Geoeconomics of Solar Energy: An Inquiry into Trade Policy and Cooperation

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# Geoeconomics of Solar Energy: An Inquiry into Trade Policy and Cooperation

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## Abstract

*The rapid global transition towards solar energy is not only an environmental imperative but also a geoeconomic reshaping of global power structures, trade policy, and international cooperation. This paper investigates how solar energy—especially photovoltaics (PV)—has evolved into a strategic domain where nations leverage policy, trade instruments, and alliances to advance national interests and global influence. With China controlling over 80% of the global solar manufacturing capacity and the United States, India, and the European Union employing varied tariff regimes and subsidy models, the solar trade has become a battleground of protectionism and innovation.*

*This research uses a mixed-method approach, policy analysis, SWOT evaluation, and scenario modelling to assess the global solar landscape, focusing particularly on emerging economies. The paper evaluates the divergent trade and subsidy strategies among the top ten solar economies and the effectiveness of multilateral frameworks like the International Solar Alliance (ISA), IRENA, and the Clean Energy Ministerial (CEM). It also analyses the strengths, weaknesses, opportunities, and threats (SWOT) faced by emerging nations in their solar transitions, including financial constraints, grid limitations, and geopolitical trade-offs. Scenario analysis reveals that cooperative globalisation enables the fastest and most equitable solar deployment, while protectionist fragmentation slows progress and increases costs. The study concludes with strategic policy recommendations for emerging economies, emphasising finance de-risking, regional cooperation, and technology diversification. Ultimately, the solar transition is not merely about energy; it is about sovereignty, industrial transformation, and reordering global economic relations.*

**Keyword**: Solar Trade Policies; Solar Corporation; SWOT; Solar Futures; ISA; IRENA;
JEL codes: F13, Q42, Q48, O13, F18

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## INTRODUCTION

Solar energy has emerged not only as a cornerstone of the global transition to sustainable energy but also as a strategic instrument shaping international economic relations. As of 2024, solar photovoltaics (PV) accounted for over 1,300 GW of installed capacity worldwide, contributing more than 5% of global electricity production (International Enegry Agency, 2025). Nations across the globe are increasingly prioritising solar investments to address climate change, reduce energy dependence, and stimulate green economic growth. However, the solar revolution is not merely technological or environmental it is deeply geoeconomic, involving a complex interplay of trade policies, strategic partnerships, and global governance structures.

The solar industry is profoundly globalised. China alone commands over 80% of global solar PV manufacturing capacity, while the European Union and the United States remain major markets and innovation hubs (International Renewable Energy Agency, 2025). This asymmetry has led to WTO-level trade disputes, particularly concerning anti-dumping tariffs, subsidies, and intellectual property rights. Simultaneously, cooperative frameworks like the International Solar Alliance (ISA), the International Renewable Energy Agency (IRENA), and the International Energy Agency (IEA) are fostering diplomacy, cross-border investments, and institutional alignment.

In this context, the concept of solar diplomacy has gained traction. Countries are now using solar energy as a tool to assert soft power, forge new alliances, and reshape global energy governance. India's leadership in the ISA, China's Belt and Road renewable investments, and the U.S.'s Clean Energy Ministerial engagement reflects this trend. These developments indicate that solar energy has become a critical domain where geoeconomics, diplomacy, and sustainability intersect.

This research paper explores how solar energy policies are embedded within broader trade and cooperation strategies. It aims to unpack the geoeconomic mechanisms through which countries seek influence, secure resources, and shape the global energy transition through solar power.

## LITERATURE OVERVIEW

The transition to solar energy has been widely explored in academic literature, especially from technological and environmental perspectives. However, the geoeconomic dimensions of solar energy, how it intersects with trade policy, international cooperation, and power dynamics, have emerged as a critical focus only in recent years. Scholars increasingly argue that solar energy is not just a technological solution to climate change, but a geopolitical tool reshaping the global energy order.

