CHAPTER I
INTRODUCTION

1.1 Background

The global demand for energy has been continuously increasing approximately 47.9%, from 290.02 Exajoules (EJ) in 2000 to 429.11 EJ in 2023 as a consequence of population growth, industrial expansion, and improvements in living standards. At present, the majority of global energy consumption, including the household sector, is supplied by fossil fuels such as petroleum, coal, and natural gas (International Energy Agency, 2025). The reliance on fossil fuels has been recognized as a major driver of environmental degradation. The combustion of these fuels is responsible for substantial greenhouse gas emissions, particularly carbon dioxide (CO_2), which has been identified as the primary contributor to global warming.

The Intergovernmental Panel on Climate Change (IPCC, 2022) indicated that in 2019 approximately 34% (20 $GtCO_2$-eq) of total net anthropogenic GHG emissions came from the energy supply sector. Furthermore, air pollutants such as carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and fine particulate matter ($PM_{2.5}$) are released during the combustion of fossil fuels. These pollutants contribute to the degradation of air quality and significantly elevate the risks of respiratory, cardiovascular, and neurological diseases, with long-term exposure leading to severe health issues like asthma, heart disease, and stroke (Taha et al., 2025).

In response to these adverse impacts, a global transition towards cleaner and more sustainable renewable energy sources has been promoted. In Indonesia, the National Energy General Plan or *Rencana Umum Energi Nasional* (RUEN) targeted an increase in the renewable energy share to 23% by 2025 and 31% by 2050. However, the 23% target for 2025 has not been achieved, with the actual renewable energy share reaching only around 16%. This gap highlights the need for more effective strategies and further research to accelerate renewable energy

development, particularly in the utilization of renewable energy sources such as biomass (Dewan Energi Nasional, 2020).

Biomass has been identified as one of the most promising renewable energy resources due to its abundance, renewability, and wide availability across various regions in Indonesia. In addition to serving as an environmentally friendly alternative to fossil fuels, biomass offers significant potential for supporting national energy security and reducing greenhouse gas emissions. The national biomass potential is estimated at approximately 146.7 million tons per year. Despite this substantial resource base, its actual utilization remains remarkably low, reaching only about 5.57% (Tun et al., 2019).

Various types of biomass sources have already been explored for renewable energy applications, including agricultural residues (rice husks, palm oil residues, coconut shells), forestry residues, municipal organic waste, and livestock manure. Among the various biomass resources available, young coconut peels have not been fully exploited. This waste, consisting of husks, shells, and fibers, is generated in significant quantities, particularly in tourist destinations and culinary centers, such as Pantai Padang (Padang Beach) in West Sumatra.

Based on the findings of Azzahra (2024), the average daily generation of young coconut peels in the aforementioned area reaches 10.8 kg per vendor, all of which is disposed of in landfills without further processing. Such disposal practices not only diminish environmental aesthetics but also pose a risk of air pollution when open burning occurs. Nevertheless, the high lignocellulosic content of young coconut peels renders it a potential feedstock for the production of densified biomass fuel in the form of biopellets.

Biopellets are considered advantageous over raw biomass due to their higher energy density, uniform size and shape, lower moisture content, and ease of storage and transportation (Obernberger, 2010). The use of biopellets has been recognized not only as an alternative to fossil fuels but also as a means of reducing organic waste. In order to achieve optimal utilization of biopellets, efficient and clean combustion technology is required. One technology that meets these requirements is the Top-Lit Updraft (TLUD) stove. In this system, the fuel bed is ignited from the top while

primary air is supplied from beneath the fuel, creating an upward flow of hot gases. As these gases pass through the secondary air inlet, volatile gases released during pyrolysis are oxidized. This two-stage combustion process has been shown to improve thermal efficiency and significantly reduce harmful emissions (Scharler et al., 2021).

Research on utilization of young coconut peels for biopellet production has been conducted by several authors. Biopellets produced from a mixture of young coconut peels and coconut shells have been shown by Aulia et al. (2024) to possess a calorific value of 7,468.51 kcal/kg and a moisture content of 7%, complying with SNI 8021-2014 standards. The incorporation of 5% natural zeolite and molasses binder in young coconut peels biopellets was reported by Rozi et al. (2023) to increase the burning rate to 0.017 g/s.

However, despite these advancements, previous studies have generally relied on mixtures of biomass materials or the addition of binders to improve performance. Moreover, data regarding the quality of pure young coconut peel biopellets in compliance with relevant standards, their combustion emissions, and their combustion performance in TLUD stoves remain unavailable. This gap highlights the need for further research focusing on the direct potential of young coconut peels.

