

PLTS for Indonesia's Clean Energy Transition: A Narrative Review of Environmental Benefits and Implementation Readiness

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ABSTRACT

Indonesia faces two main challenges: increasing energy demand and the increasingly visible impacts of environmental change related to greenhouse gas emissions, land-use pressure, and climate risk. Previous PLTS studies in Indonesia mainly discuss technical feasibility, rooftop adoption, economics, policy, or grid issues separately. Fewer reviews explain why PLTS should be prioritized as a climate-mitigation option and why it is especially suitable for Indonesia. This paper addresses that gap through a document-based narrative review of climate reports, emission statistics, PLTS studies, policy literature, adoption studies, and environmental-impact evidence. The novelty is a climate-centered PLTS suitability argument for Indonesia. By synthesizing 43 references across five analytical dimensions, this review identifies five reasons why PLTS deserves priority: high solar-resource potential, modular deployment on roofs and reservoirs, compatibility with daytime public-building and cooling loads, scalability from household to utility-scale systems, and measurable avoided emissions when solar generation replaces fossil-based electricity. The review finds that PLTS can support climate-change mitigation, but its benefits depend on realistic site assessment, grid compatibility, storage evaluation, monitoring, public acceptance, maintenance readiness, and lifecycle management. This article contributes practical guide for the energy transition to cleaner energy and is suitable for Indonesia as an archipelagic country located in the equatorial region.

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1. Introduction

Climate change and environmental change have become important challenges for Indonesia. Environmental change in Indonesia can be observed through the increasing occurrence of extreme weather events, land degradation, forest and peatland fire risks, coastal abrasion, changing rainfall patterns, and rising temperatures. These issues are influenced not only by natural dynamics but also by human activities, including fossil energy use, land clearing, industrialization, and unsustainable

consumption patterns. The IPCC emphasizes that human-induced climate change has caused widespread impacts on human systems and ecosystems, while future risks increase with every additional rise in global temperature [1]. In the Indonesian context, environmental change is not merely an environmental issue, but is also related to food security, public health, infrastructure, coastal settlements, energy reliability, and the direction of the national energy transition, which still faces contradictions between the need for growth and emission reduction [2].

The energy sector is an important part of this discussion. Household, industrial, transportation, educational, public-service, and digital-infrastructure activities require continuously increasing electricity supplies. However, if the energy supply remains dominated by fossil fuels, growth in electricity demand will be followed by higher carbon dioxide emissions and air pollutants. BPS data show that greenhouse gas emissions from the energy sector reached 752,279.84 thousand tons of CO₂e in 2023, higher than 727,330.26 thousand tons of CO₂e in 2022 [3]. This condition provides a strong reason to accelerate clean electricity technologies that can reduce fossil-energy dependence while maintaining reliability and affordability.

Solar photovoltaic technology, or solar photovoltaic power plants (PLTS), is one relevant option for Indonesia and compatible clean-energy options. The Ministry of Energy and Mineral Resources states that solar energy has one of the largest technical potentials among renewable energy sources in Indonesia, at approximately 207.8 GW [4]. Studies on the status of renewable energy in Indonesia also show that clean energy development still requires stronger technology mixes, policies, and infrastructure [5]. PLTS can be implemented in several forms, such as rooftop PLTS, utility-scale PLTS, floating PLTS, and building-integrated PLTS. This modular characteristic makes PLTS suitable for Indonesia's geographical character as an archipelagic country and this flexibility is important for an archipelagic country where energy demand is dispersed across many islands and where land availability, grid access, and public-building loads differ from one region to another.

The climate-mitigation suitability of PLTS in Indonesia can be explained through five mechanisms [1], [3]-[13], based on the literature synthesis. First, PLTS generation does not require direct fuel combustion, so it can reduce fossil-based electricity use when properly integrated into the electricity system. Second, rooftop and floating PLTS can produce electricity close to loads and reduce land-use pressure compared with purely land-intensive generation. Third, PLTS output is naturally aligned with daytime loads in schools, offices, commercial buildings, and cooling-intensive facilities, making it relevant for urban and public-building applications. Fourth, PLTS can be scaled from small rooftop systems to utility-scale and floating systems, allowing gradual deployment under different financial and grid conditions. Fifth, PLTS can be combined with storage, monitoring, and grid-support technologies so that its contribution to climate mitigation becomes more measurable and reliable. These characteristics explain why PLTS is not simply one renewable option among many, but a practical technology that fits Indonesia's climate, spatial, and energy-transition conditions.