(International Renewable Energy Agency, 2021) emphasizes the role of international collaboration in lowering the cost of solar photovoltaic (PV) systems, highlighting how global trade and investment have enabled the diffusion of solar technology across borders. The (International Energy Agency , 2024) reports provide empirical evidence of how solar has become the world's cheapest source of electricity in many regions, primarily due to policy coordination and global manufacturing chains. These findings underline the growing importance of solar value chains in international trade relations.

(Goldthau, Westphal, & Bradshaw, 2019) introduced the idea of "renewable energy diplomacy," wherein states leverage solar and wind initiatives to advance foreign policy objectives. Their work underscores how countries like China, through its Belt and Road Initiative, and India, via the International Solar Alliance (ISA), are engaging in solar diplomacy to strengthen their influence in the Global South. Similarly, (Jacobsson & Lauber, 2006) explored how government policies such as feed-in tariffs, public procurement, and R&D subsidies shape national solar industries, which in turn affect global competitiveness and strategic interdependence.

From a trade conflict perspective, (Lewis, 2014) studied the US-China solar panel disputes at the WTO, revealing how solar energy can become a flashpoint for protectionist policies and anti-dumping measures. These legal battles demonstrate that solar energy, despite its green credentials, is embedded in traditional concerns of trade balances and domestic job protection. More recent literature by (Kuzemko, et al., 2020) blends political economy with energy security studies, arguing that the global shift to renewables is creating new dependencies, alliances, and vulnerabilities, especially around rare earth materials, solar panel supply chains, and intellectual property rights.

Despite this growing body of literature, a comprehensive economic inquiry into the combined effects of trade policy, international institutions, and cooperative diplomacy in the solar sector remains limited. This study attempts to fill that gap by examining how solar energy is strategically embedded in global economic governance and the policy tools used to shape it.

## OBJECTIVE

- To critically analyse the role of trade policies in shaping the geoeconomic dynamics of the global solar photovoltaic (PV) industry.
- To examine the effectiveness and strategic implications of international cooperation frameworks in advancing solar energy deployment.
- To assess the geoeconomic risks and strategic opportunities associated with solar energy transitions, particularly focusing on emerging economies.

## METHODOLOGY

This study adopts a mixed-method approach, integrating both qualitative and quantitative techniques to address the multidimensional nature of geoeconomics in the solar photovoltaic (PV) sector. The research is structured into three interlinked phases corresponding to the stated objectives.

A comparative analytical framework is employed to examine trade policies, cooperation frameworks, and the risks/opportunities of solar transitions. This approach enables cross-country comparisons, time-series trend analysis, and integration of case-specific qualitative insights.

This study will use secondary data from reliable global and national sources. Trade policy insights will be drawn from WTO statistics, UN Comtrade, and national policy documents, including India's solar import duties. International cooperation will be examined using ISA reports, IEA assessments, and UNFCCC/COP outcomes. Market and technology trends will be analysed through IRENA statistics, BNEF market outlooks, and global PV manufacturing capacity reports, ensuring a well-rounded evidence base.

## ANALYTICAL TOOLS & TECHNIQUES

For Objective 1: *Role of trade policies in shaping geoeconomic dynamics*

- Policy Content Analysis: Comparative review of national trade regulations, tariff structures, and subsidy regimes for PV products.

For Objective 2: *Effectiveness of cooperation frameworks*

- Assessment of the effectiveness of International Cooperation Frameworks

For Objective 3: *Geoeconomic risks and opportunities in emerging economies*

- SWOT Analysis: Structured evaluation of strengths, weaknesses, opportunities, and threats in solar transitions for emerging economies.
- Scenario Analysis: Simulation of possible future outcomes under different trade and cooperation policy settings.

