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Understanding coconut as a biomass fuel

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Development of the Modern Coconut Industry

The coconut palm is a year-round crop that yields a highly versatile fruit, wood and other valuable materials. Coconut palm products are many and varied; and the crop is relatively easy to grow, harvest and store. Coconut farming was a key part of early agrarian culture, and continues today on a vast and commercial scale.

The main uses for coconut are culinary, but coconut "coir", or fibre is used to make ropes, brushes and sacks; whilst the fronds are used for brooms and baskets. Husks and shells have traditionally been used for utensils and also have medicinal applications. However, until very recently, the intrinsic value of leftover waste as a fuel or energy source has not been fully developed or exploited, due partly to the complex and varied characteristics of coconut waste.

Today, the Asia-Pacific region is responsible for around 90% of global coconut production. The top 6 coconut producers are (in order of volume): Indonesia, Philippines, India, Brazil, Sri Lanka, Vietnam[1]. Together, these nations account for roughly 50 million tons of annual output. Demand continues to grow for the three main culinary end products – coconut milk or water, coconut oil and desiccated coconut; and the industry outlook is positive. The harvesting and production processes for these products create significant amounts of residue, including husks, fronds, leaves, stems and fibres – all of which can be considered as potential biomass feedstock and are abundantly available. With the right technology these can be used as feedstock to create renewable biomass energy.

Coconut as a Biomass Fuel

As a non-seasonal crop, coconut provides a continuous supply of fruit throughout the year, requiring little to no maintenance. Trees are long lived (up to 100 fruit-bearing years) and are a constant and long lasting source of economically valuable materials. Coconut wastes have a high potential for energy production (see table below) but aside from niche applications for using residues, the wastes are barely used. In SE Asia, some inefficient and polluting small scale processes are used to make a crude charcoal, but the vast majority of waste materials remain unexploited. Traditionally coconut farmers dispose of waste residues by burning or leaving it to rot in the fields, which is damaging for the environment. In SE Asia and Asia Pacific alone, the estimated annual waste is around 25 million tons.

[1] *Food and Agriculture Organization of the United Nations. FAOSTAT 2014*

Fuel Summary

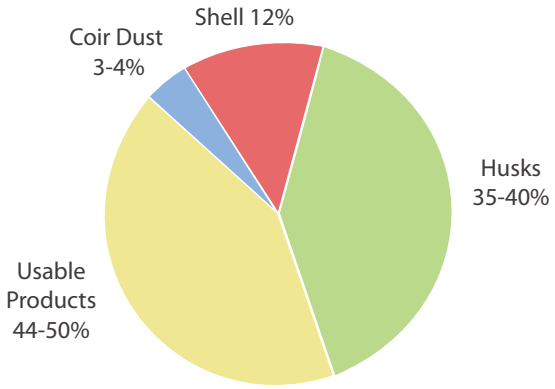
Typical coconut waste averages around 50% of the total coconut production mass.

Coconut husk forms the majority of waste (~35-40%), and consists of the 5 -10 cm of thick stringy fibre layer covering the fruit. It varies in colour depending on the ripeness of the fruit.

The husk is surrounded by ***coir "dust"*** (~3-4%). The husks and dust make up about 40% of the fruit's mass. The shell makes up about 12%.

The coconut palm itself regularly sheds ***fronds***. Typically about 40 fronds, each weighing about 10kg are shed over a 5-6 year period.

Typical Composition of Total Coconut Waste



The varying chemical properties and physical characteristics of each type of waste material pose challenges for effective use, and traditionally these have proved to be too difficult to overcome.

The fuel analysis below illustrates the typical moisture levels and energy values for a calculated 'standard' mix of coconut residues and fronds.

Fuel Composition	Fuel Mixture of Design Fuel (% mass)		Fuel Range (% mass)	
	Mixture Ratio	Moisture Content	Mixture Ratio	Moisture Content of Fuel Mix
Coconut residues (shell, husk, bunch)	65%	50%	50-80%	30-50%
Coconut fronds	35%	35%	0-50%	

Moisture Content and Energy Values

Fuel Composition	Moisture Content (% mass)	Lower Heat Value (MJ/kg)
Coconut residues, as delivered (shell, husk, bunch)	50%	7.63
Coconut frond, as delivered	35-50%	9.69
Mixed fuel, as delivered (35% frond, 65% residue)	44.75%	8.35
Coconut residues, dried (shell, husk, bunch)	-	17.7
Coconut frond, dried	-	16.22
Mixed fuel, dried (35% frond, 65% residue)	-	17.1

The Challenges of Coconut Waste

There are many handling and processing challenges in using coconut wastes as a biomass fuel. Each type of coconut residue (husk, shell, bunch, fronds, leaves and trunk) has different physical and chemical properties. Each will have varying levels of lignin, cellulose, pectin, tar, tannin, potassium to name a few. They will also vary in moisture content. The differing compositions and moisture levels significantly affect the level of equipment corrosion and fouling.

Furthermore, shapes, sizes and densities are not uniform, thereby complicating collection and transportation logistics, as well as the design of an efficient fuel handling and combustion process.

- **High moisture content**
- **Acid corrosion and fouling**
- **Inconsistent shapes, sizes and densities of feedstock**

Variety of coconut wastes

Overcoming the Challenges

Proper feasibility studies and planning

Fortunately, such challenges can be addressed with proper planning, the right level of expertise and advanced technology solutions. Locating plants near harvesting and production points; grid infrastructure and government policy are important factors in feasibility analysis and project economics. Selecting the right technology for cost effective fuel handling and optimal combustion is also crucial for long term equipment reliability and availability of output. DP has unrivalled expertise in conducting an end to end evaluation of biomass logistics, economics and technology options for any power plant proposal.

Fuel expertise and advanced technology

DP has unparalleled experience in 'difficult' or 'complex' fuels, and has successfully demonstrated the ability to handle over 60 fuel types, many exhibiting similar properties to coconut waste. DP has successfully adapted its high performing, specialist technology for the reliable handling and efficient HTHP combustion of such fuels.

The DP Specialist Solution

DP's HTHP combustion is the optimal technology for handling all types of complex biomass waste. DP has developed an innovative, first-of-type HPHT Specialist solution that allows coconut waste of all types, shapes and sizes to be simultaneously handled and effectively exploited for renewable energy – on an economically efficient scale. The highly automated, state-of-the-art power plant in Mahachai, Thailand uses a variety of coconut wastes and has been operating successfully since April 2015.

Fuel	Coconut residues (husk, shell, bunch, frond, leaves, trunk)
Fuel consumption	Design fuel mix: 323t/d (45% moisture) or 167t/d (dry)
Calorific value	8.35 MJ/KG
Power output	9.9MWe (gross)
Steam flow	40t/h
Steam pressure	92 bar
Steam temperature	537 °C
Boiler efficiency	90%
Gross plant efficiency	31%
Availability	>8,000 hours/year