Comparative Analysis of Solar Energy Policies and Deployment in ASEAN Countries

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Abstract. The ASEAN region, characterized by rapid economic growth and increasing energy demand, has emerged as a critical area for renewable energy development, particularly solar photovoltaic (PV) systems. This study provides a comparative analysis of solar energy policies and deployment across selected ASEAN countries, examining regulatory frameworks, incentive mechanisms, and market development. Using a qualitative-quantitative approach, the research evaluates policy effectiveness by analyzing solar PV capacity growth, targets within national renewable energy plans, and alignment with regional sustainability commitments, including ASEAN Plan of Action for Energy Cooperation (APAEC) and the Paris Agreement. The findings reveal significant disparities in policy ambition and implementation. Countries such as Vietnam and Thailand demonstrate rapid deployment through strong feed-in tariff schemes and investment incentives, while others, including Indonesia and the Philippines, face challenges due to regulatory complexity and financial barriers. Singapore's innovation-driven policies highlight the role of technology and grid management in addressing land scarcity. The study concludes that harmonizing policies and fostering cross-border collaboration can accelerate ASEAN's solar energy transition. Recommendations are provided for enhancing policy design, investment frameworks, and regional cooperation to achieve a sustainable and inclusive low-carbon future.

1 Introduction

Global efforts to shift toward renewable energy have accelerated in recent years, with solar photovoltaics (PV) becoming a key technology. In 2024, the world added a record 582 gigawatts of renewable power capacity, with solar PV making up around 452 gigawatts—about 78% of all new renewable capacity that year [1]. This surge underscores the crucial part solar PV plays in driving decarbonization and the growth of sustainable energy.

South East Asia is experiencing a sharp rise in electricity demand, driven by factors like urban growth, industrialization, and increasing cooling needs. The IEA's Southeast Asia Energy Outlook 2024 predicts that electricity demand in the region will increase by around 4% per year until 2035, rising from over 1,300 terawatt-hours today to more than 2,000 terawatt-hours by 2035 [1]. According to Ember’s report, ASEAN's electricity demand

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increased by 3.6% in 2023, which was entirely fueled by fossil fuels, resulting in a 6.6% rise in emissions that year. Various ASEAN countries illustrate this trend in unique ways. Malaysia, for example, is expected to experience a sharp increase in power demand as data centers expand—projected to jump from 9 TWh in 2024 to 68 TWh by 2030, accounting for 30% of its national consumption [2].

Vietnam is still the region's leader in renewable energy capacity, with solar and wind making up 24.1% of its electricity mix in 2024—a remarkable jump from nearly zero just a few years ago [3]. Indonesia, on the other hand, plans to get 23% of its energy from new and renewable sources by 2025, and 31% by 2050. In 2024, Thailand generated only about 15% of its electricity from low-carbon sources like solar, wind, and hydro, with solar and wind accounting for around 5%—well below the global average of 15%.

As part of its 13th National Economic and Social Development Plan (2023–2027), the Power Development Plan (2015–2036), and the Energy Strategic Plan (2023), the goal is to decrease greenhouse gas emissions by 20% by the year 2030 and to guarantee that at least 50% of newly added power generation capacity originates from renewable energy sources by 2050. By early 2024, the Philippines had solar energy accounting for approximately 2.4% and wind contributing 3.1% of its total capacity. Targets aim to raise these to 5.6% (solar) and 11.7% (wind) by 2030. Renewables made up about 22% of installed capacity in 2023, with a goal of 50% by 2030 (~15.3 GW). Singapore, under its Green Plan and "4 Switches" strategy, is expanding solar PV capacity to 2 GW by 2030 and plans to import up to 6 GW of low-carbon electricity by 2035, potentially covering 30% of the nation's demand.

Collectively, ASEAN has set a renewable energy capacity target of 35% by 2025, and is nearing this benchmark with approximately 32% already achieved. The ASEAN Power Grid (APG) initiative supports regional energy security and sustainability by interconnecting national grids to maximize renewable energy sharing. According to ASEAN Energy Investment 2024, renewables—including solar, wind, and hydro—could account for over half of electricity generation by 2050 if large-scale projects and favorable policies materialize [4].

