United Nations Development Programme

BIOMASS ENERGY FOR CEMENT PRODUCTION: OPPORTUNITIES IN ETHIOPIA

UNEP RISØ CENTRE ENERGY, CLIMATE AND SUSTAINABLE DEVELOPMENT

CDM Capacity Development
in Eastern and Southern Africa

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FOREWORD

Biomass and biomass residues, if sourced in an environmentally and socially sustainable fashion, represent a vast – and largely untapped – renewable energy source for the countries of sub-Saharan Africa. This guide, jointly developed by UNDP and UNEP Risoe Centre, seeks to outline the potential, taking the Ethiopian cement sector as a specific example of how biomass energy might be deployed in practice. Many of the issues covered, such as the need for biomass pre-treatment and densification, the problems of biomass availability in space and time, and the importance of appropriate on-site storage and handling facilities, are equally applicable to other countries of the region and, indeed, other manufacturing sectors.

It is hoped that the guide will assist policy makers, industrial operators and the technical community to engage with the opportunities and challenges presented by the use of biomass energy, particularly in the context of the financing opportunities provided by the Clean Development Mechanism.

The guide is based on three studies conducted by acknowledged Ethiopian experts: Yisehak Seboka, Ethiopian Ministry of Mines & Energy; Mulugeta Adamu Getahun, energy consultant; and Yared Haile-Meskel, industrial consultant. The views expressed by the authors are those of the authors alone.

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CHAPTER ONE

SOURCING & TREATMENT OF BIOMASS FOR ENERGY APPLICATIONS IN THE CEMENT INDUSTRY

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1. BACKGROUND

Agricultural and agro-industrial residues constitute 15% of the total energy consumed in Ethiopia. Residues are mostly used in the domestic sector for cooking and baking, using very low efficiency devices. Residue supply is seasonal and residue use as fuel is also seasonal.

In different parts of the country, various types of crops are cultivated and, as a result, a considerable volume of crop residues is also produced. Generally, for use as fuel, crops with a higher residue-to-seed ratio provide the largest volume of potential biomass. However, it is often not desirable, socially and environmentally acceptable or, indeed, economically viable to divert all types of biomass residue for fuel.

Agricultural residues have different uses. Residues from wheat and maize, for example, may be left on the ground or burned in the field to recycle soil nutrients; some parts are used as animal feed, as building materials and as cooking fuel. The fraction that is available for fuel, either for direct use or further processing, is therefore limited and varies from crop to crop.

In the small (subsistence) scale farming context, residues are generally better used for ecological, agricultural or construction purposes than for fuel. However, in large commercial farms and in agro-industries a large proportion of the residue available cannot be used on-site due to limited demand in the immediate vicinity. As a consequence, residue tends to be disposed of wastefully.

Crop and agro-industrial residues have low bulk and energy density, and for these reasons cannot be transported far from production sites without some form of processing. Residues from large commercial farms and agro-industries can be converted to relatively high-quality and high-energy density fuels for use in the domestic, commercial and industrial sectors through a number of physical, biological and thermo-chemical conversion processes.

Cement factories can potentially use alternative fuels, including biomass and biomass residues, to heat their kilns. The substitution of fossil fuel by biomass and biomass residues qualifies, in principle, for CDM carbon crediting. Biomass can substitute for approximately 20% of process heat requirements without the need for major capital investment.

Throughout this Guide, reference will be made to Mugher Cement plant as an indicative example of the opportunities and challenges Ethiopian cement operators can expect to encounter should they decide to utilize biomass energy in their operations. Mugher Cement plant is a large, state-owned cement factory located 105 km west of Addis Ababa. Currently, the plant produces 900,000 tonnes of cement per year - Ordinary Portland Cement (OPC) and Portland Pozzolana Cement (PPC) – and plans are being implemented to expand its capacity to 2.3 million tonnes/year.

The production process of cement clinker is energy-intensive and requires a large amount of fuel. Table 1 shows the increase in fuel consumption experienced by Mugher Cement plant over time.

Table 1. Furnace Oil Consumption by Mugher Cement Plant, 1999-2000 (Taddele, 2008)

Year	Fuel Consumed (litres)	Fuel (Birr)
1999	57,614,478	88,645.635
2000	57,673,490	97,095.467
2001	58,303,321	123,116.129
2002	59,080,215	129,527.180
2003	61,080,215	134,291.435

2. OBJECTIVES

- To replace 20% of Heavy Fuel Oil (HFO) or other fossil fuel with agro-industrial wastes such as coffee husks, cotton stalks, saw dust, castor husks or chat stem. This will significantly reduce the fossil fuel usage required to produce cement.
- To introduce alternative fuels into the cement-making process without compromising the clinker quality or quantity.
- To reduce the amount of imported fossil fuel used for cement production.
- To achieve greenhouse gas emission reductions through partial substitution of fossil fuels with alternative fuels in cement manufacture.

