well insulated high efficient dryer
- Four trays to hold chipped tender coconut husk
- Can dry 100 kg of Coconut husk per batch
- Uses biomass fuel for hot air generation
- Provides clean fuel during rainy season also

Annexure II

The process diagram for value addition to use of "Tender Coconut husk": as clean fuel, is sown in figure 10 below:

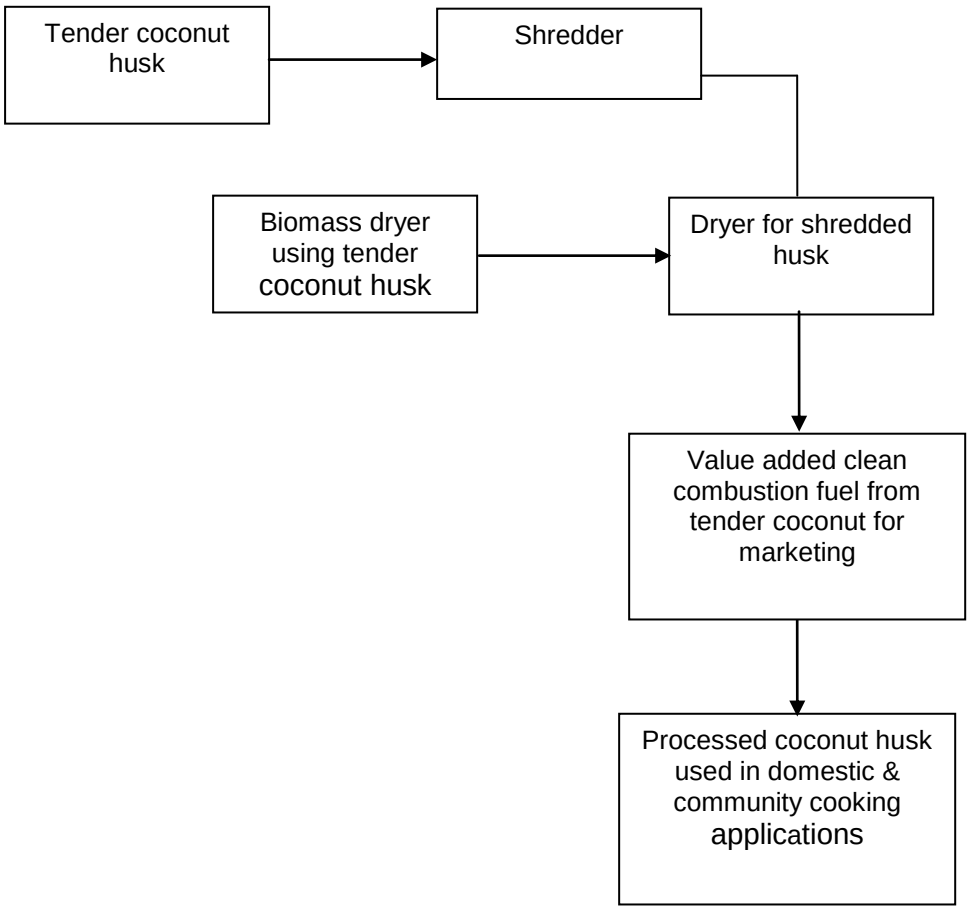


Figure 10: Value addition to use of "Tender Coconut husk": as clean fuel

- **Project schedule**

Activity	Months							
	3	6	9	12	15	18	21	24
Detailed study and analysis of "Tender Coconut husk"								
Procurement of commercially available biomass shredder and modifications to process "Tender Coconut husk"								
Design and fabrication of Biomass dryer for drying "Tender Coconut husk"								
Mid term report								
Test run and fine tuning of shredder (chipper) and dryer								
Proximate and ultimate analysis of processed "Tender Coconut husk"								
Testing the processed fuel in cook stoves								
Detailed data analysis, and optimization								
Final report submission								

Annexure-III
Tender Coconut husk Chipper.

Figure 11: A view of the tender coconut husk chipper

Features:

- Works at 3500 RPM
- Output : 100 to 200kg per hour
- Size of chipped husk: 3cmx3cm
- Can be Operated with single phase motor
- Vibration free mounting frame
- Can be easily transportable for use at multiple locations in a cluster

Annexure IV

A clean combustion high efficiency stove developed to use biomass is being tested for performance with use of processed tender coconut husk. A detailed performance test to assess the efficiency will be carried out by varying size and moisture content.

Figure 12: A view of the turbo stove in use

To convert tender coconut husk in to convenient form of fuel for clean combustion

Annexure V

As a part of the study to understand the scope for up scaling processing and usage of tender coconut husk, a market survey was conducted. The potential users shown interest for tender coconut processing and usage are categorized in three categories as given bellow.

