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2nd International Conference on Circular Economy, Renewable Energies and Green Hydrogen in Africa

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Preface

Introduction

The rapid increase in energy costs due to the double effect of inflation and currency depreciation means that smart choices driven by research, development, demonstration, and sustainability should lead the way, especially as they affect the growth of developing countries.

African countries, therefore, have the opportunity to leverage the current global economic situation for sustainable technology enhancement and growth, and also transition towards green and sustainable pathways while securing energy needs and ensuring modern energy fuels from alternative and non-conventional sources. These energy sources, therefore, can easily be made available to the population at affordable and competitive prices.

This conference focuses on Africa and seeks to bring together various stakeholders such as academia and research scientists, industrialists, small and medium-scale enterprises, technocrats and political actors, NGOs, etc. to exchange knowledge on the following:

1. Establishing facilities.

2. Producing and marketing different green fuels and renewable energy options.

3. Creating an alternative sustainable future for Africa.

4. Advocating and considering the energy and fuel needs of rural, peri-urban, and urban communities.

5. Shaping the inclusive green pathways within the continent.

The conference will create an opportunity for thematic interactions between various stakeholders and carve out a unique growth pathway for the African continent and its partners.

Background

In most of the African countries, access to electricity and modern energy fuels is still a big concern for the population. More than half of the population in Sub-Saharan Africa (SSA) representing about 570 million people, still lack access to electricity, while only about 18% of the population have access to modern fuels for cooking. What is more worrying is the fact that many of the countries with even high access to electricity are overly dependent on fossil fuels as a primary energy source. For instance, Ghana's electric generation capacity is heavily dependent on light crude oil and natural gas, meaning price fluctuations on the international market have a direct effect on consumers. Similarly, fossil fuels account for about 86% of South Africa's primary energy demand. These conditions as examples are alarming as many countries in Africa are facing major challenges due to massive debts, lack of maintenance, and system failures raising the need for new investment in the transition of the sector.

The need for diversification of energy and fuel sources, investment in technologies, and a new paradigm shift in energy and fuel access is more urgent than ever before. In addition, even though Africa is not a heavy emitter of greenhouse gases, the current situation of overdependence on fossil fuel coupled with the growing demand for energy and fuel as the economy expands and a strong positive population growth rate means the business-as-usual case will not persist for long. Rather sharp increases in greenhouse gas emissions are expected over the near to long-term future.

Even though the use of biomass as an energy source is predominant in Sub-Sahara Africa, it is mostly used in its raw state thus posing health hazards as a result of incomplete combustion. On the other hand, the amount of waste produced is also increasing due to various factors such as urbanisation, increased economic activities, rise in living standards, etc. Based on which waste management is also becoming one of the most pressing challenges faced by most of the countries on the continent. Although the per capita waste generation of Africa is lower compared to other, more developed continents, the lack of treatment technologies, finance, and legal and regulatory mechanisms makes the management of waste a very challenging aspect.

The lack of treatment has resulted in many calamities in several African countries including flooding, cholera outbreaks, pollution of surface water bodies and the ocean, and the pollution of the marine environment. Lastly, the generation of agricultural residues as a result of agriculture and agro-processing activities across the continent presents a great opportunity for energy transition. The diverse and large quantities of agricultural residues generation, amounts of energetic valuable wastes, and utilisation of non-conventional fuels mean various energy carriers can be developed and generated using these residues to meet or supplement Africa's energy and fuel demand. The current situation offers a window of opportunity for Africa to transition from a more dependent fossil-based economy to a more sustainable green economy pathway through technology, knowledge, and skills leveraging to support rapid transition and economic growth.

Objectives

The main objective of the conference is to encourage a discussion on Africa's green transition to modern sustainable fuels to setup an action plan in each of the countries in Africa. Thus, the conference will offer the opportunity to the following objectives.

Interact & share

Researchers, academia, industry policymakers, and other stakeholders to interact and share ideas.

Create a platform for continuous exchange

Pathway to green energy Development of a strategy and action plans with specific focuses of individual countries on the transition towards green and sustainable energy and fuel economy.

Transfer technology

Enhance the transfer of technology and skills in the area of green energy generation.

Africa to the world - connect

Build on research collaboration between researchers from Africa and the rest of the world.

Promote new technology Promote knowledge and experience sharing on various sustainable energies and fuel technologies.

Observation of regulations Creation of country-based protocols as suggestions for implementation within the continent.

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A - Biomass and Waste as a Sustainable Resource

(A-1) Strategies for improving the quality of low-pressured rice husks briquettes: A Mini-Review

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Abstract

In recent years, there has been a growing interest in the production of briquettes from biomass. While this has been encouraged through the advocacy for reducing, reusing, and recycling of waste as part of measures for attaining a sustainable green future and mitigating climate change, it is on the other hand a result of the energy deficit experienced in most parts of developing countries. Despite this advancement, the processing of rice husks briquettes using the low-pressured technique has been quite slow and a bit challenging due to the recalcitrant nature of rice husks resulting from their large grade sizes, low density, high silica content, and ash content. This paper brings together recent literature on the strategies for improving the quality of briquettes produced through low-pressure densification to establish the current state of knowledge. These include pretreatment measures such as carbonization and torrefaction intended to improve the physical and thermal properties of the biomass and resulting briquettes, hot compression technique, co-densification with other biomass, or the use of blends to improve bonding and curtail the ash content, and by increasing the application pressure of the machines without necessarily increasing energy consumption. Through this, the compression process will be enhanced thereby yielding briquettes that are dimensionally stable and durable. The paper also reports the potential of applying the aforementioned measures on rice husks intended for low-pressured densification. In the same vein, the measures of handling the briquettes without compromising their shelf life were highlighted. Having looked at the reviewed strategies, the paper also summarized some pathways for future application and possible adoption at domestic and industrial scales.

Keywords: Rice husk, briquettes, co-densification, low-pressure

(A-2) Factors affecting cookstove efficiency in utilization: Case of Chitetezo cookstove

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Abstract

Despite the promotion of one of the improved cookstoves, the clay stove, locally known as chitetezo cookstove in Malawi, there is still an outcry on the scarcity of woodfuel which has caused the prices of the fuel to rise and this has impacted household's welfare. A number of studies have rated the cookstove to be under IWA thermal efficiency tier rating 4 as it improves fuel saving by up to 46% from the use of the three stone open fire. However, there are some factors that cause the stove to be less effective as it is purposed to be while being used in homes. This research paper explored some of the factors that influence the cookstove's efficiency. The cookstove's thermal efficiency was pre-determined through a controlled cooking test and it was found to be rated 4 with a specific fuel consumption of 299g/kg. Thereafter, an uncontrolled cooking test was conducted in sampled households. There is a 33.8% increase in the average SFC from 299g/kg to 400g/kg and cooking time from 49.7 minutes to 51 minutes. The difference in SFC indicated a decrease in the effectiveness of the cookstove as it was being used by the cooks in the households. On average, the households that were sampled showed an income of Mk45,000 (25.95 USD) per month and an expenditure of MK8000 (4.61 USD) on fuel per month. Therefore the 33.8% increase in SFC was calculated to cause a rise in fuel expenditure by MK2,700 (1.56 USD) which is almost 6% of the average income of the sampled households.

The following factors were observed to have contributed to the increase in fuel consumption: time: Cooking time elongated due to the cook's multitasking, time taken from fire ignition to start of cooking, pot transition period, cooking procedure, and fuel overloading. The loss in fuel consumption translated into MK4000 per month. For the average income of the sampled households, this Mk4000 is an average of 10% of their income. Therefore, promotion of cookstoves needs to include the promotion of sustainable cooking habits. The model that was developed from the results has shown the difference in the stove efficiency as measured in controlled environments and in households where the stove's efficiency is affected mainly by the time taken to cook which is a result of the other cooking practices of the users. The model Y= 2.7X + 179 (where Y is the specific fuel consumption and X is the time taken to cook the food) was tested and validated only if the assumptions were taken into consideration. Therefore, this model can be a helpful tool in assessing the differences of many other stoves that are being developed. This will help to prevent overestimated benefits in fuel savings that the new technologies may bring if they were only tested in the laboratory. The further important part of the model is that it can also be extended to calculate the amount of money being spent unnecessarily due to the reduced efficiency of the cookstove.

Keywords: Cookstoves, thermal efficiency, fuel consumption, Modelling

(A-3) Valorization: of leaves and wood teak into briquettes and pellets

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Abstract

Every year in Togo, teak plantations produce large quantities of dead leaves and first thinning products, which are unfortunately a source of fuel for bush fires. These fires affect forest resources and are accompanied by significant greenhouse gas emissions, which are responsible for climate change. However, these by-products can be valorized into ecological charcoal and pellets to add value to teak plantations and diversify cooking energy sources. The general objective of this study is to contribute to the sustainable management of teak plantations in Togo through better valorization of dead leaves and products of first thinning. Specifically, the aim is to study the energy characteristics of green coals and pellets produced from dead leaves and first thinning products from teak plantations. To this end, samples of dead leaves and first thinning products from Togo's teak plantations were collected, dried at 105°C and then ground. These shreds were then compressed to produce five types of briquettes and pellets, three of which were blends of leaf and wood shreds at different percentages. The briquettes were carbonized to produce ecological coal. The energy characteristics of the different coals and pellets produced were determined through analysis followed by combustion tests. The energy characteristics obtained vary from one fuel to another. The calorific value of coals ranged from 17123±38.89 to 29280±16.97 KJ/Kg. Pellet calorific values range from 17394±24 to 18629±14 KJ/Kg. Teak plantation by-products have the potential to make a significant contribution to satisfying household cooking energy needs.

Keywords: Teak, dead leaves, first thinning products, pellets, energy characteristics, calorific value, ash content

(A-4) Exploration of agricultural and agro-industrial wastes as raw materials to produce biological control agents

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Abstract

On its official website under "Understanding Poverty", the World Bank indicates that healthy, sustainable, and inclusive food systems are essential to achieving global development goals. In addition, agriculture is also a key factor in economic growth: in 2018, it represented 4% of global gross domestic product (GDP) and, in some least developed developing countries, its share can exceed 25% of GDP. As proof, the agricultural sector represented in 2018, 28% of Côte d'Ivoire's GDP and 40% of the country's exports. Finally, note that 70% of Ivorian industries use agricultural products as raw materials. Unfortunately, the sustainability of the agricultural sector is threatened by multiple abiotic and biotic constraints that affect yields, the environment, and human health. Furthermore, one of the main factors that cause damage to the environment is pollution caused by the use of chemical pesticides for the control of harmful insects and plant-pathogenic microorganisms. In this regard, biological control using microbial pesticides, particularly those based on Trichoderma virens and Bacillus thuringiensis (Bt), constitutes an interesting alternative to chemical control. Despite the many advantages that microbial biopesticides offer, their application has long been limited due to the relatively high production costs due to the culture medium. According to the World Bank, 2.01 billion metric tons of waste is generated annually worldwide which is expected to rise up to 3.40 billion metric tons by 2050. These wastes can prove to be an ideal cost-effective raw material to produce value-added products including biopesticides. To do this, a collection of residues will be made according to the richness in carbohydrates and nitrogen. Additional physical and chemical analyzes will be carried out before carrying out culture tests to assess the suitability of the different media for the growth and sporulation of our bioagents. At the end of the work, our results suggest that agricultural residues rich in carbohydrates, carbon/nitrogen and minerals (P, K, Mn, and Fe) such as corn bran, ripe mango flesh, cassava water Fermented cashew apple residue, rice bran, yam peels and cashew apple juice can be used as alternative media to produce Trichoderma virens and Bacillus thuringiensis. The results of this study, in addition to reducing the production costs of Trichoderma virens and Bacillus thuringiensis, thus offer prospects for the formulation of microbial biopesticides at lower cost to strengthen the sustainability of the agricultural sector. In perspective, we wish to optimize the yield of alternative media and evaluate their impact on the secondary metabolites of our two microorganisms to consider large-scale production.

Keywords: Recovery, waste, biotechnology, biopesticides

(A-5) Evolution of some physicochemical parameters during the composting of agricultural waste: case of corn and sorghum stalks

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Abstract

Composting is a technique for recovering waste by transforming it into a stable, humus-rich finished product, compost, to help improve soil fertilisation and crop yields. Maize and sorghum stalks are by-products of farming activities, widely available, renewable and virtually free of charge. They are a real source of organic matter, mainly made up of lignocellulosic compounds that can be used in agriculture as an organic amendment. The aim of this study is to monitor changes in a number of physico-chemical parameters, in particular temperature (T°), organic matter (OM) and hydrogen potential (pH), during the composting process for this agricultural waste. To this end, a composting study was carried out in Koudassi (Togo) with the aim of understanding the decomposition process of these stalks. A total of six composts were produced, namely compost A (100% maize stalks), compost B (100% sorghum stalks), compost C (70% sorghum stalks + 25% cow dung + 5% ash), compost D (65% sorghum stalks + 35% cow dung), compost E (50% sorghum stalks + 50% cow dung) and compost F (35% sorghum stalks + 65% cow dung). The results showed that the temperature of the six composts ranged from 29.42°C to 60.46°C, showing two phases: oxidation, characterised by an increase in temperature, and mineralisation due to a drop in temperature. Organic matter decreased during the process, with losses of 35 to 40% for composts B, C and E and 40 to 50% for composts A, D and F. This decrease can be explained by the degradation of the substrates, which undergo significant mineralisation. The pH of the six composts was basic and varied between 9.08 and 10.18, showing that there was no acidification phase at the start of the process. From the changes in these physico-chemical parameters of the various windows, we can deduce that the composts produced are mature.

Keywords: Composts, agricultural waste, soil improvers, maize, sorghum

(A-6) Estimation of Abattoir Waste for Bioenergy as Sustainable Management and Knowledge, Attitude and Practice of Workers among Selected Abattoirs towards Utilization of Abattoir Waste; Eastern Ethiopia

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Abstract

Livestock production in abattoirs is considered a potential food for the world's needy people and huge amounts of abattoir waste are generated from them in all parts of the world. This becomes a major pollutant and the possibility to increase of greenhouse gases, when the abattoir wastes are not properly managed; in addition, when it discharges into waterways, it can introduce enteric pathogens and excess nutrients into surface water, which is a major environmental challenge in all parts of the world particularly in developing countries. These problems are happening due to the lack of well-designed abattoirs, lack of regulations on restriction and prohibition of abattoir wastes discharge, the insufficient skill of human power, poor quality of equipment of abattoir, and lack of political awareness. Yet, Eastern Ethiopia abattoirs have been releasing their huge amount of waste into an open environment without any management system. In addition, there wasn't data available on the quantification of abattoir waste and greenhouse gases estimation as well as a study on perception of abattoir workers in this study. Therefore, knowing the quantity of abattoirs and the knowledge, attitude, and practice levels of workers is significant for future improvement. Different types of mathematical models were used to estimate abattoir waste generation, greenhouse emission, biogas, and Bio-fertilizer while a questionnaire was used for the survey part. Accordingly, the study reported that about 4.40ton/day and 1,606ton/year of abattoir waste was estimated and 2,581kgCo2/day and 887,768kgCo2/year of greenhouse gases were estimated from disposal sites of abattoirs. When returning to bioenergy, about 233m3/day and 85,139m3/year of biogas and 324kg/day and 111,249kg/year of bio-fertilizer were estimated. Into cost, about $160(4578ETB)/day and $55,645 (1,589,216ETB)/year of price was estimated from disposed abattoir waste sites. In the study survey, 267 (99%) of the respondents participated in the study. The other investigation of the study was to assess the level of knowledge, attitude, and practice of workers towards abattoir waste. Accordingly, the majority of the workers had good knowledge (76%), neutral attitude (72%), and fair practice (83.9%) towards issues of abattoir waste. Descriptive statistics of the study revealed that education, work experience, and income salary had significant with their knowledge level (M=1.24, SD =0.37), attitude (M=3.65, SD =0.83), practice (M=1.43, SD =0.34) of workers (p-value<0.05). The correlation revealed significant positive linear correlations between knowledge-attitude (r = 0.404, p = 0.013); knowledge -practice (r = 0.229, p=0.009); and attitude -practice (r = 0.717, p= 0.023).

