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Correcting Market Failure: An Analysis of India's Solar Energy Market

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ABSTRACT

India's growing electricity demand and continued dependence on coal have created significant environmental and economic challenges. Coal-based electricity generation produces negative externalities, including air pollution, health-related costs and carbon emissions, resulting in a divergence between private and social costs and creating allocative inefficiency. In response, the Government of India has introduced several policies to promote solar energy, including subsidies, production-linked incentives, Renewable Purchase Obligations and other financial and regulatory measures. This paper evaluates the extent to which these interventions have corrected market failure and improved allocative efficiency in India's electricity market.

The analysis first applies microeconomic concepts of negative and positive externalities, marginal private and social costs, allocative efficiency, welfare loss and corrective subsidies to establish the theoretical basis for government intervention. It then applies these concepts to India using evidence on coal dependence, solar capacity growth and changes in renewable-energy costs. The paper further evaluates the effectiveness of government intervention by examining whether the expansion of solar energy has shifted electricity production towards a more socially efficient outcome. Finally, the analysis considers broader macroeconomic and long-term factors, including the fiscal cost of subsidies, energy security, dependence on imported solar technology and critical minerals, trade implications, storage requirements and the risk of government failure.

The findings suggest that government intervention has partially corrected the market failure by increasing incentives for renewable-energy investment, lowering the relative cost of solar power and encouraging a shift towards cleaner electricity generation. However, the continued dominance of coal, fiscal and infrastructure constraints, and dependence on imported components indicate that allocative efficiency has not yet been fully achieved. Therefore, India's solar-energy policies represent a significant movement towards a more socially efficient energy market, but their long-term effectiveness depends on reducing structural constraints and ensuring that government support becomes increasingly targeted and economically sustainable.

Keywords: market failure; negative externalities; allocative efficiency; solar energy; coal; government intervention; subsidies; India

INTRODUCTION

To help address these market distortions, the Government of India has introduced a range of policies to promote renewable energy and increase investment in solar power. These include subsidies for rooftop solar installations, production-linked incentives (PLI) for domestic solar manufacturing, renewable purchase obligations (RPOs), tax incentives and viability-gap funding. The PLI scheme, for example, was introduced to develop large-scale domestic manufacturing capacity for high-efficiency solar photovoltaic modules and reduce dependence on imports (Ministry of New and Renewable Energy [MNRE], 2026). These interventions have occurred alongside a substantial decline in the cost of solar technology globally, contributing to the rapid expansion of India's solar sector. By January 2026, India's installed solar capacity had reached approximately 140.6 GW, demonstrating the significant growth of the sector (Central Electricity Authority [CEA], 2026; MNRE, 2026).

This paper examines the extent to which government intervention in India's solar energy market has succeeded in correcting market failure and improving allocative efficiency within the electricity sector. Using microeconomic concepts including negative and positive externalities, marginal social cost, marginal private cost and welfare economics, the analysis evaluates whether government intervention has encouraged a shift towards a more socially efficient allocation of energy resources. The paper subsequently considers broader macroeconomic implications, including the fiscal cost and opportunity cost of government support, energy security, dependence on imported energy and solar equipment, trade implications and the long-term sustainability of India's energy transition. India's commitment to achieving 500 GW of non-fossil fuel capacity by 2030 and net-zero emissions by 2070 provides an important long-term context for evaluating these policies (MNRE, 2026). Overall, the study seeks to determine whether government intervention has merely increased solar energy production or has meaningfully contributed to correcting the underlying market failure and improving economic welfare.

