CHAPTER 1
INTRODUCTION

1.1 Background

Over the past few years, 5G technology has emerged as a significant milestone in the global advancement of telecommunications, including in Indonesia. 5G technology offers a versatile network capable of connecting individuals and billions of devices at any time and in any location. 5G networks provide an optimal solution for high-speed data transfer and real-time communication, offering significantly lower latency and greater network capacity compared to 4G LTE and earlier generations [1], [2]. 5G technology offers three distinct types of services: Extreme Mobile Broadband (eMBB), which provides a high-speed internet connection, Massive Machine Type Communication (mMTC), which enables long-distance communication with cost-effectiveness and reduced power consumption, and Ultra-reliable Low Latency Communication (URLLC), which provides low latency, ultra-high reliability, and a high quality of services (QoS). In addition, the 5G networks are capable of achieving data rates of up to 20 Gbps/s with connectivity density of 106 devices/km². Therefore, 5G networks are capable of facilitating communications with a level of reliability that has not been present in previous generations [3].

The deployment of 5G technology in Indonesia remains in its early phases and is developing gradually. In 2021, 5G technology was first introduced in Indonesia, encompassing 49 cities, including important urban centers such as Jakarta, Surabaya, Bandung, Medan, and Makassar [4]. Indonesia is experiencing a rapid digital transformation, propelled by advancements in technology and the internet. The increasing number of smartphone users and growing internet access are accelerating digitalization in various sectors. By 2023, the number of active smartphone users in Indonesia reached 209.3 million, an increase from 192.6 million the prior year [5]. Furthermore, survey findings published by the Indonesian Internet Service Providers Association (APJII) indicate that the internet penetration in Indonesia in 2024 attained 79.5%, an increase of 1.4% from the previous year [6]. The proliferation of smart devices, along with the adoption of 5G devices and the demand for fast, reliable, and extensive communication services has led to an increase in mobile data consumption, especially in urban areas. It also supports the demand for the adoption of 5G technology in Indonesia. As one of the developing countries,

Indonesia has its own challenges in 5G implementation, including infrastructure and financial constraints [7]. The Indonesian government intends to auction the 700 MHz frequency spectrum, formerly utilized for Analog TV services, which has recently undergone Analog Switch-Off (ASO). The 700 MHz frequency band is categorized as a low band, offering extensive coverage and effective building penetration. Therefore, the utilization of this frequency band has a great opportunity in the development of 5G networks in Indonesia [8], [9].

The prospect of utilizing the 700 MHz frequency range for 5G networks is quite promising. Numerous prior studies have discussed the use of the 700 MHz frequency spectrum. In 2022, a study was undertaken to evaluate the utilization of the 700 MHz frequency in urban areas, revealing favorable outcomes about signal propagation in urban settings. This research has limitations, including insufficient demographic data which impacts the network design, particularly regarding capacity and coverage, as well as an economic analysis that does not include cost analysis, such as initial investment, the potential of 5G services, and other factors [10]. In addition, there is another study on the use of the 700 MHz frequency spectrum for 5G in Bali Province. This analysis indicated that the spectrum is appropriate for facilitating 5G implementation in Bali, with the potential to enhance network capacity and spectrum efficiency. This research has drawbacks, such as only focusing on technical aspects and neglecting non-technical factors, including social and economic considerations [8]. Moreover, studies on the application of the 700 MHz frequency for 5G networks in industrial areas showed advantages when compared to the 2.3 GHz frequency. It is mentioned that the 700 MHz frequency is more efficient in terms of signal coverage because it has better SS-RSRP and SS-SINR values [11]. Jakarta as one of the most densely populated and digitally active regions in Indonesia, is home to approximately 10 million people, with 82.47% of its population projected to own a mobile phone by 2023 [12]. The Jakarta Metropolitan Area is selected due to its strategic importance as Indonesia's economic hub, its high urban population, and the increasing demand for advanced mobile broadband services. The growing demand for seamless digital connectivity, coupled with high data consumption, highlights the need for a 5G network in DKI Jakarta.

Therefore, this study aims to bridge the gaps identified in previous research by providing a comprehensive techno-economic evaluation of the 700 MHz spectrum for 5G deployment in Jakarta. This study aims to conduct a detailed techno-economic analysis focusing on the utilization of the 700 MHz spectrum for the implementation of 5G Non-Standalone (NSA) networks in dense urban areas, specifically DKI Jakarta which exhibits high mobility levels. This study examines the

capacity of 5G networks to fulfill anticipated user demands and requirements, along with their commercial feasibility. Network planning and simulation will determine the required gNodeBs, throughput performance, and infrastructure specifications. Furthermore, this study includes financial modeling to assess feasibility, covering Capital Expenditure (CAPEX), Operational Expenditure (OPEX), Net Present Value (NPV), Internal Rate of Return (IRR), Payback period (PBP), and Profitability Index (PI).