Keywords: Abattoir, Attitude, Bioenergy, Knowledge, Management, Sustainable, Waste

(A-7) Assessment of the degradable organic fraction of household and similar waste from the Aképé Technical Landfill Center (Togo): potential for recovery by anaerobic digestion

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Abstract

In this work, four series of physical characterisations of household and similar waste (HSW) from the Aképé Technical Landfill Center (Togo) were carried out over two years, in 2022 and 2023, with the aim of assessing the degradable organic fraction of the waste mass, made up of putrescible (food waste and green waste), unclassified fuels (wood) and paper and cardboard (unsoiled), to which was added the category of "fines". To overcome the problems associated with the evolution of this fraction, which is a source of biogas production, wells have been placed in the waste mass to capture this biogas, which is then burnt through a flare, causing environmental impacts. The composite samples HSW1 (rainy season) and HSW2 (dry season) from 2022, HSW3 (rainy season) and HSW4 (dry season) from 2023, all in triplicate (three days), underwent physical characterisation using the MODECOM household waste characterisation method, by size (large: > 100 mm, medium: < 100 mm and > 20 mm, and fine: < 20 mm) and by category (Putrescible, Paper-Cardboard, Textiles, Plastics, Unclassified Fuels, Glass, Metals, Unclassified Incombustibles, and Specials) on the large and medium fractions with the exception of the fine fractions, where the breakdown by category was not carried out because of the difficulties of sorting small pieces, followed by an assessment of the content of degradable organic fraction recoverable energetically by anaerobic digestion. The results of this assessment showed that the average values for degradable organic fractions were 67.54 ± 17% for HSW1, 68.64 ± 18% for HSW2, 66.48 ± 16% for HSW3 and 70.71 ± 18% for HSW4. It was therefore concluded that samples taken during the rainy season contained less degradable organic fraction than samples taken during the dry season, regardless of the year. In addition, the recoverable degradable organic fraction represents more than 66% of the composite waste samples from the Aképé Technical Landfill Center.

Keywords: landfill, degradable organic fraction, household and similar waste, biogas.

(A-8) Assessment of the bioenergetic potential of slaughterhouse wastewater in the port zone of Lomé

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Abstract

The increase in world population and industrial development have increased the consumption of energy resources. This has led to an increased use of fossil fuels which, unfortunately, are becoming increasingly rare, hence the need for new energy sources, including bioenergy, a renewable energy source. Our aim in this study is to evaluate the bioenergetic potential of slaughterhouse wastewater, the performance of certain control factors, the kinetics of organic matter removal, and biogas production by anaerobic digestion process for environment preservation.

The biomass used is slaughterhouse wastewater and COD, BOD5, pH, and NTK parameters are analysed. Wastewater collected from a slaughterhouse was characterized according to the French standard method "AFNOR, 1986". The following parameters were analysed: pH, Temperature, Chemical Oxygen Demand (COD), biochemical oxygen demand in five days (BOD5), total Kjeldahl nitrogen (TKN), and the ratio BOD5/COD was calculated to evaluate the biodegradability of the biomass. 1L bioreactors were used in batch mode. The medium was inoculated with activated sludge.

The biogas production was evaluated by the water displacement method. The COD, pH, temperature and influence of the C/N ratio parameters are monitored to optimize biogas production. The BOD5/COD > 0.5 ratio shows that slaughterhouse wastewater is easily biodegradable. The pH was between 6-9 and the temperature in mesophilic conditions was between 25°-30°C.

The specific production of biogas would be around 550 mL/gCOD, 395 mL/gCOD, 280 mL/gCOD and 160 mL/gCOD respectively for the ratios R1 = 0.337, R2 = 0.505, R3 = 1.011 and R4 = 2.028. The inoculation enhanced the biogas production whereas a decrease in C/N would have an inhibition effect. The average percentage of methane in the biogas produced is around 74%. The energy equivalent of 1 m3 of this biogas with 74% methane is equal to 24.3 MJ/m3.

An efficient management of the slaughterhouse wastewater in the port zone of Lomé can be a promised source of energy.

Keywords: Biogas, renewable energy, inoculum and biodegradable

(A-9) assessment of energy potential of residential solid waste in asokore mampong municipality.

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Abstract

Waste management is a major challenge for various nations for which Ghana is no exception. The amount of waste generated from the capitals keeps increasing at a faster rate without increasing facilities to match its management. In the Asokore Mampong Municipality, for example, all the waste generated ends up at the final landfill sites without any recovery of the valuables. Administration of waste requires reliable data which could assist in the management process. Waste types and generation rates, composition, and calorific value of waste were studied over a four-week period in the Municipality. Mini-questionnaire interviews and surveys were employed in the collection of data among low, middle, and high-income neighbourhoods in the study area. The data were analysed using excel and Oxygen Bomb Calorimeter (Parr 6400). The generation rates of 0.344kg, 0.484kg and 0.580 kg/cap/day in the various classes neighbourhoods respectively with a mean rate of 0.470 kg/cap/day. The compositions of the residential solid waste were dominantly organics 68%, plastic 15.4%, papers and cardboard 6.1%, metals 5%, glass 2%, and textiles 1%. and 2.5% "Others''. The calorific values of the major components: organic, plastic, paper, textile, paper, and cardboard were found to be 15.835±0.168, 33.979±1.251., 13.229±0.0281, 18.340±0, and 17.219±0.0262MJ/kg respectively with a mean calorific value of 19.72±0.2273MJ/kg. The calorific values of combustible contents of household waste in municipal solid waste were reported to be 7.5GMWh per day as the cumulative energy content in the municipality, which is potentially good for waste-to-energy recovery through incineration. The data documented on the generation rate, physical characteristics, and calorific value in the Municipality would play a positive role in sustainable solid waste management through resource recovery and also help stakeholders in solid waste management policy formulations.

Keywords: Waste Generation Rate, Waste to Energy, Household Waste, Separation Efficiency.

(A-10) Physicochemical Properties and Energy Potential of Combustible Municipal Solid Waste from Lomé, Togo

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Abstract

The adoption of thermochemical conversion processes with combustible municipal solid waste (CMSW) was widely used around the world, but a misunderstanding of the waste stream composition under any given region often leads to their operationalization failure. Indeed, this study aims to fill the knowledge gap regarding the properties of CMSW from Lomé under the climate conditions of wet and dry seasons. A characterization campaign was conducted for the physical composition of waste fractions, then proximate and ultimate composition assessment of CMSW, such as putrescible, non-classified combustible (NCC), plastic, textile, and paper & cardboard was carried out, as well as energy and ash content. The results showed that putrescible had the highest weight proportion, with a significant difference among waste fractions from the wet and dry seasons. The highest moisture content was obtained from the textile and putrescible in the wet and dry seasons, respectively. Globally, textile and plastic achieved the highest and lowest volatile and fixed carbon contents, respectively, while putrescible and plastic achieved the highest ash content in the wet and dry seasons, respectively. The highest carbon, hydrogen, and oxygen contents were obtained from textiles, whereas the highest nitrogen-sulfur content was obtained from plastic. The energy potential was in the order of plastic > putrescible > textile > NCC > paper & cardboard. Moreover, silicon dioxide (SiO2) and calcium oxide (CaO) were predominantly obtained from waste fractions, whereas manganese oxide (MnO) achieved the lowest concentration. The overall results demonstrated that the CMSW could be used for energy recovery on a dry basis, while on a wet basis with a relatively high moisture content, a proper thermochemical process should be adopted for energy conversion efficiency. In addition, it is recommended to adopt good waste segregation practices to reduce the presence of fines from municipal solid waste, thereby reducing ash and oxide content.

Keywords: Waste Characterization, Energy Potential, Proximate Analysis, Ultimate Analysis, Combustible Municipal Solid Waste

(A-11) Improving the Properties of Biofuels through Thermochemical Treatments: Principal Component Analysis (PCA) of the Effects of Torrefaction and Carbonization.

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Abstract

Although lignocellulosic biomass is a promising source of renewable energy, its undesirable physicochemical properties limit its efficiency and versatility in energy applications. To overcome these obstacles, this study focused on improving biofuels derived from lignocellulosic biomass through two thermochemical treatment methods: torrefaction and carbonization. Principal Component Analysis (PCA) was used to evaluate the impact of these treatments on the properties of the biofuels, including calorific, physicochemical, mechanical, and combustion characteristics. Sawdust from five tropical woods (Samba, Iroko, Dibetou, Dabema, and Fraké) was selected for this study, treated by torrefaction and carbonization, and then densified for specific energy applications.

The results show a significant variation in specific fuel consumption. Torrefied Samba (Sam t) consumes 0.69 kg/L, whereas carbonized Samba (Sam c) consumes 1.48 kg/L. This difference suggests that torrefaction could provide a more efficient use of biofuel compared to carbonization, likely due to a higher resulting energy density from the torrefaction process. In terms of higher heating value, torrefied biofuels also showed promising results. Torrefied Samba (Sam t) has a heating value of 23,983 kJ/kg, while torrefied Iroko (Iro t) reaches 27,442 kJ/kg. These figures exceed those obtained by carbonized biofuels, suggesting that torrefaction could be the preferred method to maximize the energy produced per unit of biomass.

The combustion rate, another key performance indicator, also varies depending on the treatment. Carbonized Samba (Sam c) burns at a rate of 3.07 g/min, while torrefied Iroko (Iro t) reaches a rate of 4 g/min. These variations demonstrate that thermochemical treatment not only influences energy density but also the speed at which the biofuel releases its energy, which is crucial for certain industrial applications. The results of PCA revealed that the initial properties of biomass play a significant role in the effectiveness of thermochemical treatments. Therefore, treatment strategies should be tailored to the specific characteristics of each biomass type to optimize the performance of the produced biofuels.

In conclusion, this study demonstrates that torrefaction and carbonization are promising methods to enhance the properties of lignocellulosic biofuels. The use of PCA has provided a better understanding of the complex effects of these treatments, paving the way for more efficient and environmentally sustainable biofuels.

Keywords: Lignocellulosic biomass; Thermochemical treatment; Torrefaction; Principal Component Analysis (PCA)

(A-12) Carbonization of mango waste for use as a biofuel

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Abstract

Face of climate change and the harmful effects of the misuse of fossil fuels, the use of new and renewable energies is essential as a solution for the salvation of humanity. In addition to the harmful effects of the misuse of fossil energy sources, there is the pollution of the environment by plant waste such as post-harvest waste (cocoa pods, rice husks and straws, coffee, and peanut shells, etc.) but also waste from the consumption of fruits such as mango stones and skins or other foodstuffs of plant origin. This plant waste, left in nature, releases toxic gases and is a nuisance to the environment as well as to human and animal health. However, this waste can be upgraded to be used as biofuel.

Côte d'Ivoire produces between 180,000 and 200,000 tons of mangoes per year. But 40% of this production ends up in post-harvest losses, not counting mangoes which are left in nature and therefore become putrescible waste. They are therefore harmful to the environment while they can be transformed into biofuel. It is with a view to recovering this waste energetically that samples of mango kernels from Côte d'Ivoire were collected to be carbonized in a muffle oven. The aim is to determine the experimental conditions for the manufacture of biochar from these mango kernels.

From the experimental results obtained, it appears that a heating rate of 10°C/min to reach a maximum temperature of 250°C and a maintenance time at this temperature of two (2) hours make it possible to obtain a good-textured charcoal with a calorific value of 34.98 MJ/kg. These results show that mango kernels can be validly transformed into biochar and used as fuel just like charcoal. Its large-scale production can therefore become a source of income for the producers of this fruit.

The rest of the study will be devoted to the popularization of the results obtained, the analysis of the gases produced by combustion, and the manufacture of carbonizers for the transformation of mango kernels into biochar.

Keywords: Mango; mango kernel; biofuel; higher calorific value; Côte d'Ivoire

(A-13) Toxicity, Nutritional Quality, and Microbial Loads of Source-Separated Dried Food Waste as Poultry Feed

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Abstract

On a global scale, a third of food prepared, manufactured, and distributed is wasted. This costs the global economy $2.6 trillion annually. In Ghana, daily, 20 tonnes of waste is sent to the landfill. Food waste comprises 60%. This study aims to depict how food waste generated from sources can be collected, heat-treated, and included in poultry feed diets confirming its potential with sensory and market analysis. Two heat treatment alternatives (oven vs rotary drying) were incorporated into food waste treatment to ascertain which is more economical and efficient.

Food waste collected was categorised into Cereals & Grains (CW), Roots and Tuber (R&T) and Vegetable (VW). The general feed formulation of FW was 60% CW, 40% R&T and 10% VW. A total number of 250 Ross broilers were assigned five treatments in a completely randomised design for 7 weeks. Treatments design consisted of control (T1), 50% FW (T2), 50% FW with 2% soybean oil (T3), 100% FW (T4) and 100% FW with 3% soybean oil (T5).

Data were analysed using one-way analysis of variance (ANOVA) using the generalized linear model procedure of SAS Statistical software. A comparison of means was performed using Tukey's Studentized Range (HSD) test at a probability of 5%. The dehydrated food waste had 8.49% - 14.538%, 2.85% - 16.42% crude protein, fat 0.35% - 1.45% and fibre of 20.3% -30.96% respectively and average metabolizable energy of 2421.67 Kcal/kg. The results indicate the treatment group, T2 (50%FW) had the highest body weight with 2743.32g. The next treatment by body weight was a FW diet with 50% maize as well however inclusive of soybean oil (T3) with a body weight of 2361.53g. Corresponding with body weight and FCR (1.76), the feed intake of T2 was 3.39kg. Subsequent treatments (T1, T3 and T5) conformed to this positive relationship except for T4 which had a poor FCR of 2.3 despite a high feed intake of 2.9kg. Abdominal fat was within the expected range of 17.75g – 33g with the highest amount of fat being 50% FW with 2% soybean oil as expected. Internal and visceral organs were discovered to be within range, indicating a level of good health amongst birds. Hematological parameters of WBC, RBC, and HCT were at low levels, suggestive of anemic conditions yet to manifest. The microbial analysis confirmed the presence of bacteria and fungi active on feed, indicating feed to be of lesser quality. Toxicological analysis did not bear much influence on growth performance due to their minute amounts. Sensory analysis performed by 10 participants resulted in food waste inclusion meat dry matter 50% FW being selected as the overall best.

