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Biomass conversion to energy in India—A critique

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ABSTRACT

This paper critically discusses the scope, potential and implementation of biomass conversion to energy in Indian scenario. The feasibility as well as suitability of the various categories of biomass to energy in India has been discussed. Brief descriptions of potential conversion routes have been included, with their possible and existing scope of implementation in Indian context. As far as possible, the most recent statistical data have been reported from the available sources. The figures reported have been updated as on March 2009, in most of the cases. The discussion reveals that a large potential exists for the biomass feed-stocks from the various kinds of waste biomass. The gasification as well as anaerobic digestion processes seem to be most attractive in Indian scenario.

Contents

1. Introduction

India is a fast developing country which is achieving constant upward industrial growth in past few decades. Likewise, its commercial energy consumption is also growing with the same pace of high economic growth and industrial development. The major sources which meet the energy requirement of India are coal and oil. The primary energy consumption during 2008 are reported

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to be: coal—53.4%; oil—31.2%; natural gas—8.6%; hydroelectricity—6.0%; and nuclear energy—0.8% [1]. The domestic sector consumption of energy is basically coal and kerosene. The use of these fuels is not only problematic due to emission of green house gases; these are also fast depleting sources of energy. Secondly India is dependent on the imports for oil requirements. In 2004–05, 72% of India's total oil consumption was dependent on the imports [2]. This figure reached to 76.5% during 2006–07, 78% for 2007–08, and the tentative figure for 2008–09 is 79.3% [3]. These imports are increasing year after year with the growing economy of the country and contribute in continuous increase of the import bills. In view of this, it is rather imperative on the part of researchers and energy planners, to search for alternate and renewable sources of the energy.

The major renewable sources of energy available freely are solar energy, wind energy, small hydropower, biomass, biogas, and energy recovery from municipal and industrial wastes. India is a country which is very rich in natural resources. Many of these resources have a great potential for exploitation in India. Renewable sources have advantage of complete perpetuity; easy local availability without any need for major transport, thus less green house gases release in environment; modularity, i.e. economy is independent of scale; and non-polluting in nature. The first ever attempt to exploit renewable energy in India dates back to 1897 when a small hydropower project of 130 kW capacities was implemented at Sidrapong in Darjeeling [4–6]. This was followed by two more hydro projects of 40 and 50 kW capacities respectively, each installed at Chamba (1902) and Jubaal (1911).

In the past decade there has been renewed interest in the biomass as a renewable energy source worldwide. The major reasons for this are as follows. First of all technological developments relating to the conversion, crop production, etc. promise the application of biomass at lower cost and with higher conversion efficiency than was possible previously. For example when low cost biomass residues are used for fuels, the cost of electricity is often competitive with fossil fuel-based power generation [7]. More advanced options to produce electricity are looking promising and allow a cost-effective use of energy crops e.g. production of methanol and hydrogen by means of gasification processes. In Western Europe and in the US, the second main stimulus is food surpluses producing agricultural sector. This situation has led to a policy in which land is set aside in order to reduce surpluses. In these regions, a number of factors associated with surplus land, such as the de-population of rural areas and payment of significant subsidies to keep land fallow, have provided sufficient driving force to the introduction of alternative, non-food crops desirable. The constantly rising demand for energy will provide an almost infinite market for energy crops grown on this potentially surplus land. Thirdly, the potential threat posed by climate change, due to high emission levels of greenhouse gases, the most important being CO_2, has become a major stimulus for renewable energy sources in general. When produced by sustainable means, biomass emits roughly the same amount of carbon during conversion as is taken up during plant growth. The use of biomass therefore does not contribute to a build up of CO_2 in the atmosphere.

The present paper presents a critical appraisal of the potential and scope of the bio energy production and implementation in Indian scenario. Here we have attempted to analyze the present day situation in the light of available facts and figures in the open literature. A brief description of the processes for conversion of identified biomass feedstock to energy and fuels has also been included. As far as possible, biomass availability and usage statistics has been updated to the latest figures available till date.

2. Feasibility of biomass energy conversion

In spite of many ostensible benefits, the feasibility of the biomass energy conversion especially in terms of GHG emissions is still debatable [8–10]. Avis [8] has classified the bio-energy resources into two main categories. One is agro-fuels and other bio-fuels. Bio-fuels are biomass-derived fuels designed to replace petroleum and used mainly in the transport sector. Although the words "bio-fuel" and "agro-fuel" are often used interchangeably, he emphasises to differentiate the two in order to have better assessments of their impact on the environment as well as economic analysis. An agro-fuel, is a type of bio-fuel, consisting of crops and/or trees grown on a large scale (i.e. monoculture). Examples include fuel crops such as maize, corn, oil palm, soya, sugar cane, sugar beet, oilseed rape, canola, jatropha, rice and wheat. Bio-fuels derived from waste, such as biogas from manure or landfill, or waste vegetable oil are not agro-fuels. Ethanol and bio-diesel are probably the most well known forms of agro-fuels for gasoline and diesel substitution respectively. They have been used for many years in several parts of the world.

According to this perspective, the pure plant oil, which is a bio-fuel, is sustainable when used in an integrated fashion on a farm. That is, the farmer planting the designated crops and then pressing and filtering them himself/herself to make the plant oil-fuel from it. Bio-diesel (in addition to agro-fuels such as ethanol) is usually produced on a mass-scale and marketed to conventional transportation channels, and suffers the certain drawbacks as discussed in subsequent paragraphs.

2.1. Environmental factors

The International Panel on Climate Change (IPCC) guidelines, and the World Resources Climate Analysis Data, the review produced an interesting pie-chart (Fig. 1), showing the GHG emissions by source for the year 2000. It is evident from this chart that 35% of emissions are from agriculture and changes in land-use. The land-use change is the 2nd largest source of emissions (18%), after the power sector (24%). Further, it is evident that agriculture emissions are equal (14%) and land-use change emissions are greater (18%) than the contribution from transport.

The source of agriculture emissions, due to intensive farming is nitrogen fertilizer production/utilization and emissions of nitrous oxide (NO_2) from the field. Because of the very powerful GHG effect of nitrous oxide (300 times that of CO_2) even relatively small emissions can have a significant impact on the overall GHG balance. Thus the reduction in GHG emissions basically depends on a number of things. First of all, factors such as yield, climate, soil type, and ground cover and cultivation method assumptions have a

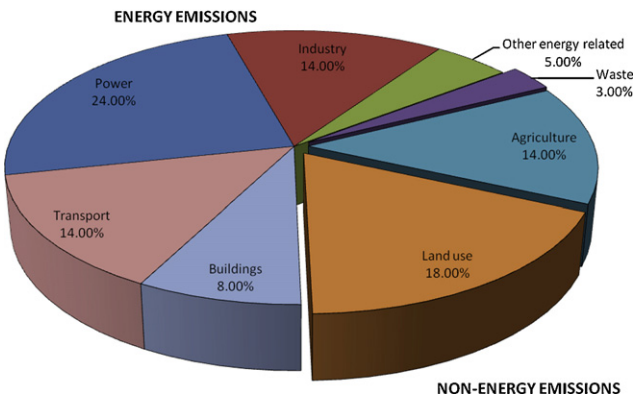

Fig. 1. GHG emissions by source for the year 2000.