I. Potential manufacturers to manufacture the equipment related to processing of tender coconut husk.
II. Potential dealers for marketing of the equipment related to processing of tender coconut husk.
III. Potential users showing interest for using processed tender coconut husk, as a value added fuel for cooking applications.

The details of the manufacturers, dealers and users shown interest on the project objective are provided below.

Table 11: Potential manufactures want to be involved in processing of Tender coconut husk, as a value added fuel for coking applications.

S.No.	Name	Address	Telephone/ email I.D
1	A K Krishnan	Alampallam village, Kollengode, Palakad, Kerala	9249509646
2	M.Sundram pillai	M.S.Fibre, Gopalapuram Road, Srivilliputhur (Tk)- 626132	9994383122
3	R.Sathuragiri	11,Nadar St	9952243288
4	K K Jamal	Kapalath House, Edakochi	9846431799
5	V Vijayanath	Kalappurakkal House, Azad Road Kaloor, Ernakulam	9895892125 9895711318
6	P. Thiagarajan	M.P Coir Exports, No.5 Dharapuram Road, Udumapet-642126	9865160300 thiyaga08@gmail.com
7	K R Radhakrishnan	Kuchappillil, Panangad, Ernakulam	9544846595
8	Francis Njalian	Illithodu Mmalayattoor, Kalady, Kerala-683587,	9447974654
9	V.A.Murali	Vadakkedath House, Yuvakalatharang Road, Keerthi Nagar, Elamakkara PO, Ernakulam	9895890944 vamurali67@gmail.com
10	Antonyp.Mathur		9446206738

Table 12: Potential dealers for Tender coconut husk chipper and dryer

S.No.	Name	Address	Telephone/ email I.D
1	K.T.R. Glorry	No.4, Mayer Nnandagopal St, Lawspet, Pondichery-8	9042136005
2	Tom Joseph	Malayapuram, Poonthope Ward, Alleppy-688006	0477-2234744
3	K. Saravanakumar	1/82 Periramm Nayar, Nachipallayam Road, Tirpur-641605	9994417770
4	P.S. Bhaskaran	Bhoomika, Puthuvyne Post - 682508	9446503084
5	M. Rajesh	Santhipri Coir, Alappuzha	
6	Paul Mathiew	Thottappilly, Vadayampady, Ernakulam	0484-2760519
7	V. Govindaraju	Keorkodahalli, Dharmapuri, Karimangalam-635111	9976575668
8	Elizabeth Thomas	Kochi House, Kumbalanghi, Opp-Malat Backery, Kochy-682007	9447397058

Table 13: Potential customers to use processed Tender coconut husk as fuel for cook stove

S.No	Name	Address	Telephone/ Email ID
1	P.Nagesh	61,Keelakatturoad, Singam Pural, Tirupattur Tk, Sivagangai Dist 630502	9381030987
2	L.Boopathiraja	Salem	9943438777
3	K.T.R.Glorry	No.4, Mayer Nandagopal St. Lanspet, Pondichery-8	9042136005
4	Dr Deepu.MD	Niketham, Valapad Bech, Trichur Dist 680567 Kerala	9.19447E+11 dr.deepues@gmail.com
5	Antony P. Mathur		9446206738
6	Sunil kv.pandu	Odisha	9040689232 sunilkadua@rediffmail.com
7	T.Nagaraj	c-5ABD,Abd-TNAU-Cbe	9600876767
8	Tom Joseph	Malayapuram, Poonthope Ward, Alleppy-688006	0477-2234744
9	S.Maria Selvaraj	97, Pilavilat, Azhagan Ponai, Pin-682508	9486909706
10	Bhaskaran .p.s	Bhoomika, Puthuvyne Post-682508	9446503084
11	Joseph	Kudisukal House, Koltai Can Road, Cochin-18	9656327924
12	M.Sundram Pillai	M.S.Fibre, Gopalapuram Road, Srivilliputhur (tk)- 626132	9994383122
13	R.Sathuragiri	11,Nadar St	9952243288
14	Pradeep Kumar		9037568055