Keywords: Food waste, Poultry Feed, Heat Treatment, Data Analysis, Microbial Analysis

(A-14) Valorization of Cocoa Pods in Côte d'Ivoire: An Eco-Friendly Promising Solution for Hospital Wastewater Management.

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Abstract

The growing global population and increasing pharmaceutical consumption have led to a rise in water pollution, particularly from diclofenac and ibuprofen. These drugs, commonly used for pain relief and fever reduction, pose significant environmental threats due to their persistence in aquatic ecosystems. Adsorption has emerged as a promising and economical method for removing these pollutants from wastewater. In Côte d'Ivoire, the world's leading cocoa producer, cocoa pods, a byproduct of cocoa production, represent a substantial agricultural waste stream. Often neglected, these pods can be transformed into biochar, a material with remarkable properties for wastewater treatment. Biochar's porous structure and high surface area make it an effective adsorbent for capturing and removing contaminants like pharmaceuticals, pathogens, and organic pollutants. This study explores the potential of cocoa pod biochar as a sustainable solution for treating pharmaceutical wastewater. We investigated the preparation and characterization of biochar and functionalized biochar derived from cocoa husks for the removal of diclofenac and ibuprofen from aqueous solutions. Our findings demonstrate that both biochars exhibited an acidic surface, as confirmed by zero-point charge pH values and surface function quantification. This acidic nature is advantageous for the adsorption of pharmaceuticals, which are predominantly basic in nature. Batch adsorption experiments revealed that both biochars effectively removed diclofenac and ibuprofen within 10 minutes. The optimal adsorption pHs were found to be 1 and 2 for diclofenac and ibuprofen, respectively. These results suggest that the adsorption process is strongly influenced by the pH of the solution. Mathematical modeling of the adsorption kinetics indicated that pseudo-first and second-order models best described the adsorption behavior of both pollutants. The high R2 values obtained for these models suggest that a monolayer chemisorption process occurs on an energetically heterogeneous surface. Furthermore, thermodynamic studies revealed enthalpies below 80 kJ/mol, confirming physisorption as the primary adsorption mechanism. Positive entropies indicated an endothermic process, while decreasing negative free energies with temperature suggested a decrease in adsorption feasibility at high temperatures. These findings highlight the potential of cocoa pod biochar as a sustainable and efficient adsorbent for removing diclofenac and ibuprofen from wastewater. The utilization of this biochar not only addresses the issue of pharmaceutical pollution but also valorizes an abundant agricultural waste stream, contributing to a circular economy approach. Further research is warranted to optimize the adsorption process and evaluate the performance of cocoa pod biochar in real-world wastewater treatment scenarios. This research demonstrates the potential of cocoa pod biochar as a sustainable and effective solution for removing pharmaceuticals from wastewater. The utilization of this biochar not only addresses the issue of pharmaceutical pollution but also valorizes an abundant agricultural waste stream, contributing to a circular economy approach.

Keywords: Pharmaceutical Pollution, Wastewater, Agricultural Waste, Biochar, Mathematical Modeling

(A-15) Synthesis of lactic acid from sugarcane molasses collected in Côte d'Ivoire by Lactobacillus fermentum using a batch fermentation process

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Abstract

Lactic acid has a wide range of applications, particularly in the pharmaceutical, cosmetic, chemical, and food industries. One of its primary uses is as a precursor to polylactic acid (PLA), a biodegradable and biocompatible polymer that serves as a sustainable alternative to conventional plastics derived from fossil fuels. Current research efforts are focused on reducing the high production costs of PLA to enhance its competitiveness with petrochemical-based plastics. Côte d'Ivoire produces about 10,000 tonnes of molasses annually, yet potential valorization pathways remain unexplored, leading to the indiscriminate disposal of this by-product. Using molasses as a raw material offers a promising cost-reduction strategy due to its low cost and high glucose content. In this study, the production of lactic acid from sugarcane molasses under laboratory conditions using Lactobacillus fermentum was investigated. Experiments were conducted in batch mode (in a bioreactor) to determine the appropriate operational parameters for efficient lactic acid production. The study involved defining the bioreactor parameters, inoculating Lactobacillus fermentum, and fermenting the molasses. In a batch system, 2 liters of molasses substrate diluted to 32 g/L (sugar content) were directly added to the bioreactor. Various concentrations of Lactobacillus fermentum (5%, 10%, and 15% v/v) were introduced into the fermentation medium. Molasses fermentation was monitored over a period of 72 hours, with sampling and analysis every 8 hours. The highest concentration of lactic acid (36.4 g/L), with a yield of 0.33 g/g and a selectivity of 62% relative to other secondary metabolites, was achieved in the molasses fermentation with the addition of 10% (v/v) starter culture over a period of 72 hours. This study demonstrates the potential of using locally sourced molasses for sustainable and cost-effective lactic acid production in Côte d'Ivoire.

Keywords: Lactic acid, Molasses, Cost reduction, Fermentation

(A-16) Methanogenic potential of Palm oil mill Effluents

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Abstract

The processing of palm fruit into crude oil results in the production of various residues, of which liquid effluents are the most significant, with 0.5 - 0.8 m3 of effluents produced per ton of processed seed bunches. The systems put in place to treat this waste have revealed some shortcomings and still entail a number of environmental risks. To remedy this situation, an alternative is being considered: anaerobic digestion, which is recognized as a sustainable process. In addition to treating palm oil mill effluent, this technology offers the prospect of making this activity profitable through the production of energy (gas, heat, electricity). However, given the high acidity (pH = 4.74), load (COD = 60,716 mg O2/ L), and VFA content (VFA = 5000.33 mg/L) of palm oil mill effluent, it will be important to monitor these parameters during digester tests to reduce the risk of acidosis, a limiting factor in methane production. BMP tests carried out over 39 days at a constant temperature of 37°C, using sludge from a stationary digester as inoculum, revealed a methane yield of 205.195 Nml CH4/g MV. This shows that palm oil mill effluent is an excellent source of renewable energy. In order to stabilize the reaction medium and achieve these yields on a larger scale, we need to find more suitable and optimal parameters.

Keywords: Methanization; palm oil mill effluent; methanogenic potential.

B- Green hydrogen production, utilization, policy, regulatory framework, industrial requirements and transition

(B-1) Mauritania's Green Hydrogen Revolution: A Beacon of Hope for Sustainable Prosperity

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Abstract

As the world grapples with the challenges of climate change, Mauritania is poised to take a giant leap forward in the quest for sustainable development. By harnessing its abundant renewable energy resources, the country is set to become a global leader in green hydrogen production. This groundbreaking transition promises not only to significantly reduce carbon emissions but also to unlock new economic opportunities and drive growth. This paper explores the strategic initiatives and far-reaching implications of Mauritania's green hydrogen projects, and how they can pave the way for a more sustainable, diversified, and prosperous future.

Keywords: Green Hydrogen, Renewable Energy, Sustainable Development, Economic Diversification, Mauritania, Green Steel

(B-2) Systematic literature review of hydrogen production technologies, feedstocks and pathways, and its prospects in sub-Saharan Africa.

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Abstract

This study aims to address the data gaps hindering the development of a hydrogen market in sub-Saharan Africa (SSA) by conducting a systematic literature review on hydrogen production technologies, feedstocks, and pathways. Through analysis, practical avenues for further research and development on hydrogen production in the region are identified, considering financial and environmental factors. After systematically screening four (4) databases (Google Scholar, Scopus, Science Direct and Springer) following the PRISMA Protocol, 62 articles meeting all inclusion criteria underwent full review and quantitative analysis. Results indicate that 80% of articles identified steam methane reforming (SMR) of natural gas as economically viable but environmentally polluting. Meanwhile, 60% favoured water electrolysis with renewable energy and 13% preferred biomass-derived hydrogen as the most environmentally friendly hydrogen production method. Given SSA's abundant solar and biomass resources, and taking environmental friendliness as a key parameter, the authors recommend exploring solar-powered electrolysis and biomass gasification for hydrogen production in the region. Additionally, developing regional and national hydrogen development strategies is crucial to outlining a roadmap, setting deployment targets, and engaging key stakeholders. These findings provide policymakers and investors with updated data on hydrogen technology, guiding future hydrogen initiatives in sub-Saharan Africa.

Keywords: Hydrogen, Production, PRISMA, Technology, sub-Saharan Africa, Clean Energy.

(B-3) Leveraging the Green Hydrogen Economy to Promote Gender Equality: A Synergistic Approach

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Abstract

The movement towards a green hydrogen economy, characterized by hydrogen production through renewable energy sources, is not just a response to climate change but a unique and timely opportunity to enhance sustainable development and generate extensive economic opportunities. By 2030, up to 139 million new jobs are projected to be created in the global energy sector, with 38.2 million in the renewable energy sector alone. The transition to renewable energy and the circular economy could potentially generate over 100 million jobs by 2050. This growth is not limited to the sector but also has the potential to significantly promote gender equality. In 2019, the renewable energy sector employed 11.5 million people, with women making up 32% of the workforce, compared to 22% in the overall energy labor force. This data underscores the potential for a just energy transition to bridge gendered gaps that have become systemized (UN, 2021b). However, without immediate and inclusive policy interventions, these opportunities may perpetuate gender disparities in the energy sector, and it is essential to address the gender gap in the energy sector, especially as many new jobs in the green economy will be in traditionally male-dominated sectors and occupations.

This paper delves into the intersections between the burgeoning green hydrogen sector and gender equality, proposing actionable strategies to ensure women play an integral role in this transformative industry. It not only scrutinizes current gender dynamics within the renewable energy sector and pinpoints barriers that impede women's participation and advancement but also highlights the significant role women can play in the green hydrogen sector. Through an in-depth literature review and case studies from various countries, the paper underscores best practices and successful models of gender integration in energy projects. A noteworthy example is Solar Sister in Kenya, a social enterprise that has empowered women through clean energy entrepreneurship in East Africa. Solar Sister has trained over 5,000 women entrepreneurs, equipping them with the skills and resources to market solar-powered products and clean cookstoves. This success story not only aids in alleviating energy poverty but also fosters economic empowerment among women, instilling confidence in the potential of gender integration in the green hydrogen sector. Furthermore, the paper presents a comprehensive framework for policymakers and industry stakeholders to embed gender equality principles in developing the green hydrogen economy. This framework ensures a comprehensive approach to gender integration. It includes essential components such as Education and Workforce Development, Policy and Regulatory Measures, Support for Women-Led Enterprises, Inclusive Work Environments, and Monitoring and Evaluation. Each component is detailed and addresses a specific aspect of gender integration, providing a clear roadmap for action.

Keywords: Green Hydrogen, Circular Economy, Gender Equality, Renewable energy, Energy Transition

(B-4) Green Hydrogen Production from Floating Photovoltaic Systems (FPV) in Existing Hydropower Dams for Decarbonization and Sustainable Energy Transition in Africa.

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Abstract

Recent research has shown that integrating Floating Photovoltaic Voltaic (FPV) technology into Africa's hydropower dams has enormous potential. This integration could double installed capacity and improve energy generation by 58 percent. Despite this promising growth, there is a need to address the delivery of this generation to sectors and regions disconnected from the grid. In this analysis, we extend this opportunity to explore green hydrogen (GH2) and its potential to facilitate the delivery and decarbonization of fossil-fuel usage in the transportation, electricity, and heat production sectors. Our study evaluates this GH2 potential from FPV in 31 African countries, including Egypt, Ethiopia, Ghana, Nigeria, Mozambique, South Africa, and others. We used secondary data from the literature to comprehensively analyze the GH2 potential from the FPV, water consumption, fossil fuel replacement, and corresponding greenhouse gas emission reduction (CO2) in these countries. We employed three scenarios for our analysis based on the efficiency of three types of electrolyzers: Alkaline, Proton Exchange Membrane (PEM), and Solid Oxide Electrolyzer (SOE). The result reveals that Egypt has the highest potential of 0.189Mt of hydrogen using the PEM scenario; likewise, the PEM scenario has the highest production potential for all countries and could generate 1.282 Mt of hydrogen annually with an average water consumption of 46.2 ML (without accounting for losses). This could replace a total of 4853 ML of gasoline combustion, contributing to about a 4 percent reduction of the total 1311 Mt CO2 emissions reported in the transportation, electricity, and heat production sectors in the year 2021 in Africa. This innovation could be a game-changer in the renewable energy transition strategies and contribute to accelerating decarbonization efforts in African countries.

Keywords: Green Hydrogen, Hydropower, Floating Photovoltaics, Energy Transition, Decarbonization.

(B-5) Deep learning-enabled image analysis of oxygen bubble dynamics in proton exchange membrane water electrolyzers

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Abstract

The massive exploitation of fossil fuels to drive industrialization and sustain exponential population growth is the cause of human-made climate change and many other adverse impacts on the environment. This situation increases the urge for the transition towards renewable energy technologies. Green hydrogen, as an energy storage option, represents an inherent part of this shift. With the aim to produce and store hydrogen on a large scale, significant strides are being made to enable the development of economically viable proton exchange membrane (PEM) water electrolyzers. However, water electrolyzers suffer from performance loss due to the formation and accumulation of oxygen bubbles on the anode side. Understanding the processes involved in bubble formation and transport and their impact on transport and reaction properties in the anode catalyst layer is crucial for efforts in the design and optimization of PEM electrolyzers. Manual analyses of bubble distributions turn out to be inefficient, unreliable, and expensive. The presented study represents an effort to overcome these limitations, using an approach based on deep learning for the reliable and rapid analysis of bubble size distributions in electrolyzer modes. The work encompasses the training and evaluation of a UNet (2D) model on a collection of 35 manually annotated images for semantic segmentation, followed by the analysis of bubble area distributions. Results that will be presented demonstrate good model performance and robustness. The deep learning-based approach employed offers the benefit of rapid and precise analysis of thousands of bubble images, thereby providing a more accurate representation of bubble dynamics. While the results obtained in the present study are promising, the trained model struggles to individually identify bubbles that are close to each other, indicating that improvement is needed. Future work encompasses training a more advanced model using a semantic segmentation approach, real-time extraction and statistical analysis of bubble parameters, and establishing correlations between these extracted parameters and validating them against the physical model.

Keywords: Artificial intelligence, deep learning, oxygen bubble dynamics, autonomous analysis, proton exchange membrane electrolyzers.

(B-6) Waste Recovery In The Design Of Microbial Fuel Cells

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Abstract

For many years, the aquatic ecosystem has been under great threat caused by the intense pressure of industrial activities, particularly that of oil, which is the most consumed energy resource in the world. Specifically, it will be a question of characterizing its refinery effluents, of being able to identify the autochthonous microorganisms that can degrade its hydrocarbons.

Characterization of wastewater by analysis of physicochemical parameters such as pH, TDS, CE, BOD, COD, MES, etc., The values of the parameters before treatment are: pH = 6.5-7.5; MES: 0.03-0.04 g/l; EC: 5.2-8 ms/cm; COD: 750-1600 mg/l BOD: 300-1000 mg/l. Several strains can also be isolated, namely Bacillus, Pseudomonas aeruginosa, Sphingomonas changbaiensis, Pseudomonas stutzeri,

The isolates which have degraded the hydrocarbons will be put into an electrochemical process to produce energy. This study reveals the possibilities for further developing biotechnology and water treatment.