Although we have high ambitions and abundant solar potential, a comparative evaluation of solar energy policies across ASEAN is still limited. A recent study highlights the diversity of approaches but calls for a comprehensive cross-country analysis [5]. Notably, this observation reveals a significant research gap: the lack of a systematic comparison of solar PV policies—such as regulatory frameworks, incentives, and deployment outcomes—across the ASEAN region. To address this knowledge gap, this study aims to achieve the following objectives:

- Compare solar energy policies and deployment status across ASEAN countries in a systematic way.
- Assessing how well various policy tools can support the growth of solar PV.
- Identify the best practices and challenges, providing valuable insights to inform policy harmonization and regional cooperation

2 Methods

This study used a comparative policy analysis approach to look at how solar photovoltaic (PV) energy has developed across ASEAN countries. The method focused on both the numbers of solar PV systems in place and the policy frameworks that support them. By merging statistics with regulatory analysis, the study seeks to give a complete picture of how different ASEAN countries are addressing solar energy as part of their shift to sustainable power systems. Researchers collected data from reliable sources, including key international datasets from IRENA, IEA, and the World Bank, which formed the basis of quantitative

analysis. Regional publications from ACE, like the ASEAN Energy Outlook (AEO) and ASEAN Renewable Energy Reports, provided regional context.

Additionally, we reviewed national energy policies, power development plans, and relevant regulations to understand the policy landscape in each country. We also consulted peer-reviewed journal articles from 2024 and 2025 to gain academic insights and critical perspectives. The analysis followed a three-stage process.

Initially, we evaluated the status of solar PV deployment by gathering data on installed capacity, yearly growth, and national targets for 2030 or later. To make comparisons more comparable, we normalized the data using indicators like installed capacity per person and the share of solar energy in the electricity mix. The second stage mapped policy instruments like feed-in tariffs, renewable standards, auctions, net metering, tax incentives, and green finance, categorizing them by design and implementation, and assessed their alignment with regional and global commitments like ASEAN's APAEC and the Paris Agreement. The third stage compared ASEAN countries, noting policy similarities and differences.

This thematic synthesis pinpointed the best practices, main challenges, and supporting factors—such as strong political commitment, clear regulations, adequate financing, and grid infrastructure readiness. The study's scope included all ten ASEAN member states: Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam.

3 Results and Discussion

This section presents the study results and discusses solar PV development in ASEAN countries. It analyzes installed capacity, policies, drivers, and challenges for each nation, highlighting diversity and similarities. After individual assessments, a comparative analysis synthesizes findings, identifies best practices, and suggests regional cooperation and policy harmonization.

3.1 Vietnam

Vietnam has become the ASEAN frontrunner in solar photovoltaic (PV) development. By 2023, the country had installed approximately 16 GW of solar PV capacity, representing More than half of the region’s total, driven by Feed-in Tariff. (FiT) schemes introduced in 2017 and 2019, which provided attractive purchase rates and triggered unprecedented private investment [2]. In 2019, nearly 9 GW of solar was commissioned, making Vietnam a rapidly growing market.

The Power Development Plan VIII (PDP8) aims for 25,32 GW of solar by 2030, focusing on system reliability, transmission, and transitioning from FiTs to auctions. Vietnam’s experience illustrates that clear and bankable incentives can unlock massive renewable energy investment, but sustaining growth requires stronger grid infrastructure, stable regulatory frameworks, and diversification of financing sources. These lessons are highly relevant for other ASEAN countries seeking to accelerate their solar deployment.

3.2 Thailand

Thailand is among the first countries in ASEAN to adopt solar photovoltaic (PV) energy, with around 1.04 GW of installed capacity as of 2023. The country led the way in using feed-in tariffs (FiTs) and adder schemes in the early 2000s, which effectively spurred large-scale solar projects. Consequently, Thailand became the first ASEAN country to surpass 1 GW and has continued to see steady growth thereafter.

Thailand's solar sector is still facing challenges, despite its successes. Since feed-in tariffs were phased out, growth has slowed down, and the limited number of auctions is holding up project pipelines. Additionally, integrating intermittent solar power into the grid requires better grid management and stronger coordination between regulators [6]. Thailand's steady policy environment, combined with its early experience in solar deployment, makes it a key player in ASEAN's shift to renewable energy.

3.3 Malaysia

Malaysia has made steady progress in its solar photovoltaic (PV) sector, achieving an installed capacity of around 1,58 GW in 2023. Unlike Vietnam, which used feed-in tariffs (FiT) to drive growth, Malaysia took a more measured approach with the Large Scale Solar (LSS) program, launched in 2016. The LSS scheme uses competitive auctions, which have helped lower solar tariffs to some of the lowest levels in Southeast Asia.

