Potential for Rural Electrification in India: An overview

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2 authors:

Karthickkumar Paramasivan
College of Fisheries Engineering Tamil Nadu Dr J Jayalalithaa Fisheries University

Balasubramanian Paramasivan
National Institute of Technology Rourkela

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Potential for Rural Electrification in India:

An overview

P. Karthickumar
Assistant Professor,
Department of Agricultural Engineering,
Vanavarayar Institute of Agriculture,
Pollachi, India.
agrikarthi@gmail.com

P. Balasubramanian
Assistant Professor,
Department of Biotechnology,
National Institute of Technology,
Rourkela, India.
biobala@gmail.com

Abstract: **With depleting fossil fuel resources (coal, petroleum and natural gas), increasing population and expanding industrial areas, the need for renewable energy options has become very obvious in India. Acute dependence on conventional fuel sources in the past century has resulted in global energy crisisand deteriorative environmental impacts. Among various renewable energy options, biomass is appropriate for a country such as India where agriculture and forestry occupy over 43.5 % and 23.5 % of the total land area respectively. As a cheap fuel source with sufficiently high calorific value (3585 Kcal/ Kg at 6 % on dry basis moisture content), rice husk, the major 'waste' product of paddy milling, accounts to an annual availability of over 30 MT from the 152 MT paddy produced in the country. At present, rice husk is used as an energy source for steaming (during parboiling) and drying of paddy and for a handful of chemical industry applications. However, reports record that over 10 MT of rice husk remain unutilized and is dumped on landfills or incinerated. Research however shows that 1 KW of electricity can be produced from 1.5 kg of rice husk itself. The objective of the present study is to project the scope of this bio-resource; that can be effectively used for electricity generation, particularly for rural requirements.**

Key words: **Fossil fuels; renewable energy; biomass; rice husk; electricity generation.**

INTRODUCTION

The power sector is undergoing a serious reform across the world; the Indian power industry is not exempted to this remark. India ranks as the 7thtop consumer of energy in the world. About, 40 % of the total energy requirement is at rural areas, in which the domestic sector constitutes a major portion; accounting to about 60 % of the total energy. Awasthi and Deepika (2013) highlight that about 24,500 villages across India have been identified as remote villages and extension of grid electricity is not feasible in such places. In order to provide electric power, possibility of utilization of renewable energy sources such as solar photovoltaic, hydro, wind and biomass gasification need to be explored. Among these options, biomass-based electrification is significant in the Indian context owing to its rich availability.

All countries are found to be having abundant potential in the world with respect to bioenergy sector. While comparing with India, South America is one of the leading zones which estimated to have 500 MTOE (million tonnes of oil equivalent) and above. Next to South America zone, North America, former Soviet Union, Asia and Sub-Saharan Africa counts to 250 MTOE. In this aspect, India's potential placed in and around 100-250 MTOE and comparable to China, irrespective of 3 times higher area than India. (Asok Rajkumar*et al.*, 2013).

Biomass based energy has a vital role in rural livelihood in India, where agriculture and forestry occupy 43.5 % and 23.5 % of the total land area (FAO, 2012). More than 320 million tonnes of agricultural residues, a quantity equivalent to around 250 million tonnes of coal, is produced annually and has the capability to generate 17,000 MW power. In a rural area, household requirement for electricity is comparatively low (10 KWh/ month). In India, annually around 74 million tonnes of agricultural residues available as biomass feedstock can be effectively used for energy production applications. Biomass gasification projects could reach up to 31 GW, with the capability to generate more than 67 TWh of electricity annually. The annual CER potential of biomass gasification projects in India can reach a rough estimate of 58 million tonnes by 2020 (Purohit, 2009).

Around 20% of the villages in India has to be electrified yet and this critical scenario delineates the scope of an environment-friendly technique for rural power generation in India. The recent status of rural electrification in India has been shown in Table 1.