Previous PLTS studies have provided important contributions. Renewable-energy studies discuss Indonesia's energy-transition contradictions and future development pathways [2][5]. Provincial and techno-economic studies examine solar PV potential, grid-connected PV, grid parity, cost-reliability trade-offs, floating PV, and feasibility analysis using tools such as RETScreen [7][11]. Rooftop PV studies examine household adoption, public perception, regulatory tension, and public discourse [14]-[18]. Other studies discuss battery energy storage, grid-code requirements, environmental output factors, lifecycle assessment, sustainability, feasibility and net-zero energy scenarios [19]-[26]. These studies are valuable, but they often examine PLTS as a technical, economic, policy, or adoption issue separately.

A knowledge gap therefore remains. Existing PLTS research in Indonesia has produced valuable findings on resource potential, grid-connected feasibility, rooftop economics, adoption barriers, floating PV, storage, and policy acceptance. However, many reviews still treat these issues as separate technical, economic, or regulatory discussions. Fewer studies develop a direct novelty argument that answers two practical questions: why PLTS should be prioritized for climate-change mitigation in Indonesia, and why the Indonesian context is especially suitable for PLTS compared with a generic

renewable-energy discussion. This paper addresses that gap by integrating environmental-change drivers, fossil-energy dependence, solar-resource suitability, modular PLTS applications, measurable emission-reduction logic, and implementation-readiness barriers into one climate-oriented synthesis.

The novelty of this article is strengthened in three ways. First, it reframes PLTS as a climate-change mitigation technology rather than only as an electricity-generation or techno-economic option. Second, it quantifies the review scope by synthesizing 43 references across five analytical dimensions: climate and emission drivers, PLTS technology options, environmental mitigation benefits, implementation readiness, and supporting sustainability requirements. Third, it formulates five Indonesia-specific suitability arguments for PLTS: equatorial solar-resource availability, modular deployment across roofs/reservoirs/islands, compatibility with daytime building loads, scalability across household-public-utility levels, and measurable avoided emissions.

2. Proposed Method

This research was conducted by reviewing and analyzing literature such as journals and policy documents, or through a document-based descriptive qualitative research method (Table 1 and Table 2). This method was selected because the purpose of the article is not to calculate a single quantitative effect size, but to synthesize evidence from climate science, Indonesian emission statistics, PLTS technology studies, policy documents, and implementation cases into a climate-oriented applied-science argument. The review emphasizes the relationship between environmental change and energy technology, rather than developing a site-specific energy-mix model.

The reviewed sources were grouped into five categories: climate and environmental-change assessments, Indonesian emission and energy-transition data, PLTS technology and feasibility studies, policy and adoption studies, and environmental or lifecycle studies. Priority was given to credible international reports, official Indonesian statistics, peer-reviewed literature, and Indonesia-relevant PLTS studies.

The analysis followed a problem-solution-readiness-recommendation structure. First, climate and emission problems were identified. Second, PLTS options were mapped according to their possible contribution to emission reduction and environmental benefit. Third, implementation readiness was analyzed through technical, economic, grid, policy, and social dimensions. Fourth, recommendations were formulated to strengthen the role of PLTS in Indonesia's climate-mitigation and clean-energy transition agenda.

Table 1. Review Method and Analytical Outputs

Stage	Analytical focus	Output
1. Problem identification	Climate change, environmental impacts, and fossil-energy emissions.	Climate and energy rationale for PLTS.
2. Literature grouping	PLTS potential, feasibility, rooftop adoption, floating PV, storage, grid, and lifecycle studies.	Evidence map of PLTS roles.
3. Gap analysis	Comparison between technical-economic studies and climate-centered review needs.	Knowledge gap and novelty statement.
4. Readiness analysis	Technical, economic, grid, policy, social, and lifecycle conditions.	Implementation-readiness framework.
5. Practical synthesis	Translation of findings into recommendations.	Climate-oriented PLTS planning guidance.

