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Coconut shells as an alternative fuel

In this article Dirk Lechtenberg from MVW Lechtenberg & Partner gives an overview of coconut shells as an alternative fuel source. This is an excerpt from MVW Lechtenberg & Partner's Alternative Fuels & Raw Materials Handbook. The second volume of the handbook, to be published at the end of 2012, will provide essential information about more than 40 different types of alternative fuels and raw materials with detailed descriptions of the availability, common use and practice in the cement industry. This includes processing considerations, the influence on the environment, clinker production and the economics of the various alternative fuels.

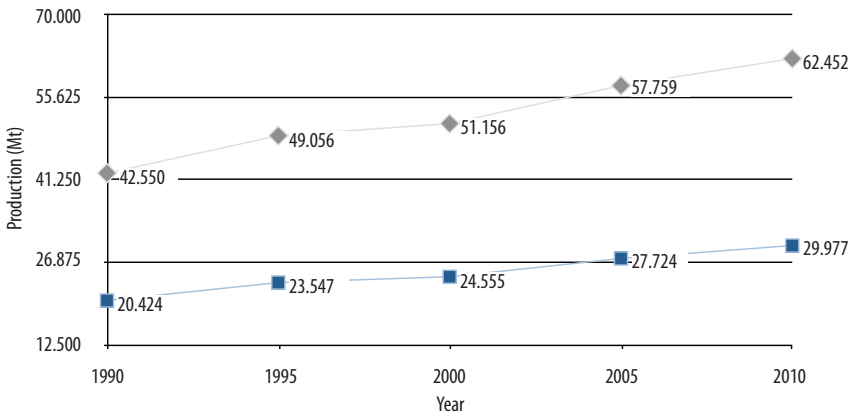
Global coconut production has been growing steadily in recent decades. Figure 1 shows the growth in worldwide coconut production between 1995 and 2010. Table 5 shows that Indonesia is the world leader in coconut production, followed by the Philippines and India (in 2010). Table 1 shows regional variations. Asia is the world's main source of coconuts.

Taking into consideration that approximately 15% of a coconut consists of the shell, the total quantity of coconut shells is around 9.3Mt/yr. With a calorific value of ~5500kCal/kg this quantity can replace ~6.9Mt/yr of coal. It is therefore worth looking at as a potential alternative fuel for the global cement and lime industries.

Right- Table 1: Regional coconut production in Mt/yr.[1]

Year	C. America	S. America	Africa	Asia	Oceania
1995	1.36	1.01	1.92	42.34	1.97
2000	1.29	2.29	1.91	42.90	2.20
2005	1.35	3.49	2.02	48.19	2.09
2010	1.12	3.10	2.06	53.10	2.65

Below- Figure 1: Global coconut production (grey) and potential alternative fuel sourced from coconut production (blue), including ***all*** calorific content.[1,2]



Additionally, coconuts are a permanent crop and available throughout the whole year. There is therefore a constant, year-round supply.

Once coconuts are harvested, the main products are separated and processed; these are the coconut fibres (coir), the milk and the meat. Usually everything except the shell is used. These are often just thrown away.

Coconut shells

Around 15% of a de-husked coconut by weight is the shell. Coconut shells are used, for example, in southern India and Sri Lanka without pretreatment as fuel in villages and by local industries like laundries, bakeries and iron foundries. Coconut shells are one of the raw materials for charcoal production. Shell charcoal is manufactured with burning shells of wholly ripe nuts in a limited-oxygen atmosphere, which is suitable only for carbonisation and not suitable for complete destruction. Activated carbon is also manufactured from coconut shells. It is advised, to use only the coconut shells as fuel, as the other components can be recycled and reused.

Large quantities of coconut shells are especially easy to collect in places where coconut meat is used traditionally in food processing. They can be collected in big bags or containers or directly in covered and wind-protected areas at the production site. Transportation is commonly performed by truck.