Malaysia not only supports large-scale solar deployments but also encourages rooftop solar adoption through the Net Energy Metering (NEM) program, which has been updated several times to make it more appealing to homeowners, businesses, and industrial users. As part of the Transforming Energy Scenario (TES), Malaysia aims to reach 83 GW of solar PV by 2050, making a significant contribution to its goal of 53% renewable energy in its overall mix [7].

3.4 Indonesia

Indonesia, despite having vast solar potential of over 200 GW of technical capacity, is lagging behind in deploying solar photovoltaic (PV) systems. As of 2023, the country had installed only about 0.21 GW of solar PV, which is less than 1% of its total power generation capacity. The slow growth is due to complex regulations, grid integration problems, and limited financial incentives.

Indonesia aims for 5.3 GW of solar by 2030 and 31% renewable energy in the primary energy mix by 2050 under the RUEN. To achieve this, the government issued MEMR Regulation No. 2/2024 to simplify rooftop solar permitting and align with PLN's planning. PLN's RUPTL 2021–2030 also allocates significant capacity for solar, especially in eastern Indonesia [3].

3.5 Philippines

The Philippines has made steady progress in solar photovoltaic (PV) deployment, with an installed capacity of approximately 2.34 GW in 2023. Solar energy has become the largest contributor among variable renewable sources, benefiting from favorable policies such as the Renewable Energy Act of 2008, the Renewable Portfolio Standards (RPS), and the Green Energy Auction Program (GEAP) introduced in 2022. These frameworks establish mandatory renewable quotas for distribution utilities and include competitive procurement mechanisms that have attracted private sector investment [8].

The Department of Energy (DOE) targets 15 GW of solar PV by 2030, which would significantly increase solar's share in the country's energy mix. Recent GEAP auctions secured several gigawatts of capacity at competitive prices, highlighting the Philippines as a top solar market in ASEAN. However, challenges such as the country's geography complicate grid integration and raise project costs. Transmission congestion in Luzon delays new project connections, and financing risks from currency fluctuations and regulatory uncertainties worry investors.

3.6 Singapore

Singapore's solar photovoltaic (PV) deployment is limited by land scarcity and high urban density, which restrict large-scale ground-mounted projects. By 2023, the country installed about 0.17 GW of solar capacity, mainly from rooftop and floating PV systems. The government aims for 2 GW by 2030, projected to meet 4% of national electricity demand.

The SolarNova program, launched in 2014 and managed by the Housing and Development Board (HDB) and the Economic Development Board (EDB), has driven rooftop solar expansion in public housing. The government also encourages private sector participation through green financing and corporate power purchase agreements (PPAs). To tackle intermittency, Singapore has invested in smart grids, battery storage, and regional interconnections, with plans to import up to 6 GW of low-carbon electricity, including solar from neighboring countries, by 2035[9].

3.7 Myanmar

Installed solar photovoltaic (PV) capacity remains modest at less than 0.19 GW as of 2023. Most of the capacity comes from independent power producer (IPP) projects developed through bilateral agreements or small-scale tenders with support from foreign investors and multilateral development banks.

The government's National Electrification Plan (NEP) aims for solar energy to play a significant role in achieving universal electricity access in Myanmar by 2030. To attract investors, the government has also introduced limited feed-in tariffs and power purchase agreements. However, the implementation of these policies has been inconsistent, largely due to institutional and political instability. Key challenges include weak grid infrastructure, insufficient regulatory clarity, and limited domestic financing. Political uncertainty since 2021 has further deterred foreign direct investment, stalling several planned solar projects [10].

3.8 Cambodia

Over the past few years, Cambodia has seen significant growth in its solar photovoltaic (PV) capacity, hitting around 0.43 GW of installed capacity as of 2023. This growth is mainly fueled by independent power producer (IPP) projects backed by international development partners, such as the Asian Development Bank (ADB). They've helped organize competitive solar auctions that achieved some of the lowest tariffs in ASEAN]. Cambodia is shifting towards solar energy to diversify its power mix, traditionally dominated by hydropower. The ASEAN Renewable Energy Targets estimate that by 2030, solar will make up about 3.5% of Cambodia's energy, contributing to a broader 27% renewable energy goal.