3. Results and Discussion

3.1. Environmental Change, Fossil Energy Dependence, and Mitigation Needs

The relationship between environmental change and energy use can be explained through direct and indirect pathways. Directly, the combustion of coal, oil, and natural gas releases carbon dioxide and other pollutants into the atmosphere. Indirectly, extraction, transportation, and fossil-energy-based industrial activities also contribute to land disturbance, waste, and local environmental

degradation. In Indonesia, fossil energy still plays an important role in electricity generation and transportation. Therefore, reducing the environmental footprint of the energy sector is a priority for climate-change mitigation and public-health protection.

BPS sectoral emission records show that energy-sector emissions are one of the major components of the national greenhouse gas inventory [3]. This makes the energy transition a strategic response to environmental change. PLTS cannot immediately replace all fossil-based electricity because of intermittency and system-planning constraints. However, PLTS can reduce daytime electricity demand from the grid, supply public facilities, support electrification in remote areas, and reduce emissions when integrated into a well-designed energy mix.

3.2. PLTS Opportunities in Indonesia

Geographically, Indonesia is in the equatorial region, where solar irradiation is relatively constant and has a very high potential of 4.8 kWh/m². With a land area of 2 million km², up to 112,000 GWp could be generated if its potential were maximized, while approximately 207.8 GW could be optimized [4][6]. Provincial-level studies also show that the feasibility of grid-connected PLTS varies across regions because it is influenced by radiation potential, system costs, electricity tariffs, and local grid conditions [7]. This potential is not evenly translated into electricity without proper planning, but it shows that solar resources are available at a scale relevant to national mitigation needs. For a climate-oriented review, the important point is that PLTS can convert a widely distributed natural resource into electricity without the direct combustion process that characterizes fossil-based generation. So, this resource base makes PLTS a strategic technology in the national energy transition.

The second reason PLTS is suitable for Indonesia is its deployment flexibility. Indonesia's archipelagic geography creates varied energy needs: dense cities require clean electricity close to load centers, public buildings need daytime electricity, islands and remote areas often face high diesel dependence, and reservoirs or degraded lands may offer space for non-rooftop systems. PLTS can respond to these different contexts because it can be implemented as rooftop PLTS, floating PLTS, utility-scale PLTS, or hybrid PLTS with storage. This makes PLTS more adaptable than a single centralized solution and allows deployment to be phased according to local grid readiness, financing capacity, and institutional capability [7][11].

The third reason is load compatibility. In many schools, campuses, offices, commercial buildings, hospitals, and government facilities, electricity demand is significant during daylight hours because of lighting, cooling, computers, laboratories, and public services. This makes rooftop and building-related PLTS relevant because generation can partially match daytime consumption. This does not remove the need for storage or grid support, but it improves the practical logic of PLTS for public-building and urban mitigation programs. Therefore, the novelty of this review is not only to state that Indonesia has solar potential, but to connect solar potential with spatial suitability, load characteristics, environmental benefit, and implementation readiness.

PLTS can be implemented through several pathways. Rooftop PLTS can be applied to houses, schools, campuses, hospitals, government offices, commercial buildings, and industrial facilities. Utility-scale PLTS can supply larger loads in locations with available land and grid access. Floating PLTS can reduce land-use pressure by using reservoirs or water bodies. Hybrid PLTS with batteries can support islands, remote communities, or critical facilities that require better reliability. These pathways make PLTS suitable for Indonesia's archipelagic geography and diverse electricity needs.

Environmental benefits of PLTS include avoided emissions from fossil-based electricity, lower direct air pollution compared with combustion-based generation, lower operational noise, and opportunities for distributed clean-energy access. However, these benefits should be assessed using actual generation data, not merely installed capacity. Studies on environmental factors affecting PV output show that solar PV performance is influenced by radiation, temperature, dust, shading, and other site-specific conditions [12]. Therefore, climate benefits must be linked with realistic performance estimates and monitoring.