STATUS OF RURAL ELECTRIFICATION IN INDIA

Sl. No.	*Percentage of Electrified Villages*	*No of states*	*Name of the States*
1	100%	9	Andhra Pradesh, Delhi, Goa, Haryana, Karnataka, Kerala, Punjab, Sikkim and Tamil Nadu
2	90-99%	12	Assam, Bihar, Gujarat, Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Chattisgarh, Maharashtra, Mizoram, Rajasthan, Uttaranchal and West Bengal
3	81-90%	4	Jharkhand, Manipur, Meghalaya, Uttar Pradesh
4	71-80%	4	Arunachal Pradesh, Nagaland, Orissa, Tripura

(Source: As per CEA, 2013)

Energy requirements in rural areas are mainly for agricultural operations such as irrigation. Energy sector is vital to sustainable development and poverty reduction efforts. It affects all aspects of development (social, economic, and environmental) including livelihoods, access to water, agricultural productivity, health, population levels, education, and gender-related issues. None of the Millennium Development Goals (MDGs) could be met without major improvement in the quality and quantity of energy services in developing countries. (Balasubramanian and Karthickumar, 2012).

BIOMASS GASIFICATION OF RICE HUSK FOR ELECTRICITY GENERATION

'Gasification' is the process of converting solid fuels (such as wood, wood-waste or agricultural residues) into a combustible gas mixture, usually referred as 'producer gas' or 'synthesis gas'. Most commonly used agricultural residues include: dried leaf, straw, bagasse and coconut shells. The process involves the partial combustion of such solid fuels under insufficient air supply (O_2). During partial combustion, solid biomass fuels breakdown in an oxygen-starved environment under the application of heat to produce a mixture of combustible gases. High concentration of combustible gases like H_2, CO and CH_4 increases the combustion energy of producer gas. The calorific value of producer gas varies between 4.0 and 6.0 MJ/Nm^3. This is equivalent to about 10 to 15 percent of the heating value of natural gas.

The total annual production of rice is estimated as 152 MT according to FAO (2012). Rice husk is the outer cover of rice that accounts for about 20 % weight of the kernel and requires to be removed before consumption. 30 MT of rice husk ash is annually produced in India. The availability of rice husk depends upon the production of paddy, production process and husk-to-paddy ratio (HPR). Typical HPR values are in the tune of 0.14 to 0.27. In the past, rice husk was mostly dumped as waste that caused acute disposal problem for millers. Methane emission from disposed rice husk fermentation is a contributor of global warming (Bhattacharya *et al.*, 1999). Hence, there exists are need to find a suitable method to dispose rice husk. Figure 2 provides the possible utilization schemes of rice husk, which were once regarded as a mere waste.

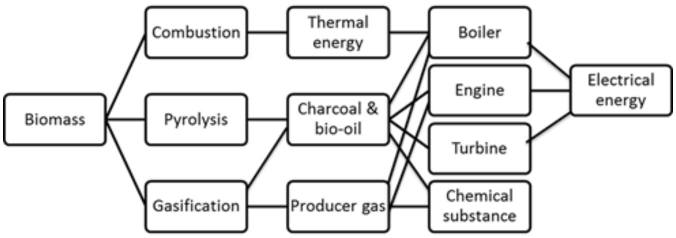

Figure 2. Utilization of biomass (rice husk)

Electricity generation from rice husk (Figure 3) depends on the availability of raw material and the technology for converting rice husk in to energy. To better explain: for a steam turbine power plant, the consumption of rice husk is 1.3 Kg per KWh electricity as reported by Singh (2007); on the other hand, for a gasification power plant consumption of rice husk is 1.86 Kg per KWh electricity generation (Islam 2008). The advantage of gasification technology is that it is cost effectiveness and higher efficiency. In this process, electrical and thermal energy can be generated simultaneously. Gasifier offers a flexible option for thermal applications as they can be fitted into existing gas-fuelled devices such as ovens, furnaces and boilers where producer gas can be conveniently replace fossil fuels and lower household demands for natural gas.

