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Techno-Economic Assessment of Municipal Solid Waste (MSW) Incineration in Ghana

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Abstract: Waste incineration with energy recovery is a matured Waste-to-Energy (WtE) technology which has contributed immensely to the disposal and management of Municipal Solid Waste (MSW) in industrialised nations. The adoption of this technology in developing countries is currently gaining momentum due to the numerous benefits that can be derived from its use. In this study, a techno-economic assessment of MSW incineration in proposed waste incineration facilities for use in Ghana was carried out. The technical assessment was conducted by determining the plant capacity and annual electricity production based on the combustible residues of MSW collected from various population sizes in the country, while the economic assessment was carried out by determining two key economic indicators, Net Present Value (NPV) and Levelised Cost of Energy (LCOE). It was found that a total of about 400 MW of electricity can be generated from the total of about 14,000 tonnes of MSW generated in the country daily. The NPV for a 35.81 MW installed capacity of waste incineration facility was found to be USD 166,410,969.24. However, the LCOE for the 35.81 MW capacity and all others considered was greater than the tariff of electricity for their respective capacities, which means waste incineration facilities are not economically viable ventures in Ghana. The implementation of these facilities in the country would, therefore, need governmental support in the form of subsidies and tax rebates. Three locations were proposed for the piloting of waste incineration facilities in the country, and these locations are in the Accra Metropolitan, Asokore-Mampong Metropolitan, and Sekondi-Takoradi Metropolitan Assemblies.

Keywords: waste incineration; energy recovery; waste-to-energy; municipal solid waste; net present value; levelised cost of energy

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1. Introduction

Global solid waste generation was estimated to be 2.01 billion tonnes per annum in 2016 [1], which was an increase of over 50% with respect to the quantum generated in 2012 [2]. In Sub-Saharan Africa, it is estimated that the waste generation was 174 million tonnes per annum in 2016 [1], which was an increase of over 100% with respect to the 81 million tonnes per annum generated in 2012 [3]. In Ghana, the population stood at 6.64 million in 1960 [4], and has seen a remarkable surge to about 32 million in 2022 [4], representing an extraordinary growth of almost 400%. The growth in population, coupled with urbanisation and the increase in economic activities, has been attributed to the high volumes of Municipal Solid Waste (MSW) generation worldwide [5–8].

Over the past few decades, there has been a significant increase in the public's call for environmentally responsible handling of MSW, with MSW now constituting the largest volume of residues generated globally [9,10]. Integrated Solid Waste Management offers a range of approaches to mitigate the adverse impacts of waste on both society and the environment. This encompasses waste reduction, material reclamation, recycling, energy conversion, and the responsible management of landfills, all contributing to a holistic set of solutions within this framework. This approach is an essential component of any advanced MSW management strategy. Within the European Union (EU), the Waste Framework Directive introduced the "Waste Hierarchy", which prioritises waste prevention as the foremost strategy, followed by reuse, recycling, resource recovery, and disposal in that order. This directive aims to promote sustainable waste management practices, minimise waste generation, and drive the shift towards a circular economy within the EU. Waste-to-Energy (WtE) technology, specifically waste incineration with energy recovery, is recognised as a sustainable method of waste disposal. This technology is considered mature and suitable for managing MSW in developed countries [11]. Notably, the USA has approximately 77 waste incineration facilities [12], the European Union operates around 492 [13], and Japan runs about 1900 such facilities [14]. These developed nations favour waste incineration facilities due to their ability to reduce landfill waste and recover valuable energy in the form of electricity and heat.

This problem of MSW disposal and management in Ghana has brought substantial obstacles to successive governments, as indicated by the widespread presence of open landfill sites in various communities, especially in urban communities nationwide [15]. The adoption of WtE can effectively alleviate environmental pressure by bypassing the need for landfill disposal and improving waste management approaches [16]. In recent times, Ghana has faced challenges in meeting its electricity demand due to insufficient power supply. Consequently, the Power Company of Ghana has had to implement frequent load shedding practices for its customers. A significant portion of Ghana's electricity production, approximately 61%, is attributed to the combustion of fossil fuels in various thermal power facilities operated by the Volta River Authority and other independent power producers. This makes fossil fuel combustion the dominant component of Ghana's energy mix [15].