Table 2. Matrix of Several Journals Supporting this Paper

Source	Focus	Main evidence	Implications for the article
IPCC [1]	Climate risk	Climate change caused by human activities creates broad impacts and increases risks.	Positions environmental change as a global and local mitigation issue.
BPS [3]	Sectoral GHG emissions	Energy-sector emissions increased from 727,330.26 thousand tons CO ₂ e in 2022 to 752,279.84 thousand tons CO ₂ e in 2023.	Supports the urgency of energy-sector mitigation.
ESDM [4] and IESR [6]	Solar potential	Indonesia has solar energy potential of approximately 207.8 GW.	Explains why PLTS is a context-compatible mitigation option for Indonesia rather than only a generic renewable technology.
Veldhuis and Reinders [7]	Provincial PV potential and cost-effectiveness	Grid-connected PV feasibility differs by province because resource potential, costs, tariffs, and local conditions vary.	Supports the argument that PLTS planning must be location-sensitive across Indonesia.
Putranto et al. [8]	Grid parity of rooftop PV	Rooftop PV competitiveness depends on tariffs, investment cost, utilization, and policy conditions.	Links PLTS climate benefits with economic feasibility and adoption readiness.
Tanoto [9]	Cost-reliability trade-off	Rooftop PV in Indonesian urban households involves trade-offs between cost, reliability, and system configuration.	Prevents the paper from presenting PLTS as a simple installation solution without reliability considerations.
Paradongan et al. [10] and Rifansyah and Hakam [11]	Techno-economic feasibility and floating PV	RETScreen-based studies show that utility-scale and floating PV require financial, technical, and sensitivity evaluation.	Shows that PLTS implementation needs evidence-based feasibility assessment before replication.
Bamisile et al. [12]	PV output and environmental factors	Solar PV output is influenced by environmental factors such as temperature, irradiation, dust, and site conditions.	Strengthens the claim that climate benefits depend on actual field performance, not only installed capacity.
Adiansyah et al. [13]	Lifecycle environmental impacts	Lifecycle assessment is needed to evaluate the environmental impacts of PV systems, especially for small-island communities.	Keeps the mitigation argument balanced by considering module lifecycle, disposal, and local impacts.
Pambudi et al. [5]	Renewable-energy status in Indonesia	Indonesia has substantial renewable-energy potential but still faces policy, infrastructure, and implementation challenges.	Positions PLTS within Indonesia's broader clean-energy transition context.
Hidayatno et al. [14], Setyawati [15], Fathoni et al. [16], Mulyani et al. [17], Kurniawan et al. [18], and Afifi et al. [27]	Rooftop PV policy, perception, and adoption	Adoption is shaped by policy incentives, public perception, stakeholder tension, discourse, behavior, and household preferences.	Shows that PLTS mitigation benefits require social acceptance and regulatory stability, not only technical potential.
Amiruddin et al. [19] and Ali et al. [20]	Storage and grid readiness	High renewable penetration requires energy-storage configuration, grid-code readiness, and interconnection standards.	Explains why BESS, grid compatibility, and technical rules are supporting requirements for PLTS climate-mitigation performance.

Source	Focus	Main evidence	Implications for the article
Siregar [23], Massagony et al. [24], Zhong et al. [25], Fitriana et al. [26], Afriani and Poletti [28], Reyseliani et al. [29], and Gulagi et al. [30]	Net-zero and energy-transition pathways	Recent transition studies discuss decarbonization pathways, policy economy, cost-benefit analysis, and coal-to-renewable transition scenarios.	Places PLTS as one component of Indonesia's long-term decarbonization strategy, not as a stand-alone solution.
Wibisono et al. [31]	Renewable-energy project failures	Renewable-energy failures in Indonesia can be shaped by weak implementation credibility, institutional learning problems, and public trust issues.	Supports the argument that PLTS climate benefits require credible implementation, not only installation.
Reyseliani et al. [29]	Power-sector decarbonisation	Power-sector decarbonisation in a coal-producing developing country depends on the ability to reduce fossil-energy dependence through cleaner generation pathways.	Connects PLTS with Indonesia's fossil-energy dependence and emission-reduction pathway.
Muthia et al. [32]	Floating PV and green hydrogen	Floating solar PV can support green-hydrogen production and expand solar applications beyond conventional rooftop or building-scale electricity.	Shows that PLTS can support industrial decarbonisation beyond building-scale electricity.
Rudolph et al. [33]	Local implications of floating PV	Indonesia's first large floating PV project creates mitigation opportunities but also requires attention to local social, environmental, and water-use implications.	Adds social and environmental caution to the floating-PLTS climate-mitigation argument.
Aripriharta et al. [34]	PV-EV charging with BESS	PV, EV charging, and BESS modelling on Kalimantan Island shows how solar generation can support emerging electricity demand when combined with storage.	Shows the relevance of PLTS for storage-supported new electricity demand.
Hutabarat [35]	Solar-energy subsidy design	Solar-energy subsidy design can be evaluated as a policy instrument for improving the economic attractiveness of solar deployment in Indonesia.	Strengthens the discussion of financing and policy instruments.
Eliva et al. [36]	Rooftop-PV adoption intention	Extended UTAUT evidence shows that adoption intention is affected by perceived cost, knowledge, performance expectation, and user acceptance factors.	Adds recent evidence on perceived cost, knowledge, and user acceptance.
Gulagi et al. [30]	Coal-to-renewables transition	A coal-to-renewables transition toward a net-zero energy system requires prioritising renewable electricity options within broader system transformation.	Supports the broader climate-mitigation logic of prioritizing PLTS and renewables.