THEORETICAL FRAMEWORK: MARKET FAILURE AND ALLOCATIVE EFFICIENCY

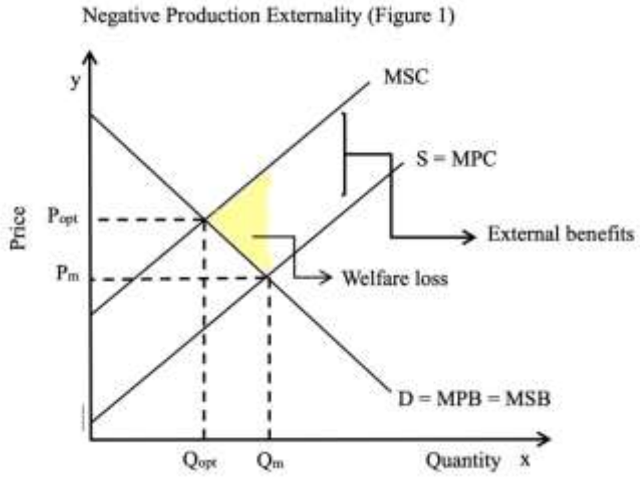
1.1 Negative Externalities and Market Failure

In a free market economy, resources are allocated through the interaction of demand and supply, with prices acting as signals that guide producers and consumers. Under ideal conditions, competitive markets can allocate resources efficiently and maximize social welfare. However, markets may fail when the actions of producers or consumers impose costs or benefits on third parties that are not reflected in market prices. These unintended effects are known as externalities. (Greenlaw et al., 2022)

A negative externality occurs when the production or consumption of a good imposes external costs on individuals who are not directly involved in the transaction. In the context of electricity generation, coal-based power production provides a clear example of a negative production externality. While producers consider costs such as labour, fuel, maintenance, and capital investment, they may not bear the full costs associated with environmental damage, air pollution, public health impacts, and greenhouse gas emissions. These costs are instead imposed upon society as a whole. (Greenlaw et al., 2022; Tutor2u, 2021)

As a result, the marginal private cost (MPC) of producing electricity from coal is lower than the marginal social cost (MSC), which includes both private and external costs. Since producers base their decisions primarily on private costs rather than the full social cost, the market may produce a greater quantity of electricity than is socially desirable. This leads to overproduction and an inefficient allocation of resources. (Tutor2u, 2021)

Figure 1: Negative Production Externality in Coal-Based Electricity Generation



In Figure 1, the market equilibrium occurs where marginal private cost equals marginal benefit. However, once external costs are considered, the true cost of production is represented by the marginal social cost curve, which lies above the marginal private cost curve. The socially optimal level of output is therefore lower than the market equilibrium quantity. The resulting difference between the market outcome and the socially optimal outcome represents a welfare loss, demonstrating that society's resources are not being allocated efficiently.

This situation is an example of market failure because the free-market outcome fails to account for the full social costs associated with production. The divergence between private and social costs can therefore result in an inefficient allocation of resources and provide an economic justification for government intervention. (Greenlaw et al., 2022)

1.2 Allocative Efficiency and Welfare Loss

Allocative efficiency occurs when resources are distributed in a way that maximizes total social welfare. In economic terms, allocative efficiency is achieved when the marginal social benefit (MSB) of a good is equal to its marginal social cost (MSC). At this point, the quantity produced represents the level at which the additional benefit to society from one more unit is equal to the additional cost of producing it. (Greenlaw et al., 2022)

In markets affected by negative externalities, allocative efficiency is not achieved because producers make decisions based primarily on private costs rather than the full costs borne by society. Consequently, output exceeds the socially optimal quantity. At quantities beyond the social optimum, the marginal social cost of additional production exceeds the marginal social benefit, meaning that the resources used to produce these additional units generate less social benefit than their true cost. (Tutor2u, 2021)

The resulting reduction in total social welfare is commonly referred to as deadweight loss. Deadweight loss represents the welfare that is lost when resources are allocated at an inefficient quantity rather than at the socially optimal level. In the case of a negative production externality, this loss occurs because production beyond the socially efficient quantity imposes external costs that exceed the additional benefits generated by those units.

