Scheduling and Optimizing Mixture of Agri-Residues for Power Generation from Biomass

Gurpartap Singh Saggar1, Khushdeep Singh2
1M.Tech student, Guru Nanak Dev Engg College Ludhiana, India
2Professor, Guru Nanak Dev Engg College Ludhiana, India

Abstract—For a developing country like India, Energy is most important resource in economic growth. In this paper, an investigation of agri-residues (rice and wheat straw) has been conducted in blocks Ludhiana I and Ludhiana II of district Ludhiana, Punjab. Regression analysis in MATLAB has been applied for analysis of load consumption data and scheduling of energy generated by power plant is done using simplex method in MATLAB along with obtaining optimum mixtures of agri-residues. The optimized mixture of 67.66% of rice is used for peak off-load months generating 66.63 MW Electric Power and 32.34% of rice is used along with wheat for peak on-load months generating 78.30 MW Electric Power.

Keywords—Regression analysis, MATLAB, Biomass, Peak on-load months, Peak off-load months, Agri-residues, Energy

INTRODUCTION

The perception of an energy plan for a rural municipal by making use of native accessible resources to meet electrical and other energy necessities has been revisited over the years. A lot of this may be indebted to slow but continuous rise in awareness among countries. The assessment of Biomass supplies is confounded by several ways in which biomass is generated and utilized primarily biomass is composed of remains from agricultural and societal deeds. India is 5th largest producer and third largest consumer of energy. With only 1.6% of geographical area of the country, Punjab produces 22% of wheat, 10% of rice and 13% of cotton majorly. There are two major agricultural crops in the state “Rabi” (winter crop) and “Kharif” (summer crop). The major crops grown during Rabi season are Wheat, Arhar, Sunflower, and Cotton while during Kharif seasons are Paddy, Bajra, Jowar and Sugarcane. A crop is considered major if its crop area fraction is 10% or above of the total cultivated area. A crop is considered minor if its crop area fraction is 2.5% or above. Crops that do not qualify either as major or minor are considered as “Insignificant Crops”. In this study survey is conducted for Rabi crop (wheat) and kharif crop (rice) in blocks Ludhiana I and Ludhiana II of district Ludhiana, Punjab. Block Ludhiana I consists of total 59 villages with total land area of 82463 acres consisting of 42830 acres of land under cultivation. Block Ludhiana II consists of total 178 villages with total land area of 129337 acres out which 95143 acres land is under cultivation. The areas under investigation have great potential of 1.36440e+12 Kcal.

Regression analysis stands in recognizing relationships amongst variables and uses these relationships to sort predictions. This technique can be used to recognize the line or curve that is responsible for the best fit through a set of data points. This line or curve can recognize a pattern in data, like linear or parabolic.

Here in this work, curve fitting tool box of MATLAB has been used in which particularly non-linear regression analysis is conducted for investigating the data and generate best curve for the problem. The polynomial models in non-linear regression analysis have been considered in this work.

Polynomial models for curves are given by:–

\[ y = \sum_{i=1}^{n+1} P_i x^{n+1-i} \]

Where \( n + 1 \) is the order of the polynomial and \( n \) is the degree of the polynomial. The order gives the number of coefficients to be fit, and the degree gives the highest power of predictor variable. Polynomials are expressed in terms of their degree. For e.g.

\[ y = P_4 x^3 + P_2 x^2 + P_3 x + P_1 \]

Allocation & Analysis of Load consumption data in MATLAB

The load consumption data is plotted using MATLAB programming. Table I shows month-wise load consumption data of the area under consideration. Fig 1 shows plotting of the data in Table I using MATLAB. By investigating the traced pattern, Peak off-load months include Jan- April, Nov and Dec whereas peak on-load months include May-Oct.
TABLE I Load consumption data month-wise

<table>
<thead>
<tr>
<th>S.NO</th>
<th>MONTH</th>
<th>LOAD (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>January</td>
<td>2850.0786</td>
</tr>
<tr>
<td>2</td>
<td>February</td>
<td>2934.1463</td>
</tr>
<tr>
<td>3</td>
<td>March</td>
<td>3179.2682</td>
</tr>
<tr>
<td>4</td>
<td>April</td>
<td>2987.8048</td>
</tr>
<tr>
<td>5</td>
<td>May</td>
<td>3300.5365</td>
</tr>
<tr>
<td>6</td>
<td>June</td>
<td>3894.909</td>
</tr>
<tr>
<td>7</td>
<td>July</td>
<td>3646.3414</td>
</tr>
<tr>
<td>8</td>
<td>August</td>
<td>3564.634</td>
</tr>
<tr>
<td>9</td>
<td>September</td>
<td>3560.9761</td>
</tr>
<tr>
<td>10</td>
<td>October</td>
<td>3369.5121</td>
</tr>
<tr>
<td>11</td>
<td>November</td>
<td>3123.1707</td>
</tr>
<tr>
<td>12</td>
<td>December</td>
<td>3182.9268</td>
</tr>
</tbody>
</table>

FIG I Analysis of Load Consumption Data by Tracing in MATLAB

Curve Fitting by Regression analysis in MATLAB

The equations obtained from regression analysis for peak off-load months data is expressed as:-
\[ y = 4.1x^4 - 46.7x^3 + 133.7x^2 - 51.0x + 2780 \]

The equation obtained from regression analysis for peak on-load month’s data is expressed as:-
\[ y = -26.6x^4 + 399.9x^3 - 2118.2x^2 + 4526.3 + 522.8 \]
FIG II Curve fitting by using Regression Analysis for Peak off-load Months

FIG III Polynomial function by Regression Analysis for Peak off-load Months
FIG IV Curve fitting by using Regression Analysis for Peak on-load Months

FIG V Polynomial function by Regression Analysis for Peak on-load Months

Calculations using MATLAB

Total agri-residue of wheat is 109624350 kg with capacity of generating potential 4.3465e+11 Kcal and that of rice is 278540640 kg with capacity of generating potential 9.2974e+11 Kcal.

