Executive Summary of MSc Thesis

Title: Evaluating the Energy Efficiency of Material Recovery Facility (MRF) and In-vessel Composting (IVC) Facility

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Objectives

The fundamental aim of this study is to evaluate the possible ways of improving energy efficiency in both material recovery facility (MRF) and in-vessel composting (IVC) plant. Various aspects are taken into account including technological, economic and from a political point of view. In order to achieve this goal, several objectives have been listed down. Firstly it is essential to understand thoroughly the process flow in the MRFs and IVCs. Next, the energy consumption for every component involved in these processes is evaluated and hence, identify the energy intensive components in the facilities. New technologies are proposed to boost energy efficiency in the plants, and the application costs as well as the environmental benefits will be estimated. Besides that, it is also important to evaluate the barriers to energy efficiency. Lastly, several recommendations are provided for further researches to be implemented.

Introduction

World’s primary energy consumption has been growing over the years due to population growth and industrialisation. The issue of global warming and climate change has drawn people’s attention to search for ways to improve energy efficiency. Energy efficiency can be defined as the ratio of energy services output to energy input and getting the most out of every unit of energy being bought [1]. In recent years, waste management system is targeted as one of the effective ways to enhance energy efficiency where energy can be recovered from treated waste. Thus, material recovery facility (MRF) and in-vessel composting (IVC) facility act as a part of the waste management system have the role of boosting energy efficiency. In this study, the main focus would be on how energy efficiency can be improved by replacing with new technologies that are eligible under the enhanced capital allowance (ECA) scheme.

Methodology

A research strategy has been developed by combining several research methods in order to meet the aim and objectives of this study. These research methods can be separated into three sections, which are the background research, case studies and data collection. Background research comprises different aspects, ranging from the review of current technologies used in both the MRF and IVC facilities to current government schemes and policies involved. Two case studies within the UK were chosen to implement this study, where MRF1 and IVC1 are part of an integrated waste management plant while MRF2 is a standalone waste treatment plant. These two case studies have provided an insight into the opportunities to improve energy efficiency. Data is collected from the facility coordinator for these three plants, which include the energy consumption for each of the components involved and also the waste compositions that enter the facilities. Other data is obtained from the internet, and these data is analysed together with the data from the facilities in order to provide a rough guide to the possible strategies to conserve energy.

Results and Analysis

The results and analysis are presented in different sections according to the objectives of the study. Hence, results are shown in correspondence to the methodology and the aim of this study.

- **Objective 1 – to understand the process flow**

  The process flows in the MRFs and the IVC facility are studied. Apart from that, the waste composition that arrives at MRF2 is the only data obtained from plant coordinator, and it is used to compare with the typical waste composition that arrives at a MRF. The comparison shows similarity where paper materials (including old corrugated cartons (OCC), newspapers, magazines and cards) comprise the majority of the input materials, with approximately 59.5% for MRF2 and 75.7% for a typical waste composition[2].

- **Objective 2 – to evaluate the energy consumption**

  Data for the energy consumption of every components involved in the treatment process are obtained in order to evaluate the energy consumption as well as identify the energy intensive components in these facilities. Generally, the most energy intensive components for a MRF plant can be grouped into 4 different parts, which are the heating, ventilation and air conditioning (HVAC) units, compressed air equipment, balers, and near infrared (NIR) auto sort technologies. For instance, the energy demand of HVAC units and the balers are 75kW and 55kW respectively, while most of the other components have the power rating of less than 10kW only. On the other hand, the components that involved in the composting process such as the humidifier fans, tunnel fans and floor suction fans are the energy intensive equipment for an IVC facility. For example, the humidifier fans have the power rating as high as 75kW while the equipment that does not involve in composting process has the power rating in the range between 0.25kW to 11kW.