Choosing a WtE technology is challenging due to the abundance of developing options [17]. Additionally, economic, engineering, social, environmental, and ethical dilemmas exist throughout WtE technology selection and development. A study [15] highlighted the prospects of waste incineration in the management of MSW in a developing economy like Ghana. The study recommended that a techno-economic assessment should be performed on proposed waste incineration facilities for use in Ghana if the technology is to be implemented. This current research work seeks to answer the following two questions: Firstly, what is the total power and energy that can be generated from the total MSW generated in Ghana? Secondly, can waste incineration facilities be economically viable ventures in a developing economy like Ghana? This research work forms part of a research investigation with the broader aim of proposing the optimal integration of WtE in Ghana and presents the techno-economic assessment of MSW incineration in facilities proposed for use in Ghana.

2. A Brief Description of the Study Area

Ghana is a country located in West Africa along the Gulf of Guinea. Ghana is bordered by Cote d'Ivoire to the west, Burkina Faso to the north, Togo to the east, and the Atlantic Ocean to the south. Ghana has a total land area of approximately 238,533 square kilometres and is estimated to have the same land size as Oregon in the USA [18]. Half of the country is estimated to be less than about 152 metres above sea level, with the highest point being 883 metres above sea level. Ghana is known for its diverse geographical features, which include coastal plains, hills, and mountains in the interior. The coastline of Ghana stretches for about 539 kilometres along the Gulf of Guinea. Major rivers in Ghana include the Volta, Ankobra, Pra, and Tano rivers. The climate in Ghana is generally described to be tropical with estimated average temperatures between 21 °C and 32 °C, and is characterised by two distinct seasons, the wet season (which runs from April to October), and the dry season (which runs from November to March). The population of Ghana is estimated to be a little over 32 million [19]. The capital and largest city of Ghana is Accra, which is situated along the south-eastern coast of the country. Other major cities in Ghana include Kumasi, Sekondi-Takoradi, Tamale, and Cape Coast.

The southern parts of Ghana, particularly the coastal areas, are more densely populated relative to the sparsely populated northern regions of the country. The population in Ghana is predominantly concentrated in the urban and peri-urban areas, with quite a significant rural population that is engaged in agriculture and related activities.

The Ashanti region, which has Kumasi as its capital, is one of the most populous regions in the country. Other regions with a relatively high population density include the Volta, Eastern, Western, and Greater Accra regions. Figure 1 shows a population distribution map of Ghana.

