IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 10, December 2014.
www.ijiset.com
ISSN 2348 – 7968

Small Scale Pine Needle Gasification Based Decentralized Energy Generation System

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Abstract

Sustainability issues are raised along with climate change especially when we are addressing the issue of available fuels. Conventional fuel sources are limited, hence there is a need for new power generation sources.Along with other non-conventional resources, biomass is gaining more and more attention as an alternative energy source and is considered one of the most promising
renewable energy sources. Pine needles, a forest biomass is widely available in the Himalayan region, and due to the lack of availability and accessibility through the grid, there is a need for decentralized power generation systems.
In India power deficit exists to an extent of 8% .This shortfall can be manage by increasing the share of renewable sources.
The de centralized power generation concept will not only manage the power deficit but also provide accessibility to households in the Himalayan region which are not yet connected to the grid system.
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Keywords: *Sustainability, Decentralized Power Generation, Renewable energy, Pine Needles, Himalayan region.*

1. Introduction

It is a well known fact that access to quality, reliable and affordable energy is critical for the economic and social development in rural areas. The energy situation in rural India is characterized by low quality fuels, low efficiency of use, low reliability of electricity supply and access, all of which lead to lower productivity of land and water use as well as human effort, resulting in low quality of life and environmental degradation [2]. As per the Ministry of Power (MOP), Govt. of India[1] estimates, about an 8% power deficit is prevalent in the country. This has strained the availability of power in rural areas. On therural electrification front, the Ministry estimates that 74% of villages are electrified with still 154,230 villages remaining un-electrified. Of these, around 18,000 villages have difficulty in linking with the grid and hence need to be electrified by a decentralized source of energy. Even in villages which are so called grid linked, the availability of power is poor.

The Indian sub-continent has been at the forefront of biomass gasification technology development with numerous success stories. Many research institutions are engaged in the fabrication and installation of gasifiers. Some of the notable successes include the decentralized energy systems India (DESI), a power gasifier which generates 80kW of electricity that is supplied to the surrounding colleges. Another notable case is in Malawi where ethanol is produced for blending of diesel and petrol fuels up to 20% thereby reducing the country's fuel imports. Saran renewable energy (SRE) gasification plant in India supplies about 220MWh per year, saving approximately 0.35 litres of diesel per kWh. This project has reduced an estimated 206 tonnes/year of CO2 and increased local incomes through the sale of biomass feedstock.

Gasification is well proven technology and is used by several organizations in different ways but the terms pine gasification is new in this category.Due to the wide availability of pine in the Himalayan region, The Himalayan Subtropical Pine Forests are the largest in the Indo-Pacific region. They stretch throughout most of the 3,000-km length of the world's youngest and highest mountain range. The Himalayan subtropical pine forests are a large subtropical coniferous forest eco-region covering portions of Bhutan, India, Nepal, and Pakistan. They cover almost 76.2 Lakhs Hectares
According to the Uttarakhand Renewable Energy Development Agency (Department of Renewable Energy,

ISSN 2348 – 7968

Govt. of Uttarakhand) the total area of Pine Forest in reserve forest in Uttarakhand is about 3.43 Lakh Hectare. These Pine forests in Uttarakhand produce about 20.58 lakhs tonnes of dry biomass which means every hectare produces 6 tons of pine needles or every m2 yields 0.6 kg of pine needles, so with respect to the whole Himalayan region we are getting 457.2 Lakh tons of pine needles.

Since the transportation of pine needles is not easy, we need to consider only the pine forests near habitation or near the road head. This means we can hope to get about 182 lakhs Tones every year

2. GASIFICATION OF PINE NEEDLES

Gasification of pine needles is a thermo-chemical process which converts pine needles (biomass materials) into gaseous components. The results of gasification are the producer gas, containing Carbon Monoxide, Hydrogen, Methane and some other inert gases.

2.1 Composition of pine needles

Like other biomass pine needles contain carbon, hydrogen, and oxygen as major chemical constitutive elements. The ultimate analysis gives the value of different content like ash, Carbon, Hydrogen, and Oxygen. Ultimate analyses are reported using the CxHyOz formula where x, y, and z represents the elemental fractions of C, H, and O, respectively. To fully describe biomass characteristics, it is customary to provide the proximate analysis. Proximate analysis gives the composition of the biomass in terms of gross components such as moisture (M), volatile matter (VM), ash (ASH), and fixed carbon (FC).

