CHAPTER I
INTRODUCTION

1.1 Background

The escalating global population and economic growth have led to a substantial surge in energy consumption. This increased demand is primarily met by fossil fuels, which are not only finite but also major contributors to greenhouse gas emissions and environmental degradation, particularly CO_2 emission. Octavianthy & Purwanto (2019) finds out that fossil-based fuels are still used to generate power in Indonesia which around 80%, unfortunately. The urgency to transition towards sustainable and renewable energy sources has never been greater. A comprehensive review by Hassan et al. (2024) highlighted the significant growth of renewable energy adoption internationally, emphasizing the need for continued research and development in this area. Waste-to-Energy (WtE) technologies offer a promising avenue to address both the energy crisis and the mounting waste management challenges faced by cities worldwide. Beyene et al. (2018) reviewed various WtE technologies and concluded that they present a viable solution for simultaneously managing waste and generating clean energy.

Padang City, like many urban centers, grapples with the increasing generation of municipal solid waste (MSW). In 2024, Central Statistics Agency (BPS) states that Padang City has reached 954,177 population with approximately 660.06 tons per day MSW generation according to national Waste Management Information System (SIPSN). This waste, consisting of various components such as food waste, paper, cardboard, and plastics, often ends up in landfills, where it decomposes and releases methane, a potent greenhouse gas (Raharjo & Ariska, 2022). However, this waste also represents a valuable yet underutilized energy resource. In the case of Padang City, this biodegradable component of MSW could be harnessed through Anaerobic Digestion (AD) to produce biogas, creating both environmental and economic benefits. AD not only reduces the volume of organic waste requiring disposal but also contributes to the city's energy supply by generating sustainable fuel.

The Ministry of Energy and Mineral Resources (2014) states that biogas is a colorless and odorless gas produced through the fermentation process of organic materials in conditions without the presence of oxygen, a biogas is flammable, and has a methane gas content of about 50-70%, has a high calorific value of about 6,400 to 6,600 kcal/m^3, contents of 1m^3 equivalent to 0.62 kg of kerosene or 0.46 liters of LPG. Jameel et al. (2024) described that biogas can be used for electricity generation, heating, even as vehicle fuel, thus contributing to a circular economy and reducing reliance on fossil fuels. Biogas is a renewable energy source that can play a major role in sustainable energy transition through green electricity generation which appears to have potential as an alternative energy source, especially for rural communities like Limau Manis District. Typically, biogas can be processed into biomethane, which is used for heat and electricity generation as well as the production of chemicals and renewable fuels. Biogas comes from biogenic materials and is a type of biofuel, generally referring to gas produced by bacterial fermentation of organic materials under anaerobic (in the absence of oxygen) conditions, which can be produced from various types of organic materials, including MSW (Raja & Wazir, 2017).

This study is particularly important in the context of Padang City due to its alignment with national and regional policies that promote renewable energy and sustainable waste management. Indonesia's National Energy Policy (RUEN) in President Regulation No. 22 of 2017 aims to achieve a 23% renewable energy mix by 2025 and reduce greenhouse gas emissions by 29% by 2030. Similarly, the Regional Medium-Term Development Plan (RPJMD) of Padang City (Padang City Government, 2021) emphasizes the importance of sustainable waste management and the utilization of renewable energy sources. This study directly supports these policy objectives by investigating the potential of anaerobic digestion to convert Padang City's municipal solid waste generation into biogas, a renewable energy source. The findings of this study will provide valuable insights for policymakers and stakeholders in Padang City to develop effective strategies for waste management and renewable energy implementation.

The Padang City Government has implemented several programs related to WtE (Waste to Energy) such as Waste Banks, Composting, and Landfill Gas Recovery

(LFG) at the Air Dingin Landfill in Padang, but there is not yet an Anaerobic Digestion program. Anaerobic digestion (AD) is a promising technique to process organic waste, compared to other methods, including thermal, biological, and chemical approaches. AD comprises a series of four biochemical reactions, i.e., hydrolysis, acidogenesis, acetogenesis, and methanogenesis. AD of organic waste from landfills releases CH_4 and CO_2 thereby causing environmental pollution (Prasanna Kumar et al., 2024). To effectively implement AD for MSW in Padang, a comprehensive understanding of the waste composition and its energy potential is crucial. This includes analyzing the elemental composition (carbon, hydrogen, oxygen, sulfur, and nitrogen) of the MSW and estimating the potential biogas yield based on these characteristics. Additionally, identifying the waste components most suitable for AD will help optimize the process and maximize biogas production.

This study aims to address this knowledge gap by conducting a thorough analysis of the energy potential of MSW in Padang. Currently, there is no existing research that estimates the energy potential on the scale of Padang City specifically for biogas production from MSW using AD. The method used for this research are characterizing the waste composition, determining the energy content of different waste fractions, estimating potential biogas yields, and identifying suitable waste components for AD, this research will provide valuable insights for developing effective and sustainable WtE strategies in Padang City.

1.2 Research Purpose and Objectives

The purpose of this study was to determine the potential energy content of municipal solid waste in Padang City through anaerobic digestion.

The objectives of this study were:

1. To evaluate the existing condition of municipal solid waste management especially in relation to Waste to Energy in Padang City
2. To identify and analyze the characteristics of Padang City's municipal solid waste through proximate and ultimate analysis.
3. To estimate the potential biogas yield based on its chemical composition and identify the characteristics of waste components within Padang City's MSW that are most suitable for AD.

4. To formulate a preliminary implementation plan for electricity generation from municipal solid waste in the Limau Manis area of Padang City.

1.3 Research Benefits

The benefits of this study are:

1. To help develop a more effective strategy for managing waste in Padang City;
2. To obtain data on waste generation and composition that can be taken into consideration in managing the waste energy potential of Padang City.

1.4 Research Scopes

The scope of this study research problem was:

1. This research was conducted in selected districts of Padang City for solid waste sampling and across all districts for questionnaire distribution to gather community opinions. The collected data were used to calculate the average electricity consumption and to estimate the overall renewable energy potential of Padang City. Limau Manis sub-district was specifically chosen as the sample location to implement and observe the study's findings as a practical test site representing a smaller-scale model of the city's potential.
2. The study analyzed eight major components of municipal solid waste collected from several representative sampling points in Padang City.
3. This research analyzed the chemical element composition (C,H,N,S,O) using ultimate analysis and estimated biogas production based on sample characteristics.
4. The research focused on the following waste components: food waste, wood/twigs, paper/cardboard, plastic, metal, fabric, rubber/leather, and glass.
5. This research utilized a descriptive quantitative method to obtain information about the energy potential and characteristics of municipal solid waste in Padang City
6. Questionnaires scope are residents of Padang City based on each districts population percentage to represent each of all districts in Padang City.

1.5 Writing Systematics of Final Project

The systematics of this final project are:

CHAPTER I INTRODUCTION

This chapter contains background, aims and objectives of the research, research benefits, research problem boundaries and writing systematics.

CHAPTER II LITERATURE REVIEW

This chapter discuss waste caused by natural disasters, waste caused by non-natural disasters, and other supporting theories related to the research.

CHAPTER III RESEARCH METHODOLOGY

This chapter describes stages of research carried out, literature study, location, and research time.

CHAPTER IV RESULTS AND DISCUSSION

This chapter contains the results of the research along with its discussion.

CHAPTER V CONCLUSION AND SUGGESTION

This chapter contains conclusions and suggestions based on the research and discussion that has been described.