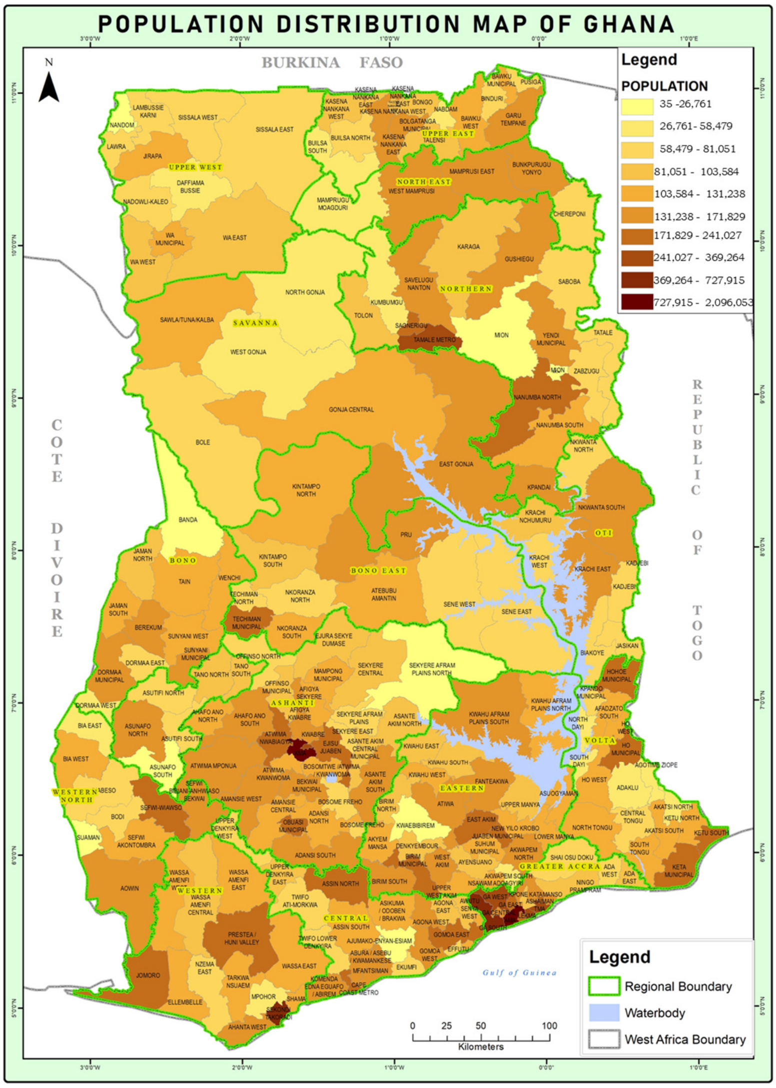

Figure 1. A population distribution map of Ghana [20].

3. Materials and Methods

The focus of this research work was to perform a techno-economic assessment of a waste incineration facility proposed for use in Ghana. In performing this assessment on the proposed waste incineration facility, the following are some general approaches that were adopted.

I. Technical assessment: In performing the technical assessment of the waste incineration plant, the calculation of waste generation based on population definitions is defined explicitly. Appropriate relations are then used to determine the total power available in the combustible residues in the waste generated by a set of populations in the country, and the total energy available that can be produced by the population sizes as defined was subsequently determined.

II. Economic assessment: In performing the economic assessment of the proposed waste incineration facility, two key economic indicators were determined: the Net Present Value (NPV) and Levelised Cost of Energy (LCOE). The total Net Present Value of costs represents the present value of all costs associated with the energy project over its lifetime, including capital costs, operating costs, maintenance costs, and any other relevant expenses.
The total Net Present Value of energy output represents the present value of all energy generated by the project over its lifetime, taking into consideration the capacity factor (that is the ratio of the actual energy generated to the maximum possible energy generation).
Dividing the total Net Present Value of costs by the total Net Present Value of energy output gives the LCOE, which provides an estimate of the average cost of producing each unit of energy over the project's lifetime. It is imperative to note, however, that the LCOE formula may incorporate additional factors or adjustments depending on the specific characteristics and requirements of the energy project. This may include tax incentives, government subsidies, and/or any other financial considerations.
It must be underscored that for the proposed waste incineration facility to be economically viable, there are two conditions that must be met [21,22].
    A. NPV must be greater than zero (additionally, the greater the value, the more attractive the venture),
    B. LCOE must be less than the tariff for energy sales.

III. One of the benefits of implementing waste incineration is the reduction in the emission of CO_2 when it replaces the conventional fossil fuel-fired power plants in the country; as such, the total amount of CO_2 emitted from the various thermal power plants operating in the country is determined. After this, the amount of CO_2 emissions that can be saved when waste incineration plants are to replace the conventional fossil fuel-fired thermal power plants operating in Ghana, considering three scenarios, business as usual (with no incineration and continued uncontrolled landfilling), low deployment (with a few waste incineration facilities installed), and high deployment, is determined.

3.1. Technical Assessment

The technical assessment was carried out by performing a calculation of waste generation based on population definitions, a calculation of the total waste generation for each population size, and a calculation of available power and energy in the combustible waste residues.

3.1.1. Calculation of Waste Generation Based on Population Definitions

Calculations were performed for 15 data sets of population sizes (1000, 2000, 5000, 10,000, 25,000, 50,000, 100,000, 150,000, 200,000, 300,000, 500,000, 1,000,000, 1,500,000, 2,000,000, and 3,000,000), and these population sizes were established based on the population limits of population sizes defined in the national population distribution [19].

3.1.2. Calculation of the Total Waste Generation for Each Population Size

The total waste generation per day for each population size is the first step of calculation. This was calculated using Equation (1)

$$W_T = \frac{P_t \cdot W_P}{1000} \quad (1)$$

where W_T is the waste production (tonne/day), P_t is the total population as defined earlier, and W_P is the per capita waste generation index (measured in kg/person/day), which is 0.47, as in a study [23].

The total production of each type of waste residue in each analysed population was also calculated using Equation (2)

$$W_i = W_T F_i \tag{2}$$

where W_i is the daily production of each type of MSW residue, and F_i is the fraction of each MSW residue as obtained from the gravimetric composition of waste from Ghana [23].

