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A comprehensive review on biomass cookstoves and a systematic approach for modern cookstove design

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ABSTRACT

Improved biomass cookstoves has been a topic of research for more than 40 years, but still 2.6 billion people cook over an open biomass fire. A large volume of information on the biomass cookstoves though widely scattered, is available in the literature. This paper gives a comprehensive review of the available literature on biomass cookstoves. The review covers a detailed discussion on various aspects of biomass cookstoves: historic overview, performance characteristics, cooking accessories, testing protocols, barriers to dissemination and adoption, and future pathways. In addition, comparison of energy and emissions performance for different biomass cookstoves is given. Data is obtained from reliable sources, arranged logically, plotted carefully, and analyzed to draw some interesting conclusions. Learning from the review and comparison made, is used to propose a novel "Systematic Approach for Modern Cookstove Design".

Contents

Abbreviations: TSF, three stone fire; ICS, improved cookstove; IAP, indoor air pollution; CO, carbon monoxide; PM, particulate matter; ARC, Aprovecho Research Center; NPIC, Indian National Programme on Improved Chulhas; NISP, Chinese National Improved Stove Programme; MNRE, Ministry of New and Renewable Energy; EPA, Environmental Protection Agency; CDM, clean development mechanism; NBCI, National Biomass Cook stove Initiative; ABS, advanced biomass stove; VITA, Volunteers in Technical Assistance; TLUD, top lift updraft stove; TEG, thermo-electric generator; WBT, water boiling test; CWBT, comparative water boiling test; CCT, controlled cooking test; HTP, heterogeneous testing protocol; KPT, kitchen performance test; SUMs, stove use monitors; UFT, uncontrolled field test; UCT, uncontrolled cooking test; BCT, burning cycle test; CDT, cookstove durability testing; CFD, computational fluid dynamics; NGOs, non-governmental organizations; ISO, International Standards Organization; IWA, International Workshop Agreement; TOP, tiers of performance

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1. Introduction

In the era of spacecrafts, computers, and electronic gadgets, about 2.6 billion people do not have access to clean cooking facilities; and if predictions are believed the approximately same number will still be so in 2030 [1]. About 1.6 million people die prematurely per year; from indoor air pollution, resulting from solid-fuel cooking; causing more than 2% of the whole world diseases (4% in the poorest nations) [2]. Cooking with solid biofuels also has a significant global impact on, greenhouse gas and black carbon emissions, accounting for 1–3% of all human generated global warming [3]. Venkataraman et al. concludes that, the solid biofuel combustion is the dominant source of global black carbon emissions, with as much as 42% of total black carbon emissions in India [4]. The heavy dependence on biomass resources and their inefficient utilization can be a significant source of deforestation and resulting climate change, as observed in studies conducted independently, in six Tanzanian cities [5] and three urban regions of Ethiopia [6].

As a solution to these global problems, energy and emission efficient ICSs can reduce: diseases, by decreasing indoor air pollution (IAP); time and cost of obtaining fuel; risk of violence against women and children gathering fuel in conflict areas; consequent climate change and deforestation. Hence, in the "Biomass Cookstoves Technical Meeting" held on January 2011, the expert team on cookstove technologies set new benchmarks for ICS: "at least 90% emissions reductions and 50% fuel savings over baseline technology (three-stone fire)" [7].

Currently more than 160 cook stove programmes are running in the world, across different nations [8]. Since 1970s, the laboratory, the field, and the policy aspects of biomass cookstoves have been studied under ICS projects by many renowned researchers like Samuel Baldwin [9], Barnes, Smith [10,11], Prasad [12], and Bryden [13]. Numerous studies conducted by such researchers, helped build a database regarding various issues related to cookstoves such as design, development, testing, materials, dissemination and field performance. Unfortunately, much of the literature is widely spread, and it is hard to get a good outline of the subject. This review paper is an effort to address the need for concise and simplified discourse; on scientific knowledge related to biomass cookstoves.