3.3. Environmental Benefits and Limits of PLTS

PLTS has an important environmental advantage because electricity is generated without direct fuel combustion. When PLTS replaces fossil-based electricity, it can reduce carbon dioxide emissions and combustion-related pollutants. In public buildings, daytime solar generation can also reduce electricity purchased from the grid during working hours. For schools, campuses, hospitals, offices,

and government buildings, rooftop PLTS can combine energy savings, emission reduction, and public education about clean energy.

Nevertheless, PLTS should not be presented as a perfect or unlimited solution. It requires materials, land or roof area, supporting structures, inverters, cables, and sometimes batteries. Lifecycle studies show that PV systems can have environmental impacts associated with manufacturing, transportation, installation, operation, and end-of-life handling [13]. Therefore, the environmental argument for PLTS should be balanced: PLTS is cleaner than fossil-based electricity during operation, but its full benefit depends on proper design, long-term performance, and responsible lifecycle management.

Floating PLTS provides an example of environmental and land-use relevance. The Cirata Floating Solar PV project, with reported capacity of 145 MWac or 192 MWp, demonstrates that reservoirs can be used for large-scale solar generation where land constraints are important [37]. PLN Nusantara Power reported that Cirata Floating Solar PV can generate up to 300 GWh of clean electricity per year and reduce carbon emissions by approximately 214,000 tons of CO₂ per year [38]. This case shows how PLTS can support mitigation targets while reducing pressure on land use, although ecological and water-body management should remain part of project evaluation.

3.4. Technology Readiness and Implementation Pathways

PLTS technology readiness in Indonesia can be evaluated through resource assessment, system design, grid integration, storage readiness, maintenance, and policy support. A technically sound PLTS project begins with solar-resource data, roof or site assessment, shading analysis, load-profile measurement, inverter selection, protection design, and financial analysis. Small-scale PLTS design studies explain the basic photovoltaic conversion mechanism and the need for proper component sizing [39]. Larger projects require more detailed feasibility studies, including energy-yield estimation, net present cost, levelized cost of electricity, payback, and sensitivity analysis [11].

Grid-connected rooftop PLTS requires attention to technical approval, reverse power flow, voltage rise, inverter settings, and interconnection rules. Grid-code studies highlight that renewable integration requires clear technical standards to maintain reliability and safety [20]. In locations where electricity demand does not match solar generation, BESS can improve flexibility, but it also increases cost and requires safety and replacement planning [19]. Therefore, PLTS implementation readiness is not only about the availability of panels but also about system-level compatibility.

From a climate-mitigation perspective, technology readiness must be linked with real emission reduction. This means that PLTS sizing should match load patterns, monitoring should verify actual generation and avoided-emission calculations should use appropriate emission factors. Without these steps, PLTS may be visible as a green symbol but less effective as a mitigation technology.

3.5. Policy, Social Acceptance, and Sustainability Adoption Barriers

Regulation is a determining factor in PLTS adoption. The Government of Indonesia has issued Ministry of Energy and Mineral Resources Regulation Number 2 of 2024 concerning rooftop solar photovoltaic power plants connected to the electricity networks of holders of electricity supply business licenses for public interest [40]. The existence of this regulation indicates support for rooftop PLTS, but implementation still requires clarity in technical approval, billing mechanisms, capacity allocation, safety standards, and coordination among users, PLN, installers, and local governments. Policy and public-perception studies show that rooftop PLTS adoption in Indonesia is influenced by incentive design, perceived benefits, conflicts of interest among actors, and certainty regarding electricity export-import rules [14][16].