For this reason, the present study aims to utilize young coconut peels as a single, unmixed feedstock for biopellet production, analyze the resulting biopellet quality based on the Indonesian National Standard (SNI 8675:2018), measure combustion emissions, and evaluate combustion performance using a TLUD stove in accordance with SNI 7926:2013. The outcomes of this research are expected to contribute to the advancement of renewable energy development, reduce organic waste accumulation, and provide an environmentally friendly alternative fuel.

1.2 Research Aims and Objectives

1.2.1 Research Aims

This research aims to utilize young coconut peels as raw material for biopellet production, analyze its quality based on SNI 8675:2018, and assess its emission factors and combustion performance in TLUD stove based on SNI 7926:2013.

1.2.2 Research Objectives

The objectives of this research are as follows:

1. To analyze the quality of young coconut peels biopellets based on SNI 8675:2018 concerning Biomass Pellets for Energy and compare with previous research.
2. To calculate and analyze the emission factors of $PM_{2.5}$, CO, and CO_2 from combustion of young coconut peels biopellets in TLUD stove based on SNI 7926:2013 concerning Biomass Stove Performance and compare with previous research.
3. To evaluate the combustion performance of TLUD stove in burning young coconut peels biopellets based on SNI 7926:2013 concerning Biomass Stove Performance and compare with previous research.

1.3 Research Benefits

The benefits of this research are as follows:

1. To provide scientific information regarding the characteristics and potential of young coconut peels biopellets as an alternative fuel, as well as to serve as a reference for further studies related to the utilization of young coconut peels.
2. To offer an alternative solution to address the issue of young coconut peels waste and to reduce dependence on fossil fuels.
3. To serve as a source of information for the government and the public regarding the potential utilization of young coconut peels as an alternative fuel.
4. To encourage innovation and the application of appropriate technology in the field of renewable energy and young coconut peels processing.

1.4 Problem Boundaries

In the implementation of this study, the problem boundaries are set as follows:

1. Research Object

   This research focuses on the utilization of young coconut peels for biopellet production, along with the analysis of its quality, emissions factor, and combustion performance using TLUD stove.

2. Research location
    a. The production process of young coconut peels biopellet was carried out at the Integrated Waste Management Center or *Pusat Pengolahan Sampah Terpadu* (PPST), Universitas Andalas.
    b. The quality testing of young coconut peels biopellet was conducted at the Solid Waste Laboratory, Department of Environmental Engineering, Faculty of Engineering, Universitas Andalas.
    c. The emission and combustion performance testing of the biomass stove will be conducted at the Emission Testing Room, in *Pusat Studi Lingkungan Hidup* (PSLH), Universitas Andalas.
    d. The sulfur content and calorific value tests of young coconut peels biopellet were conducted at the Basic and Central Laboratory, Universitas Andalas.
3. Tools and materials
    a. The biopellets used were made from young coconut peels.
    b. The biomass stove used in this study was a TLUD stove.
4. Research method
    a. Preparation of young coconut peels biopellets includes the stages of shredding, initial drying, pelletization, final drying, and packaging.
    b. Quality testing of young coconut peels biopellets was carried out based on SNI 8675:2018 about Biomass Pellets for Energy.
    c. Emission testing and combustion performance were conducted using a TLUD stove, based on SNI 7926:2013 about Biomass Stove Performance.
    d. Data were analyzed through descriptive statistics and comparative tests.
5. Measured parameters
    a. Quality of biopellets: density, ash content, moisture content, volatile matter, fixed carbon content, net calorific value, and sulfur content.
    b. Emissions factor: $PM_{2.5}$, CO, and CO_2.
    c. Combustion performance: specific fuel consumption, combustion efficiency, and thermal efficiency.
6. This research does not cover the economic and social aspects of utilizing young coconut peels biopellets.

1.5 Systematization of Report Writing

The systematic report writing in this research is as follows.

CHAPTER I INTRODUCTION

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

CHAPTER II LITERATURE REVIEW

This chapter contains a review of the literature relevant to the research as a theoretical basis that supports the implementation of research and report preparation.

CHAPTER III RESEARCH METHODOLOGY

This chapter describes the stages of the research, starting from the literature review, primary data collection, sampling methods, and analysis methods, to the research location and period.

CHAPTER IV RESULTS AND DISCUSSION

This chapter presents the research results obtained based on the methods that have been applied, as well as their analysis and discussion. The data generated includes the quality of biopellets, emissions factor, and combustion performance of the biomass stove.

CHAPTER V CONCLUSIONS AND SUGGESTIONS

This chapter contains conclusions and suggestions that are compiled based on the results of the research and analysis that has been done.