Recent developments indicate rapid growth. By 2024, Cambodia has installed about 456 MW of solar, supplying over 4.6% of the national electricity, with projections of 7% by 2025. Despite conservative government targets, deployment is more ambitious due to falling costs and increased private sector involvement [11]

3.9 Laos

Laos has substantial renewable energy resources, but its solar PV sector remains underdeveloped. As of 2023, installed solar capacity was under 0.1 GW, a small part of its hydropower-dominated power generation [12]. Solar development has been mainly project-based, supported by PPPs and bilateral agreements with neighbors.

Laos has long positioned itself as a regional energy exporter, with more than 70–80% of its electricity exported to neighboring countries, primarily Thailand and Vietnam. Recent agreements reaffirm this trajectory. Notably, partnerships with Chinese state-owned enterprises aim to develop large-scale renewable projects, including solar and wind, for export to Yunnan Province in China. Similarly, Laos has expanded green energy trade discussions with Vietnam, reinforcing its regional role in cross-border electricity markets.

3.10 Comparative Analysis

Comparing solar PV development across ASEAN reveals different national paths and shared regional challenges. Vietnam led with about 16 GW by 2023. Countries like Laos, Myanmar, and Cambodia remain in early stages with capacities under 0.5 GW (Figure 1). Thailand, Malaysia, and the Philippines advance steadily thanks to clear policies, while Singapore innovates due to limited land. Indonesia, despite vast technical potential, lags due to regulatory and grid issues.

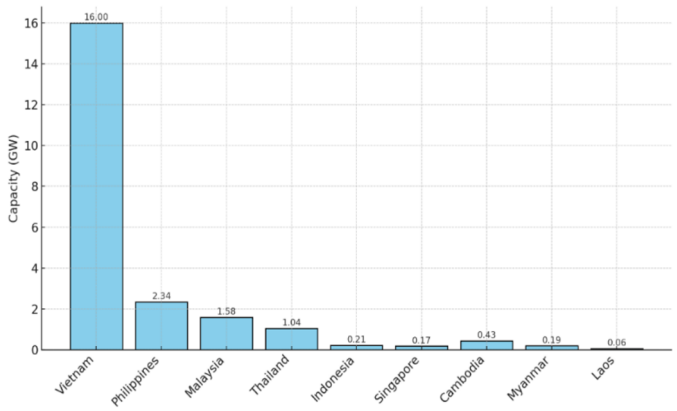

Fig. 1. Installed solar PV Capacity in ASEAN (2023).

Policy tools vary across countries. Vietnam and Thailand began with generous feed-in tariffs, promoting rapid growth, but later shifted to auctions and net-metering pilots to sustain investment. Malaysia and the Philippines implemented competitive procurement via Large-Scale Solar tenders, the Green Energy Auction Program, net-metering, and renewable portfolio standards. Cambodia adopted competitive auctions with international support, while Singapore used rooftop programs like SolarNova, green finance, and corporate power purchase agreements. Laos and Myanmar depend on project-based public–private partnerships and bilateral agreements linked to export strategies. Indonesia advocates regulatory reforms, including MEMR Regulation No. 2/2024 and amendments to PLN's

Renewable Energy Purchase Obligation Law, though implementation remains slow.

Targets for 2030 and 2037 vary. Vietnam aims for 25.3 GW by 2030 under PDP8, while Thailand's AEDP targets 14.86 GW by 2037. The Philippines seeks 15 GW by 2030, Malaysia projects 83 GW by 2050 under its Transforming Energy Scenario. Singapore's goal is 2 GW by 2030, plus 6 GW of imports. Indonesia's RUEN targets 5.3 GW by 2030, modest compared to its potential. Cambodia aims for 3.5% solar share by 2030, with external estimates of 700–850 MW by 2025–2030. Laos is planning about 1 GW of additional renewable capacity by 2030, mainly for export. Key policies are summarized in Table 1.

Table 1. Key Policy Instruments and Policy Highlights in ASEAN Solar PV Development.

