THE ESTIMATION AND PROJECTION OF THE ELECTRIC POWER GENERATION FROM CORN RESIDUES IN NIGERIA BASED ON LINEAR REGRESSION ANALYSIS

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To

My parents:

Mohammed and Munirat

My lovely and heartwarming families:

Amina and Hajara

The coolness of my eyes:

Saifullah, Fazlullah and Bushra

For your unalloyed love, fortitude, support and lustrous wishes

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ABSTRACT

A global desire for sustainable energy development to combat greenhouse gases (GHGs) emissions from energy sector has incited research endeavours on the exploitation of various kinds of renewable energy. However, presence of biomass resources in nearly every part of the world coupled with their ability to decarbonise electric power sector when used for electricity generation has attracted a very important attention for their exploitation. Thus, estimation and projection of the potential capability of different kinds of biomass resources for power generation is imperative. In the estimation and projection of electric power potential of a bio-residue, a standard formulation involving only two parameters is commonly employed by researchers. The parameters are the calorific value of residue and residue conversion factor. The estimations were made in country case study without taking into account another factor where some quantity of residues is diverted for contending applications. Therefore, this research presents a new mathematical technique called a Modified Nominal Bio-Power Capacity (MNBPC) by introducing the concept of residue availability factor. The new formulation is used for estimating the nominal power capacity of three corn residues (cob, straw and stalk) in Nigeria as a case study. A period of 15 years (1996-2010) is chosen for the estimation using corn production quantity obtained from United Nations Food and Agriculture Organisation while the calorific values of the sample residues are obtained experimentally. The computation is also based on the average of different gasification efficiency of 31% adopted from literature. A projection of 10 years (2011-2020) based on the new formulation was performed using linear regression which is in line with the plan of action to integrate bioelectricity into the nation's power sector by the year 2020. The least squares technique is considered to be superior for the projection because of its ability to correlate production quantity with time in a long forecasting scenario compared to other techniques. Based on the 70% collection rate (availability factor) of the residue surveyed in the country case study, computational findings estimated 2,570 MW (2.57 GW) nominal power capacity in the year 2010. This potential is approximately 33% of the total current installed capacity of 7,876 MW and 25.7% of the national electric power demand of 10,000 MW. The projection result shows that by the year 2020, a total capacity of 3,200 MW (3.2 GW) could be achieved with corn stalk residue exhibiting the highest potential of 73.1% of the total. This is based on 61% coefficients of determination between the residues' production trend with respect to time variation as evaluated using Pearson's Product Moment Correlation Coefficient. Finally, the estimated and projected potential in this study has shown a significant contribution from the corn residues to the proposed biomass power generation in the country.

ABSTRAK

Satu keinginan global bagi pembangunan tenaga mampan untuk mengurangkan pelepasan gas rumah hijau (GHG) daripada sektor tenaga telah mencetuskan usaha penyelidikan mengenai eksploitasi pelbagai jenis tenaga boleh diperbaharui. Walau bagaimanapun, kehadiran sumber biomas di hampir setiap pelusuk dunia ditambah dengan keupayaan untuk 'nyah-karbon' sektor kuasa elektrik apabila digunakan untuk penjanaan elektrik telah menarik perhatian yang sangat penting untuk dieksploitasi. Oleh itu, anggaran dan unjuran keupayaan potensi pelbagai jenis sumber biojisim untuk penjanaan kuasa adalah penting. Dalam anggaran dan unjuran potensi kuasa elektrik bio-sisa, penggubalan standard yang melibatkan hanya dua parameter biasanya digunakan oleh penyelidik. Parameter adalah nilai kalori sisa dan sisa-sisa faktor penukaran. Anggaran yang telah dibuat dalam kajian kes negara tanpa mengambil kira faktor lain yang mana beberapa kuantiti sisa dialihkan untuk aplikasi yang berbagai. Oleh itu, kajian ini membentangkan teknik baru matematik dipanggil "Modified Nominal Bio-Power Capacity" (MNBPC) dengan memperkenalkan konsep faktor ketersediaan sisa. Formulasi baru digunakan untuk menganggar kapasiti kuasa nominal tiga sisa jagung (Tongkol, jerami dan tangkai) di Nigeria sebagai kajian kes. Tempoh 15 tahun (1996-2010) dipilih untuk anggaran menggunakan jagung kuantiti pengeluaran yang diperolehi daripada Pertubuhan Makanan dan Pertanian Pertubuhan Bangsa-Bangsa Bersatu manakala nilai kalori sisa sampel diperoleh dari ujikaji. Pengiraan juga berdasarkan kepada purata kecekapan pengegasan berbeza sebanyak 31% diambil daripada kajian literatur. Satu unjuran 10 tahun (2011-2020) berdasarkan penggubalan baru telah dilakukan menggunakan regresi linear yang selaras dengan pelan tindakan untuk mengintegrasikan bioelektrik ke dalam sektor tenaga negara menjelang tahun 2020. Teknik kuasa dua terkecil dianggap yang terbaik untuk unjuran kerana keupayaan untuk mengaitkan kuantiti pengeluaran dengan masa dalam senario ramalan yang panjang berbanding dengan teknik-teknik lain. Berdasarkan kadar kutipan 70% (faktor ketersediaan) sisa yang ditinjau dalam kajian kes negara, penemuan pengiraan menganggarkan 2,570 MW (2.57 GW) kapasiti kuasa nominal pada tahun 2010. Potensi ini adalah kira-kira 33% daripada jumlah kapasiti semasa sebanyak 7876 MW dan 25.7% daripada 10,000 MW permintaan kuasa elektrik kebangsaan. Hasil unjuran menunjukkan bahawa menjelang tahun 2020, jumlah kapasiti sebanyak 3,200 MW (3.2 GW) boleh dicapai dengan sisa tangkai jagung mempamerkan potensi tertinggi sebanyak 73.1% daripada jumlah keseluruhan. Ini berdasarkan kepada 61% pekali penentuan diantara halatuju pengeluaran sisa berbanding kepada perubahan masa sebagaimana dinilai menggunakan Momen Pekali Korelasi Product Pearson. Akhir sekali, potensi yang dianggarkan dan diunjurkan dalam kajian ini telah menunjukkan sumbangan yang ketara daripada sisa jagung untuk penjanaan kuasa biojisim yang dicadangkan di negara ini.