- **Objective 3 – to estimate the application costs and environmental benefits**

Assume MRF1 and MRF2 operates for ten hours a day, six days a week, and the cost of electricity charged is £0.07 per kWh, the estimated cost of operating MRF1 and MRF2 is around £70,000 and £250,000 per annum, respectively. Whereas, the cost of electricity in one year for IVC1 is estimated to be approximately £320,000 (based on the assumptions that it operates for twenty two hours a day, seven days a week and the rate of electricity charged at £0.07 per kWh). According to Air User (2011)[3], the breakdown of the costs of compressed air equipment (one of the energy intensive components) is assumed to be approximately 75% of energy costs. Hence the enhancement of energy efficiency could save an organisation a significant amount of energy bill. As for the environmental benefits, the main focus is on the carbon emissions and costs that could be saved by replacing with energy saving technologies that are eligible under Enhanced Capital Allowance scheme. By using the conversion factor obtained from Carbon Trust (2011), the carbon dioxide equivalent (CDE) for MRF1, MRF2 and IVC1 are approximately 550 tonnes, 1,900 tonnes and 2,500 tonnes respectively. Substantial amount of electricity cost and carbon emissions could be reduced by replacing the current technologies with energy saving equipment.

- **Objective 4 – to evaluate the barriers to energy efficiency investments**

Despite the fact that new energy policies have been created aiming to help reduce the greenhouse gas (GHG) emissions and improve energy use by all means, barriers to the investment on energy efficiency still exist. Generally, the barriers to energy efficiency can be categorised into four sections, which are the economic non-market failure, economic market failure, behavioural factor and organisational factor[4].

**Discussion**

One other option that can be considered to improve energy efficiency in the plants is the mobile unit – forklifts. There are three forklift types in the market, the battery-powered forklifts, fossil-fuelled forklifts and the fuel cell forklifts. Fossil-fuelled or the Internal combustion engine (ICE) forklifts can be further separated into spark ignition (SI) (powered by gasoline, propane and compressed natural gas) and the compression ignition (CI) that powered by diesel fuel, which is currently used in the facilities. Even though diesel-powered forklifts is cheaper and provide good lift capacity, but it is also the least environmental friendly type where it releases the most carbon emissions compared to battery-powered and fuel-cell forklifts. However, there are also disadvantages for using battery-powered and fuel-cell forklifts, higher capital and maintenance cost is one of them. In addition, it is still lack of fuel cell market in the UK especially for forklifts. Comparatively, there are much more incentives and policies to encourage the utilisation of fuel-cell technologies in the US.

ECA scheme that managed by Carbon Trust on behalf of the UK government plays a vital role in encouraging businesses to participate in energy efficiency investment. There is a wide range of technologies registered on the energy technology list (ETL),

which is approved as energy saving equipment to assist organisations to improve energy efficiency and reduce GHG emissions. ECA scheme not only provides a 100% tax relief on the first year of investment, but would also save businesses a significant amount of energy bill and reduce the operation cost as a long term investment.

Other opportunities are such as new energy saving technologies could be applied in the facilities. For instance heat exchanger or heat pump can be installed next to a baler to capture the heat generated from the baler and used it within the facility or transferred to nearby facilities (eg. heat generated from MRF1 transferred to IVC1). The heat wasted is useful in reducing the energy used for heating processes such as the HVAC units or the composting process where certain temperature is required.

Conclusion and Implications

Energy efficiency can be improved by technologies with higher energy saving features or higher efficiency. More researches need to be carried out in order to provide accurate and solid evidence on the methods of enhancing energy efficiency. A combination of efforts from individual, organisations and government is required to achieve the goal of boosting energy efficiency and meet our society’s future energy needs.

Lack of data is the main limitation to this study, where most of the calculations were based on assumptions basis.

A detailed record and analysis of the energy consumption in the MRF and IVC would be recommended to provide an accurate report. More data such as the waste composition, operation hours and the efficiency of the equipment are required to implement precise calculations. Furthermore, an analysis on the forklifts that include fuel consumption, capital expenditure and operation expenditure should be carried out.