3.1.3. Calculation of Available Power and Energy in the Combustible Waste Residues

The energy calculations are based on the heat-generating values that can be derived from each type of residue present using Equation (3) [24], where LCV_{ex} is the lower calorific value of each type of waste residue measured in kCal/kg as determined from experimental studies which are shown in Table 1, R_1 is a conversion constant which converts kCal/kg to kJ/kg and is given as 4.184, LCV_i is the calorific value contained in each fraction in kJ/kg, and the total heat values can be calculated using Equation (4) [25].

Table 1. Specific lower calorific values of various components of MSW [24].

MSW Component	Lower Calorific Value on Wet Basis (kCal/kg)
Organics	712
Paper	2729
Textile	1921
Plastic	8193
Rubber	8633

The available power in the combustible residue was calculated using Equation (5) [26], where η is the electricity recovery of all energy generation systems from incineration, R_2 is a unit adjustment constant such that the resulting power is in kW (given as 0.01157), and the energy that can be produced in the incinerator was subsequently calculated using Equation (6) [27], where C_F is the capacity factor, adopted to be 80% [24], and 8760 is equal to the number of hours of operation of the incinerator per year.

$$LCV_i = LCV_{ex} \cdot F_i \cdot R_1 \tag{3}$$

$$LCV_T = \sum_{i=1}^{n} LCV_i \tag{4}$$

$$P = LCV_T \cdot \eta \cdot W_T \cdot R_2 \tag{5}$$

$$E = P \cdot C_F \cdot 8760 \tag{6}$$

3.2. Economic Assessment

The initial investment cost (I) of the waste incineration facility was calculated as a function of the electrical power generated in the waste incinerator in kW using Equation (7) [28], and the NPV values were also calculated using Equation (8)

$$I = 15{,}797\ P^{0.82} \tag{7}$$

$$NPV = \sum_{t=1}^{m} \frac{(E \cdot tf) - C_{om}}{(1+i)^n} - I \tag{8}$$

where tf is the energy sales tariff in USD/kWh, C_{om} is the operating and maintenance cost per year, which was adopted to be 4% of the initial cost of investment in USD [28], m is the project life (which is taken to be 25 years in this study), n is the year of analysis, and i is the interest rate, which was taken to be 12.5%. The tf used in this assessment was 0.1462 USD/kWh according to the Public Utilities Regulatory Commission of Ghana, which was the tariff for waste-to-energy feed-in tariff for waste to energy electricity generation in 2021. The Levelised Cost of Energy (LCOE) was calculated using Equation (9)

$$\text{LCOE} = \frac{\sum_{t=1}^{m} \frac{C_n}{(1+i)^n}}{\sum_{t=1}^{m} \frac{E_n}{(1+j)^n}} \quad (9)$$

where C_n is the total cost of the enterprise, which includes the investment cost (which is a one-time cost, determined earlier using Equation (7)), and the maintenance and operational costs of the facility per year (which are the same as adopted earlier). The E_n is the total energy produced per year of the facility, and j is the degradation of the waste incineration facility, which was taken to be 1% in this study.

3.3. Determination of the Total CO_2 Emissions from Thermal Power Plants in Ghana

This section explains how the total CO_2 emissions from the fifteen (15) thermal power plants operating in Ghana were determined. To achieve this, there was a need to determine the amount of electricity generated by each plant and the carbon intensity of the fuel source used to generate electricity from each plant. The following general approach was used.

I. Gathering of data on the total electricity generation from all the installed thermal power plants that are operating in Ghana over a given period of time (the period considered in this case is one year). Table 2 lists the thermal power plants (including their power output) that are currently operating in Ghana.
II. Determination of the carbon intensity of the fuel source used to generate the electricity at each thermal power plant. The carbon intensity of the fuel can be expressed as the amount of CO_2 per kWh of electricity generation. Table 3 lists the carbon intensity of some selected fuels used in thermal power plants.
III. Calculation of the total CO_2 emissions from each thermal power plant by multiplying the electricity generation by the carbon intensity of the fuel source.
IV. Summing up the total CO_2 emissions from all the thermal power plants operating to obtain the total minimum CO_2 emissions for a year.

Table 2. List of thermal power plants operating in Ghana [29].