Keywords: Water treatment, Microbial Fuel Cells, Physicochemical Parameters, Energy Production

(B-7) Analysis of the influence of humidity on the electrical performance of a PEM Fuel Cell.

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Abstract

Research and development of fuel cell systems for various applications have experienced a significant surge over the past ten years. The proton exchange membrane fuel cell (PEMFC) emerges as one of the most promising alternatives for stationary and automotive applications, aiming to replace traditional systems such as internal combustion engines. However, the operation of these fuel cells is strongly influenced by various operating variables such as temperature, pressure, and humidity. This article presents a numerical model developed in the MATLAB/Simulink environment, incorporating all major auxiliary components (air and hydrogen supply line, cooling and humidification circuit) as well as the PEMFC unit to analyze its performance. The developed model allows for the estimation of the influence of various parameters on the fuel cell's performance throughout its lifecycle. This study focuses on evaluating the effects of relative humidity on the electrical parameters of a PEMFC in automotive applications. The simulation results indicate that a decrease in relative humidity, particularly at the cathode, leads to a significant decline in fuel cell performance, resulting in reduced voltage and power. Similarly, the greater the number of cells in the fuel cell, the more pronounced the influence of relative humidity. In contrast, gas humidification at the anode does not have a significant impact on the fuel cell. Additionally, this study highlights the importance of optimizing operating conditions to enhance the efficiency and durability of PEMFC systems in real-world automotive applications.

Keywords: Fuel cell, relative humidity, performance, numerical model.

(B-8) Enhancing Biohydrogen Production through Dark Fermentation of Food Waste: A Review of Substrates, Inoculums, and Pre-treatment Strategies

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Abstract

The growing population and economic expansion have led to an increased demand for energy while also presenting complex challenges in waste generation and management, particularly in light of climate change. In the context of a circular economy, waste management through bioenergy production is gaining increasing attention, resulting in extensive research on waste bioconversion methods and strategies. Green hydrogen, which is considered a major future renewable energy carrier, can also be generated from food and food processing waste through a process known as dark fermentation. The production of dark fermentative hydrogen from food waste and food processing waste, as well as from organic residues in general, is influenced by pretreatment of the feedstock and the type of inoculum used in the process. This review provides a critical assessment of food waste and food processing waste sources, with a focus on their physical and chemical compositions, pretreatment methods, and strategies for optimizing dark fermentative hydrogen production. This paper also highlights and critically discusses various inoculum types and innovations related to the pretreatment and enrichment applications of inoculums for dark fermentative hydrogen production. The reviewed literature indicates that food waste and food processing waste possess complex physical and chemical compositions that contain inhibitors of dark fermentation. The major pretreatment strategies employed in the literature for these waste sources include thermal, chemical, thermochemical, ultrasound, enzymatic, bacterial, and physical pretreatments. Pretreatment methods for hydrogen production have yielded mixed results. While some methods have a positive effect, others have a negative effect on productivity. The sources of inoculums for dark fermentation of food waste and food processing waste vary and include anaerobic digestion effluents, animal manure, wastewater treatment effluents, river sludge, soil, and compost materials. These inoculums are often treated with heat and enriched through acclimatization and cultural strategies. However, ineffective treatment and handling of the inoculum can result in hydrogen consumption by H_2 consumers during dark fermentation. To address this issue, further research is needed to develop more sustainable and specific pre-treatment methods that consider the characteristics of food waste and food processing waste, as well as the nature of the inoculum. This will help prevent inhibition and inefficiency during dark fermentation.

Keywords: Dark Fermentation; Biohydrogen; Food waste; Inoculum; Pre-treatment; optimization

(B-9) Biohydrogen Production from Pineapple Peels Waste by Dark Fermentation

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Abstract

The lack of proper management of pineapple peel waste has been an environmental and health challenge in developing countries such as Togo. Pineapple peel wastes could be a promising feedstock in the generation of bioenergy such as biohydrogen and biogas which has the potential to be used for cooking, transport, and electricity generation. This study assessed the feasibility of theoretically producing biohydrogen from pineapple peel waste through dark fermentation. A biogas test was also conducted from which a 53.0% methane production from the biogas was assumed to theoretically calculate the biohydrogen production potential. This process offers the best solution for properly managing pineapple peel waste, reducing the environmental and health impacts of releasing greenhouse gases (GHG) into the atmosphere and accelerating the energy transition.

The ultimate analysis of the pineapple peel sample was conducted using an Optic digital microscope (LIBS Analyser) VHX-7000 and the results show carbon 44.40%, hydrogen 9.40%, and oxygen 40.90%. These results were then used to theoretically calculate the biohydrogen production potential. The proximate analysis was conducted to determine the moisture content, total solids, and volatile solids in the pineapple peel sample. The fiber analysis test was also done for cellulose, hemicellulose, and lignin contents using Fibretherm. The biogas test was conducted in bottles using the pineapple peel sample. The loading was such that 5 g of the sample, 200 g of inoculum, and 100 g of water were added into the bottles and then placed in a water bath at a mesophilic temperature of 380C for 21 days.

The results obtained from the theoretical biohydrogen production was 3.5 moles and the biogas test was 493.14 mLg-1VS. The estimated theoretical hydrogen production potential from the 53.0% methane yield in the biogas assuming 90% conversion efficiency was 1045.84 mLg-1VS.

Keywords: Biohydrogen; Dark fermentation; Pineapple peels; Energy transition; Greenhouse Effect

(B-10) Green Ammonia Production Project by Africa Green Hydrogen Partners: Feasibility Study and Perspectives

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Abstract

Africa faces unprecedented challenges due to its growing population and increasing demand for food and energy. To achieve the 1.5-degree target set out in the Paris Agreement, it is crucial to address climate change through sustainable development policies that take into account the special vulnerabilities and development needs of African countries.

Green hydrogen, produced from renewable energy, is seen as a key solution for decarbonizing sectors such as industry and transport. It offers opportunities for intra-African trade and export to regions with high energy-intensive demands. Green hydrogen is emerging as a significant issue for the global economy, being decisive for various sectors, including agriculture.

African Green Hydrogen Partners (AGH2) is at the forefront of the hydrogen revolution in Africa, focusing on agriculture, energy production, and power generation. AGH2 aims to promote sustainable development and reduce dependence on fossil fuels. By integrating hydrogen technology with solar systems and other renewable sources, AGH2 delivers innovative solutions that stimulate economic growth, create jobs, and foster a sustainable future.

A key initiative by AGH2 is the green ammonia production project in Kolondieba, Sikasso region, Mali. The project is structured in two phases:

- Phase1 (2027-2035): Pilot phase with a scalable capacity.
- Phase2 (2035-2040): Expansion phase.

Green ammonia has the potential to revolutionize agriculture by reducing the carbon footprint of fertilizers and other agricultural products, supporting the agri-food industry, and aligning with broader sustainability goals. The project methodology includes technical studies, economic analyses, and environmental evaluations. Preliminary results indicate significant environmental benefits and promising economic potential.

This project underscores the central role that green hydrogen, particularly via the green ammonia pathway, can play in the decarbonisation of Africa and the planet, with significant socio-economic impacts. AGH2 welcomes partnerships to enhance its technical expertise and expand its network within the renewable energy sector, contributing to a sustainable and resilient future for African countries.

Keywords: Green hydrogen; Green ammonia; Decarbonization

(B-11) Exploring Bioenergy with Carbon Capture and Storage (BECCS) Technologies – Its Application to Biogas System Upgrading and Green Hydrogen Production: A Review

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Abstract

Bioenergy generation is a widely adopted approach that is considered to be carbon-neutral. Even though it is neutral, the CO_2 released from biomass-generated energy contributes to the same atmospheric effects as CO_2 obtained from fossil fuels. Bioenergy with Carbon Capture and Storage (BECCS) is a decarbonization tool for mitigating climate change. This advanced technology involves capturing, transporting, and storing the resulting CO_2 produced from any energy pathway derived from a biogenic source such as biofuels, electricity, heat, or hydrogen. Carbon capture technologies used in bioenergy include absorption, adsorption, membrane separation, chemical looping, cryogenic distillation, and hydrate-based separation. These carbon capture and storage (CCS) technologies are being modified to fit into bioenergy technologies making up BECCS technologies. Based on the literature BECCS technologies being investigated comprise woody biomass combustion, fermentation, gasification, biogas upgrading, municipal solid waste combustion or landfill gas combustion with CCS, and algae-based BECCS through thermochemical processes. According to the International Energy Agency, the current rate of biogenic CO_2 capture is about 2 million tonnes per year. Based on these 60 million tonnes of CO_2 is estimated to be captured annually by 2030. While the 2050 net-zero scenario requires capturing approximately 185 million tonnes of CO_2 per year, implying that more BECCS projects must be implemented. Although BECCS is currently more prevalent in bio-ethanol/methanol production its usage in other forms of biofuels and electricity generation is gradually increasing. The potential to capture and sequester carbon from bioenergy generated from the organic fraction of municipal solid waste and agricultural residue is lower than the amount required to achieve the net-zero scenario. Meeting this target puts pressure on the utilization of first, second, and third-generation biomass leading to environmental sustainability and economic concerns. These challenges include sustainable biomass, land use change, soil erosion, biodiversity loss, and water use. Some literatures highlight economic challenges such as price increases on agricultural commodities through competition for land. From a technological perspective, low energy efficiency due to the high energy consumption of BECCS technologies is also a major challenge. To mitigate these challenges various possible solutions have been proposed such as the use of vertical farming as a possible solution to mitigate land use challenges. This paper will explore the benefits and problems of BECCS and conduct an in-depth assessment of the respective improvement techniques proposed in other studies. The gaps in BECCS technologies will be analyzed, and possible solutions assessed. The review paper aims to provide a comprehensive understanding of the BECCS technology's potential for achieving climate change mitigation goals based on their respective technological readiness level.

Keywords: Net-zero emissions, BECCS, Technological readiness, System Upgrading, Green Hydrogen

(B-12) Creation Of A Comprehensive, Workable Plan Based On Research That Would Enable Togo To Use Alternative Fuels To Augment Its Needs For Industrial Energy.

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Abstract

The study looks at how Togolese energy crops or waste might be used in industry to replace fossil fuels. It looks at co-processing and pre-processing workflows, calculates kinetic parameters, and assesses the kinetic needs of pyro systems. The results of the study show a relationship between process severity and Higher Heating Value (HHV), with HHV being strongly influenced by temperature and reaction time. Developing green industry strategies and optimizing waste management are the goals.

Keywords: Energy crops, Waste, Alternative Fuels, Higher heating value

(B-13) Sustainable energy transition in ceramic production and recycling: An overview

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Abstract

Ceramics are manufactured by firing clay materials at high temperatures in furnaces. High energy and fuel costs are the two main drivers leading to the decline of the ceramic sector of Ghana. Unlike countries such as China, Japan, the United Kingdom, the United States of America, etc., the cost of these resources is borne by the local manufacturers without any subsidy by the government. This results in high production costs thereby leading to the influx of imported cheap products from China, Japan, and the like. This research project aims to provide a sustainable energy alternative for the ceramic industry which is consistent with the Ghanaian government's aim to further develop the sector. The authors consider a solar PV system with battery storage connected on-grid to be established in Tamale, Ghana as the most efficient and practicable solution for the manufacture of ceramics. The production capacity is 5 tonnes per year. It is estimated that the proposed system should be able to reduce close to 7500 kg per year of carbon dioxide (CO_2) emissions into the atmosphere. This research seeks to make ceramic production locally more affordable to salvage the Ghanaian ceramic industry. The attainment of United Nations Sustainable Development Goals (SDGs) 7 (affordable and clean energy), 9 (industry, innovation, and infrastructure), 12 (responsible consumption and production), and 13 (climate action) would be realized from the implementation of this project. The project will attract PhD and Master students with an interest in renewable energy; non-governmental agencies (NGOs) will be integrated to raise awareness, technology diffusion, and sector-specific outreach to promote the benefits of sustainable management practices; and provide local employment opportunities, among others. Finally, four main capacity-building workshops will be organized on the topics: (1) plant operation and maintenance (2) plant optimization (3) plant sizing and specification (4) training courses and workshops for all relevant stakeholders. This will serve as a strong basis to replicate the idea in other regions of Ghana and to a larger extent other African Countries.

Keywords: Ceramics, Energy Transition, Sustainable Development, Capacity Building

C- Legal regulatory framework governing waste utilization and financial models

(C-1) Circular Economy as a Tool for Development and Sustainability Program with emphasis on Solid Waste Management at Abesim Community: GCfPEE.ACCC CIDA.PAPR.ICURA:IDRC-SSHRC-.AMPLE-USAID.amg

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Abstract

In an attempt to provide long lasting solutions to problems of waste generation and disposal, which most often leads to an outbreak of diseases and loss of lives such as cholera, food poisoning etc. in 2009, the Malaspina: Ghana-Canada Partnership for Environmental Education (GCPfEE) - Association Canadian Community Colleges-Canadian International Development Agency (ACCC-CIDA) was launched, which continued 5 years to Protected Areas & Poverty Reduction (PAPR) project under the International Community University Research Alliance (ICURA) program, funded by International Development Research Centre (IDRC) - Social Sciences and Humanities Research Council of Canada (SSHRC), international partnership with Sunyani Technical University, Kwame Nkrumah University of Science & Technology (KNUST) Faculty of Forest Resources Technology (FFRT), and Vancouver Island University (VIU) Canada. This study is an action research program in which several knowledge mobilization strategies were used at the Abesim Community to collect information on current ways of waste collection and disposal:, mainly pickups and burning of solid waste at the landfill site at the Abesim Community. The quantity of waste generated by households was not known by the study. The waste generated by the households was not segregated, according to 55 percent of the respondents of this study stated, 56 percent of the solid waste generated by households, ends up at the banks and the shores of our drainage systems and water bodies such as in Accra at the beaches on the same lane of the location of the Dr. Kwame Nkrumah Museum, Arts & Cultural Center where International Fair Trade, Nature-based Solutions, Circular Economy, etc certified and crafted products (empty plastic bottles of Kaesar Apple non-alcoholic drinks, Special Ice Grape Fruits non-alcoholic drinks, etc. and empty pure Natural Mineral Water sachets bags used for school, traveling, both ladies & guys bags, etc.) are exhibited and marketed. It is recommended by this study that there should be more education on waste management and adequate technical and financial resources should be provided in order to curb the problems of waste in our communities in Ghana.

Keywords: Circular Economy, Replicator, Climate Reality, Climate Smart.

(C-2) An Economical Analysis Of Household Waste Recovery

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Abstract

The issue of waste recovery constitutes a real concern for governments despite the various laws that govern this sector with regard to the direct economic impact which is overestimated compared to other impacts such as the environmental and social impact. Thus, the objective of this study is to quantify the available waste deposits and to identify and characterize the economically viable waste recovery sectors.