TABLE 1 ultimate Analysis of pine needles

S.N.	parameters	Available %
1	Ash	1.31
2	Carbon	52.60
3	Hydrogen	07.00
4	Oxygen	40.10

TABLE 2 proximate Analysis of pine needles

S.N.	parameters	Available %
1	Mean moisture content	9.76
2	Mean ash content	4.37
3	Mean volatile matter content	70.03
4	Fixed carbon content	15.83

2.1Chemistry of Gasification

In a gasifier, the carbonaceous material undergoes several different processes like drying, pyrolysis, combustion, and gasification processes. The dehydration or drying process occurs at around 100°C. Pyrolysis processes occur at around 200-300°C.

The combustion process occurs as the volatile products and some of the char reacts with oxygen to primarily form carbon dioxide and small amounts of carbon monoxide, which provides heat for the subsequent gasification reactions. The basic reaction here is

$C + O2 \leftrightarrow CO2$ (1)

$\Delta H = -393.5$ kJ/mol

Gasification process occurs as the char reacts with carbon and steam to produce carbon monoxide and hydrogen, via the reaction

$C + H2O \leftrightarrow H2 + CO$ (2)

$\Delta H = 131.3$ kJ/mol

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$CO + H2O \leftrightarrow CO2 + H2$ (3)

$\Delta H = -41.1$ kJ/mol

3. DECENTRALIZED SYSTEM

Pine trees are widely available in the Himalayan region, due to its geographical condition it's not very easy to connect the Himalayan locality. Although most of the villages in these regions are connected to the grid system, the remaining localities are still waiting for grid supply which is difficult due to the geographical conditions or due to transmission & reduction losses. Thus pine needle gasification will be able to provide electric power to those areas where the cost of providing grid supply is very high.

2.1 The two successful projects

Hosahalli is the first un-electrified village in India to be served by a biomass gasifier in terms of quality supply of electricity. The village is located 100 km from Bangalore in Tumkur District, Karnataka. The bio-energy project was planned and implemented by the Centre for Sustainable Technology (CST), Indian Institute of Science (IISc) in the year 1988. The gasifier was operated only to provide home lighting and pump drinking water requirements. In Hosahalli village there are 35 house holds and the total population of the village is 218, the installed gasifier capacity is 20kw, in which 4kw is provided for lights, 2.6 Kw is provided for drinking water, and 5.6Kw is provided for irrigation pumps.

Kasai, which is located in Betul district- This village is located far away from the district center and is not easily accessible by road. The villagers are mostly tribals and agriculture is their main economic mainstay. The village has about 55 households with a population of 392. The Kasai Village Gasifier under the Village Energy Security Program (VESP) the Ministry of New and Renewable Energy Sources (MNRE), Govt. of India has a mandate of addressing the complete energy requirements of un-

ISSN 2348 – 7968

electrified villages in the states of Madhya Pradesh, West Bengal and Uttaranchal. The electricity is generated in the 2 x 9kW gasification plant installed under this project The system operates for 5 hours a day and on an average generates 40 units per day or 1200 units per month. The operation and maintenance of the plant is done by the local youth who have been trained in this aspect.

4. Conclusions

The paper studies bring out the message that pine needle gasification technology holds large promise as a decentralized power generation system in terms of improving the quality of life, which includes supply of hygienic drinking water, irrigation and supply of quality electricity for rural Himalayan regions.

The generation of power is not the only benefit of this technology; it also contributes towards protecting the environment. The result is a two-pronged strategy of development where we can save the environment and the cost for this is itself paid by energy production. This technology can be sustained using local available resources like raw material and manpower for day-to-day operation of the plant.

An important conclusion is that even at small capacities a sustained economical environment friendly operation is possible, as the major operational costs are related to raw material (pine needles) cost which is locally available. Due to the decentralization it will also reduce the cost of transportation of pine needles thus reducing the dependence on fossil fuel, an important concept for distributed power generation packages for the rural sector.

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