The Potential for Gasification of Coffee Stems to Provide Bioenergy for the Coffee Sector

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Abstract

The coffee industry represents an important part of the global economy, particularly for developing country producers. Here, the industry provides foreign exchange earnings and livelihood to around 25 million smallholder farmers growing almost 80% of global coffee production. The scale of this industry poses a challenge with the utilization or disposal of the residues generated along the coffee cultivation-processing chain. Coffee stems, obtained after coffee tree pruning, are one of those abundant and untapped resources in the coffee supply chain. Their lignocellulosic content and gross calorific value of 19.7 MJ/kg make them a suitable solid fuel for thermochemical conversion processes. Using a process modelling approach and the Colombian coffee sector as a case study, this research evaluates the feasibility of using these residues in small-scale downdraft gasifiers coupled to internal combustion engines (ICE) for power generation and recovery of low-grade heat. The producer gas heating value of 5.6 MJ/Nm^3 and the gasifier's performance characteristics (e.g. cold-gas efficiency of 71%) show that this gas could be utilised in ICE devices for power generation. The overall system efficiency of 45.6% also indicates that the deployment of these systems could be attainable, particularly if low-grade heat is recovered for the coffee grain drying in the Colombian coffee sector. An analysis of the energy demand and coffee stems availability within the sector shows that medium-to-large scale coffee farms (with average coffee productions of 25 t/year and cultivated lands above 5 ha) offer particularly attractive opportunities to deploy this bioenergy system. The biomass production level in these farms is well matched to their energy demands from the coffee-processing chain and household applications. Overall, this work adds to the existing knowledge base by assessing the feasibility of providing coffee stems-sourced low carbon energy for global coffee production at relevant operating scales.

Keywords: *Coffee stems; Gasification; Process modelling; Biomass resource availability; Power generation; Low-grade heat recovery; Coffee drying*