Thermal Power Plant	Power Output (MW)
Takoradi Power Company (TAPCO)	330
Takoradi International Company (TICO)	340
Tema Thermal I Power Plant (TT1PP)	110
Tema Thermal 2 Power Plant (TT2PP)	87
Cenit Energy Ltd.	110
Kpone Thermal Power Plant	220
Ameri Plant	250
Sunon Asogli Power (Ghana) Ltd.	560
KarPowership	470
Trojan	44
Amandi	203
AKSA	370
CenPower	360
Early Power/Bridge	144
Genser	155

It is worth noting, however, that the actual CO_2 emissions from the thermal power plants may be higher as calculated using this approach as there may be additional emissions from sources such as the mining and transportation of the fuel sources. Additionally, in determining the total CO_2 emissions from the thermal power plants operating in Ghana, information on the energy source of all the thermal power plants could not be obtained;

as such, natural gas was adopted as the source of fuel (natural gas has the lowest carbon intensity among the various fuel sources used in Ghana) for such thermal power plants.

Table 3. The specific CO_2 emissions of fuels used in thermal power plants [30].

Fuel Type	CO_2 Emissions ($kgCO_2/kg_{fuel}$)	CO_2 Emissions ($kgCO_2/kWh$)
Natural gas	2.75	0.18
Diesel	3.15	0.22
Coal	3.37	0.37
Heavy fuel oil	3.11	0.27
LPG	3.01	0.22

4. Results and Discussion

The results obtained from the research work are presented and discussed in this section. Additionally, the analysis of incorporating waste incineration plants into the energy mix of Ghana considering three scenarios is presented in this section.

4.1. Technical Assessment

The annual power (in kW) and energy (in MWh/year), that can be produced from the various population size distributions as was determined earlier using Equations (5) and (6), respectively, are presented in Table 4. It can be observed that with a population of 3,000,000 inhabitants, the installed waste incineration capacity was 35.81 MW and the energy production was 250,940.06 MWh/year of electricity, which is capable of supplying electricity to meet the electricity demand of about 630,000 inhabitants in Ghana per year (although the average electricity demand can vary depending on factors such as location, income level, household size, and lifestyle, with the average per capita electricity energy demand in Ghana estimated to be 399.22 kWh/year) [31]. With a population of 1,000,000 inhabitants, the installed waste incineration capacity was 11.94 MW and the energy production was 83,646.69 MWh/year, which is capable of supplying electricity to meet the electricity demand of about 200,000 inhabitants in Ghana per year. It is therefore obvious from Table 4 that with an increasing population, the total amount of solid waste generation increases, subsequently increasing the total amount of power and energy that can be generated.

Table 4. Power and energy production.

Population (Inhabitants)	Waste Generation (t/d)	Power (kW)	Energy (MWh//Year)
1000	0.47	11.94	83.65
2000	0.94	23.87	167.29
5000	2.35	59.68	418.23
10,000	4.70	119.36	836.47
25,000	11.75	298.40	2091.17
50,000	23.50	596.79	4182.33
100,000	47.00	1193.59	8364.67
150,000	70.50	1790.38	12,547.00
200,000	94.00	2387.18	16,729.34
300,000	141.00	3580.77	25,094.01
500,000	235.00	5967.94	41,823.34
1,000,000	470.00	11,935.89	83,646.69
1,500,000	705.00	17,903.83	125,470.03
2,000,000	940.00	23,871.77	167,293.38
3,000,000	1410.00	35,807.66	250,940.06

4.2. Economic Assessment

The economic assessment for the proposed waste incineration facilities is presented in this section. Table 5 presents the investment costs (in USD), the operating and maintenance costs (in USD/year), the revenues that can be generated from the sales of electricity generation from the facilities (USD/year), the NPV (in USD), the LCOE (in USD/kWh), and the unit costs of electricity to be generated (in USD/kW) for the various population size definitions considered in this study. Figure 2 illustrates a graph of the investment cost as against NPV, while Figure 3 depicts a graph of installed capacity against LCOE.

Table 5. The investment cost, operating and maintenance costs, revenues, NPV, LCOE, and unit costs for proposed waste incineration facilities for use in Ghana.