S.No	Name	Address	Telephone/ Email ID
15	K.Govindarajan	113,Bhrathy St, Suthana Nagar, Pondicherry-605004	8870096016
16	A Skuknu	Pallimuttom Aroor,	9633449329
17	S.Rajarathinam	Vanangamdi Industries, 66 Old Hospital Rd, Arantan	9842434259
18	V.Anavaranthan	S/o Veeramurthy Devar, Pallathevayam, Podukkothai Dist	9965156664
19	Saravanan	Chithamohra Devar, Puthukottai Dist-614616	8883370317
20	Joseph Ottaplackal	35/1310 St Martin Road, Palarivattam, Cochin-682025	
21	T.Devawanam	K.Nagoor, Kanjamatti, Pollachi, Coimbatore	9865639855
22	T.Thangadurai	Coimbatore	9486411628
23	Abraham John	Nedunhall & Malliakel, Convent Road, Noparvtur-683513	9061929929, 0484-2443055
24	V.Govindaraju	Keorkodahalli, Dharmapuri, Karimangalam-635111	9976575668
25	V.S.S.Sunder	182, Kabak Road, Austin Town, BawGal	9845134513
26	A. Shamsudeen	Kokkalae, Payuvassery, Palakkad	9744703610
27	Pinth sarkar	8, Doctor Baganhake, Ashabari Appertment, Serampore, Hooghly-712203	9051341662
28	V.P.Sathiyendranath	Bhaskaranroad, Irimpanam, Kochi-682309	9895144088
29	Amit kumar.k.p	Maveli Nagar, 12, Across Road, Kochi-682022	9447157522
30	K.K. Jamal	Kapalath House, Edakochi	98464317999
31	V.J. Suraj Kurian	Valappan House, K.K. Road, chalakudy-680307	
32	D.Vishnu Prasad	Jaya Nivas, Kutinathode, Alleppey-688533	9446564443
33	E.K.Bhagyanathan	Edakkatu House, P.O. Cherai, Ernakulam Dist, Kerala	9744878765, 4842488765
34	Sunil babu	Anakkallulal, Kurumannu	9442568814
35	Sri selvakumarari	c/o Sethu Ramalingam, Reddiar Madama, Reddiarur (Post), Pollachi (TK), Coimbatore(Dist)-642007	9942608200
36	S.Viswanath	2/251 Kannarapulayan, Coimbatore-638451	9994462334
37	R.Suresh Babu	Rasmi Ambalapara Road, Tejus Nagar, Palachuvadu, Kakkanad, Cochin-682030	9962505913
38	P Prasand	Bodhi 45/1978, pachalam, cochin	9847015041
39	Shaji M.R	Malikottu, Nedungad, Narayananbalam, Ernakulam	9846993193 4842493193
40	ELDO M.P	Elsen consultants & Advertisers , Shop No.77, Valaanchirangara P.O., Perumbavoor-683556	9447988301
41	E.P.Kurikose	Edayanal (h), Kaninadu	9447251721

S.No	Name	Address	Telephone/ Email ID
42	Anil Kumar	Vadakkaveeth, Octanthuuth, Pin 682508	9895280642
43	K J Jose	Koikkaramparambil, Thottakkatu Lane, Panampilly Nagar, Kochi -682036	9288900674
44	K. Lalavan	Greeshma Vikras 49, Kopparambu Lane, Poonithura, Kochi-682338	9495975651
45	National Coir	At/P O Pathanaikia, Dist-Pune	
46	V Vijayanath	Kalappurakkal House, Azad Road Kaloor, Ernakulam	9895892125 9895711318
47	MC Anil Kumar	B-5, Ambas Residency, Chandrahil Road, Edappalley-682024	9447138140
48	K R Radhakrishnan	Kuchappillil, Panangad, Ernakulam	9544846595
49	V.Babu	Narayanan Niwas, Thekkethena, Pnlhajannan	9947427061
50	Francis Njalian	llithodu Malayattoor, Kalady, Kerala-683587	9447974654
51	V.A.MURALI	Vadakkedath House, Yuvakalatharang Road, Keerthi Nagar, Elamakkara PO, Ernakulam	9895890944 vamuali67@gmail.com
52	Satheesh		satheesh@fibredust.india.com
53	B.Saravanan		ba.saravanan@gmail.com

The Biomass Energy Technology Applications (BETA) area of TERI relates to the development and dissemination of biomass gasifiers for thermal and electrical applications. With a history of over 25 years, the Area has taken a lead in promoting biomass gasification and developing of small biomass gasifiers suited for the use in Ovens, kilns and furnaces based on biomass gasifier technologies have been developed for industries such as silk reeling, textile dying, magnesium chloride production, brick drying, and spices drying apart from electricity generation for rural village electrification purposes and for developing countries.

The group also focuses on developing biomass pretreatment processes applicable in a decentralized manner to produce value added materials from the lignocellulosic agricultural residues. The ingenious biomass pretreatment process aimed at processing of lignocellulosic agricultural residues on the site of production to curb the problems associated with the open field burning of it and rural development. The biomaterials production in biorefineries using the materials of biomass pretreatment intended to meet the energy and chemical demands of the country.

The technology developed for treatment of wastes is suitably designed for treatment of organic waste in decentralized manner for recovery of resources. TEAM is ready to be adopted in any part of the world, except for the extremely cold regions. The target areas could be any source of organic waste such as industrial canteens, townships, vegetable markets, small cities, food and fruit processing units, sugar industries, and so on.

Services Offered are:

- *Research and development*
- *Technology and product development*
- *Feasibility studies*
- *Awareness programme, training and capacity building*
- *Implementation of turn-key projects*
- *Policy research and linkages*

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