Country	Key Policy Instruments	Policy Highlights
Vietnam	Feed-in Tariffs (2017, 2019); Transition to competitive auctions; PDP8 planning	Rapid capacity growth to 16 GW by 2023; FiT triggered massive private investment; ongoing grid curtailment issues
Thailand	FiT/Adder schemes; Net-metering pilots; Community solar; AEDP targets; Auctions	Early adopter, first ASEAN country >1 GW; Now shifting to auctions and exploring floating PV, battery storage, hydrogen
Malaysia	Large Scale Solar (LSS) competitive auctions; Net Energy Metering (NEM)	1.58 GW installed; LSS reduced tariffs significantly; NEM revisions boosted rooftop adoption
Indonesia	MEMR Regulation No. 2/2024 (rooftop solar); PLN's RUPTL; RUEN national targets	0.21 GW installed; vast potential >200 GW; barriers include PLN overcapacity and policy inconsistency
Philippines	Renewable Energy Act (2008); Renewable Portfolio Standards (RPS); GEAP auctions	2.34 GW installed; DOE target 15 GW by 2030; auctions awarded several GW competitively
Singapore	SolarNova program; Green financing; Corporate PPAs; Regional electricity imports	0.17 GW installed; target 2 GW by 2030; innovative rooftop & floating PV; imports 6 GW by 2035
Myanmar	National Electrification Plan (NEP); Limited FiTs; PPPs and bilateral tenders	<0.19 GW installed; high solar potential; stalled by political instability since 2021
Cambodia	ADB-supported competitive auctions; IPP-driven projects; ASEAN RE target	0.43 GW installed; 3.5% solar share by 2030; delivered some of ASEAN's lowest tariffs
Laos	NSEDP; SDG7 Roadmap; PPPs; Bilateral agreements; Export focus	<0.1 GW installed; target ~1 GW (solar + wind) by 2030; majority for export to Thailand, Vietnam, China

Across the region, common challenges emerge: grid integration bottlenecks (Vietnam, Philippines, Malaysia); regulatory instability (Indonesia, Vietnam, Myanmar); financing risks due to high cost of capital (Cambodia, Laos, Indonesia); and political uncertainty (Myanmar). Space constraints are unique to Singapore, while overcapacity in conventional generation limits solar uptake in parts of Indonesia and Thailand.

Best practices can also be pinpointed. Vietnam's FiT experience demonstrates how bankable incentives can attract investment, although long-term sustainability demands a strong grid expansion. Malaysia's auction framework shows how competitive procurement leads to cost savings, while the Philippines' RPS guarantees a minimum level of demand. Singapore highlights how innovation and regional trade can overcome geographic limitations, and Thailand's early adoption experience stresses the need for consistent policies.

Looking forward, ASEAN's solar transition will benefit from greater regional cooperation. The ASEAN Power Grid (APG) could facilitate cross-border trade to balance variable solar resources and monetize export-oriented projects from Laos and Cambodia. Harmonization of auction design and power purchase agreements could lower financing costs, while regional green financing initiatives could address investment barriers. Coordinated investment in transmission, storage, and digital grid solutions will be critical to transform ambitious targets into bankable projects.

4 Conclusions

This study shows diverse solar PV development in ASEAN, highlighting progress and ongoing challenges. Vietnam leads with over 16 GW in 2023 thanks to feed-in tariffs attracting private investment. The Philippines, Malaysia, and Thailand each deploy over 1

GW supported by policies like renewable standards, auctions, and net-metering. Singapore, limited by land, uses rooftop PV, floating systems, and cross-border imports to innovate and meet energy needs.

On the other hand, Indonesia, Cambodia, Laos, and Myanmar are still in the early stages of developing solar power, despite having a lot of technical potential. Indonesia's complicated regulatory system and PLN's overcapacity have limited the amount of solar power installed to just 0.21 GW. Meanwhile, Cambodia's growth has been mainly driven by donor-backed auctions, which have reached 0.43 GW by 2023. Laos has mainly focused on solar projects designed to export power, while Myanmar's progress has been slowed down by political instability and weak institutional frameworks.

Comparative analysis shows that Bankable FiTs can foster growth but must shift toward auctions and integrated grid planning, as in Vietnam and Malaysia. Philippines' renewable standards boost investment via regulation. Malaysia and Singapore's rooftop projects showcase distributed generation. Underdeveloped markets like Indonesia, Cambodia, Laos, and Myanmar need stable governance, transparent regulation, and affordable financing. ASEAN Power Grid offers regional cooperation to manage variability, monetize exports, and share best practices. Achieving solar goals requires harmonized policies, expanded infrastructure, and blended finance to cut costs. ASEAN's sustainable energy future depends on aligning national strategies with regional integration, making solar central to climate and development goals.

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