Population (Inhabitants)	Investment Cost (USD)	Operating and Maintenance Cost (USD/Year)	Revenues (USD/Year)	NPV (USD)	LCOE (USD/kWh)	Unit Cost (USD/kW)
1000	120,668.92	4826.76	12,229.15	−64,566.17	1.62	10,109.76
2000	213,029.64	8521.19	24,458.29	−92,242.20	1.32	8923.91
5000	451,596.78	18,063.87	61,145.73	99,134.09	1.10	7567.04
10,000	797,251.67	31,890.07	122,291.46	112,099.08	1.01	6679.45
25,000	1,690,076.03	67,603.04	305,728.64	114,679.09	0.92	5663.85
50,000	2,983,670.36	119,346.81	611,457.29	746,037.69	0.81	4999.50
100,000	5,267,389.53	210,695.58	1,222,914.58	2,404,223.34	0.72	4413.07
150,000	7,344,974.10	293,798.96	1,834,371.87	4,331,035.63	0.63	4102.46
200,000	9,299,081.04	371,963.24	2,445,829.15	6,418,759.09	0.52	3895.43
300,000	12,966,861.28	518,674.45	3,668,743.73	10,907,529.58	0.44	3621.25
500,000	19,712,914.56	788,516.58	6,114,572.89	20,653,292.83	0.40	3303.13
1,000,000	34,801,297.50	1,392,051.90	12,229,145.77	47,333,091.25	0.32	2915.69
1,500,000	48,527,762.61	1,941,110.50	18,343,718.66	75,787,686.76	0.26	2710.47
2,000,000	61,438,419.15	2,457,536.77	24,458,291.54	105,305,411.51	0.22	2573.68
3,000,000	85,671,202.92	3,426,848.12	36,687,437.31	166,410,969.24	0.19	2392.54

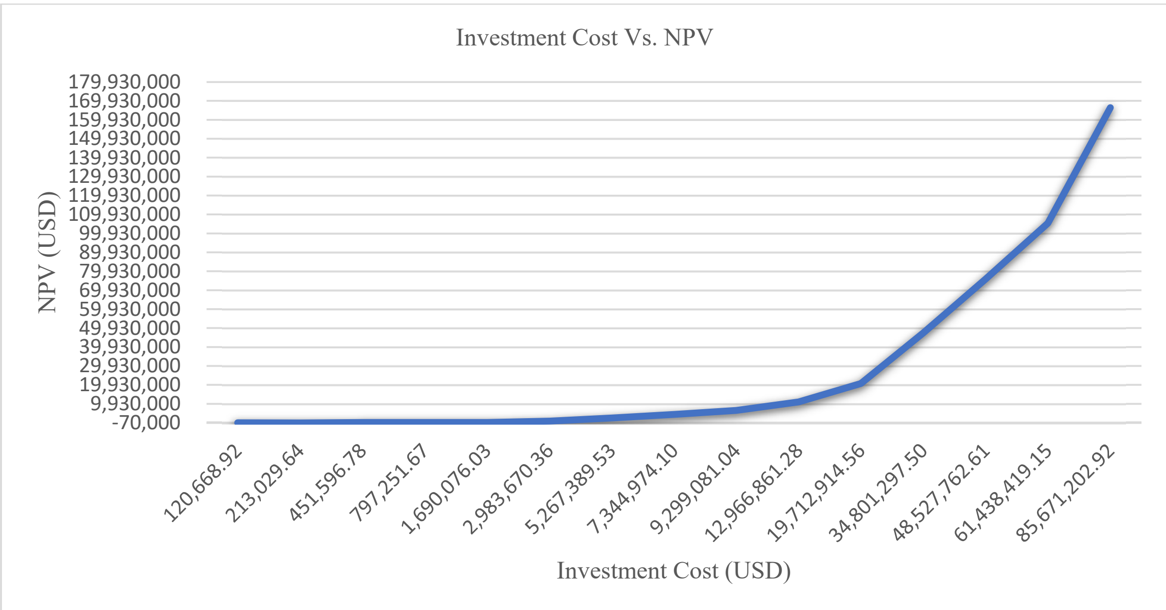

Figure 2. The investment cost of the proposed waste incineration facility vs. NPV.

