Renewable Energy Production from Agricultural Waste and Hydrogen Battery Formation

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Abstract- In recent years, the growth of solar and wind power installation has not grown in par with its electrical grid integration. Hence this proposed work uses frictional Pyrolysis to enable this integration by converting electrical energy into mechanical work without any indication of excess heat requirement. The renewable energy that is in excess can be used in conversion of agricultural residue to biocoal. This is the basis of of renewable battery. In this work a case study is presented such that biomass characteristics are examined and further transformed to bio coal. Observations indicate that in the past decade there is a significant increase in wind power installation (258%) and the number of solar PVs installed have also accounted for 21,437 GWh. From the biomass initial stage, the total amount of energy produced lies within the range 78% to 89%. This methodology of using renewable battery ensures that the environment state cleaner and carbon sequestration and also be implemented in agricultural development.

Keywords: Renewable energy, renewable battery, biocoal, agricultural carbon sequestration, solar and wind power generation

1.Introduction

A survey shows that renewable energy source increases in growth by about 7% per annum till the year 2040. This project is based on the global contribution of energy from the four major sources accounting for 25% of the total energy produced. In countries like Denmark and Germany that is a noticeable increase in the production of primary energy contributed by renewable sources [1]. It has been identified that 28.6% of the energy produced in the state of California is contributed by renewable sources. Similarly in India a total of 15.8% total energy produced is from renewable sources. The use of renewable energy has laid a profound foundation for cleaner energy production and healthier green practices. This overwhelming increase in renewable energy production has lead to an increase in the operation cost. In [2] a study was conducted the increase in renewable energy due to congestion effects on the grid. A conclusion was drawn that when compared with wind power, solar power has a higher impact on the economic front. Similarly, the energy produce shows fluctuation on an hourly fashion which is represented in [3] and feasible solution based on energy storage were also recommended. In 2016, a novel introduction of battery based energy production was introduced. Storage of renewable energy was a major obstacle which prevented the expansion and installation of renewable energy means. The alternatives introduced so far involve high installation costs as well as operations safety which makes it an unsuccessful option [4].

One of the biggest sources of renewable energy is crop residues. It contributes for a large quantity of phytomass and when used with the right technological aids, will prove to be highly effective. The crop resides that hold good potential are rape straw, barley straw, corn stover wheat straw and rice straw [5]. According to survey report, a total of 1245 TWh of biomass residue can be used for thermal applications, resulting in 425 TWh energy generation potential [6]. Vietnam, Thailand and Indonesia are the highest contributors of biomass residue. Similarly, India has the potential of producing 5.28 EJ of energy using a crop residue of 782 Mt, annually. This contributes about 19% of the total energy consumed by the population of India. Similarly many countries in South America such as Argentina and Brazil show high energy potential using biomass residues [7-8].

Agriculture is also known as the backbone of India. Using the agricultural waste will prove to be an excellent way to increase energy production, using the right technological aids. It has been identified that over 50% of the agricultural products are used in landfills without being used. This unused agricultural residue after found to be carbon neutral resulting in excellent practical applications. Solid carbonaceous products production is a means of

conversion pathway used in industrial, agricultural and energy applications [9]. To produce charcoal carbonisation is one of the most highly preferred methodologies used since ancient times. On the other hand torrefaction is an interesting alternative that is being used by the current generation [10-11]. This process requires roasting or pyrolysis of organic waste to eliminate volatile sub particles thereby improving the heat value present. The output obtained represents substances which can co-combust with coal. It also has a number of positive effects such as improved grind ability and reduction in moisture [12]. Another alternative used is intermediate Pyrolysis which takes place at a temperature of 300-500 °C [13].

In this proposed work, we have introduced a methodology of using renewable biomass to store energy in a compatible manner. To enhance circular economy, store energy and sequestrate carbon, the agricultural waste that is available is converted into biocoal using frictional Pyrolysis. The output of the work is recorded in results and discussion which shows the efficiency of the battery. This paper is organised as follows: Section 2 describes the methodology proposed and the results observed are recorded in section 3. A conclusion for the work is drawn in section 4.

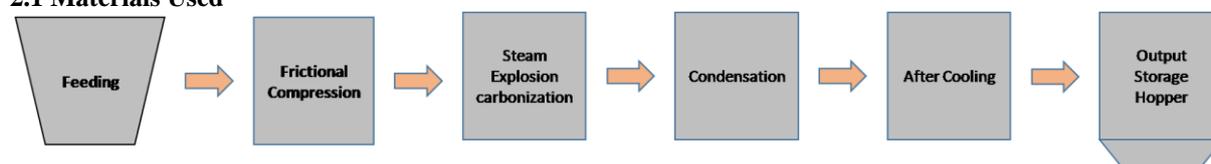## 2. Proposed Methodology
2.1 Materials Used

Fig.1 Process of Frictional Pyrolysis

The underlying concept behind renewable battery is a conversion of excess energy by means of an electric grid to the facility. This energy produced can be used to make an electric motor function search that it produces mechanical energy that can be used to screw in an RCU. Based on the availability, this type of renewable energy can be used in various forms. In the case of India, the excess energy is obtained primarily from wind power and solar power from the states of Tamil Nadu and Karnataka. The output results in solid carbonaceous fuel with improved combustion properties and high energy density as shown in Fig.1. The elimination of water after pyrolysis will increase the the level of carbon present. The biocoal thus formed and be stored temporary and further transported for the purpose of co-combustion in a coal plant.