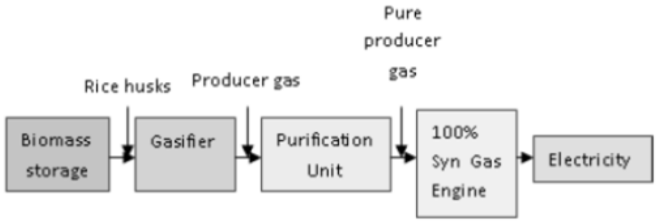

Figure 3. Electricity generation by rice husk gasification

The main component of the biomass gasification system is a reactor into which the feed stock is supplied with a limited supply of air to facilitate a chemical breakdown process to result in the formation of producer gas. Several types of gasifiers e.g. fixed-bed updraft and downdraft gasifier, fluidized bed gasifier and bubbling bed Gasifier are available in the existing market with their respective pros and cons. However, the downdraft gasifier is comparatively cheap and gasification in this type of gasifier can produce a product gas with very low tar content (Giltrap*et al.*, 2003). Hence, the fixed-bed downdraft gasifier can recommended for a small-scale rice husk biomass plant, applicable for rural electrification. Here, rice husk is fed at the top of the reactor/gasifier. The rice husk then slowly moves down, allowing the fuel to react with the insufficient air supplied (the gasification agent) by suction of a blower or an engine (Figure 4). The moisture content of the rice husk should not be less than 25 % by weight. This results in the formation of combustible producer gas after the fuel had dried, de-volatilized and combusted. In a nut shell, the process is a complicated chemistry of oxidation, reduction, and pyrolysis reactions. The generated ash can be then removed from the bottom of the reactor and sent for silica production. Most of the primary tar (consisting of oxygenated organic compounds) formed during pyrolysis is cracked and burnt in a process called flaming pyrolysis. The flame temperatures are in the range of between 1273 K and 1673 K, but the flame occurs in the interstices of the pyrolysing particles which have temperatures between 773 K and 973 K (Reed et al., 1988). About 0.1 % of the primary tars are converted to secondary tars and the rest are burned to supply the energy for pyrolysis and char gasification. Downdraft gasification produces secondary tars whereas tars produced by updraft gasifiers are primary tars. Therefore, the produced gas is cleaner than when provided by the counter-current model.

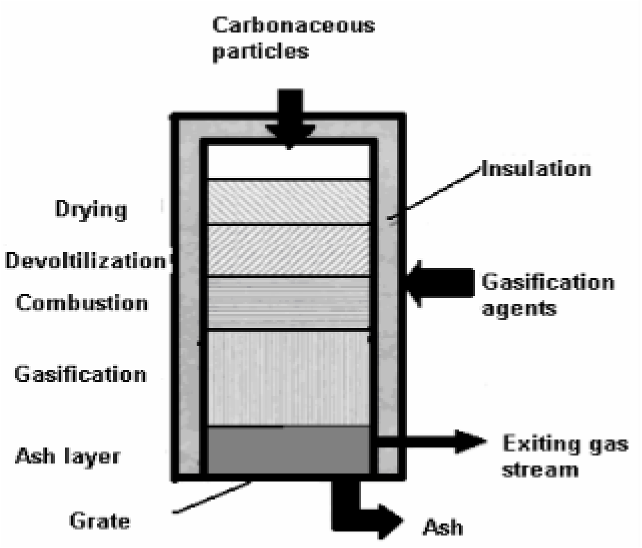

Figure 4. Downdraft Gasifier

Yoon *et al.*, (2012) studied the characteristics of rice husk ash and rice husk pellet in the downward gasifier. Results showed that the heating value of the synthetic gas shows higher value of 1314 KCal/ Nm^3 than the synthetic gas produced from rice husk gasification.The cold gas efficiency was more than 60 % and 70 % for rice husk and rice husk pellet gasification respectively.

BENEFITS OF ELECTRICITY PRODUCTION FROM RICE HUSK

a. Direct benefits

Electricity for Rural Usage

There is a need for electricity in rural areas, particularly in remote industrial locations. Rice mills in those areas can be the most benefited from power generation from rice husk. The approach minimizes both the transportation cost of raw materials and the distribution cost of electricity. Further, biomass based power generation systems do not impose heavy investment burdens on farmers, unlike a competitive approach – electricity from solar energy.