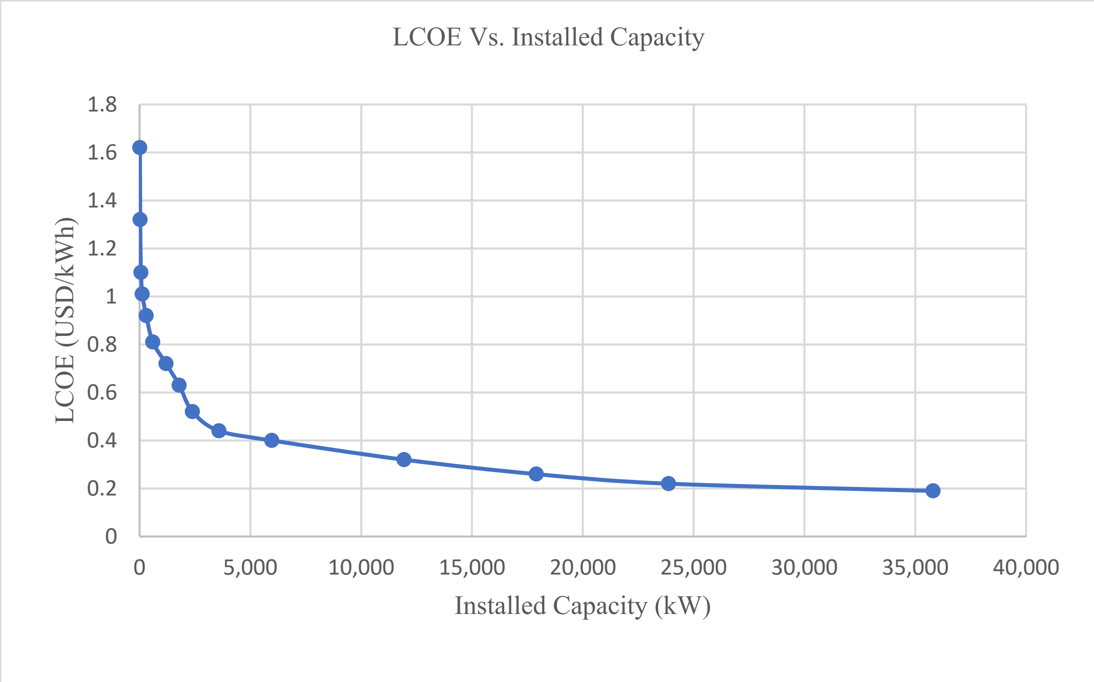

Figure 3. Installed capacity of the proposed waste incineration facility vs. LCOE.

It can be observed from Table 5 that the unit cost of electricity generated per kW in the waste incineration facility decreases with increasing installed capacity. With a population size of 5000 inhabitants, the installed capacity was 59.68 kW and the unit cost of electricity was 7507.04 USD/kW, with a population size of 100,000 inhabitants, the installed capacity was 1193.59 kW and the unit cost of electricity reduced to 4413.07 USD/kW, with a population size of 500,000 inhabitants, the installed capacity was 5967.94 kW and the unit cost of electricity reduced to 3303.13 USD/kW, and with a population size of 3,000,000 inhabitants (which happens to be the largest population size defined in the country), the installed capacity was 35,807.66 kW and the unit cost of electricity further reduced to 2392.54 USD/kW.

It can also be observed that the NPV (with a 25 year lifespan of the facility as considered in this study) increases with increasing installed capacity. With an installed capacity of 59,679 kW, the NPV was USD 746,037.69; increasing the installed capacity to 3580.77 kW increased the NPV to USD 10,907,529.09, increasing the installed capacity to 17,903.83 kW increased the NPV to USD 75,787,686.76, and finally increasing the installed capacity to 35,807.66 kW increased the NPV to USD 166,410,969.24. Figure 2 depicts the returns on investment with respect to NPV. It can clearly be observed that the NPV improves substantially with higher investment costs.

It can also be observed that increasing the installed capacities decreases the LCOE. With an installed capacity of 2387.18 kW, the LCOE was 0.52 USD/kWh; increasing the installed capacity to 11,935.89 kW decreased the LCOE to 0.32 USD/kWh, increasing the installed capacity to 23,871.77 kW decreased the LCOE to 0.22 USD/kWh, and finally increasing the installed capacity to 35,807.66 kW decreased the LCOE to 0.19 USD/kWh.

It can clearly be observed from Figure 3 that increasing the installed capacity of the facility reduces the LCOE. The unit cost of electricity (in USD/kW) for 1000 inhabitants (with an installed capacity of 11.94 kW) was as high as 10,109.76, reducing to 2392.54 for 3,000,000 inhabitants (with an installed capacity of 35.81 MW), which implies that for a cheaper cost of electricity, it is prudent to invest in a higher installed capacity.

