

**UNIVERSITI TEKNOLOGI MARA**

**OPTIMIZATION OF PITCH VALUE  
FOR A FIXED TILTED BIFACIAL  
GRID-CONNECTED  
PHOTOVOLTAIC SYSTEM FOR  
SOLAR FARM IN TROPICAL  
MALAYSIA**

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Thesis submitted in fulfilment  
of the requirements for the degree of  
**Master of Sciences**  
**(Applied Physics)**

**Faculty of Applied Sciences**

**November 2025**

## ABSTRACT

This research presented an optimization study of the pitch value for a fixed tilted bifacial grid-connected photovoltaic (bGCPV) system intended for solar farm in tropical Malaysia. Despite increasing bPV adoption in Malaysia, there is little research on pitch optimization under tropical, space constrained conditions. This study aimed to determine the optimal pitch value for different module in height and observed pitch-tilt coupling for fixed-tilted bifacial systems in tropical Malaysia under land-use constraints. The pitch parameter, which is the row-to-row distance between PV module arrays, directly influenced mutual shading, bifacial gain, and ground coverage ratio (GCR). Despite its importance, pitch optimization for bPV systems under space-constrained conditions in tropical regions remained sparsely investigated. This study addressed this gap by integrating a hybrid approach using AutoCAD for spatial layout planning and PVsyst software for performance simulation at an approximately 76,500  $m^2$  site in Ijok, Selangor. Unlike previous PVsyst-only studies, this work integrates AutoCAD spatial analysis with bifacial-specific. The pitch values ranging from 1.0 m to 10.0 m, with increment of 0.1 m were analyzed for three cases of portrait PV module orientation: Case A (1 module-in-height), Case B (2 module-in-height), and Case C (3 module-in-height). The planned power for each configuration was calculated in AutoCAD based on array rows, module orientation, and capacity. These layout inputs were then simulated in PVsyst using site-specific meteorological data, bifacial module settings, and fixed tilt angles ( $5^\circ$ ,  $10^\circ$ , and  $15^\circ$ ). System losses, shading factors, and bifacial gain contributions were also included to replicate real-world performance. This study indicated that a minimal pitch increased from 2.4 m to 2.5 m led to a 3.95% drop in planned capacity due to reduced installable rows. The analysis of module in height configurations revealed that increased the module in height required wider optimal pitch and reduced land efficiency, the 1-module configuration achieved the highest specific yield (1558 kWh/kWp/year), offering the best balance between bifacial gain and ground coverage. Coupled tilt-pitch analysis showed that lower tilt angles ( $5^\circ$ – $10^\circ$ ) consistently outperformed higher ones across all cases, with Case A at  $5^\circ$  and 4.6 m pitch emerging as the most efficient design under space-constrained tropical conditions.

## ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest gratitude to my main supervisor, Associate Professor Dr. Hedzlin Zainuddin, for her continuous guidance, encouragement, and invaluable insights throughout the course of this research. Her unwavering support and constructive feedback have been instrumental in shaping the direction of this study.

I would also like to extend my sincere appreciation to my co-supervisors, Associate Professor Ts Dr. Shahril Irwan Sulaiman, and Dr. Nurmalessa Muhammad @ Atan, for their expert advice, technical assistance, and encouragement throughout the research process. Their contributions have significantly enhanced the quality and depth of this study.

A heartfelt thank you to the Green Energy Research Centre (GERC), Solar Photovoltaic Energy Conversion Technology Research Applications (SPECTRA), and Faculty of Applied Physics, Universiti Teknologi MARA for providing the necessary resources, facilities, and a conducive research environment that has allowed me to conduct this study effectively.

A special acknowledgment to my beloved parents, Fuadi bin Manaf and also my beloved husband, Khairul afiq bin Mohamad Rashid for their unconditional love, sacrifices, and endless support throughout my academic journey. Their encouragement and belief in my abilities have been the driving force behind my achievements. I also extend my heartfelt gratitude to my sisters, Nurdiyana Nabilah and Nur Diyana Nazihah, for their unwavering support during this challenging yet fulfilling journey. Their constant encouragement has been a source of strength for me.