The methodological approach implemented is characterized by household surveys on a sample in 13 municipalities of the Autonomous District of Greater Lomé, semi-structured interviews with institutions and organizations and actors involved in the waste management chain, physical characterization for quantitative and qualitative analysis of waste, and then an economic analysis of waste streams recovery.

The physical characterization of household waste at source highlighted a production of 469 626 tons/year of household waste with the predominance of the Fines fraction (39.8%) and biodegradable waste estimated at 30.7% including 2.3% paper and cardboard. The plastic fraction is estimated at 10.9%, i.e. a production equivalent to 9000 t/year. Metals, glass, and electronic waste represent less than 1.5% each.

The economic analysis shows that in the plastics waste sector, the average benefit-cost ratio is 1.8. Thus, for 1 FCFA invested, an average financial reward of 0.8 FCFA is obtained. The flow captured and recovered for biodegradable organic waste is 2.5% and the flow remaining to be recovered amounts to 97.5% (116,369 tonnes/year). Concerning the Fines fraction, the remaining fraction to be captured is 99.36% (154,044 tonnes/year). The economic analysis makes it possible to establish that the composting sector presents an average benefit-cost ratio of 1.6 over 5 years for the promising option which is the co-production of compost and potting soil. Thus, for 1 FCFA invested, an average financial reward of 0.6 FCFA is obtained. For the glass waste sector, the residual deposit estimated at 4,896 tonnes/year seems considerable enough to invest in this sector; the economic analysis makes it possible to establish that the glass sector (powder production) presents an average benefit-cost ratio of 2.2 for the sector considered optimal (mono valuation: powder production). Thus, for 1 FCFA invested, an average financial reward of 0.5 FCFA is obtained in year 1 compared to 0.9 FCFA in year 10. For the paper-cardboard sector, the captured flow is around 1,000 tonnes/year and the remaining flow is estimated at 9,003 tonnes/year. The economic analysis shows that the cardboard paper industry is characterized by an average benefit-cost ratio of 2.0 over 15 years. Thus, for 1 FCFA invested, an average financial reward of 0.6 FCFA is obtained in year 5 and 2.4 in year 15 with financial support per tonne of waste collected and then recovered.

Keywords: Household waste, Waste characterization, economic analysis, waste streams and recovery

(C-3) Accelerating circular economy transitions in Accra, Ghana: A system dynamics model analysis

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Abstract

Transitions towards a circular economy are increasingly recognized as an avenue of critical importance for cities' sustainable development. Municipal Solid Waste (MSW) management is inherently linked with such a transition, becoming an issue of increasing global concern, mainly due to its health and environmental implications. The negative consequences of unsustainably managed MSW are particularly evident in developing countries, where landfilling and open burning are the dominant practices. However, a successful transition from the current linear model towards a resource-efficient circular economy model requires a shared understanding of the interplay among the building blocks of the circular economy and the interaction among various decision factors. Moreover, planning for sustainable MSW management has to address several inter-connected issues such as landfill capacity, environmental impacts, and financial expenditure. It, therefore, becomes increasingly necessary to understand the dynamic nature and magnitude of these interactions.

This paper explores the dynamic nature of the transition dynamics that impact Accra's transition pathways towards a Circular Economy. A System Dynamics (SD) modelling approach is employed, to develop a model representing Accra's MSW system. SD is a prevailing method to simulate the environmental, societal, and economic impacts of various policies. It facilitates coping with increased complexity via identifying the causal structures underlying the behaviour of a system and permitting to proactively experiment with the system through simulation. The SD model developed in this paper simulates the entire process of MSW production, sorting, collection and final treatment, to estimate the economic, environmental and social impact of possible circular transition scenarios for Accra and assess the focal points of policy. Based on a 20-year timeframe, seven scenarios were simulated, the amounts obtained for sorting and recycling, composting, and disposal in landfills were evaluated, as well as the investments needed for implementing the policies and the resulting revenues and operational costs. The analysis is based on secondary data along with empirical evidence from forty-seven in-depth interviews, three transition management workshops, and field observations of the authors. The results show that energy recovery from waste management demonstrated the highest environmental impacts, in terms of GHG mitigation, yet it requires a longer timeframe for the benefits to be realised. In the short-run, composting, along with the promotion of waste sorting and recycling initiatives need to be prioritised.

This paper makes three unique contributions to the sustainability transitions literature. First, it provides an SD-based conceptual model (causal loop diagram) that enables the analysis of different transition dynamics at landscape, regime and niche-level for a circular transition of a SWM system, providing a synthesis of the socio-technical transitions frameworks with the SD modelling literature.

Second, it develops a simulation model (stock-and-flow diagram) that enables gaining knowledge on the effects of different CE strategies on specific indicators, that define the city's sustainability performance.

Third, it discusses how the use of SD modelling enables the analysis of scenarios that can boost the circular economy as a new form of thinking of current urban planning and management issues, considering trade-offs and opportunities and the capabilities of such a model to facilitate CE transitions under different contexts, in particular for developing countries.

Keywords: Circular economy, System dynamics, Waste treatment, Model simulations

(C-4) Circular economy in Africa: old wine in new bottle?

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Abstract

The circular economy has been presented as a paradigm for sustainable development. A circular economy is regenerative and restorative by intention and design. In this presentation, I will question the novelty of the circular economy concept in the African context. Using a decade of research experience in Africa and the Global North context, I will show that the circular economy is not an entirely new concept in the African context. African economies including households and industries have long engaged in resource efficiency and effectiveness activities which can be described as following circular economy principles e.g., the recovery of scrap metals and the extensive repair of e.g., electronics widespread in many African countries. Nonetheless, the circular economy initiatives in Africa are often not by intention and design and are largely driven by resource constraints, cheaper labour and the necessity to be effective with limited resources. Thus, the CE practices are sub-optimised and focused on the recirculation of materials where there is a ready market e.g., metals and plastics. This does not lead to societal transformation and radical changes but rather path dependent and incremental improvements. To challenge this African narrative and drive a real shift towards a circular economy, there is a need for a more intentional approach to the circular economy driven by design and life cycle thinking. Furthermore, African economies have had limited success with the re-circulation of organic materials through for example anaerobic digestion to produce biogas which could go a long way to address multiple challenges such as waste management, energy needs and the creation of local jobs. Thus, my presentation will serve as a wakeup call for both practitioners and researchers highlighting the state of circular economy in Africa and show areas where there is a need for active research and practitioner effort to drive a real change and impact towards a circular economy and where there are real economic opportunities.

Keywords: Waste management, Circular Economy, Sustainable Development, Recycling

(C-5) Challenges and Opportunities in The Adoption of Circular Economy Principles by Businesses in Developing Countries

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Abstract

This presentation explores the multifaceted challenges faced by businesses in developing countries when adopting circular economy (CE) principles. The circular economy, a restorative industrial model, aims to minimize waste and optimize resource use by closing the loop of product lifecycles through enhanced efficiency, reuse, and recycling. The adoption of CE principles holds significant promise for sustainable development, especially in developing nations grappling with resource scarcity and environmental degradation (Ellen MacArthur Foundation, 2013). However, despite its potential to drive sustainable development and economic resilience, the uptake of CE in these regions remains limited.

The discussion begins with a comprehensive review of CE concepts and their applicability to developing economies. CE offers a transformative approach to economic development by decoupling growth from resource consumption and environmental degradation. In the context of developing countries, CE principles can address critical issues such as resource scarcity, waste management challenges, and environmental pollution, thereby contributing to sustainable urbanization and industrialization. Analysing the barriers to CE adoption reveals several key impediments, including limited awareness, lack of technological infrastructure, inadequate regulatory frameworks, and financial constraints. Through case studies from various sectors such as manufacturing, agriculture, and waste management, specific areas where CE principles have been successfully implemented and the challenges encountered were highlighted

The potential benefits of CE adoption in developing countries are substantial, yet several barriers persist. Limited awareness and understanding of CE concepts among businesses and policymakers are significant obstacles. Additionally, developing countries may lack the necessary technological infrastructure and expertise to implement CE practices effectively. Inadequate regulatory frameworks and policy support can further impede the adoption of CE principles. Financial constraints also play a crucial role, as limited access to finance can restrict the ability of businesses to invest in CE initiatives.

Several case studies illustrate successful CE implementations in developing countries. For instance, the recycling industry in India has created jobs and reduced environmental impact by processing electronic waste. In Kenya, the adoption of circular farming practices has improved soil health and increased agricultural productivity. In South Africa, the shift towards CE in the construction sector has shown promise in reducing waste and promoting the use of recycled materials. In Ghana the rapid development of compost and recycling plants has contributed significantly to job creation and the reduction of carbon emissions.

By elucidating the challenges and presenting actionable insights, this paper contributes to the ongoing discourse on sustainable development and offers a roadmap for businesses and policymakers aiming to transition towards a circular economy. By addressing resource scarcity, improving waste management, and enhancing economic resilience, CE can contribute to more sustainable and resilient economies. However, overcoming the challenges and barriers to adoption requires concerted efforts from businesses, policymakers, and other stakeholders. Through targeted capacity building, public-private partnerships, and supportive policy interventions, developing countries can harness the full potential of the circular economy.

Keywords: Circular economy, Policies, Waste management, Economic development

(C-6) SONAGED Leading Institution for Circular Economy in Senegal: Proposition of Rational Waste Management to Private Companies

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Abstract

SONAGED, created in May 2022, is the National Company for Integrated Waste Management in Senegal. The inclusion of Circular Economy represents one of the major changes during the transition from UCG (Coordination Unit for Waste Management, 2011-2022) to SONAGED. It embodies SONAGED's commitment to responsible resource management and significant contribution to environmental preservation. Leveraging its technical and scientific expertise, SONAGED is dedicated to promoting sustainable practices and implementing innovative solutions to optimize waste management and valorization. Aligned with the principles of the circular economy and adopting a proactive approach, SONAGED plays a crucial role in transitioning from a linear economy to a circular one, respectful of our planet in Senegal. Indeed, as outlined in our strategic plan "Eksina", this transition involves creating an industrial ecosystem around waste, encompassing collection, sorting, valorization (reuse, recycling, or solid recovered fuel), and ultimately minimizing landfilling for non-recyclable waste. Through SONAGED, Senegal enters a phase of waste industrialization with the management of treatment and valorization units, conducting extensive technological and scientific monitoring. Consequently, it can effectively advise private investors with projects in this field and raise awareness among waste producers. Based on this foundation, SONAGED can also provide reliable data to various stakeholders, including the government, institutions, and researchers. Lastly, drawing upon this wealth of experience, SONAGED is capable of proposing legislative texts to govern the waste sector. Recently, SONAGED has provided characterization services to private companies in Senegal in order to help them put in place an environmentally sound management system, thereby contributing to the circular economy. This study explores innovative waste management practices to encourage businesses to adopt viable and sustainable practices.

Keywords: Senegal, SONAGED, Waste management company

(C-7) Paradigm of Microfinance Circular Economy to Reduce Poverty or Not? – Achieving Sustainability

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Abstract

The objective of Sustainable Development Goals (SDG's) is to achieve a net-zero climate cuts across all economic targets. Microfinance is not a magic potion for poverty reduction. However, it is one among many necessary interventions to reduce poverty. Finance institutions are being pressured to finance circular projects and investments.

Achieving sustainability through microfinance within circular economy means increasing the ability of people to increase incomes through different activities promoting the reuse of waste materials from agriculture, forestry and other related activities under climate change conditions. This reflects an actual growing recognition that people need and use financial services to expand their choices and financial lives. Moreover, the question is how to create products or services from waste materials with a value proposition for making a difference.

Poverty is often the result of low economic growth or high population growth or very unequal distribution of wealth/resources. There is an argument that a concentration on a single intervention mechanism as credit is much less effective in poverty reduction. What if we add a differential product with social and environmental value? The combinations of microfinance and other instruments? will be more effective depending on the nature of poverty in a specific context. In this paper, we will explore microcredits as an incentive to reduce poverty and increase the income of rural communities. The main idea is to create additional value by creating incentives to the local population to conserve their forest while gaining 7-year incentives for not cutting the forest or using waste material. The paradigm is that products or services with social and environmental value are difficult to sell although however are more profitable.

While the positive impact of services on poverty reduction has been frequently referenced, most of the existing literature on microfinance circular economy lacks evidence of this impact. Despite this, many studies on some projects related to microfinance have showed significant improvement in lives of many low-income families. This study will focus on defining linear economic models to adopt effective market strategies with the environmental and social impacts of climate change.

Keywords: Sustainable economy, poverty reduction, green economy, trends of microfinancing in Africa.

D- Health, environmental, and Cultural Aspects of harnessing green energy in the African context

(D-1) Consumers' attitudes and valuation for renewable energy and electric vehicles: A case study from Centrale region of Togo

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Abstract
Decarbonizing residential building and transport sectors arguably depends on the choices of the final consumer. The two sectors' energy-intensiveness and domination of non-renewable energy sources constitute a huge challenge to energy sustainability in Togo. Moreover, transiting from conventional energy sources and vehicles to renewable energy and electric vehicles means paying a higher price for the latter than the former. Therefore, investigating final consumer attitudes can greatly contribute to the energy transition. The recently launched programs in Togo regarding renewable energy diffusion and decarbonization of the transport sector enable citizens to choose renewable energy (RE) sources and electric vehicles (EVs). However, are consumers willing to support additional energy costs due to energy transition and how can they be motivated to move towards such a behavior? These consumers' perceptions and inadequacy of price levels usually can constitute the main barriers to adopting and using RE and EVs. To answer these questions, this article aims to explore consumer attitudes and valuation for renewable energy and electric vehicles in the same context. Focusing on shifting outcomes, we explore consumer attitudes and valuation for renewable energy and electric vehicles in Togo using collected data from 462 households in the Centrale region. This region is selected based on its regional distribution regarding electricity access rate, solar home systems (SHS) market size, potential sensitivity of this market, and its social security and the absence of terrorism We employ the contingent valuation method with Tobit model estimation.

Results show that households mostly agreed that renewable energy and electric vehicles contribute to climate change mitigation. Households interviewed stated that finances, lack of recharging systems, and frequency of recharging limit their willingness to choose EVs. We estimate the willingness to pay for renewable energy at 42.10% more of the current annual energy cost and respectively at 36.6% and 42.40% more for electric motorbikes and cars of fuel-powered price. In terms of determinants, socioeconomic factors such as household size and dependency, age, marital status, life satisfaction, and homeownership were correlated with either their WTP for RE, or EEs. From the socioeconomic factors, younger generations should be addressed with awareness-raising campaigns on green mobility. As the increase in life satisfaction level could also contribute to the increase of WTP for RE and EVs, it is expected that upon achieving the economic level of the country, people in Togo will feel more satisfied and inclined to pay more for RE and EVs not only due to environmental awareness but also due to being able to pay more. This validates poverty reduction project initiatives and points out the fact that green transition and poverty reduction should not be perused separately.

Future research may identify the optimal bid in terms of the energy mix with production costs and the willingness to pay of Togolese households. This would resolve the problem of the reliability of willingness to pay and improve the relevance of the energy transition policy in terms of subsidies and transfers in the two energy-intensive sectors.