The study will draw on secondary data from reliable global and national sources to ensure a comprehensive analysis. Trade policy information will be obtained from WTO statistics, UN Comtrade databases, and national policy documents, including India's solar import duty notifications and records of the US–China trade dispute. International cooperation will be assessed through reports and agreements from the International Solar Alliance (ISA), policy assessments by the International Energy Agency (IEA), and outcomes from UNFCCC and COP meetings. Market and technology trends will be examined using data from the International Renewable Energy Agency (IRENA), Bloomberg New Energy Finance (BNEF) market outlooks, and global PV manufacturing capacity reports.

## ANALYSIS AND INTERPRETATION

Solar Trade Policies, Tariff Structures, and Subsidy Regimes

This comparative review examines solar trade regulations, tariff structures, and subsidy regimes across the top ten solar economies. It highlights how diverse policy approaches—ranging from protective tariffs to open trade—shape the photovoltaic (PV) market. By assessing these frameworks, the study offers insights into global geoeconomic patterns influencing solar energy deployment.

Table 1 - Comparative Analysis of Solar Trade Policies, Tariff Structures, and Subsidy Regimes in the Top Ten Solar Economies.

| S. No. | Country | Trade / tariff measures (PV) | Subsidy / incentive regimes (PV) |
|---|---|---|---|
| 1. | China | Relatively low import tariffs on many upstream inputs; strong industrial policy and support for domestic manufacturers (export incentives, provincial subsidies, occasional adjustments to rebates to manage capacity). | Large manufacturing support (tax breaks, R&D, cheap finance), aggressive domestic deployment programs and provincial incentives. |
| 2. | United States | Multiple trade measures (safeguards, AD/CVD rulings, Section 201 actions); recent AD/CVD duties on cells/modules from certain origins and rising duty pressure to protect domestic makers. | Strong demand-side and supply-side support (Inflation Reduction Act tax credits, manufacturing tax incentives, state rebates). |
| 3. | India | Historically applied safeguards and basic customs duties (BCD); 2025 | Central auctions, viability-gap funding, rooftop subsidies and |

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|---|---|---|---|
| | | budget adjustments changed BCD on cells/modules (notably reductions from earlier peaks) while using policy levers to support local manufacturing. | production-linked incentives to scale domestic manufacturing and deployment. |
| 4. | Japan | Generally low import tariffs; policy emphasis on deployment via FITs/auctions rather than import protection. | Feed-in tariffs and auction round for residential / C&I / utility scale; planned auctioned volumes for 2024–25. |
| 5. | Germany | Open trade for components (EU single market); industrial policy focuses on deployment support and targeted measures to bolster European supply chains rather than broad import tariffs. | Auction and FiT-based systems, market reforms (2024 package to remove red tape); incentives for rooftop and storage integration. |
| 6. | Brazil | Increasing import duties on modules (recent moves raised module import tax to ~25%); relies partly on imports for components while supporting local deployment. | Net-metering, auctions and tax incentives for distributed generation; evolving rules after 2023–24 reforms. |
| 7. | Spain | Operates within EU trade framework (low external tariffs inside EU); recent national rules and taxes at regional level affect project economics. | Auctions and strong utility & rooftop deployment support historically; recent surge in additions via auctions (2024). |
| 8. | Italy | EU customs regime (low external tariffs within EU); growing preference for EU-made modules in some incentive lines (to boost local/EU industry). | Generous fiscal incentives (tax credits, Transizione 5.0, Superbonus legacy elements) and targeted higher credits for EU-made modules. |
| 9. | France | EU trade rules apply; focus on auctions/tenders and selective support for European manufacturing rather than external protectionism. | Tenders/auctions, incentives for storage and PV, and targeted measures supporting industrial capacity in France/EU. |
| 10. | Australia | Low-to-moderate import duties; policy mix leaves tariffs small relative to deployment incentives; state/federal differences in non-tariff regulations. | Federal Small-Scale Renewable Energy Scheme (SRES), Large-Scale Renewable Energy Target (LRET), state rebates and battery schemes strong rooftop incentives. |

Source: (Solar Power Europe, 2025) Compiled.