2.2. Characterization
Pine, Oak and corn stover are the lignocellulosic residue that are processed. Their energy and mass balances are estimated and provided on output input basis. This material will be evaluated to determine the heating value increase and also the decrease in water content. This calculation is performed based on changes observed in the output values when compared with the actual output values. Water content is measured after the material is dried for a period of one day at 105 degree Celsius and heating values is estimated using a bomb calorimeter following specific standards of measurement. It has been observed the transmission loss registered in Tamil Nadu is more than that of the national average. This shows that the use of smart control and microgrids prove to be a positive step towards improvement.

3. Constraints and Solutions
3.1. Boundary Conditions
Setting the lower and upper boundary conditions is based on number of variables and search space complexity. The boundaries are set such that

$$N_x^{min} \leq N_x \leq N_x^{max}, x \in \{FC, Biomass\} \text{ ----- (1)}$$

The boundary values are set such that the numbers are identified based on trial on error methodology, in order to get the optimal results.

3.2. Storage Limits Constraint
The energy constraint on the storage capacity is governed by the following equations:

$$E_{c2,min} \leq E_{c2} \leq E_{c2,max} \text{ ----- (2)}$$

Here $E_{c2,max}$ and $E_{c2,min}$ are the maximum and minimum conditions of the tank's storage capacity and it is found that 7% of $E_{c2,maz}$ is fixed as $E_{c2,min}$

3.3. Energy Management

An overall control of constraints, objectives, inputs and outputs are represented mathematically and together is known as dilemma of energy management. In this methodology, there are three tactics used to solve the multi-objective sizing issue related to smart grid and load with respect to energy exchange.

- Tactic I: over demand
- Tactic II: over a generation
- Tactic III: Micro-grid meets demand of load

3.3.1 Tactic I

If it is not possible to satisfy the demand of the load, the shortage in power generation can be compensated by using fuel cells to store energy. If the hydrogen present in the storage is very low, there will be loss of power while the load is not satisfied.

$$P_{shortage}(t) = \frac{P_{load}(t)}{\eta_{inv}} - P_{bio}(t) \text{ ----- (3)}$$

Where P represents power with respect to the fuel, storage and load and η denotes efficiency of the system.

3.3.2 Tactic II

If there is a surplus generation of electricity that exceeds the demand put forth by the load, the extra electricity can be used to develop hydrogen as an electrolyser. This way it is also feasible to sell the extra hydrogen for a profitable amount.

$$P_{excess}(t) = P_{bio}(t) - \frac{P_{load}(t)}{\eta_{inv}} \text{ -------(4)}$$

3.3.3 Tactic III

In this condition, both demand and supply are equivalent and hence there is not excess power generated to provide for the electrolyser.

$$P_{bio}(t) = \frac{P_{load}(t)}{\eta_{inv}} \text{ ------ (5)}$$

4. Results and Discussion

Fig.2 represents an increases energy capacity during the past decade in India. It shows that a good percentage of energy is contributed by renewable energy technology. It indicates that one of the most successful technologies that are growing in India is that of Solar power. It accounts for over 18, 432 GWh. This hike in the use of renewable sources resulting in an increased production of renewable energy generally faces issues with grid integration. The hydrogen based battery proposed in this paper will be effective in enhancing carbon sequestration and decreasing the emission of green house gases.
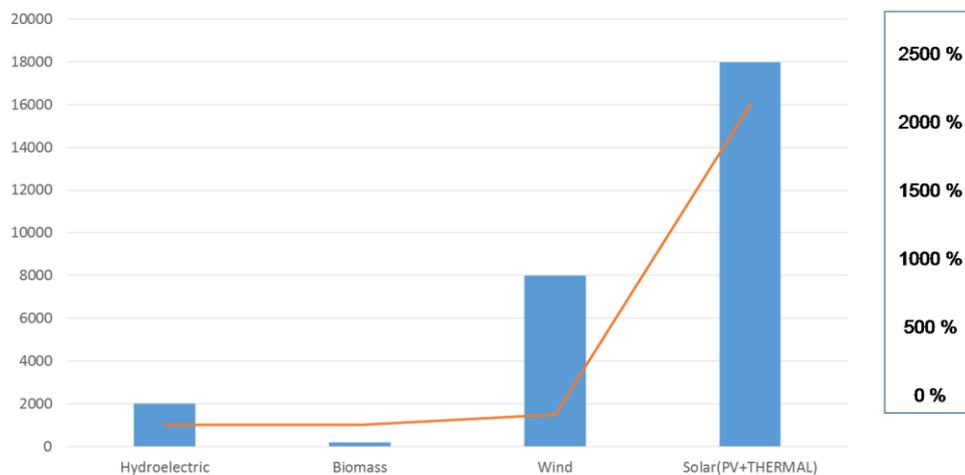

