

Chapter 60

Sustainability, Business Models, and Techno–Economic Analysis of Biomass Pyrolysis Technologies

Manuel Garcia-Peréz

Washington State University, USA

Jesus Alberto Garcia-Nunez

Washington State University, USA & Colombian Oil Palm Research Centre, Colombia

Manuel Raul Pelaez-Samaniego

Washington State University, USA & Universidad de Cuenca, Ecuador

Chad Eugene Kruger

Washington State University, USA

Mark Raymond Fuchs

Washington State Department of Ecology, USA

Gloria Eileen Flora

U.S. Biochar Initiative, USA

ABSTRACT

The objective of this chapter is to review and discuss sustainability and techno-economic criteria to integrate pyrolysis, biochar activation, and bio-oil refining into sustainable business models. Several business models such as the production of biochar with heat recovery and bio-oil refining are discussed. Cost data needed by engineering practitioners to conduct enterprise-level financial analyses of different biomass pyrolysis economy models are presented. This chapter also reviews life cycle assessments of pyrolysis business models. If the feedstock used is produced sustainably and if the pyrolysis vapors are used for bio-oil or heat production, both, the production of biochar through slow pyrolysis and its use as a soil amendment to sequester carbon, and the production and refining of fast pyrolysis oils to produce transportation fuels could have a positive environmental impact.

DOI: 10.4018/978-1-5225-9615-8.ch060

INTRODUCTION

In 2002, in a speech at the Jorburg Summit, Kofi Annan pointed out the existence of two extreme schools of thought about economic development and the environment (Annan, 2002). The first school considers that it is not possible for any economic growth because of its effect on the environment. The second proclaims that economic growth at all cost is socially acceptable. Under these extreme schools of thought it will be difficult to spread the prosperous life style enjoyed by nearly one fifth of the population especially considering rapid population growth, high standards of living, and resource consumption rates. Current world population consumes more resources than the world can sustainably produce by 20% (World Fund for Nature, WFN). Regardless of environmental destruction, economic growth cannot be reduced dramatically because even greater damages that could be inflicted by market forces (AtKisson, 2001). Dr. Annan recommended to look beyond these two paradigms and to find ways to live in harmony with the environment. Annan calls for finding synergisms between economic growth and environmental protection rather than allowing social degradation by inhibiting economic growth or enduring the consequences industrial growth inflicts on the environment (Annan, 2002).

Attaining a more sustainable future increasingly includes the development and expansion of biomass-based fuels, chemicals and materials. Anex et al. (2007) underscored this when they stated:

Whether this is a positive impact or a negative impact will depend largely on how biomass feedstocks are produced and converted, and the extent to which these two activities are integrated. As in any managed ecosystem, nutrient management in industrial biomass ... must address multiple criteria, including air and water quality, nutrient use efficiency, and ... economics.

Biomass pyrolysis is one of the thermochemical conversion technologies currently studied for the production of fuel and chemicals from lignocellulosic materials, which is carried out in the absence of air/oxygen at temperatures between 350 and 600 °C. This process can be controlled to maximize either the production of charcoal or liquid products. “Fast pyrolysis” is optimized to produce liquid products (bio-oil). This is achieved by processing biomass with particle sizes < 2 mm at temperatures ~ 500 °C and with carrier gas flows reducing pyrolysis vapors residence time inside the reactor to < 2 seconds. The most common fast pyrolysis reactors are: bubbling fluidized bed, circulating bed and ablative reactors. Conversely, “slow pyrolysis” or “carbonization” maximizes the production of biochars. The biomass is processed in chip form.

This chapter focuses on biomass pyrolysis technologies, prospective business models to maximize growth and key financial considerations for sustainable recovery of energy, carbon, nutrients, and products from lignocellulosic and organic wastes.

A SUSTAINABLE BIOMASS ECONOMY

Laird (2008) argued that given that the half-life of carbon (C) in soil charcoal is more than 1000 years, the application of this material will have a lasting contribution to soil quality and to the removal of C from the atmosphere. The authors concluded that given that the United States can annually produce 1.1×10^9 Mg of biomass, the implementation of a pyrolysis based economy could displace 1.91 billion barrels of fossil oil every year (or about 25% of current US annual consumption) and could lead to the permanent

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