The analysis reveals that while some leading solar economies prioritize domestic manufacturing through tariffs and subsidies, others focus on open trade and deployment incentives. These differing strategies reflect unique national priorities, market maturity, and industrial capacities, collectively shaping global PV supply chains, technology diffusion, and the future trajectory of solar energy expansion.

**International Cooperation Frameworks**

International solar energy cooperation frameworks, encompassing multilateral, regional, and bilateral initiatives, play a pivotal role in advancing renewable transitions. By fostering technology transfer, financing mechanisms, and capacity-building, these frameworks bridge the gap between resource-rich and technology-rich nations, accelerating deployment, enhancing energy security, and supporting global climate commitments.

Table 2 - Assessment of the effectiveness of International Cooperation Frameworks

| No. | Framework | Founded | Membership | Core functions & mechanisms | Effectiveness |
|---|---|---|---|---|---|
| 1 | International Solar Alliance (ISA) | 2015 India & France initiative; treaty-based alliance. | 100+ signatory countries (primarily sunshine countries). | Technical assistance, project financing instruments (Global Solar Facility), capacity building, concessional funding for mini-grids/rooftop. | Strengths: Focused on solar for developing/low-income countries; mobilises concessional capital and technical support. Limits: Limited capital vs. needs; implementation scale constrained by project pipelines and donor flows. |
| 2 | IRENA (International Renewable Energy Agency) | 2009 — intergovernmental agency. | 170+ member states; global remit for renewables. | Data, country roadmaps, capacity building, global outlooks, policy guidance (e.g., World Energy Transitions Outlook). | Strengths: Authoritative data/roadmaps and policy guidance; strong convening power. Limits: Not a financier; translation of guidance into finance/deployment requires other actors. |
| 3 | IEA — PVPS / IEA Solar workstreams | PVPS formed 1993; IEA broader. | IEA member countries + PVPS participants worldwide. | Technical R&D collaboration, best-practice reports, performance testing, standards, market analysis. | Strengths: Deep technical expertise, rigorous analysis, standards-setting. Limits: Membership skewed toward advanced economies; less direct on financing/deployment in low-income states. |
| 4 | Clean Energy Ministerial (CEM) | 2010 — coalition of major economies (ministerial forum). | 30+ member economies and initiative partners. | Initiative platforms (e.g., Transforming Solar Supply Chains), policy dialogues, campaign initiatives and shared targets. | Strengths: High-level political leverage, cross-government coordination, practical initiatives to build supply-chain resilience. Limits: Voluntary, non-binding; dependent on member political will. |

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| 5 | Mission Innovation (MI) | 2015 — R&D acceleration network (governments). | 20+ countries; collaboratives on technology topics (e.g., Sunlight-to-X). | Pooled R&D commitments, innovation communities, public-sector RD&D coordination. | Strengths: Focus on accelerating disruptive solar-adjacent technologies (fuels, advanced PV). Limits: R&D outcomes long-run; commercialisation requires industry finance. |
| 6 | World Bank Group — Scaling Solar (IFC & World Bank) | 2014 (programmatic World Bank Group product). | Client countries in Africa, Asia, Latin America (government counterparties). | "One-stop shop" to structure, tender and attract private finance for grid-connected utility PV projects. | Strengths: Proven model to rapidly mobilise private finance and reduce procurement risk; standardized contracts. Limits: Works best for larger grid projects; less suited to distributed/rural mini-grids without adaptation. |
| 7 | Sustainable Energy for All (SEforALL) | 2011 — UN-mandated partnership (CEO-level). | Global partnership with multilateral partners, finance institutions, national governments. | Energy access programs, results-based finance (UEF), technical assistance. | Strengths: Strong focus on SDG7 (access + justice); results-based financing for mini-grids and household solar. Limits: Funding scale limited vs. need; relies on donor & partner mobilisation. |
| 8 | Green Climate Fund (GCF) | 2010 (operational 2015) — UN-climate finance mechanism. | Developing countries (funding recipients); accredited entities (multilaterals, NGOs, banks). | Large-scale concessional & blended finance for climate mitigation/adaptation, including renewable energy projects. | Strengths: Sizeable finance vehicle with multi-instrument flexibility; country-owned approach. Limits: Lengthy accreditation/project cycle; competition for funds across sectors. |
| 9 | Global Solar Council (GSC) | c.2015 (industry association umbrella). | Industry, national & regional solar associations; private sector members worldwide. | Industry advocacy, trade & regulatory policy input, market data & promotion. | Strengths: Private-sector voice that can mobilise investment signals & data; advocacy for balanced policy. Limits: Industry perspective may downplay social/regulatory trade-offs; influence varies by region. |
| 10 | Global Renewables | 2023–24 — alliance of major | Umbrella of Global Solar | High-level advocacy to triple renewables, coordinate industry | Strengths: Broad industry coalition able to push for systemic |