Social acceptance also affects climate benefits. If households, schools, offices, and commercial users perceive PLTS as expensive, difficult to maintain, or uncertain under current regulations, adoption will slow. Survey-based and discourse-based studies show that preferences and public opinion influence PV adoption in Indonesia [17][18][27]. Therefore, public education and transparent cost-benefit information are important parts of climate-oriented PLTS deployment.

Across adoption studies, the main finding is consistent: technical readiness alone is insufficient. Household and commercial adoption depends on perceived cost, policy certainty, knowledge, trust in installers, institutional support, and the clarity of export-import or compensation mechanisms [14][15][18][27]. This comparison implies that PLTS policy should not be limited to capacity targets; it should reduce adoption risk through transparent economic information, credible installers, predictable regulation, user education, and performance monitoring.

At the regional and national levels, solar policy reviews in Southeast Asia and green-development evidence from Indonesia indicate that renewable-energy deployment is linked to low-carbon policy design, technological innovation, public participation, and broader development outcomes [41][42]. These studies support the view that PLTS adoption should be evaluated not only as an engineering project, but also as a policy and social-transition issue.

Sustainability also needs to be evaluated beyond carbon reduction. A PLTS project may succeed technically but be weak socially if the community is not involved, weak economically if maintenance funds are unavailable, weak organizationally if responsibilities are unclear, or weak environmentally if end-of-life equipment disposal is not managed. The sustainability dimensions proposed by Dauenhauer et al. include social, organizational, technical, economic, and environmental aspects [21].

The following summarizes why we need to shift from non-renewable energy to renewable energy:

1. Its energy sources are limited, and their use creates long-term dependence on unsustainable resources [2][5].
2. It is not environmentally friendly. Based on official Indonesian GHG (greenhouse gas) inventory data, national GHG emissions remain high, and the energy sector continues to be one of the main contributors. BPS data also show an increase in emissions in energy-related sectors in 2023 compared with 2022 [3].

GHG emission sources from the energy sector mainly come from fuel combustion in power plants, industry, transportation, and household and commercial activities, as well as from fugitive emissions caused by leakage in fossil-fuel production, processing, and distribution [3].

3. Indonesia has large PLTS potential, including rooftop PLTS on public buildings, offices, homes, schools, campuses, and public facilities [4][6]. Policy support for rooftop PLTS has also been regulated through Ministry of Energy and Mineral Resources Regulation Number 2 of 2024 concerning rooftop PLTS connected to the electricity network [40].
4. The building sector itself absorbs 40% of the world's energy sources; in Indonesia, buildings are responsible for 50% of total energy expenditure and more than 70% of electricity consumption. Apart from the generation side explained previously, GHG (greenhouse gas) emissions can also be produced by buildings. Viewed from the perspective of energy use, the building sector contributes 30% of GHG emissions in Indonesia. GHG emissions from buildings come from energy use for heating, cooling, lighting, and other functions. Therefore, efforts are needed to reduce energy consumption through energy efficiency and conservation in buildings and to realize sustainable buildings [43].

3.6. Climate-Oriented PLTS Implementation Framework

Based on the review, PLTS should be planned as a climate-mitigation technology that fits Indonesia's resource, spatial, and demand conditions, rather than only as an installed electricity asset (Table 3). A climate-oriented framework should begin by identifying the emission or environmental problem, continue by selecting the PLTS configuration that best matches the site and load, verify implementation readiness, and end with measurable climate-benefit reporting. This framework is built on the novelty argument that PLTS is suitable for Indonesia because it combines high solar-resource availability, modular deployment, public-building compatibility, scalable system sizes, and measurable avoided emissions.

