A CASE STUDY ON THE CITYWIDE-BASED WASTE-TO-ENERGY (WTE) POTENTIAL ASSESSMENT IN THE REPUBLIC OF THE PHILIPPINES

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ABSTRACT

The citywide solid waste contains significant amount of carbohydrates and other combustible chemical compounds that has potential as an alternative energy source. In this study, the synthesis of energy potential assessment from the energy resources of solid waste by using the Co Equation are presented, in order to be utilized as assessment tools for the local government units (LGUs) in NCR. The data for this study is obtained from various Philippine government agencies, such as Philippine Statistics Authority (PSA), Environmental Management Bureau-Department of Environment and Natural Resources (EMB-DENR), Metropolitan Manila Development Authority (MMDA), and others. In order to accumulate those obtained data, the Co Equation is applied in this study. A decadal forecast study was subjected for analysis, in order to predict the forecast of the solid waste-to-energy potential in NCR. Based from the decadal forecast study result in the year 2028, the CSWTE potential assessment for NCR is to be found out as 19.16 TWh.

METHODOLOGY

As shown below, the Co Equation is the developed mathematical model equation by the corresponding author. Its primary purpose is to estimate the WTE potential on a particular local government unit (LGU). This Co Equation was based on the LGU's population (PSA), growth rate (PSA), and urbanization (PSA), waste fractions (EMB-DENR), waste types (EMB-DENR), economic ratio (PSA), waste generation rate (EMB-DENR), and net calorific value (NCV) (from experimental results on bomb calorimeter) (Co, 2021).

$$\Delta \boldsymbol{E_U} = \boldsymbol{c} \cdot \boldsymbol{p_{0U}} \cdot \bar{\boldsymbol{w}}_{\boldsymbol{RS}} \cdot \boldsymbol{NCV_{RS}} \cdot \left[\boldsymbol{t_f}(\boldsymbol{m_U t_f} + \boldsymbol{n_U})(\boldsymbol{\theta_U t_f} + \boldsymbol{\mu_U})(\mathbf{1} + \boldsymbol{g_U})^{\boldsymbol{t_f}}(\boldsymbol{\alpha_U t_f} + \boldsymbol{\gamma_U}) - \boldsymbol{t_i}(\boldsymbol{m_U t_i} + \boldsymbol{n_U})(\boldsymbol{\theta_U t_i} + \boldsymbol{\mu_U})(\mathbf{1} + \boldsymbol{g_U})^{\boldsymbol{t_i}}(\boldsymbol{\alpha_U t_i} + \boldsymbol{\gamma_U})\right]$$

where ΔE is the estimated MSWTE potential change for each LGU (MWh); $p(t)$ is the population for each LGU (capita); m is the slope for the per capita waste generation rate (kg/capita/year^2); n is the slope for the per capita waste generation rate (kg/capita/year); θ is the slope for the urbanization (year^{-1}); μ is the y-intercept for the urbanization (dimensionless); α is the slope for the economic ratio (year^{-1}); α is the intercept for the economic ratio (dimensionless); g is the growth rate (dimensionless); w is the waste fraction (dimensionless); NCV is the average experimental net calorific value for each solid waste type (MWh/kg); t = time (year); c is the parametric constants for residual wastes (dimensionless); and subscripts RS, i, f, and U represent the residual waste, initial and final states, and per LGU, respectively.

CONCLUSIONS

This study discusses the utilization and assessment of the energy potential from the solid wastes, as an alternative energy source. The usage of the energy potential assessment synthesis from the waste resources and Co Equation are presented in this study. Based from the decadal forecast results in the year 2028, the WTE potential assessment for the National Capital Region is 19.16 TWh.

Further waste-to-energy technologies, such as organic Rankine cycle (ORC) and others, may be subjected for auxiliary design after conducting the assessment of the energy potential using the concepts found in this study, in order to estimate the possible harnessed energy and further applied to the said technologies.

INTRODUCTION

The solid waste (SW) is a growing problem in the Philippines and the rest of the world. Over the span of years, the generation of SW in large countries, particularly in the Philippines, grew very rapidly. Much of this increase was due to population growth, but the rate of solid waste generation per person. Landfill sites are rapidly being filled and the availability of new sites is limited, especially near cities. In addition to the problem of site availability, there are problems of groundwater contamination, odor, disease, toxic chemicals, and escaping methane (Ristinen et al., 2016)

In the study of Liamsanguan and Gheewala (2003), they introduced the usage of the life cycle assessment (LCA) as the evaluation tool. In this study, LCA compares the two services in waste incineration, such as waste management and electricity production and the conventional power production system that includes landfilling without energy recovery. In order to provide the equivalent function of waste management in Thailand. As for comparison to the present study, since the assessment tool is very different. It does not give justification on the quantity of energy to be produced. Also, since landfill gas involved in the study, the present study does not include biodegradable wastes, in order to produce landfill gas.