Appropriate Waste Disposal Option

As stated earlier, CH_4 emission from rice husk that is disposed in the land, by means of fermentation can become a significant contributor of global warming (Bhattacharya et al., 1999). Hence, the utilization of rice husk in producing electricity at rural levels by means of gasification can be a feasible alternative to dispose the waste effectively. This does not require another research or scientific concept to be developed, but is the mere utilization of an existing technology. Further, on considering the method as such, it is a renewable energy option with no negative effects on the environment as compared to most conventionally adopted energy generation schemes in India.

Multiple Benefits of Process By-Products

The by-products of a rice husk based biomass plant include silica and calcium carbonate. Silica has a huge demand in rubber, tooth paste and other applications in the cosmetic, food (anti-caking agent) and chemical sector. Calcium carbonate is vital ingredient in the manufacture of building materials.

b. Indirect benefits

Enhancement of Rural Employment

There is a high scope that a rice husk based biomass plant would provide employment opportunities for semi-skilled or unskilled members of the rural population. Ghosh et al. (2002) estimated that each day, a plant of moderate capacity can provide work opportunity for 4 men. Fung and Jenkins (2003) have also reported that biomass energy projects (on the whole) can create employment for rural people.

Improvement of Rural Livelihood

Rice husk based power generation does not only provide electricity in rural regions; but also provides numerous indirect benefits. To present it in simple terms, the development of such as system can in the long-term facilitate in improving the livelihood of the rural population.

OTHER APPLICATIONS OF RICE HUSK

Dietary Fibre

Rice husk has been identified as a valuable source of bioactive components with high antioxidant properties. Fadaei*et al.*, (2013) study confirmed that rice husk has more than 30% dietary fiber. In addition, it is also an excellent source of protein and mineral. Hence, it can be used in food industry especially developing functional foods.

Sorbent in Wastewater

Noor Syuhadah and Rohasliney (2012) reviewed as a rice husk as a sorbent in removing dyes, heavy metals and some other chemicals (Pb, Ca, Cu, Zn and Hg) have been reported. The capability of the rate of absorption of modified or unmodified rice husk is depend on few factors such as the effect of pH, initial concentration, agitation rate, sorbent dosage, temperature which could be further researched for more efficient applications.

Insecticide or Pesticide

Rice husk ash was found to be effective against bruchid beetles that attack stored legume seeds (Naito, 2000). Results showed that the ash has thesame composition as diatomaceous earth, commercially named“Insect”, and is effective in controlling pests of storedgrain. Since rice husk ash is having 96 % silica content have a lethal effect on insects.

Briquette for Fuel

Briquetting is the process such as conversion of rice husk into solid fuel to help in handling, storage, transportation and deforestation (Yahaya and Ibrahim, 2012). The briquettes will serve as substitute for fuel wood since it shows superior combustion characteristics over fuel wood and the material is readily available. The briquetting process is economically, cheap and affordable to the rural and low-income urban dwellers. Besides, the binders do not contain harmful agents.

Nano-Structured Silicon

Since rice husk is having higher silica content, an attempt has taken to derive Silica-nano particles (SiNPs) from rice husk Liu *et al.*, (2013). SiNPs exhibits high performance as Li-ion battery anodes, with high reversible capacity (seven times greater than graphite anodes) and long cycle life (86 % capacity retention over 300 cycles).

CONCLUSION

Presently, most electricity production options are from fossil fuels that have caused a rising concern for energy security and in the context of environmental deterioration. Biomass as an alternative renewable energy source is suitable for an agriculture-dependent country such as India. Rice husk that was once regarded as a waste, is now slowly being used in several applications, one such being gasification for electricity generation. This could be particularly applicable for usage in rural Indian scenario. The approach is quite cheap, relatively simple and environment-friendly. However, there is a huge unexplored potential in this energy context in addition to all other commercial options. As a final remark, it might be well accepted to summarize that electricity generation from rice husk is a feasible option for power supply in rural India.

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