Keywords: Decarbonization, Renewable energy, Electric vehicles, Socioeconomic factors

(D-2) Can sustainable energy technologies power women's enterprises in Africa? A techno-economic analysis

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Abstract

In recent years, significant attention has been given to the energy access challenge, particularly in sub-Saharan Africa, to achieve universal access to modern energy by 2030. Assessing access to productive uses of energy is crucial as it impacts income-generating activities and enhances the economic sustainability of energy projects. Recognising women's roles in these productive activities can lead to more inclusive and effective energy solutions. However, their roles as end-users of energy products and services remain underexplored, especially in developing countries where research has primarily centered on household energy access.

Our research presentation builds on prior studies conducted by the authors across North, West, and East Africa which employed a mixed-methods approach to investigate current energy access levels of women entrepreneurs and the socio-economic potential for adopting renewable energy technologies. Building on this foundation, the study to be presented addresses specific energy access challenges of women entrepreneurs, such as limited availability and reliability of existing energy carriers, health impacts associated with fuel use, and affordability issues linked to current productive use practices. We evaluate the techno-economic feasibility of different renewable energy solutions tailored to the energy needs of women entrepreneurs running micro- and small-sized enterprises. We develop business models that effectively integrate these renewable energy solutions into their operations. The technical analysis for electric demands employs the HOMER Pro software to assess the potential of solar PV with battery storage and grid integration. Other renewable energy technologies, including waste-to-energy solutions, are examined for case studies with thermal energy needs. The study findings present economically viable and socially inclusive solutions, promoting more equitable and effective energy initiatives. These insights can inform the development of policies and programmes to advance universal energy access in the productive use sector, enhance economic opportunities and contribute to broader social equity and development across the African continent.

Keywords: Techno-economic analysis, energy access, energy products, health impacts

(D-3) Waste Collection and Management in Nigeria: The Artistic Approach

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Abstract

The Nigerian contemporary art scene has undergone significant evolution in both content and choice of media. The nation's emphasis on promoting a green environment has inspired artists to adopt a "waste to wealth" approach in their creative endeavors.

This study delves into the art of transforming waste into valuable resources for the purpose of environmental sustainability in Nigeria. The principles of waste management, focusing on reduction, reusing, and recycling, are explored through various artistic processes. The study also examines the role of art as a concept, highlighting how artistic activities contribute to the conversion of waste into wealth. Furthermore, the invaluable contributions of certain artists to waste management and environmental sustainability are analyzed.

A comprehensive review will be conducted on the initiatives of the Federal Government of Nigeria, including environmental policy development and the establishment of relevant agencies and legal frameworks. The primary objective of this research is to address the challenges associated with inadequate waste management and promote the creation of a green and sustainable environment. The analysis of the gathered data will lead to the conclusion that artistic activities, such as collecting discarded materials and creating art pieces from various media, are effective strategies for fostering environmental sustainability. As a result, it is recommended that visual artists be actively engaged in decision-making processes, environmental policy development, and the planning, design, and execution of urban renewal projects and initiatives.

Keywords: Artist, Waste Management, Waste Collection.

(D-4) Factors limiting renewable energy adoption (State of play and future prospects) in Benin, West Africa

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Abstract

Over the past years, growing interest is on energy sources generally particularly renewable energy sources in developing countries since access to modern, reliable, and affordable energy supplies while reducing energy use's negative environmental impacts. Therefore, it is relevant to assess the adoption level of these energy forms and the factors affecting them. This study combines quantitative and qualitative survey approaches to investigate uses and factors affecting renewable energy adoption. Respondents' socio-demographic characteristics as well as their quantified energy needs were involved and the survey focused on local adoption, uses, and perceptions of factors affecting the dynamics of renewable energy. The study highlights how the availability of technicians, engineers, analysts, managers, and consultants interact to influence renewable energy adoption. People living in urban areas with high occurrence of different types of jobs in renewable energy use them more than those living in rural areas with low occurrence. These energies are constantly renewed and play an important role in the energy transition. A high commercial potential in renewable energy exists and this allows to reduce greenhouse gas emissions and help gain independence and energy autonomy.

Keywords: Renewable energy, production expense, adoption, environmental impacts, Benin.

(D-5) Energy access implications for unserved communities in sub-Saharan Africa: Challenges and opportunities

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Abstract

Energy is the bedrock of development and a necessary derivative to improve the quality of life in unserved communities of sub-Saharan Africa. However, 473 million people in rural areas of sub-Saharan Africa continue to lack access to energy. The extension of the National grid to sparsely populated rural communities incurs high extension costs and is generally economically unviable. Renewable off-grid solutions such as solar mini-grids offer a faster and more feasible approach to energy access in rural communities. In addition to basic energy access, a range of social and economic benefits which include improved health, education, security, and economic prospects are expected to uplift existing limitations. Conceptually, the IEA definition of energy access offers a holistic and fundamental insight to the requirements of energy access, entailing that a base connection solely is not sufficient to improve a household's quality of life because the dynamics of development and electrification in remote communities are complex and involve many underlying forces. Hence, a one-way linear assessment of impacts is insufficient as projections rarely match reality. Successful deployment of off-grid systems requires a conducive enabling environment, including supportive government policies, access to financing, and community engagement. This paper revisits the current state of energy access in sub-Saharan Africa through the lens of a detailed outlook and aims to highlight the challenges as well as opportunities. It aims to provide an in-depth approach to understanding energy access and its potential to inform energy policies and investments in off-grid rural electrification. The findings suggest that renewable off-grid technologies can be a transformative technology for rural electrification but must be accompanied by holistic development strategies to maximize its benefits for unserved communities.

Keywords: Energy access, Off-grid systems, mini solar grids, Policies

E– Recycling of valuables

(E-1) Pyrolysis of Waste Polypropylene Plastics for Energy Recovery: Study Comparisons Between Bench Scale and a Commissioned Kilogram-Scale Rotary Kiln Reactor

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Abstract

Plastic recycling via pyrolysis has been identified as a promising route to managing these recalcitrant municipal solid waste streams due to its ability to handle significant levels of contamination and consequently yield products with huge fuel application prospects. Studies on the pyrolysis of waste polypropylene (PP) have been previously conducted on a bench-scale setup, where the effects of temperature, heating rate, and pressure conditions (atmospheric and vacuum) on the yields, calorific values, and chemical composition of condensable products were probed and optimized. The quest to commercialize plastic waste conversion to fuels has received strong attention in the past years. However, studies at bench-scale are relatively fundamental and still require further improvements before commercialization is possible. Pilot scale setups act as a perfect transition point between these two stages. Investigations on pilot setups allow for the implementation of the key conclusions made from bench-scale while also revealing possible bottlenecks that could possibly arise on commercialized scale setups. This makes provisions for prior mitigation of any such drawbacks. Hence, subsequent to a previously investigated bench-scale study, a 5 kg/h semi-continuous kilogram-scale rotary kiln reactor was assembled and commissioned on which conditions previously investigated at bench-scale were mimicked. In addition to the product yield investigations of the condensable products that were investigated, the products were also characterized in terms of fuel properties (that include, density, viscosity, boiling point range, and flash point), which were compared with commercial diesel (C11-C23) and gasoline (C6-C10) fuels. It was realised from the study that cracking reactions were attained at comparatively lower temperatures on the pilot-scale reactor as compared to the bench. Regardless, trends of product yield distribution with respect to temperature change were very comparable for both stages. Unlike for the bench-scale setup, diesel range compounds predominated all condensable products recovered from the pilot scale, which was corroborated by the pseudo-vacuum conditions of the pilot setup, limiting the cracking of heavier diesel range components into lighter gasoline range components. Condensable products recovered on the pilot scale setup exhibited hybrid characteristics of both diesel and gasoline and further downstream processing such as distillation was recommended to obtain pure fractions of these liquid fuels.

Keywords: Plastic waste, Pyrolysis, Chemical composition

(E-2) Using used tyres as soil and water conservation technology in Mali.

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Abstract

Microplastics are an emerging global threat in all ecosystems and have potential negative effects through multiple exposure pathways. In Mali, innovations such as the manufacture of chairs, sandals, decorative objects, etc. are being developed to reuse used tyres in order to combat environmental pollution. The special feature of this study is the experimentation with old tyres in agricultural plots to examine their effects on infiltration, runoff, moisture and soil loss. "Pneusol" works on the basis of gathering old tyres, cutting them into arcs, and positioning them in the ridges perpendicular to the direction of flows. The experimental set-up composed by control plot pair with a “pneusol” plot (30 m long and 10 m wide) has been installed on erosion crusted soil in Djindjila. Each plot has been isolated by corrugated sheets 30 cm high above the ground, embedded 20 cm deep. The results show the effectiveness of pneusol is quite significant, since it reduces the amount of water run-off by 34%, increase average moisture by 22.33% and reduce soil lost by 52.63% compared to control plot. The ability of tyres to limit runoff, improve infiltration and increase soil moisture, thereby stimulating agricultural production, has been demonstrated in this study. This result offers interesting prospects for farmers who are already experiencing the harmful effects of climate change. The effect of capturing and infiltrating run-off water, combined with the soil amendment, make “pneusol” technique an effective agricultural production technique on degraded land from the first year of implementation. Also, the repurposing of used tyres in a circular economy makes it possible to turn a potentially problematic waste into a resource, promoting a more environmentally friendly and long-lasting model.

Keywords: Agriculture, soil and water conservation, Circular economy, Tyres, Mali.

(E-3) APPE-MALI, Acteurs de la protection et la preservation de Environment-Bamako

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Abstract

Un système économique d'échange et de production qui à tous les stades du cycle de vie de produit et service visant à augmenter l'efficacité de l'utilisation des ressources et à diminuer l'impact sur l'environnement, tout en développant le bien être des individus.

Le code de l'économie circulaire créer par l'article 70 de la loi de la transition énergétique pour la croissance verte vers les années 2015 et modifié par l'article 2 de la loi relative à la lutte contre le gaspillage et a l'économie circulaire du 10 février 2020 précise que « la transition vers une économie circulaire vise à atteindre une empreinte écologique neutre dans le cadre de respect de limite planétaire et à dépasser la mobilité économique linaire ».

Cette même loi atteste que : Economie circulaire constitue un potentiel permettant d'optimiser le cycle de vie des produits à partir leur conception à leur fin de vie en passant par leur production, leur utilisation et réutilisation contribuant aujourd'hui de réduire, recycler et réutiliser

Fabriquer, consommer et jeter en appelant à une consommation sobre et responsable de ressource naturelle et de matière première primaire ainsi que par ordre de priorité, à la prévention de la production de déchets notamment par le réemploi de produit, suivant la hiérarchie de mode de traitement des déchets à une réutilisation, à un recyclage ou à défaut à une valorisation de déchets.

. C'est ainsi qu'un grand nombre d'initiatives visent la mise en place d'une économie circulaire en Afrique à travers une optimisation de l'utilisation de l'eau, recyclage, action multi acteurs, approvisionnement durable, éco conception, écologie industrielle et territoriale, de plus en plus on assiste que les entreprises africaines s'y engagent avec la nouvelle approche des ODD définissant dans son objectif numéro 7 : Eau propre et assainissement.

Une telle initiative consiste à soutenir l'Etat dans la réalisation de l'agenda des objectifs de développement durable (ODD).Exemple de personne de référence : M. IBRAHIM ALMOU à travers la création d'une unité de gestion et de transformation de déchets en pave et charbon écologique.

Une seconde initiative venant de moi-même qui m'a permis de mettre en place un réseau des entrepreneurs « APPE-MALI » évoluant dans le diffèrent secteur de l'économie circulaire sur toute la chaine de valeur (De la gestion de déchets en passant par la transformation en différentes matières).

Aujourd'hui le concept économie circulaire tourne essentiellement autour de la gestion des déchets et le recyclage, cet élément doit être envisagé comme une opportunité de transformation et non de mitigation en Afrique et ailleurs. Ainsi l'adoption d'une nouvelle approche circulaire inclusive, tenant compte de la multitude de petites et moyennes entreprises, leur importance et impact dans la protection et préservation de l'environnement compatible à l'agenda 2030 répondant aux normes des ODD.

C'est cet horizon que doit évoquer, dans nos esprits, la notion d'économie circulaire appliquée au continent africain et le reste du monde. Afrique reste confrontée à des risques environnementaux et climatiques très complexe.

Keywords: Circular economy, waste, recycling, Environmental protection**.**

(E-4) Recovery of Magnetic Particles from Wastewater Formed through the Treatment of New Polycrystalline Diamond Blanks

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Abstract

Cobalt's pivotal role in global development, especially in lithium-ion batteries, entails driving increased demand and strengthening global trading networks. The production of different waste solutions in metallurgical operations requires the development of an environmentally friendly research strategy. The ultrasonic spray pyrolysis and hydrogen reduction methods were chosen to produce nanosized magnetic powders from waste solution based on iron and cobalt obtained during the purification process of used polycrystalline diamond blanks. With specific objectives focused on investigating the impact of reaction temperature and residence time on the morphology, chemical composition, and crystal structure of synthesized nanosized cobalt powders, our research involved 15 experimental runs using two reactors with varying residence times (7.19 s and 23 s) and distinct precursors (A, B, and C). Aerosol droplets were reduced at 600 to 900oC with a flow rate of 3 L/min of argon and hydrogen (1:2). Characterization via scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), and X-ray diffraction revealed that higher temperatures influenced the spherical particle morphology. Altering cobalt concentration in the solution impacted the particle size, with higher concentrations yielding larger particles. A short residence time (7.9 s) at 900oC proved optimal for cobalt submicron synthesis, producing spherical particles ranging from 191.1 nm to 1222 nm. This research addresses the environmental significance of recovering magnetic particles from waste solutions, contributing to sustainable nanomaterial applications.

Keywords: cobalt; ultrasonic spray pyrolysis; hydrogen reduction; recycling

F - Development of strategies and implementation

(F-1) Predictive Modeling of Electricity Consumption in Togo using deep learning: A comparative approach

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Abstract

Electrical energy plays a vital role in daily life. Since the adoption in 2015 of the new United Nations (UN) Sustainable Development Goals (SDGs), a lot of attention has been paid to the energy sector in particular. SGD number 7 aims to ensure by 2030, access to affordable, reliable, sustainable and modern energy for all. Thus, understanding electricity consumptions growth remains a fundamental aspect to achieve universal access to energy. This research aimed to investigate the multivariate modeling of yearly residual electricity consumption in Togo by conducting a comparative approach between different deep learning algorithms. The analysis uses a data-driven approach based on postpaid residential electricity consumption data from Togo Electricity Company, aggregated at regional level, from 1940 to 2020. Alongside this consumption data, additional covariates where selected through a feature selection procedure based of correlation. The data were model using deep learning algorithms. Three algorithms were used namely Multi-Layer Perceptron (MLP), Convolutional Neural Network (CNN), Long Short-Term Memory (LSTM) and a hybrid CNN-LSTM model. The model's performances were assessed using Mean Absolute Error (MAE) metric. As a result, from this study, the CNN-LSTM hybrid model performed the best with an MAE of 0.062 KWh on test set while MLP, CNN and LSTM performed with an MAE of 0.091 KWh, 0.144 KWh and 0.148 KWh respectively. These results revealed the potential of deep learning techniques in modeling yearly residential electricity consumption in Togo. Thus, the utility company can rely a such deep learning model to right-size its residential electricity supply for a more sustainable energy use and a fair and cost-efficient green energy transition.