3. SOURCES OF BIOMASS/BIOMASS RESIDUES TO BE USED AS AN ENERGY SOURCE IN THE ETHIOPIAN CEMENT INDUSTRY

3.1. COFFEE HUSK

Coffee is a major commodity export-earner for Ethiopia, accounting for 61% (by value) of the country’s annual commodity exports. It is estimated that the total area covered by coffee is approximately 400,000 hectares, with a total production of 200,000 tonnes of clean coffee per year (Gemechu, 2009).

3.11 COFFEE PROCESSING

There are essentially two ways of processing coffee beans from the freshly picked red cherries of the coffee plant: wet and dry processing. Each process produces a different quality of “green coffee” and residues with very different characteristics.

3.1.2 SUN-DRIED (UNWASHED) COFFEE RESIDUES

In the dry process, the red cherries, which initially contain approximately 65% moisture content, are sun-dried until they reach approximately 10-12% moisture content. After the cherries are dry, they are put through a dry mechanical pulping (or decorticating) process in which the green coffee bean is separated from the outer residue material (skin and husk) of the cherry. The dry process removes the upper hard cover (the husk) and the inner skin (parchment) in the milling process. This residue material is generally blown out of the rear of the processing plant, where it accumulates during the processing season and eventually composts due to ingress of moisture. Heat generated during the composting of this waste occasionally spontaneously ignites the dry layers of recently added materials, commonly resulting in slowly smouldering heaps next to the processing plants.

A mass of 100 kg of red cherries picked at 65% moisture content will result in approximately 40 kg of sun-dried coffee cherries delivered to the processing plant. Of this mass, about 17 kg will become sun-dried coffee beans while the remaining 23 kg will end up as residue at the processing plant.

3.1.3 WASHED COFFEE RESIDUES

In the wet (washed coffee processing) process the fresh cherries are milled using wet pulping machines to remove the outer skin and some of the mucilage. The processed cherry is then left to ferment in tanks for a specified period of time and the removal of the remaining mucilage is effected while the parchment is left intact.

As a result of the washed processing method, two distinct types of residue are generated. The first is the wet coffee pulp, which consists of the epicarp that is removed at the washing plants in the coffee growing regions. For 100 kg of ripe cherries delivered to a washing plant, 60% by mass ends up as washed coffee pulp with the remaining 40% consisting of the green bean and endocarp (parchment). Of this 60% washed coffee pulp, only 20 kg remains after sun-drying of the bean and parchment. This is then shipped to the washed coffee processing facility in Addis Ababa where the parchment is removed. The result is 16 kg of washed coffee beans ready for export and 4 kg of parchment as residues.

The average residue production per tonne of wet red cherry is about 600 kg or, based on green coffee bean production, the residue potential would be 1.4 times the mass of green beans produced (ESMAP, 1986).

3.1.4 RESIDUE AVAILABILITY

Most of the coffee production areas and processing plants in Ethiopia are found in the southern and eastern parts of the country, notably in the Southern Nations, Nationalities and People’s Region (SNNPR) and in Oromia, which each host more than 500 coffee processing plants.

In the case of dry processing of coffee, all residues are effectively available at the processing plant; in wet processing, about 14% of the residue (the parchment) is available at about 10 central processing stations (Addis Ababa). Currently, 84% of the coffee arriving at the central auction stations in Addis Ababa and Dire Dawa are dry-processed. Wet processing results in a better quality of coffee products, however, and its share of the market is growing.

3.1.5 POTENTIAL OF COFFEE RESIDUES: COFFEE PULPING AND HULLING PLANTS

These are concentrated in the major towns of the coffee growing areas of the country. In the Dilla area, for example, there are more than a hundred such establishments. Residue pulp is mostly dumped in streams, although a small amount of it is sold as fuel or for 'tea' making in rural areas.

With increasing participation of the private sector both in production and export, the production of coffee and coffee arrivals at coffee processing stations has increased over recent years. The total volume of coffee supply to the official market is estimated to be about 160,000 tonnes per year. However, it is estimated that a considerable amount of coffee is also traded illegally and total coffee production could be as high as 250,000 tonnes per year. Considering the lower production figure, the corresponding annual coffee residue production would be at least 200,000 tonnes.

Currently, the wet pulp is discharged into local streams and rivers where it tends to clog, forming a putrescent mass and producing a highly acidic effluent which pollutes the water, destroying aquatic life and generating an offensive odour. Recovery of this pulp for industrial fuel use would require collecting the residues as they are discharged from the pulping machine and processing them to greatly reduce the moisture content.

Husks represent over 90% of the coffee residues produced. However, the extremely low bulk density (approximately 50-80 kg/m^3) of the husks produced precludes their economic transport to cement factories 300-500 km distant. Densifying or pelleting this material to a density of 500-600 kg/m^3 would greatly reduce transport, handling and storage costs and facilitate its use as industrial fuel.