Koroneos and Nanaki (2012) emphasized the innovative strategies with the prevention of present waste generation problems for the future generations. The objective of the study was to environmentally assess the MSW in the city of Thessaloniki, Greece with the methodological framework of LCA and the account of the Integrated Solid Waste Management strategy that include social, environmental, and economic effects. The study includes recycling of paper and aerobic digestion of food waste in a biological treatment facility. As a result of this assessment, paper recycling and aerobic digestion of food waste is more preferable than landfilling. It shows that the landfilling of food waste utilized more biocell activation as compared to the anaerobic digestion. As to compared in the present study, paper recycling is included. It is considered as recyclable waste. This type of waste can produce more energy due to easily combustion and through its good chemical composition. This may serve as a good source of fuel. In contrasting to the current study, food waste is not included. Aside from its limitation, food waste is difficult to include, due to the presence of moisture content and the different composition of food waste (HHV requires first rather than its LHV for the evaporation of water present).

In the study conducted by Ferrer (2012), the researcher assessed the challenges of SWM in Metro Manila, Philippines in terms of greenhouse gas (GHG) emission as well as the abatement potentials. In this study, life cycle assessment or LCA is used as an assessment tool. Methane emission is considered as the gas medium in order to estimate the potential of utilizing landfill gas (LFG) for energy recovery. As compared to the current study. Instead of life cycle assessment, the assessment tool is parameterization technique. In contrast also, the paper focused more on the LFG, instead of waste heat coming from waste incineration.

RESULTS AND DISCUSSIONS

The decadal forecast trend uses to determine the outcome of the results on a particular model or regression. It covers a decadal or ten (10)-year period of analyses the movements of variables or a series of data over periods of time are being analyzed. In this study, the graphical representation of the annual total WTE vs time are indicated as the results of the decadal forecast trend for NCR. These values were compared with the reference values. These reference values are the products of the data gathered from the Waste Analysis and Characteristics Study (WACS) from EMB-DENR (kg ·(capita-year)$^{-1}$), the LGU's population (capita) and the experimental NCV (MWh/kg). The table shows the result of the decadal forecast trend for NCR. The figure shows the graphical representation of the decadal forecast trend for NCR. All units are in terms of terawatt-hours (TWh).

Table: Decadal Forecast Trend (All units are in terms of Terawatt-hours or TWh.)

Region	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
NCR	18.21	18.35	18.46	18.56	18.66	18.76	18.86	18.96	19.06	19.16

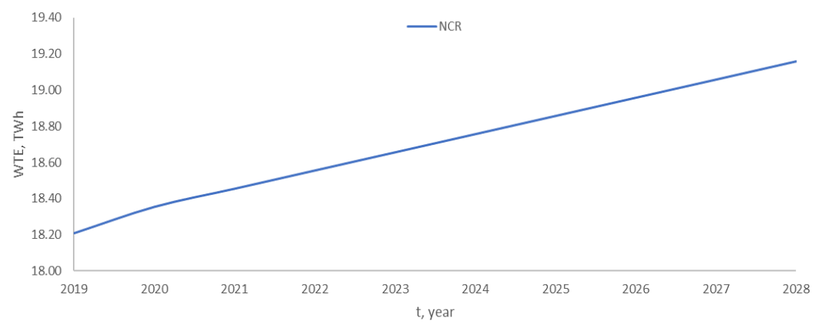

Figure: Graphical Representation of Decadal Forecast Trend for NCR

Based on the 2028 results, the evaluated WTE potential assessment on the National Capital Region (NCR) has a value of 19.16 TWh. Aside from this, it shows a positive trend that ensures a great energy potential subjected for future harvesting from municipal solid waste or MSW.

There were no comparative values from the literature, even in the local records from various Philippine agencies, like DOE or DENR. The types of waste (residual wastes) are taken to be considered. It is assumed to be a lump-sum of wastes to be taken from the residence per LGU are the main concern in this study. From the various literature gathered, specific waste were considered and subjected for analysis that was very differed in this study.