# Convert biomass to high-value fuel pellets for home use or other small scale industrial applications in an economical and applicable method.

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***The problem:***

Burning the fossil fuels release carbon dioxide ($CO_2$) into the atmosphere and it causes the global temperature rise of $0.6^{\circ C}$ in the last century. The scientists and researchers have worked on alternatives to fossil fuels. Humans have burning biomass since they discovered fire. Burning biomass also release carbon dioxide ($CO_2$) but the difference, however, is that plant takes up carbon dioxide from the atmosphere as they grow. So when the carbon dioxide ($CO_2$) is released by combustion, then the overall effect on climate change is neutral.

Moreover, in most developed petroleum gases cost has surged up every year and it affects the economy of the family or small size industries but statistics show that using wood pellets highly compressed waste sawdust for heating is cheaper and commonly has constant price over the years.

That's why in some countries such as US nonfood crops such as Calendula and echium are growing alongside wheat. Although, some are planted for cosmetic but others will simply be burned.

Over 10 % of biomass is used to generate electricity today. However, biomass is commonly used as a fuel in underdeveloped countries for cooking and heat. Moreover, in the UK and Canada biomass is used to create electricity.

***Statistics:***

According to the charts and tables provided by countries 71.4 billion kilowatt-hours of electricity in 2016 or 2 % of total generation was with biomass. Biomass was mainly agricultural residue, urban wood waste, forest residue, energy crops, and round woods. Biomass for energy especially biofuels has positive attributes that contribute to a healthy environment and economy. Biomass utilization can reduce forest management costs, help mitigate climate change, and help provide a secure and competitive energy source. Here in this project tries to develop a practical method to convert biomass to high-value energy pellets products.

***Product prototype/ work plan:***

The product is biomass fuel pellets produced by the thermal process. The biomass (Forest residue or wood waste) mixes with the agricultural residue to increase calorific value, enhance the combustion character, and reduce the emission contamination of the tar. A Variety of agricultural residue uses for this process depend on residue that exists in the region and applicable market of the fuel. The market may use fuel for power plants, ovens, agriculture, heating of public buildings such as schools, district heating, or boilers. Based on the water content of the raw material drying and pelletizing have different processes consequently; affect the final price of the fuel. Naturally, the pelletizing process needs some moisture in the raw materials. The final product may have different calorific values and applications for various markets. The product determined in this process is suitable for use in the 30 to 500 KW or small scale power plants.

In the biomass fuel industry variety of residue use for mixing with woodchips depend on the fuel that exists in the region such as almond shells, canary grass, potato, beet pulp, straw gain, peanut shells, corn cobs, miscanthus, vine pruning and marc of grape.

***Why the marc of grape?***

The marc of grape generally consists of 20 - 90 % solid components such as skins and kernels. The Utilization of this residue in the agricultural field is different because it has a high risk of putrefaction, odor nuisance, or development of vinegar flies. Moreover, the marc of grape increases the calorific value along with enhances the combustion performance and emission characteristic of green pellets. The emission has less tar, $CO_2$, and nitrogen result in better green environment fuels. The fuel pellets must produce with Europe or American standards. Also, it is possible to mix it with vine pruning to increase the quality of fuel. The marc of grape has a calorific value of 19.8 MJ/kg.

***The fuel cost:***

The fuel cost depends on woodchips and residue that varies in different countries. Based on harvesting, transport (up to 50 km), drying and pelletizing the fuel cost can be 18 -56 €/MW or 0.20 – 0.5 $/kg. Depending on the raw material and pelletizing plants usually, according to fuel standards 11-32% of fuel cost is pelletizing. Therefore, by considering an optimal operation of the plant and regard to the production of mixed raw material pellets is the large cost advantage in comparison with oil or gas (Table 1).

| Fuel | Cost in European countries | Pelletizing cost |
|---|---|---|
| Gas | 80 €/MW | ** |
| oil | 120 €/MW | ** |
| woodchips | 25 €/MW | 16 €/MW |
| Wood pellets | 59 €/MW | 38 €/MW |
| Marc of grape | 58 €/MW | 17 €/MW |

*Reference: Cost report of biomass fuel in European countries supported by the European commission under the EIE program. Kristofel Christa and Wopienka Elisabeth. 2010*

***Fuel properties:***

- Pellets produced in ring die machine with a diameter of 15 to 21 mm.
- Moisture content is around 10 w%.
- The net calorific value is around 21 MJ/kg.
- The fuel can produce by customer requirements and market demand to satisfy the market.