Let

\[ k = \text{sum of peak off-loads (MW)} \]
\[ m = \text{sum of peak on-loads (MW)} \]
\[ n = \text{total load (MW)} \]
\[ x = \text{amount of} \ k \ \text{present in} \ n \]
\[ y = \text{amount of} \ m \ \text{present in} \ n \]
\[ p_1 = \text{total potential of wheat (Kcal)} \]
\[ p_2 = \text{total potential of rice (Kcal)} \]
\[ P = \text{total potential for a year (Kcal)} \]
\[ r = \text{potential of rice used for peak off-load months (Kcal)} \]
\[ s = \text{potential of mixture of rice and wheat used for peak on-load months (Kcal)} \]
\[ p_3 = \text{potential of rice for peak on-load months (Kcal)} \]
\[ G.C.V_w = \text{calorific value of wheat (Kcal/kg)} \]
G.C.V_r = caloric value of rice (Kcal/kg)

\[ \delta = \text{power generated for peak off-loads months (MW)} \]

\[ \Delta = \text{power generated for peak on-loads months (MW)} \]

\[ l_1, l_2, l_3, l_4, l_5, l_6 = \text{percentages of load shared by months jan, feb, mar, apr, nov, dec respectively of k} \]

\[ d_1, d_2, d_3, d_4, d_5, d_6 = \text{percentages of load shared by months may, june, july, august, sept, oct respectively of m} \]

\[ k = \sum_{i=1}^{6} a_i = 18257.3954 \text{MW} \quad (1) \]

\[ m = \sum_{i=1}^{6} b_i = 21336.9092 \text{MW} \quad (2) \]

\[ n = k + m = 39594.3046 \text{ MW} \quad (3) \]

\[ x\% = 0.46111657 \quad (4) \]

\[ y\% = 0.53888343 \quad (5) \]

\[ p_1 = 4.346548363e + 11 \text{ Kcal} \quad (6) \]

\[ p_2 = 9.297486014e + 11 \text{ Kcal} \quad (7) \]

\[ P = p_1 + p_2 = 1.364403438e + 12 \text{ Kcal} \quad (8) \]

\[ r = P \times x\% = 6.29149e + 11 \text{ Kcal} \quad (9) \]

\[ s = P \times y\% = 7.3526e + 11 \text{ Kcal} \quad (10) \]

Now,

\[ p'_2 = p_2 - r = 3.00599568e + 11 \text{ Kcal} \quad (11) \]

Equation (11) is equal to equation (9) and (10) respectively, thus it proves that we have used total potential effectively for peak on-load and off-load months.

Agri-residue of rice used in mixture with wheat for peak on-load months:

\[ \frac{p'_2}{G.C.V_r} = 90055737.57 \text{ kgs} \quad (14) \]

Agri-residue of amount of rice used alone for peak off-load months:

\[ \frac{p_2 - p'_2}{G.C.V_r} = 188484902.4 \text{ kgs} \quad (15) \]

Agri-residue of wheat used in mixture with rice for peak on-load months:

\[ \frac{p_1}{G.C.V_w} = 109624350 \text{ kgs} \quad (16) \]

Total Power generated for peak off-load months:

\[ \delta = \frac{(6.29149e + 11) \times 0.40 \times 0.001163}{(183 \times 24) \times 1000} \]

\[ \delta = 66.63937394 \text{ MW} \quad (17) \]

Total Power generated for peak on-load months:

\[ \Delta = \frac{(7.3526e + 11) \times 0.40 \times 0.001163}{(182 \times 24) \times 1000} \]

\[ \Delta = 78.30665462 \text{ MW} \quad (18) \]

RESULTS

For peak off-load months 1884849.024 Quintals of biomass is used generating potential of 6.29149e+11 Kcal and for peak on-load months 1996800.876 Quintals of biomass is used generating potential of 7.3526e+11 Kcal. Intended for peak off-load months 67.66% of rice has been used for generating electric power of 66.6387 MW and for peak on-load months mixture of 32.34% of rice left along with wheat has been used for generating electric power of 78.3067 MW.
CONCLUSIONS

This study provides a new approach to Renewable technologies and their potential in district Ludhiana, Punjab in developing countries like India. This study includes scheduling Power generation from optimum mixture Biomass for peak off and peak on-load months. By use of this study Power generation of about 14500 KW could be set up in rural areas of India. Total Biomass calculated is 3881649.90 Quintals from Ludhiana block I and Ludhiana block II of district Ludhiana. Ludhiana blocks I and II can generate Power of 144.9454 MW by generating 66.6387 MW for peak off-load months and 78.3067 MW for peak on-load months. Optimal mixture is obtained by using Regression Analysis i.e. 67.66% of rice has been used for generating electric power of 66.6387 MW and 32.34% of rice is used along with wheat for peak on-load months to generate Electric power of 78.3067 MW. Per unit cost generation of Biomass Power Plant is Rs 4.76/KWh. Energy generated by Biomass Power Plant would have less adverse effects on environmental conditions than that generate by plants using Fossil fuels.

REFERENCES