Table 3. Climate-oriented PLTS Implementation Framework for Indonesia

Dimension	Main question	Key indicators	Recommended action
Climate and emission driver	What emission or environmental problem is being addressed?	Energy-sector emissions, grid emission factor, fossil electricity share, local environmental risk.	Use official emission data and define the mitigation objective before PLTS sizing.
PLTS technology option	Which PLTS configuration fits the site and load?	Rooftop, floating, utility-scale, hybrid, PV-BESS; load profile; solar irradiation.	Select configuration based on load, site, grid, and environmental constraints.
Environmental benefit	How much benefit can be measured?	Estimated generation, avoided emissions, land-use effect, air-pollution reduction.	Estimate avoided emissions using actual or projected generation and realistic performance assumptions.
Implementation readiness	Can the system operate safely and reliably?	Grid approval, inverter compatibility, BESS need, financial feasibility, maintenance plan.	Complete technical-economic design and interconnection checks before installation.
Supporting sustainability	How can climate benefits be preserved over time?	Monitoring, cleaning, user training, spare-part plan, end-of-life component management.	Treat sustainability as a supporting implementation requirement, not the main novelty.

Based on the review conducted by the researchers (Table 4), this article proposes that future PLTS research in Indonesia should be written and designed more comprehensively in relation to solar resource assessment, load assessment, system design, economic evaluation, emission-reduction estimation, monitoring plans, and sustainability governance [4][6][37]. This can deepen usefulness and sustainability. On a larger scale, such as Southeast Asia, solar energy policy also needs to be viewed as part of the agenda for emission reduction, technological innovation, and cross-sector energy-transition governance.

For future empirical research, the manuscript can be strengthened by adding measured irradiation data, electricity load profiles, PVsyst or HOMER simulations, financial indicators such as net present cost and levelized cost of energy, and validation from PLTS systems that are in operation.

Table 4. Environmental Change Issues and the Role of PLTS

Environmental issue	Main impact	PLTS-related response	Implementation note
Rising air temperature	Electricity demand for air conditioning increases.	Rooftop PLTS can supply daytime loads.	Combine energy efficiency and passive building design.
Extreme weather	Public services and local electricity supply are disrupted.	PV-BESS can support critical facilities.	Prioritize hospitals, schools, emergency posts, and communication systems.
Land-use pressure	Competition between energy infrastructure and productive land.	Floating and rooftop PLTS can reduce land demand.	Evaluate roof strength, reservoir ecology, and safety requirements.
Drought	Water stress and agricultural risks increase.	Solar-powered water pumps can support adaptation.	System sizing must consider water demand and seasonality.
Coastal flooding and abrasion	Coastal infrastructure is at risk of damage.	PLTS helps reduce fossil-based electricity and supports power decentralization.	Avoid placing equipment in flood-prone zones without protection.
Energy-sector GHG emissions	Increased climate risk and air-pollution pressure.	PLTS reduces fossil-based electricity consumption when generation replaces grid supply.	Use measured generation and grid emission factors to estimate avoided emissions.
Air pollution and acid-rain precursors	Health and ecosystem impacts.	PLTS reduces combustion pollutants when it replaces fossil electricity.	Estimate avoided emissions using local grid emission factors.
Public awareness of climate action	Limited understanding of energy-emission links.	PLTS in schools and public buildings can serve as demonstration infrastructure.	Use dashboards, education programs, and public reporting.

4. Conclusion

This paper can be used as a basis for viewing PLTS as Indonesia's Clean Energy Transition, repositions PLTS as Indonesia's Clean Energy Transition with climate-change mitigation technology for Indonesia. The review shows that Indonesia's environmental change, energy-sector emissions, and fossil-energy dependence create a strong rationale for expanding clean electricity. PLTS is especially relevant because Indonesia has large solar potential, an equatorial climate, dispersed island-based energy needs, many suitable rooftops and public buildings, reservoir opportunities for floating systems, and daytime loads that can be partially served by solar generation. These characteristics explain why PLTS is not only technically feasible, but also contextually suitable for Indonesia's clean-energy transition.

The main contribution of the paper is a climate-centered synthesis that explicitly answers why PLTS should be prioritized and why it fits Indonesia. By synthesizing 44 references across five analytical dimensions, the paper identifies five suitability mechanisms: solar-resource availability, spatial flexibility, load compatibility, scalability, and measurable avoided emissions.

The review indicates that PLTS climate benefits will be stronger when projects include credible solar-resource assessment, load analysis, techno-economic design, grid compatibility, storage evaluation when needed, policy certainty, public education, monitoring, and basic maintenance planning. Future empirical research can strengthen this article by adding measured irradiation data, load profiles, simulation results, avoided-emission calculations, and operational performance data from PLTS systems in Indonesia.

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