Keywords: Electricity consumption; Growth; Modeling; Deep learning; Togo

(F-2) In-depth waste flow analysis and determination of plastic leakage potential for exemplary tourist destinations in the MENA-Region

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Abstract

Our life on earth is threatened by a complex crisis of climate change, biodiversity loss, and pollution. Nations such as Egypt, Morocco, and Tunisia, classified as lower-middle-income countries with significant economic ties to the tourism sector, face heightened vulnerability to these challenges. A major concern revolves around inadequate waste management infrastructure, leading to littering of waste and environmental degradation through improper disposal practices and the lack of awareness of such issues. The root causes often traced back to ambiguous responsibilities, weak policies, insufficient law enforcement, and financial instability, overshadowing the imperative need for technological solutions. In these coastal nations, a significant worry is the adverse impact of marine litter and waste accumulation on beaches, particularly affecting the tourism sector. Paradoxically, while tourism exacerbates the issue with extensive use of single-use plastics and heightened waste production during peak seasons, it bears the primary economic losses resulting from environmental degradation. Recognising this intricate relationship, this research aims to assess waste flows within three tourist destinations in the MENA Region: Alexandria (Egypt), Essaouira (Morocco), and Hammam-Sousse (Tunisia). The investigation delves into determining the leakage potential of plastic and its fates, utilising the "GIZ Waste Flow Diagram". Data collection involves a combination of desk research and questionnaires targeting municipalities, hotels, and tourists in the three pilot locations. Furthermore, waste sorting analyses are conducted if practicable. The obtained results are then compared with recent beach litter monitoring campaigns carried out in the three target regions. Additionally, the baseline scenario will be compared to an improved waste management system for which improvements will be simulated. Consequently, this research strives to determine the reduction potential of waste currently being littered into the environment and to present a comprehensive strategy for improvement. Furthermore, it aims to assess and compare the economic savings achievable through reducing litter, juxtaposed with the investments required for enhancing waste management infrastructure and increasing awareness. This evaluation involves estimating the present costs associated with environmental pollution and its repercussions. Ultimately, the overarching goal is to deliver actionable insights that play a pivotal role in mitigating environmental impact and fostering sustainable practices in the targeted regions.

Keywords: Waste Flow Diagram, Circular Economy, Plastic Leakage Potential, Tourism Industries, Marine Litter, MENA-Region.

(F-3) Sustainable Solutions for Africa's Growing Cities : Trends in Urban Energy Demand

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Abstract

Many African countries have recently demonstrated a significant commitment to fostering their circular economy. In terms of energy transition, much of the African continent still possesses an energy endowment that encourages energy use. It is becoming increasingly probable that African energy systems will evolve following disruptive or microgrid-based renewable energies. An interest in circular economy has become apparent in dialogue, such as by the African Development Bank Group and Ministries of Finance, as well as the various features of modern circular economies that have been publicized. Africa is also the breeding ground for world-first or world-unique explorations of emergent circular economy considerations, especially about green hydrogen. Africa is characterized by low levels of electrification, high population growth, rapid urbanization, and a high level of informal settlements. With the global commitment to the New Urban Agenda (NUA), Sustainable Development Goals (SDGs), and Nationally Determined Contributions (NDCs), implementation of effective strategies to reduce greenhouse gas (GHG) emissions in cities is essential to achieve sustainable development in Africa. There are bodies of literature that deal with various aspects of urban development and energy use in African cities, but the complex relationships among urbanization, energy use, GHG emissions, and urban structure are yet to be fully understood. However, understanding urban growth and assessing the potential energy use associated with such growth is important and can inform important policy discussions about sustainable urbanization. Our work published in 2023, “Recent trends in urban electricity consumption for cooling in West and Central African countries” highlights that the trend in electricity consumption assessed for West and Central African cities based on non-stationary models are weather-sensitive. Temperature and relative humidity were revealed to be the main drivers of this sensitivity, and Sahelian and Tropical cities are more weather-sensitive than oceanic cities. For most cities, the sensitivity to weather has significantly increased over time. Our recent ongoing work looking at the future trend of energy demand in the hall Africa based on the new share socio-economic pathways (SSPs) of the CMIP6 shows that there will be an increase in cooling demand for all of Africa, especially in sub-Saharan Africa regardless of the scenario and period. Africa region energy demand will increase but especially following this order: West Africa due to population growth of Nigeria, followed by Central East Africa due to population growth of DRC, and North East Africa due to population growth of Ethiopia. These projections are interesting for governments, investors, city planners, policymakers, and companies to manage or mitigate future changes in energy demand in the context of circular economy.

Keywords: Energy transition, Urbanization, Electrification, Energy demand

(F-4) Hybrid Systems Control Strategies For Buildings Integration

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Abstract

Despite current renewable system technology, many isolated regions of the globe are not connected to the electricity grid. These systems, which are popular alternatives, offer an ideal solution for providing electricity to rural and isolated areas. Therefore, despite considerable advances in the management of autonomous hybrid systems, the efficiency and long-term stability of these multi-energy systems remain major challenges. Researchers have focused on the energy efficiency of production systems which presents specific difficulties due to the cumulative constraints it implies, notably: intermittency, reactivity, non-linear characteristics, production and operating costs of these hybrid systems, etc. In order to overcome these obstacles, it is imperative to study the behavior at different levels of each production unit of the hybrid system and design suitable controllers for each unit. This study proposes a standalone hybrid generation system that combines both solar panels and a wind generator with a storage system as an alternative to conventional sources of electrical energy. Simple and cost-effective fuzzy logic-based control strategies were proposed to track the operating point of the hybrid system, as well as a controller for managing the storage system. The entire hybrid microgrid is described and accompanied by comprehensive simulation results that demonstrate the feasibility of the system. It emerges from this study that a controller installed for each production unit of the hybrid system allows synchronization and rapid response of the system. The management system ensures continuous operation of the hybrid micro-grid without interruption of supply and allows load and battery protection (from 30 to 90%). The use of fuzzy rules in these controllers significantly improved the efficiency of the proposed management system by subjecting it to the different supply and demand constraints. The simulation model was developed and the performance of the proposed system was tested and validated using Matlab/Simulink.

Keywords: Renewable energies, Hybrid system, Autonomous network, Power sharing, Centralized control, Matlab/Simulink.

G- Renewable Energy

(G-1) Numerical study of four coolants heat exchanger for enhancing thermoelectric performance in the hybrid photovoltaic-thermal bi-fluid collector

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Abstract

An investigation was conducted to improve the thermoelectric performance of photovoltaic-thermal panels integrated into buildings. The study focused on a collector that incorporated photovoltaic cells into a heat exchanger. The exchanger included two channels: the upper channel, positioned between the solar cells and the thermal mass, was filled with stagnant fluid 1, while the lower channel, open to the outside, was filled with air and a heat-transfer fluid 2 that flowed continuously. The study sought to evaluate various fluids used to create a gap in contact with the photovoltaic cells, with the ultimate aim of understanding the impact of these fluids on the thermal and electrical performance of the collector. This was achieved through a numerical study of the solid's convective transfer of fluids and heat conduction. The governing transfer equations were discretized using the implicit finite-difference technique and solved using Thomas' algorithm and the Gauss-Seidel iterative method. The results included streamlines, isotherms, velocity, local Nusselt number, and the thermal and electrical efficiencies of the collector, with variations of control parameters such as Reynolds number, Rayleigh number, and Biot number. The findings indicated that hybrid photovoltaic PV/T systems with air and neon as the enclosed fluid performed better thermally, while collectors with xenon and argon as the enclosed fluid performed better electrically. Argon was deemed the most suitable filling gas considering economic and environmental factors.

Keywords: Numerical study, photovoltaic/thermal panels, bi-fluid collector, mixed convection, thermoelectric performance.

(G-2) Residencial rooftop agrivoltaic with smart irrigation and solar PV dust cleaning system: Water-Food-Energy Nexus for passive cooling, clean energy supply, zero food mile production, and sustainable land use

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Abstract

Climate change and population growth challenge urban food, building, and energy resilience, intensifying land-use competition and energy consumption. Urban rooftops offer alternative resources for multi-functional land use but its potential benefits have not been well explored. Co-locating solar photovoltaic systems with agriculture on urban rooftops can offer a sustainable solution by providing clean energy, enabling zero food miles production, and enhancing thermal comfort for building occupants. Benefits also include improved water efficiency by reducing soil evaporation and plant transpiration, prevention of photosynthesis reduction due to heat and light stress, and enhanced PV efficiency through watering and evaporative cooling effects. Research gaps remain in integrating these systems with bioclimatic building designs and smart irrigation systems to provide passive cooling, clean energy supply, and sustainable food production. This study aims to evaluate the multiple benefits of co-locating a solar photovoltaic system with tomato agriculture on a residential building rooftop area. Key objectives include assessing its impact on building microclimatic conditions, crop production, PV panels' temperature regulation, and power generation, then assessing economic viability and identifying adoption barriers and opportunities. To achieve all these objectives, a whole system modeling framework with a cross-disciplinary approach has been adopted taking into account the multi-functional aspect of the system to highlight the householder's decision-making. This framework integrates building simulation, load assessment, and multi-objective system evaluation. The building simulation results were fed into the agrivoltaic system model to do the multi-objective evaluation and to quantify the potential benefits and trade-offs between the building and the integrated system. To determine the best rooftop agrivoltaic implementation strategy and understand its impact on building energy performance three agrivoltaic configuration options are examined: stand-alone, grid-connected with surplus injection, and grid-connected with total injection. Findings indicate that a multi-functional rooftop design, which considers the whole system perspective, can enhance urban food, energy, and land sustainability by providing food and energy and regulating carbon emissions. Integrating rooftop agrivoltaic into building designs increases flexibility in building energy systems while contributing to environmentally sustainable land use and climate regulation.

Keywords: Smart irrigation, Photovoltaic Systems, Clean Energy, Agrivoltaic.

(G-3) Projet d'accès durable à l'eau par pompage solaire pour 10 unités de soins périphériques (USP) rurales au Togo

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Abstract

La pandémie de la COVID-19 a confirmé la nécessité de l'accès à l'eau dans les centres de santé, particulièrement pour les Unités de Soins Périphériques (USP) en milieu rural. En l'absence du réseau électrique, ces USP utilisent les groupes électrogènes, pour pomper de l'eau. Toutefois, l'utilisation de ces groupes présente des défis comme les coûts d'exploitation élevés, la pollution de l'environnement et la pollution sonore. Très souvent, ils sont abandonnés en raison des ressources financières limitées des USP.

Pour adresser le défi de l'accès à l'eau pour les USP au Togo, ESCO-TOGO a conçu et mis en oeuvre « le projet d'accès durable à l'eau par pompage solaire pour 10 unités de soins périphériques (USP) rurales au Togo ». ESCO-TOGO a demandé et obtenu une subvention de la part du Fonds Spécial d'Intervention de la CEDEAO par le Centre des Energies Renouvelables et l'Efficacité Energétique de la CEDEAO. Le projet a été mis en oeuvre de novembre 2023 à mai 2024.

Les activités mises en oeuvre dans le cadre du projet pour remplacer les pompes alimentées au diesel par des pompes solaires incluent : la sélection des sites bénéficiaires, la collecte de données, le dimensionnement des systèmes de pompage solaire, la préparation du dossier technique, l'approvisionnement des équipements, l'installation des systèmes de pompage solaire et la réception des ouvrages. Les USP bénéficiaires sont situées dans 10 localités rurales dont Koffitti, Agbamassomou, Affossalakopé et Sada 2, dans la région Centrale ; Kpakpo, Atchinédji et Ona dans la région des Plateaux ; et Atahonou, Zouvi, Afiadégnigba dans la région Maritime.

Pour la durabilité des installations, ESCO-TOGO a formé au moins deux membres du personnel soignant (un homme et une femme) par site pour assurer l'exploitation de l'installation. De plus, la maintenance des ouvrages est assurée par ESCO-TOGO la première année après l'installation. Un contrat de maintenance sera signé avec les USP pour la maintenance les années suivantes. Les épargnes sur les dépenses d'exploitation des groupes électrogènes constitueront des réserves financières pour le financement de la maintenance des installations. Fort des résultats obtenus, le projet peut être répliqué au Togo et dans les autres pays de la sous-région Ouest Africaine dans les localités ayant des caractéristiques similaires aux localités bénéficiaires.

Keywords: Solar Energy, Energy transition

(G-4) AI-Driven Smart Hybrid Electric System for Enhanced Energy Efficiency

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Abstract

This paper presents an AI-based Smart Hybrid Electric System (ASHES), an innovative solution integrating renewable energy sources with traditional grid power to enhance energy efficiency in residential and commercial settings. The paper details the system's topology, optimization techniques, and simulation results. A comprehensive analysis is conducted by using the Levelized Cost of Energy (LCOE) to evaluate the economic and environmental viability of y of ASHES. Moreover, HOMER Pro software is utilized to generate input data used to develop machine learning models. Based on the latter, the study attempts to create a Long Short-Term Memory (LSTM) algorithm for the predictive operation of the system and therefore, enables intelligent management of power resources, optimizing their use to achieve greater efficiency and reliability. The study demonstrates the significant benefits of smartly combining available power resources, highlighting improvements in system efficiency, reliability, economic viability, and environmental impact. The results underscore the potential of AI-driven solutions in advancing the integration of renewable energy with conventional power systems.

Keywords: Hybrid, Energy, Optimization, Renewable Energy, Simulation, Levelized Cost of Energy, System Efficiency, Machine Learning.

(G-5) Performance Analysis of an Off-Grid System in The Gambia

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Abstract

The Gambia is actively pursuing renewable energy integration, targeting a 40% threshold by 2021 in alignment with SDG7. However, regulatory, and logistical obstacles impede this progress. Leveraging the nation's abundant solar resources presents a significant opportunity, particularly in reaching remote rural communities beyond the utility grid through off-grid photovoltaic systems. Monitoring the performance of such a system is essential for sectoral growth and development. Over the course of a year, a study monitored the performance of a typical off-grid photovoltaic system, revealing notable seasonal variations. Optimal performance occurred during months with high temperatures and irradiance, notably in February, March, and April. Key performance indicators included an average reference yield of 190.55 kWh/kWp/month, array yield of 113.94 kWh/kWp/month, final yield of 99.46 kWh/kWp/month, capture loss of 77.36 kWh/kWp/month and system loss of 14.48 kWh/kWp/month. The system exhibited average array, inverter, and system efficiencies of 12,4%, 87.017% and 19.53% respectively, resulting in an average performance ratio (PR) of 52.22%. This study underscores the importance of understanding and optimizing the performance of off-grid photovoltaic systems to enhance renewable energy utilization in The Gambia and similar regions.