4.3. Analysis on Incorporating Waste Incineration Facilities into Ghana's Energy Mix

Waste incineration with energy recovery can contribute to electricity generation when integrated into the country's energy mix. The contribution that can be made by electricity generation from proposed waste incineration facilities to be installed in various localities in Ghana was therefore analysed considering three scenarios: (i.) Business as usual, meaning there are no incineration facilities built (that is, only thermal power plants fuelled by the traditional fuel sources in the country), (ii.) Low deployment, which is when there are just a few waste incineration plants built, and (iii.) High deployment, which is when the maximum possible incineration plants are built. The implementation of the low to high deployment is expected to cover a period of 15 to 20 years.

4.3.1. Business as Usual

There are currently about 15 thermal power plants operating in the country, generating about 3753 MW of electricity. The total amount of CO_2 emissions from these thermal plants was determined to be 5,986,759.20 tonnes per year; however, this is considered the minimum total CO_2 emissions from the thermal power plants as explained earlier. The emissions of these greenhouse gases into the environment have grave environmental consequences, especially in the agriculture sector. It is estimated that agriculture contributes about 54% of Ghana's GDP, constitutes about 40% of export earnings, and provides about 90% of the food needs of the country [32]; therefore, using less carbon-intense fuels in thermal power plants or replacing electricity generation from these fossil fuel-fired power plants with the waste incineration facilities with energy recovery can benefit the country's agriculture sector.

4.3.2. Low Deployment Case

In the low deployment of waste incineration facilities into the energy mix of Ghana, it is proposed that at least three (3) 35 MW waste incineration capacities are installed in the country with one (1) in the Greater Accra, Ashanti, and Western Regions of Ghana. The installation of these proposed waste incineration facilities is expected to cover a period of 15 years in this case. This would mean a contribution of 105 MW of electricity into the national grid from the incineration of MSW, and energy production of 919.80 GWh/year, which could meet the electricity demand of the about 2.3 million inhabitants in the country. The contribution of electricity generation from three waste incineration facilities could additionally mean an annual reduction of CO_2 emissions of about 179,602.78 tonnes (representing about a 3% reduction in CO_2 emissions relative to business as usual annually).

4.3.3. High Deployment Case

It was determined after performing the technical assessment on waste incineration facilities in Ghana that the maximum feasible energy that can be extracted from the total solid waste generation in Ghana is approximately 400 MW, which translates to an energy production of about 3500 GWh/year. It is expected that waste incineration facilities would be built in all regions in the country to combust the 14,000 tonnes of MSW generated daily. The high deployment case is expected to cover a period of 20 years. When this maximum feasible energy generation from waste in Ghana is harnessed, it meets the electricity demand of about 8.5 million inhabitants annually, as well as reduce annual CO_2 by about 638,077.19 tonnes (representing about an 11% reduction in CO_2 emissions relative to business as usual).

5. Conclusions

It can be concluded after this research work that waste incineration facilities can contribute immensely to the electricity generation in the country, and that a maximum total of about 400 MW of electricity can be generated from the over 14,000 tonnes of MSW generated daily, which translates into 3504 GWh/year of energy, and this can serve the electricity needs of about 8.3 million inhabitants in the country.

The NPV for the installed capacity of 35.81 MW was USD 166,410,969.24; however, the LCOE of this installed capacity was 0.19 USD/kWh, and this is greater than the tariff of energy sales of 0.1426 USD/kWh (which is even the highest price of energy sales in the country), which means the waste incineration facilities are not economically viable; as such, their implementation in Ghana would, therefore, need government support in the form of subsidies and tax rebates. It is worth mentioning that the revenues considered in this assessment were only sales from electricity generation, but there are other revenue sources (like tipping fees, and sales of other recyclables that can be recovered during the sorting and incineration of the MSW) that can enhance the total revenue generation from the facility.

Advantages of the use of waste incineration facilities include the smaller installation area, and that it can be built within the city (an example is the waste incineration facilities built in Stockholm, Sweden). Based on this, three economical and technical locations were identified after this research work for the piloting of the waste incineration facility in the country, and these locations are the Accra Metropolitan, Asokore-Mampong Metropolitan, and Sekondi-Takoradi Metropolitan Assemblies.

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