***Why the pelletized fuel:***

The wood pellets have less than 10 w% of moisture and less ash content in comparison with wood chips with 15 - 60 w% moisture content. When wood pellets are burnt because of its thermal production process all the material is burned and converted to heat but the wood chips, some amount of the energy used for evaporation of the moisture and converting it to steam result in inefficient combustion, greater volumes of ash and tarring of the combustion chamber. As described below, moisture has a drastic effect

on the energy yield of biomass materials. The comparison of the wood pellets and woodchips calories values is shown below.

| Biomass fuel | Net calorific value |
|---|---|
| Biomass pellets (EN 14967-2) Moisture content less than 10wt% | 17.65 Gj/Tonne |
| Wood chips (moisture content 25wt %) | 14.30 Gj/Tonne |
| Wood chips (moisture content 60wt %) | 7.40 Gj/Tonne |

*Reference: move2green limited, units 7 and 8, sand industrial Estate. www.move2green.org.uk. Email: info@ move2green.org.uk*

***Differentiation in the process:***

Usually, in the market, the fuel pellets are made by sawdust or residue alone. Sawdust or residue should have less than 10 wt% moisture for the pelletizing process to have a calorific value around 15-20 MJ/kg. But in this process, the sawdust goes under the thermal carbonization process that removes almost all the water content of the sawdust make it more hydrophobic with more energy density along with reducing the mass of the sawdust. Mixing it with marc of grape supplies proper moisture without adding additional moisture. Consequently, the fuel pelletizing process has a better result in homogenous pellets, higher calorific value, better combustion quality, and less ash and tar emissions.

***Definition of the technology:***

The wood scrapes go through some physical and thermal steps to make standard fuel pellets. The half dried skin of grape can use as a marc of grape in the process. The steps of the process categorized as below:

- Step 1. Grinding wood chips to make sawdust.
- Step 2. Thermal process. Torrefaction of the sawdust.
- Step 3. Mixing the torrefied wood and residue (marc of grape) with proper ratio.
- Step 4. Pelletizing the fuel.

***Torrefaction:***

Torrefaction is a pretreatment process that is a soft thermo chemical conversion technology that operates in a slow temperature range between 200 $^{C}$- 300 $^{C}$. The process is carried out under the atmospheric condition in the absence or nearly without oxygen. The torrefied biomass has improved energy density as well as a better grid ability and becomes also, more brittle and hydrophobic. Torrefaction will release the light volatile fraction and most of the oxygen content of biomass such as –OH structures and acetic acids. The sawdust torrefies to $70^{C}$ in the oxygen free environment to remove formaldehyde structure.

***Outcome and cost of the process:***

It is expected by the process to obtain the high-value biomass pellets with the calorific value around 25 GJ/tone that makes the energy consumption of around 30000 kWh for a year much more economical than gas or electricity. Here the cost of the process is estimated with the average fees for the project.
The cost estimation calculated with the assumptions below:

1. Marc of grape will add to wood chips with 20/80 or 30/70 fraction.
2. Woodchips use for the process assumed to be 1 Tonne/day.

3. Electricity price is average industrial 0.57 cent $/KWh.
4. Wood chips' price is average around 50$/day.
5. The rough price of marc of grape is around 350-750 $ per metric tonne depend on sort of grape and seed. Here the average price of 550 $/month considered.
6. The transportation of the raw material, taxes, and shipping cost of the machine in case of necessity not included in the cost calculation.

| **Steps** | **Installation cost** | **Operation and condition (Estimated)** |
|---|---|---|
| Grinding Machine | 800 $ | Power: 7.5 KWh<br>Capacity: 300 kg/hr<br>Operation hour: 3.5 hour<br>Monthly cost: 449 $/month |
| Torrefaction | 1500 $ | Power: 32.7 KWh<br>Capacity: 400-500 kg/hr<br>Operation hour: 2.5 hour<br>Monthly cost: 1397 $/month |
| Mixer | 300 $ | Power: 3 KWh<br>Capacity: 300 kg/hr<br>Operation hour: 4 hour<br>Monthly cost: 205.2 $/month |
| Pelletizing | 2000 $ | Power: 15 KWh<br>Capacity: 200 kg/hr<br>Operation hour: 6.5 hour<br>Monthly cost: 1667 $/month |
| Residue | Transportation up to 50 km | Capacity: 250 kg/day- 7500 kg/month<br>Monthly cost: 4125 $/month |
| Staff | 2 person | 7.25 $ per hour<br>Monthly cost: 3480 $/month |
| Woodchips | 50 $/tonne | Monthly cost: 1500 $/month |
| Packaging | 100 $ | Power: 0.4 KWh<br>Operation hour: 8 hour<br>Monthly cost: 57.72 $/month<br>Each 15 kg bag is around 0.0039 $<br>84 bags / day is necessary: 9.75 $/month<br>Total monthly cost is: 67.47 $/month |

| Estimation of the final product price | Installation cost | Operation cost | Cost per kg | Installation price per kg of the product | Market price of the same product in the USA and Europe |
|---|---|---|---|---|---|
| The product is fuel pellets with sawdust, residue and torrefaction process (thermal carbonization) | 4700 $ | 12890$ /month | 0.34 $/kg | The installation price calculated over the period of<br>1 years = 0.01 $/kg | 350 $/tones or<br>0.38 $/kg |

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