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|---|---|---|---|---|---|
| | Alliance (GRA) | renewables industry associations. | Council, GWEC, IHA, others; global focus. | commitments, accelerate permitting and finance. | policy/permit reforms and private-sector mobilisation. Limits: New (still building capacity & country pipelines); non-binding. |
| 11 | REN21 (Renewables Policy Network) | 2004 — multi-stakeholder network. | Governments, academia, NGOs, industry members globally. | Annual Renewables Global Status Report (GSR); policy tracking and synthesis. | Strengths: Widely-cited, neutral synthesis of policy progress (GSR); useful for policymakers. Limits: Analytical, not a financing or procurement vehicle. |
| 12 | Regional / MDB Platforms / ADB Clean Energy Initiatives | Various (MDB programme lines). | Regional focus (Africa, Asia, Latin America). | Large regional programmes to mobilise concessional finance, de-risk projects, support grids and mini-grids. | Strengths: Ability to mobilise large capital and coordinate regional pipelines. Limits: Project timelines and political complexity can slow disbursement. |

Source: (Alliance, 2025) (International Solar Alliance, 2025) Compiled.

The effectiveness of international solar cooperation depends on robust governance, equitable participation, and adaptive policy design. Strengthening these frameworks can catalyse large-scale solar adoption, especially in emerging economies. Future collaboration must emphasise inclusivity, innovation sharing, and sustainable financing to ensure a resilient, low-carbon global energy system.

**SWOT Analysis of Solar Transitions**

The transition towards solar energy in emerging economies is not merely an energy substitution but a structural transformation of their economic, industrial, and geopolitical landscapes. Drawing from the experiences of the world's ten largest solar nations, China, the United States, India, Japan, Germany, Brazil, Spain, Australia, Italy, and South Korea, this analysis evaluates the underlying strengths, weaknesses, opportunities, and threats that define the solar trajectory of the Global South. While the majority of these leaders are from advanced economies, the policy and infrastructural models they embody offer valuable templates and cautionary lessons for emerging markets.

1. Strengths – *Intrinsic and Acquired Advantages*

Emerging economies often stand on the sunny side of geography, endowed with high solar insolation a natural comparative advantage seen in India, Brazil, and Australia. This geographic capital is complemented by plummeting photovoltaic (PV) and battery costs, making solar economically competitive with conventional coal in markets once deemed high-cost.

Countries such as China have demonstrated how industrial policy, state-led investments, manufacturing subsidies, and export-oriented production can yield global dominance, with China now supplying nearly 80% of the world's PV modules. India's rapid capacity expansion, doubling installations within a single year, demonstrates the catalytic role of integrated policy frameworks, public-private partnerships, and utility-scale parks like Bhadla.

The scale effect, as evidenced by China's Huanghe Hydropower Solar Project and Brazil's distributed solar boom, reduces unit costs while creating economies of scope in ancillary industries such as battery manufacturing, smart grids, and electric mobility.