I would also like to extend my appreciation to my fellow Master's friend, Siti Nor Nakhirah Ibrahim, for her invaluable support, insightful discussions, and encouragement throughout this research journey. Her willingness to share knowledge and experiences has greatly contributed to my learning process.

Finally, I acknowledge all individuals and organizations who have directly or indirectly contributed to this research. Your support and assistance have been invaluable, and I am truly appreciative of all kindness and generosity.

Thank you.

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# CHAPTER 1

## INTRODUCTION

### 1.1 Research Background

Globally, the solar photovoltaic (PV) industry has seen accelerated growth as countries prioritize sustainable energy transitions to meet climate goals and reduce dependence on fossil fuels. The average annual global horizontal irradiation (GHI) in Malaysia ranges from 1400 kWh/m<sup>2</sup> to 1900 kWh/m<sup>2</sup>, which provides a significant advantage for electricity generation through solar energy capture, making the country highly capable of achieving success in this field. (Ahmad et al., 2011; Zainuddin et al., 2021). The installed capacity of solar PV systems in Malaysia has reached 2306 MW in 2024 according to the International Renewable Energy Agency (IRENA) Report 2025 (Renewable Energy Agency, 2025). The market and academic groups' interest in crystalline silicon cells have shifted from monofacial photovoltaic (mPV) technology to bifacial photovoltaic (bPV) technology, as shown in Figure 1.1. This shift is documented in the International Technology Roadmap for Photovoltaic (ITRPV) 2025, which states that the market increases by year and will reach nearly 100% in 2035 from approximately 90% in 2024.

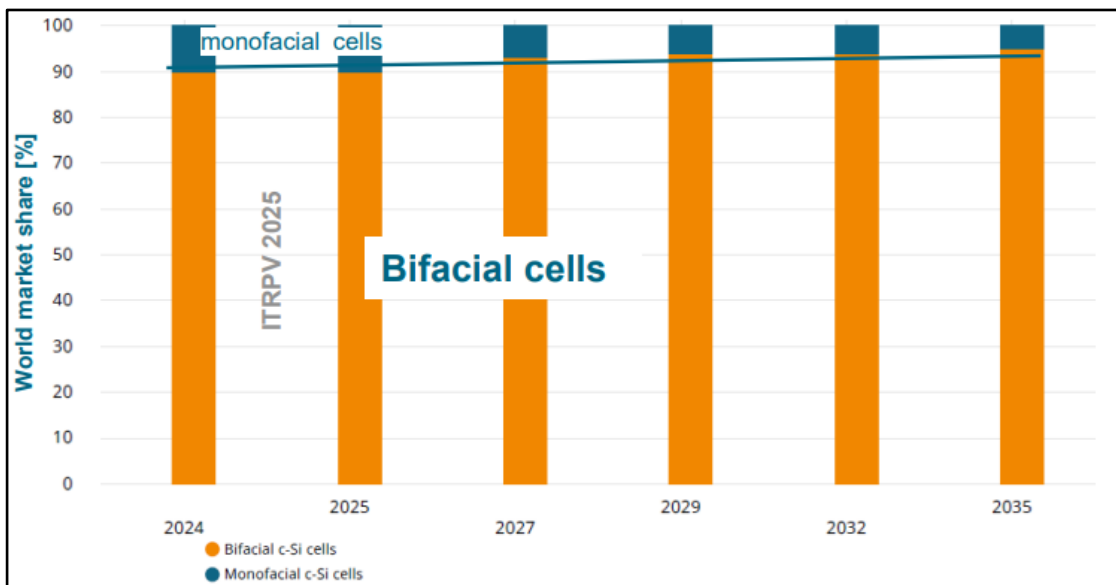


Figure 1.1 The Development Trend of the PV Market (Baliozian, 2025)