Fig.2. Increased capacity of renewable energy installation by source in India

Changes in moisture content and HHV content after the biomass residues (as shown in Fig.3) are processed is known as frictional Pyrolysis. Using this process, the moisture content present in corn stover, pine and oak is decreased to produce solid mass that can be further used to produce energy. Based on the analysis it is found that corn stover provides a higher energy level when compared with the others as shown in Fig. 4.
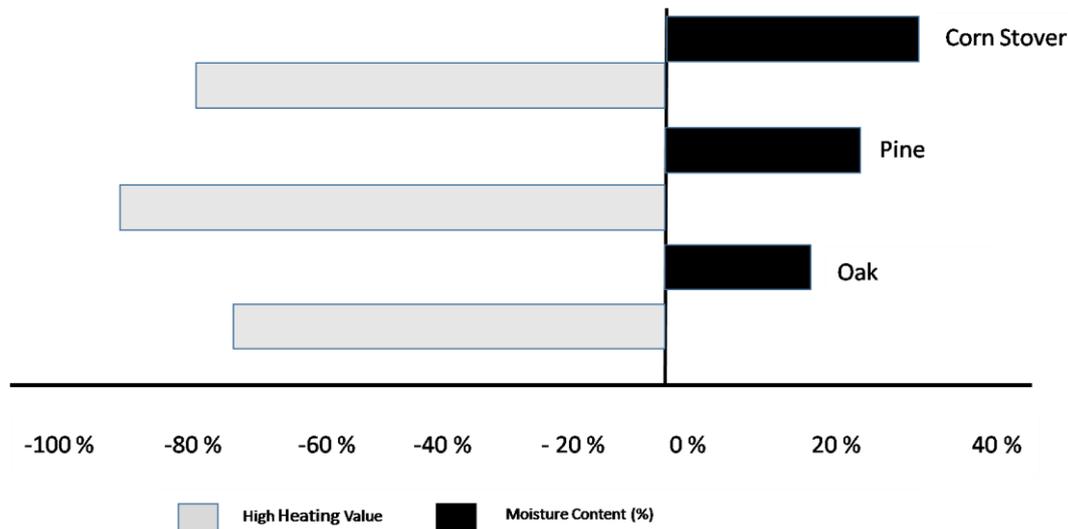

Fig.3 Moisture content and charges in the high testing value (HHV) and biomass residues after frictional pyrolysis
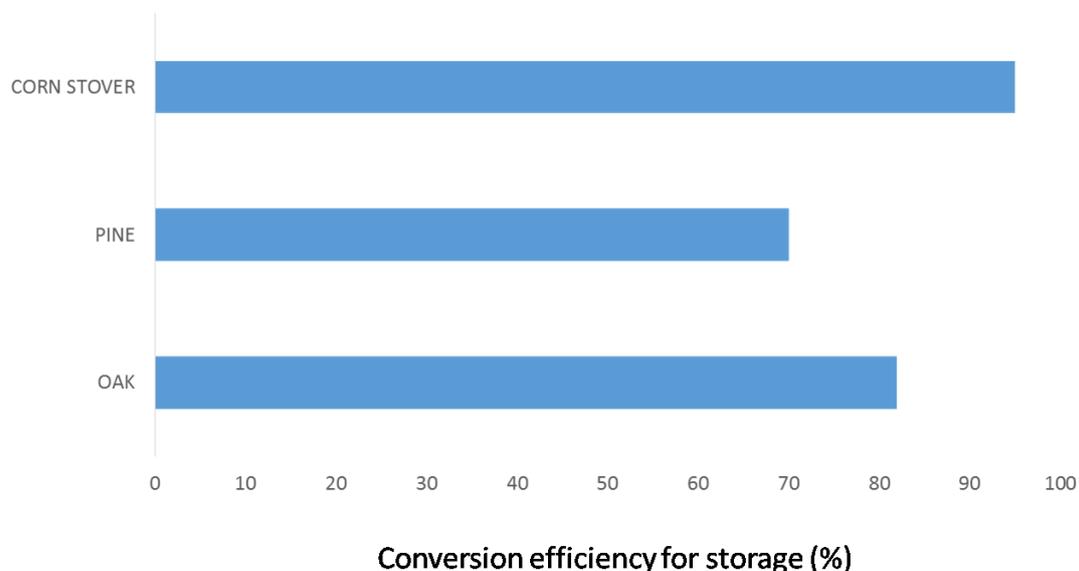

Conversion efficiency for storage (%)

Fig.4 Energy Produced from Biomass in Biocoal

5. Conclusion

In this paper, a novel renewable battery built using the process of frictional Pyrolysis to convert the agricultural waste in biocoal. This methodology can also be called the conversion of power to fuel since it involves the use of mechanical work in order to produce the energy. The renewable battery proposed paves way to the introduction of long-term carbon sequestration or energy storage means. As future work, the use of such renewable battery in specific purpose devices and systems can be experimented.

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