2. Weaknesses – *Structural and Systemic Constraints*

The Achilles' heel of many emerging economies lies in grid fragility and integration bottlenecks. The intermittency of solar generation, coupled with outdated transmission infrastructure, results in curtailment losses and wasted potential that undermines investment returns.

Financial asymmetries further constrain deployment. The Weighted Average Cost of Capital (WACC) in emerging markets hovers around 10–11%, compared to 4–5% in OECD countries, inflating project costs and deterring private capital inflows. Reliance on legacy fossil infrastructure as seen in India's persistent coal dependence, creates institutional inertia, while seasonal solar variability in high-latitude economies like Germany highlights the need for robust storage and hybridisation solutions.

In some nations, policy volatility, frequent changes in feed-in tariffs, net-metering rules, or subsidy frameworks erode investor confidence and slow technology diffusion.

3. Opportunities – *Strategic and Transformational Prospects*

Emerging economies possess a unique historical advantage: the ability to leapfrog fossil-intensive infrastructure and build renewable-native grids. Where industrial revolutions in the West were coal-dependent, the Global South has the prospect of architecting solar-centric economies from inception.

The fall in panel prices accelerated by oversupply from Chinese manufacturing hubs has democratized access to PV technology, enabling microgrid expansion in rural Africa, Latin America, and South Asia. Strategic South–South cooperation, particularly among BRICS nations (now contributing over 51% of global solar generation), offers knowledge transfer, concessional finance, and supply-chain security.

Large-scale solar parks, coupled with agrivoltaics innovations, present dual benefits: increasing renewable capacity while preserving agricultural productivity—a model increasingly visible in Spain, Italy, and parts of India.

Export-oriented renewable industries also hold promise: India's Production-Linked Incentive (PLI) scheme aims to position the country as a global hub for module manufacturing, diversifying supply chains away from a China-dominated market.

4. Threats – *Exogenous and Endogenous Risks*

The solar revolution faces geopolitical headwinds. Trade disputes such as the imposition of tariffs on Chinese PV modules by the US, EU, and India risk fragmenting supply chains, slowing cost declines, and triggering retaliatory measures.

Climate change itself, paradoxically, poses risks: extreme heat waves can reduce panel efficiency, while dust storms in arid regions accelerate module degradation. Land scarcity in densely populated nations generates social contestation, particularly when large solar projects displace farmland or forests.

Moreover, technological lock-in where economies over-rely on a narrow set of PV technologies risks obsolescence if breakthroughs in perovskite cells, concentrated solar power (CSP), or long-duration storage emerge elsewhere.

Finally, policy inertia in some emerging economies where renewable targets remain aspirational rather than binding creates a mismatch between stated climate ambitions and actual deployment trajectories.

Table 3- Dimensional SWOT Analysis of Solar Transitions in Emerging Economies

| Dimension | Strengths | Weaknesses | Opportunities | Threats |
|---|---|---|---|---|
| Technology | Rapid capacity growth, cost declines, manufacturing hubs (China, India) | Grid bottlenecks, intermittency, limited storage | Leapfrogging fossil grids, agrivoltaics | Technology obsolescence risk |
| Economics | Economies of scale, declining LCOE | High WACC in emerging markets | Export-oriented renewable industries | Trade wars, tariff barriers |
| Geopolitics | South–South cooperation (BRICS) | Policy volatility | Global supply-chain diversification | Geopolitical tensions, resource nationalism |
| Environment | High solar irradiance, rural electrification potential | Land-use conflicts | Hybrid energy-agriculture models | Climate extremes affecting output |

Source: Compiled.

The solar transition in emerging economies is not a monolithic process but a tapestry woven from technological ambition, financial realities, and geopolitical currents. The lessons of the top 10 solar nations underscore that scale alone is insufficient integration, storage, and stable policy are equally critical.