1.2 Research Problem

Several issues have been identified based on the provided background. They are enumerated as follows:

1. Performance analysis of 5G networks on 700 MHz spectrum from a technical perspective in dense urban environments
2. Study of economic aspects in the implementation of 5G networks with 700 MHz spectrum in dense urban areas
3. Sensitivity analysis of key parameters affecting the business feasibility of 5G deployment using the 700 MHz spectrum

1.3 Research Purpose

This study is to evaluate the viability of establishing and executing a 5G network utilizing the 700 MHz frequency range in heavily populated urban regions of Jakarta. This feasibility assessment will employ two primary methodologies: technical analysis, concentrating on the evaluation of coverage performance with a target SS-RSRP value of no less than -80 dBm and signal quality for capacity with an SS-SINR value of at least 10 dB and economic analysis, aimed at mitigating investment risks by scrutinizing indicators such as Net Present Value (NPV) exceeding 0, Internal Rate of Return (IRR) surpassing 10%, Payback Period within the project duration, and Profitability Index (PI) greater than 1.

1.4 Scope of Work

This study provides an in-depth analysis of the utilization of the 700 MHz frequency spectrum for the deployment of 5G networks in Jakarta Metropolitan area. The research encompasses the following areas:

1. The area used as the research location is Jakarta Metropolitan Area.
2. This study is limited to the use of the 700 MHz frequency band for 5G Non-Standalone networks.
3. Implementation of 5G networks in Non-Standalone (NSA) mode.
4. Economic analysis is limited to the calculation of Capital Expenditure (CAPEX), Operational Expenditure (OPEX), Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PBP), and Profitability Index (PI).

1.5 Research Methodology

This study was executed in multiple phases, as outlined below:

1. Literature Review

   This phase involves a comprehensive review of relevant literature related to:

   - The characteristics and propagation behavior of the 700 MHz frequency,
   - Technical studies on 5G network planning,
   - Techno-economic assessments and regulatory considerations,
   - Case studies on the implementation of 5G in urban environments.

   The goal is to establish a strong theoretical foundation regarding signal coverage, infrastructure deployment, and service efficiency.

2. Data Collection

   Both primary and secondary data are collected, including:

   - Morphological data of the Jakarta Metropolitan Area,
   - Network planning parameters,
   - Market data.

3. 5G Network Design

   A 5G network model operating on the 700 MHz frequency is designed specifically for the Jakarta area. The network planning process is divided into two technical components:

   - Coverage Planning

- Capacity Planning

The design is modeled using Forsk Atoll software as the simulation tool.

4. Simulations

   Simulations are conducted to evaluate signal strength and service quality based on key technical indicators, including:

   - SS-RSRP (Reference Signal Received Power),
   - SS-SINR (Signal-to-Interference-plus-Noise Ratio).

   These outputs help measure the network's technical performance under various deployment scenarios.

5. Result Analysis

   The final stage analyzes both technical and economic results:

   - Technical Analysis: Based on simulation outputs to assess feasibility in high-rise urban areas.
   - Economic Analysis: By calculating CAPEX, OPEX, and business feasibility using indicators, such as Net Present Value, Internal Rate of Return, Payback Period, and Profitability Index
   - Sensitivity Analysis: To strengthen the economic evaluation, a sensitivity analysis is conducted to observe how changes in key input variables affect business viability metrics. This includes varying parameters, such as number of 5G users and dollar exchange rate.

1.6 Hypothesis

The 700 MHz frequency, currently available accessible following the Analog Switch-Off (ASO), offers extensive coverage and effective building penetration. The deployment of 5G network utilizing the 700 MHz frequency has been conducted in industrial and urban areas, yielding data that support the feasibility of this frequency for 5G implementation in these areas. Therefore, the implementation of 5G networks using the 700 MHz frequency spectrum in dense urban areas, specifically in DKI Jakarta, is expected to be technically feasible, demonstrated by achieving RSRP values above -80 dBm and SINR values above 10 dB based on KPI standards. Moreover, this solution is projected to be economically viable, indicated by a positive Net Present Value (NPV), an Internal Rate of Return (IRR) greater

than the discount rate used based on the WACC estimate of one of the telecommunications companies, which is 10%, a Payback Period of less than 5 years, and a Profitability Index greater than 1.0. These business feasibility metrics are based on ARPU values, the number of users, and investment costs adjusted to the conditions of the study area.