In cases were coconut fibres are not recycled or used for other products, they can be used as alternative fuels as well. If this is the intention, they must be protected from moisture as they are strongly hygroscopic and readily absorb moisture. Therefore, before transport, the

Compound	kg	kCal/kg	kCal	% of total energy
Coconut oil	0.12	9000	1080	27.7
Carbohydrates and proteins	0.06	4000	225	5.7
Shell	0.18	5500	990	25.4
Husk	0.40	4000	1600	41.1
Total	0.76		3895	99.9

Above - Table 2: Typical energy characteristics of dry coconuts.[2]

Compound	%
Cellulose	33.61
Lignin	36.51
Pentosans	29.27
Ash	0.61

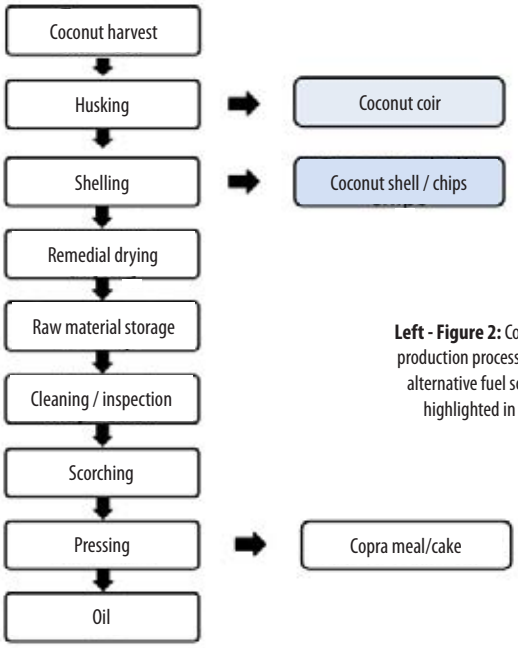
Left - Table 3: Composition of coconut shell (dry matter) by percentage.[3]

Compound	%
K_2O	45.01
Na_2O	15.42
CaO	6.26
MgO	1.32
$Fe_2O_3 + Al_2O_3$	1.39
P_2O_5	4.64
SO_3	5.75
SiO_2	4.64

Right - Table 4: Composition of coconut shell ash by percentage.[3]

Below - Table 5: Worldwide production of coconuts and estimates of coconut shell arisings (based on 15% coconut mass) in 2010.[1]

Country	Coconut (Mt)	Shells (Mt)
Indonesia	20.66	3.10
Philippines	15.54	2.33
India	10.82	1.62
Brazil	2.71	0.41
Sri Lanka	2.24	0.34
Thailand	1.30	0.19
Vietnam	1.18	0.18
Mexico	0.98	0.15
Papua New Guinea	0.90	0.14
Tanzania	0.59	0.09



Left - Figure 2: Coconut production process, with alternative fuel sources highlighted in blue.[4]

Summary

With the use of coconut shells as alternative (and locally-available) 'agrifuel' in the global cement and lime industries, the industry can develop a local and environmentally-friendly fuel source. By developing a supply chain from the small plantations to the cement plant, new jobs and additional income can be generated by local farmers. The use of fossil fuels with its negative impact on CO_2 emissions can be reduced and significant fuel costs savings can be made.

loading area should be covered to avoid loss of material by wind and to avoid becoming wet during rainfall. The dry bulk density of coconut shells is around 404kg/m^3 to 435kg/m^3.

It should be noted that copra expeller and coconut husk are classified under the HAZMAT flammable solids class 4.2 and therefore special attention should be paid during storage and transportation due to their combustible nature. Smoking and/or open flames should be prohibited throughout the loading and discharge processes and when accessing stores.

Once delivered to the cement plant, coconut shells can be used either by direct feeding to the calciner or processed into finer grain sizes (of less than 10mm) for pneumatic feeding to the kiln burner.

Coconut shells are 100% biomass, meaning that they afford a literally 100% renewable energy source. Once combusted, the CO_2 released is considered as neutral with regard to greenhouse gas emissions. However, for the implementation of CDM projects, the complete supply chain, i.e CO_2 emissions during coconut collection, baling, transportation, processing etc. has to be taken into consideration.

Below: Coconut shells being stored with whole tyres (another alternative fuel) at the Lafarge Batangas plant in the Philippines.

References

1. Food and Agriculture Organization of the United Nations (FAOSTAT) website, www.faostat.fao.org.

2. Banzon, J.A. *'The coconut as a renewable energy source.' Philippine Journal of Coconut Studies,* June 1980.

3. Amu, O.O.; Owokade, O. S.; Shitan, O.I., '*Potentials of coconut shell and husk ash on the geotechnical properties of lateritic soil for road works.' International Journal of Engineering and Technology,* Vol.3/No. 2, 2011, pp. 87 – 94.

4. *'ILO: Small-scale oil extraction from groundnuts and copra.' Technology and Employment Branch;* UNIDO, Geneva (Switzerland), Vienna (Austria), 1983.