If emerging economies can convert their solar abundance into systemic resilience, they stand to not only decarbonize rapidly but also reshape global energy geopolitics in their Favor. The challenge lies in ensuring that today’s solar surge evolves into tomorrow’s energy sovereignty a goal achievable only through strategic foresight, inclusive governance, and sustained innovation.

## FUTURE OUTCOME

The future of the solar transition will be shaped less by technology per se than by the architecture of trade and cooperation regimes. Open, rules-based cooperation with targeted industrial policies and finance de-risking yields the fastest, fairest deployment path.

Table 4 - Scenario Analysis under Solar Futures under Alternative Trade & Cooperation Regimes.

| Metric | Cooperative Globalization (Open trade + multilateral cooperation) | Protectionist Fragmentation (High tariffs + supply-chain decoupling) | Regional Autarky (Regional blocs & industrial policy) | Market Correction & Diversification (Price crash → consolidation → innovation) |
|---|---|---|---|---|
| Cumulative PV by 2030 | Highest | Lowest | Moderate–High | Moderate–High (different mix) |
| Module price dispersion | Low | High | Medium–High | High (short term) |
| WACC in emerging markets | Falls significantly | Unchanged or worse | Falls for bloc members | Falls slowly for winners |
| Supply-chain resilience | Moderate (global integration) | Low (fragile, duplicated) | High within blocs | High (after consolidation) |
| Equity & access outcomes | Best | Worst | Mixed | Mixed — depends on policy |

Source: Compiled.

Protectionist fragmentation produces short-term industrial gains at the expense of global deployment speed and higher consumer costs. Regional bloc strategies and post-shake-out technological diversification provide intermediate pathways that emerging economies can exploit but only if policy design combines security of supply with mechanisms to lower finance costs and integrate grids.

## RECOMMENDATIONS

Policy recommendations for emerging economies

1. Prioritise finance de-risking to reduce WACC. Concessional finance, government guarantees, and blended finance mobilise private capital and materially accelerate deployment.
2. Negotiate targeted trade carve-outs for critical PV inputs while building domestic value up the stack (cells → modules → balance-of-system). Time-limited protections should be paired with competitiveness roadmaps.
3. Invest in grid integration & storage simultaneously. Integration investment avoids curtailment losses and absorbs greater shares of variable solar.
4. Pursue regional cooperation rather than unilateral protection. Regional procurement, pooled R&D and harmonised standards reduce costs and improve bargaining power.

5. Design social safety nets and worker transition programs to manage consolidation shocks and ensure political sustainability.
6. Foster technology diversification and domestic R&D, capturing higher value as the industry matures.

## CONCLUSION

The geoeconomics of solar energy presents a critical frontier where climate objectives, national security, and global trade intersect. As the energy transition accelerates, solar power is no longer confined to technological or environmental discourse it is now a central element of global economic strategy and diplomacy. This study illustrates how countries employ trade policy, manufacturing incentives, and multilateral cooperation to shape the contours of the global solar landscape.

Emerging economies stand at a pivotal crossroads. While endowed with high solar potential and increasing access to affordable technology, their transitions are constrained by financial barriers, grid weaknesses, and policy volatility. Nevertheless, they also hold transformative potential through leapfrogging legacy energy systems, investing in regional collaboration, and building resilient domestic industries.

The comparative analysis of trade regimes and international cooperation frameworks shows that open and coordinated global approaches offer the greatest promise for scalable, inclusive solar deployment. Conversely, protectionist fragmentation—though yielding short-term domestic gains risks undermining both deployment speed and global cost efficiencies. The SWOT analysis further reinforces the idea that long-term success depends not only on access to technology but also on the stability of policy environments, strategic infrastructure investment, and inclusive governance.

To succeed, emerging economies must adopt a proactive stance: reduce financing costs, integrate solar with grid and storage, and foster innovation ecosystems. Solar energy is no longer a peripheral solution; it is a geopolitical asset. How nations shape their solar trajectories will define their role in the future energy order and their place in a sustainable global economy.

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