Keywords: renewable energy integration, off-grid photovoltaic system, performance monitoring, solar energy, system efficiency, performance ratio, rural electrification

(G-6) Comparative Studies of Conventional and Biofuels for Sustainable Mobility using a Mathematical Model- A case of Ghana

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Abstract

Energy is principal to economic development due to the positive correlation between its consumption and living standards. It is pivotal to the human needs because it is required for mobility, lighting, heating and cooling. Mobility is one of the fundamental conditions for sustainable development in Africa. Hence, in actualizing SDGs which most African leaders have ratified and vowed to achieve, sustainable mobility cannot be overemphasized. Ghana is confronted with an unsustainable transport system due to the high use of fossil fuels. The transport sector in Ghana is the largest emission sector within the energy sector with about 43%. Based on the demands from the Paris Agreement, many developed countries have committed to over 50% GHG emission reduction by 2030. The determined contribution of Ghana is to lower its GHG emissions by 15% (11.1 MtCO2e) based on Business- as- usual scenario emission of 73.95 MtCO2e by 2030 and additionally lower emissions by 30% if there is availability of extrinsic support. To facilitate the process of reducing emissions, sustainable transport actions by the use of biofuels will enhance safe, efficient and green transport in Ghana which can spur healthy and livable living mostly in cities. According to the report by National Energy Statistics 2021, the importation of gasoline and gasoil have augmented at annual growth rate of 7.4% and 8.7% respectively from 2000 to 2020. The total amount of petroleum products imported in 2020 was 3,965 kilo tonnes representing a 385.9% increase over the amount in 2000. The absolute dependence on imported fuels threatens energy security, devaluates the Ghana cedis currency, and also deteriorates the balance payment and the country's foreign currency reserves. Replacement of gasoline and diesel fuels with ethanol and biodiesel generated in Ghana will reduce the import bills and inject the amount saved into the domestic economy to ameliorate the GDP of the country. The study aims to curb GHG emissions by utilizing biofuels (bioethanol and biodiesel) generated from renewable energy sources as optimal alternative fuels for road vehicles. The study answers the question of how biofuel integration can be an efficient mitigation alternative in Ghana. A comparative test between conventional fuels and biofuels was conducted by employing a physical model to predict the amount of fuel consumption and emissions that will be generated from each fuel type. This will enhance the deduction of the total emission and fuel savings derived from biofuels relative to the conventional fuels. Based on author's knowledge, this is the first study to predict biofuel and conventional fuels consumption and emissions in Ghana using a mathematical model. A research gap that the study fills. The study used a physical mathematical model to ascertain the effects of bioethanol and biodiesel on fuel consumption and emissions in on-road vehicles.

The physical model was based on three vehicle forces (the forces needed to overcome air resistance, road resistance and inertial acceleration) and incorporated the brake specific fuel consumption, density and net calorific value of bioethanol and biodiesel for fuel consumption estimation. For better analysis of biofuel integration in the transport fuel system, three scenarios were employed- Business as Usual (BAU), Alternative and Extreme. BAU defined the current situation and was used as the baseline trend of fuel consumption and greenhouse gas (GHG) emissions. Under the BAU, the current gasoline and diesel fuels were considered. Alternative and Extreme scenarios were the mitigation scenarios adopted for GHG emission reduction. The alternative mitigation scenarios considered were E10 and B10 biofuels whilst the extreme/ ambiguous scenarios were E85, B50 as well as E100 and B100 base on the Ghana Energy Transition Plan which has set an ambitious target of net zero energy related emissions by 2060.

Simulations were done using various passenger vehicles and their specifications (frontal area, aerodynamic drag, mass, maximum power and acceleration) and the ambient environmental conditions in Ghana. IPCC tier 1 emission factors for biofuels were used to elicit CO2, N2O and CH4 emissions after estimating the amount of fuel consumed. The results will showcase the fuel consumption of the different biofuels and how efficiently they can be used in vehicles depending on the environmental conditions in Ghana. The emission savings from the biofuels will also be elicited and compared with the BAU scenario. Future research should include battery- powered electric and hydrogen fuel cell electric vehicles as means to attain a sustainable transportation system in Ghana.

Keywords: Biofuels, emission savings, fuel consumption savings, sustainable transportation

(G-7) Impact of household's income level on their e-waste management practices

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Abstract

Electronic waste is gaining an ever-greater place in global exchanges on the development of a circular economy based on its recovery. A better understanding of e-waste management practices can help maximize the recovery of valuable materials and minimize environmental impact. In low-income countries, the fact that e-waste management has been in the informal sector until now implies a lack of control over this management. Thus, each household manages e-waste in its own way, knowing that households are characterized by the difference between their financial resources, their access to information, and their level of education. This study aims to analyse the impact of households' living standing on the way they manage their e-waste. Data were collected from 197 households (HHs) including 35 low standing HHs, 123 medium standing HHs and 39 high standing HHs. Collected data targeted the types of e-waste they generate and the management practices of each of them. Khi-square test and residual standardized analysis were used. The different management practices found are abandon at a repair shop, disposal, sale, storing, burning and donation. Results shown that there is significant relationship between the living standing of HHs and their e-waste management practices. Moreover, results shown that low-income HHs are the one who mostly sell their e-waste to recyclers. The sale of e-waste by low standing HHs indicates a potential for a circular economy where waste is seen as a resource. Initiatives to formalize these practices can improve economic and environmental sustainability. This research findings can help local authority to encourage the creation of local start-ups specializing in e-waste recycling that can not only manage waste more sustainably, but also create jobs in low-income communities. This study can be repeated with more data in order to increase the significance of the tests and better highlight the links between household standing and the other e-waste management practices identified.

Keywords: e-waste, households, recovery, circular economy, management practices

(G-8) Geospatial least-cost mini-grid energy systems investigation for rural electrification in sub-Saharan Africa using advanced geospatial electrification planning tool: Case of Niger.

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Abstract

Electricity is essential for alleviating poverty, driving economic growth, and enhancing living standards. Access to clean and affordable energy is integral to sustainable development, social welfare, and environmental responsibility (SDG). To achieve universal access by 2030, the world must drastically increase efforts by scaling up investments and policy support. However, electricity access is unevenly distributed between rural and urban areas, particularly in Sub-Saharan Africa. In Niger, for instance, over 83% of the population lives in rural areas, but only 9.1% have access to electricity. To address this challenge, the country has established a national strategy aiming for universal electricity access by 2035. One major obstacle to electrification planning is the prohibitive cost of grid extension to reach the "last mile," characterized by scattered rural communities with low population density. This study seeks to apply a geospatial approach to optimize least-cost electrification planning for all in Niger by 2035. We propose a methodology comprising two main steps: estimating the least-cost technology combination and sizing a micro-grid system for Dar-Es-Salam village as part of the RETO-DOSSO project. First, the analysis of cost-effective technology combinations is performed based on the levelized cost of electricity (LCOE) using the novel open-source spatial electrification tool OnSSET, written in Python. The model uses geospatial input data, including population density, proximity to existing and planned infrastructure (roads, grid network), nighttime light, socioeconomic, and technical parameters, to determine the least-cost electrification strategy (grid extension, standalone systems, and mini-grids) and technology combination according to local renewable energy sources. Second, the open-source Micro-GridsPy model is used to optimize the size of micro-grid system components and the optimal power dispatch strategy. Micro-GridsPy employs a two-stage stochastic modeling approach using Linear Programming (LP) and Mixed Integer Linear Programming (MILP) developed in Pyomo using Python. The model uses hourly resolution time series input data for renewable energy sources and load demand estimation based on the Multi-Tier Framework. As a result, the least-cost electrification planning analysis using OnSSET provides the new population distribution per technology type, the required capacity, investment per technology type (Grid, stand-alone PV or diesel, mini-grids PV, Hydro, wind, diesel), and the levelized cost of electricity (LCOE). The analysis shows that grid densification and extension are the most common least-cost technologies in all scenarios. Stand-alone PV systems are the second least-cost option, particularly with fuel subsidies. As population density increases, mini-grid PV hybrids represent the least-cost technology for long-term electrification compared to stand-alone systems. The low electricity demand approach is the cheapest electrification scenario, primarily due to low population density. For instance, stand-alone and mini-grid PV systems account for over 40% of the population connected to electricity by 2035 under the low energy demand scenario, with an average LCOE of $0.36 per kWh. The MicrogridPy model proposes designs for various components of mini-grid systems according to the minimum net present cost for Dar-Essalam village over the system's lifetime.

Keywords: geospatial electricity planning, OnSSET model, MicroGridPy model, mini-grid, Levelized cost of electricity (LCOE)

(G-9) Renewable energies through the production of ecological charcoal with shea waste and other household waste

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Abstract

GTMD SARL is a company that operates in agro-business, especially the shea tree a tree whose fruit gives almonds and which is the main source of income for Malian women in rural areas thanks to the sale of shea nuts but also the transformation of almonds into shea butter, a very popular product in demand on national and international markets.

This processing activity generates waste or even cakes with a ratio of 60% of waste per 1kg of shea butter produced which GTMD recycles into ecological charcoal to replace the charcoal which devastates our forests and destroys our ecosystems.

This is how we wanted to be among the defenders of mother nature through our production of ecological coal made with high capacity adaptable equipment (carbonizer by pyrolysis and briquette machines) and the latter (ecological coal) will be able to replace charcoal is too greedy for wood, hence the excessive cutting of trees in our forests, which in turn leads to deforestation, the main scourge in our countries already occupied by the Sahara in the north

Our innovative solutions serve the fight against poverty and inequalities because it makes it possible to set up semi-industrial units for the production of compound shea butter (roaster, oil press and oil filtering systems). and which thus saves the women beneficiaries from the very difficult work to produce shea butter with a limited yield and therefore increase their production capacity, which generates a higher income and subsequently a higher standard of living. The time savings obtained through the use of shea butter production machines allows women to carry out other activities such as market gardening, soap making, etc.

GTMD SARL works to develop innovative domestic solutions to reduce or stop the cutting of wood which leads to the destruction of forests to make charcoal for energy. our objective for development is a financing system to respond to the challenges of combating poverty and inequalities by providing semi-industrial shea butter production equipment to women's groups, including 2 villages at the moment, to increase their income but also trained them in the efficient use of shea waste to make ecological charcoal and thus limited the use of wood as domestic energy.

We train these women in the good management and recovery of shea waste into ecological charcoal in the same way we can intervene in good household management and the good management of household waste deposit areas by carrying out selective sorting by category which can used to make ecological charcoal and waste that can be composted to nourish the agricultural soils of market gardens.

Production of ecological charcoal from household waste:

Also called green charcoal, the product is obtained from the processing of household waste such as corn husks, plantain peelings and rattan waste. The manufacturing process begins with the collection of biodegradable household waste

After the collection stage, the waste is dried for approximately six hours for light waste and 2 days for heavy waste.

"As a dryer, we have a solar oven 2 meters high and approximately 50 cm wide, a variation angle of 30° and a 4m2 drying chamber separated into seven compartments",

After this phase, the so-called carbonization phase occurs. This consists of putting the dried waste in ovens (drums topped with chimneys) and burning them until they turn into black powder.

This operation lasts 30 minutes for light waste and approximately one hour and thirty minutes for heavy waste.

Subsequently, the black powder resulting from the carbonization of the waste is mixed with water to which Kaolin is added (white clay at the base of the manufacture of porcelain, used in the paper industry, medicine and of cosmetics), then the mixture is passed through a device called a compactor. The product is then dried for approximately three days and ready for use.

organic charcoal is very popular with housewives because it lasts longer than charcoal and ecological charcoal does not smoke or darken the pot. It burns completely. Environmental specialists welcome this innovation which, according to them, emits half as much greenhouse gas as charcoal.

“To obtain traditional coal, we cut down trees, which accentuates climate change. However, this coal has the advantage of reducing deforestation as much as possible, since it does not resort to felling trees. However, by producing the coal from household waste, we do not damage the environment

Green coal is a trendy project that is firstly part of the dynamics of the SDGs and then of the various COPs. Beyond its notoriety, it solves crucial environmental problems. This is an innovative product which is part of a disruptive innovation.

Keywords: Household waste, Green coal, Carbonization

(G-10) Higher calorific value analysis for waste communal artificial intelligence model optimization on electrical energy

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Abstract

Characterization at source is a crucial first step in the process of recovering energy from solid waste. The aim of this study is twofold: firstly, a field study to determine the deposits and physical composition of waste in Ouagadougou, the capital of Burkina Faso in West Africa, using a structured methodology; secondly, an experimental study in the laboratory to determine the chemical composition of typical wastes. Although previous studies have been carried out in the region, there are gaps in the methodology used. This study focuses on filling the gap by analyzing waste types and volumes at source, with a particular focus on waste generated by households at different socio-economic levels (high, medium, and low). In addition, an energy content analysis was carried out through the calorific value in order to optimize the source of energy in the electricity produced. As well as household waste, this study also characterized industrial waste, thereby refining the overall characterization. Local waste management officials and community stakeholders were consulted to identify priority areas for household sampling. For the laboratory study, the materials used were gangs, knives, scales for each type of waste, a Furnace to determine moisture at 103 degrees C, a muffle furnace to measure ash content at 700 degrees C and volatility at 950 degrees C, and desiccator to cool the waste; other variables were determined through previous research. Data analysis was performed using statistical tools, and a machine learning model was used to predict the HHV nominated as input variables in the modelling process for each waste type. Several methods have been used to obtain a reliable result, one is linear regression through different models, the other is Artificial Neutral Network (ANN) through four types of machine learning methods such as Radial Bias Function Artificial Neural Network (RBF-ANN), Multilayer Perceptron Artificial Neural Network (MLP-ANN), Support Vector Machine (SVM) and Adaptive Nero-Fuzzy Inference System (ANFIS). The second is to use linear models based on research in the reviewed literature and the third is the model created in this study. The models are qualified using six performance matrices, such as coefficient of determination(R2), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), Standard deviation, Mean Absolute Percentage Error (MAPE) and Standard Error of the Estimate (SEE). The results showed that the linear model with the combination of moisture, material volatility, and ash content is the best model, as indicated by the following equation: HHV = 0.0001Moisture+0.1132Volatility_Materials-0.2848Ash_Content + 10.982. After comparison with the other models created, this model is the best, with a coefficient of determination (R2) equal to 1, a root mean square error (RMSE), a mean biased error (ABE), a mean absolute percentage error (MAPE) and a mean absolute error (AAE) below the acceptance of the performance matrix. Consequently, the ANNs optimization model created improves the error by performing an optimal data transformation that determines between data points the basis of predefined classes. It can be used as a practical tool with a high degree of accuracy and reliability for typical energy recovery from communal waste in Ouagadougou. Thus, the analysis identifies optimal waste mixtures for obtaining electrical energy in optimization analysis based on the ANN model.

Keywords: Waste Characterization, Physio-chemical composition, Artificial Intelligence, Electrical Energy

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The rapid increase in energy costs due to the double effect of inflation and currency depreciation means that smart choices driven by research, development, demonstration, and sustainability should lead the way, especially as they affect the growth of developing countries.

African countries, therefore, have the opportunity to leverage the current global economic situation for sustainable technology enhancement and growth, and also transition towards green and sustainable pathways while securing energy needs and ensuring modern energy fuels from alternative and non-conventional sources. These energy sources, therefore, can easily be made available to the population at affordable and competitive prices.

This conference focuses on Africa and seeks to bring together various stakeholders such as academia and research scientists, industrialists, small and medium-scale enterprises, technocrats and political actors, NGOs, etc. to exchange knowledge.

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Waste- and Resource Management

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