Referring again to Figure 1, the triangular area between the MSC and MPC curves beyond the socially optimal quantity illustrates the deadweight welfare loss associated with the negative externality. This provides an important economic justification for corrective government policies designed to reduce the distortion and move market output closer to the socially efficient level. (Tutor2u, 2022)

1.3 Government Intervention and Corrective Subsidies

When market failure occurs, governments may intervene to improve economic efficiency and restore a more socially desirable allocation of resources. Intervention is particularly relevant in markets characterized by significant externalities, where private decision-makers do not fully account for the broader social consequences of their actions. (Greenlaw et al., 2022)

One method of intervention involves the use of corrective subsidies. A subsidy is a financial incentive provided by the government to encourage the production or consumption of a particular good. By reducing the effective cost of production or increasing profitability, subsidies can alter market incentives and influence economic behaviour. A reduction in production costs shifts the supply curve to the right, resulting in a greater quantity supplied at a given price. (Greenlaw et al., 2022)

In the context of renewable energy, subsidies are intended to encourage investment in cleaner technologies that generate fewer negative externalities than fossil fuels. Solar energy, for example, produces electricity with significantly lower emissions during operation than coal-fired power generation. By lowering the effective cost of solar energy production, government subsidies aim to increase output and investment within the renewable energy sector.

A Pigouvian intervention refers to a government policy designed to correct a market failure by aligning private incentives more closely with social costs or benefits. In the case of a negative externality, a Pigouvian tax can increase the private cost of an activity so that it more closely reflects its marginal social cost. Conversely, where an activity generates positive externalities, a subsidy can encourage greater production or consumption by helping private decision-makers capture some of the wider social benefits. (Greenlaw et al., 2022; Tutor2u, 2023)

Figure 2: Impact of a Government Subsidy on Renewable Energy Production

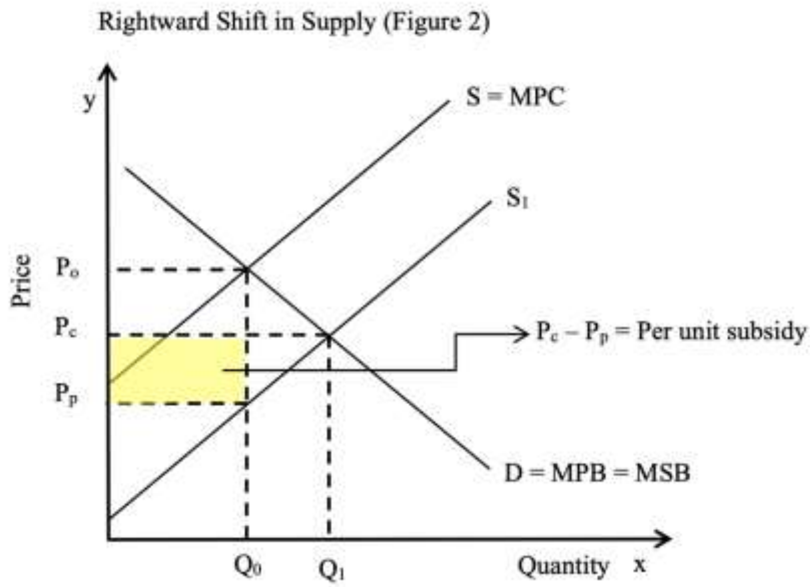


Figure 2 illustrates the effect of a government subsidy on the supply of renewable energy. Before the subsidy is introduced, the market is initially in equilibrium at Q_0 and P_0, where the original supply curve, S = MPC, intersects the demand curve, D = MPB = MSB. When the government provides a subsidy to renewable energy producers, the effective cost of production decreases. This causes the supply curve to shift downwards and to the right, from S = MPC to S_1, resulting in an increase in the equilibrium quantity of renewable energy from Q_0 to Q_1. (Greenlaw et al., 2022)

Following the subsidy, consumers pay a lower price Pc, while producers receive a higher effective price Pp after accounting for the subsidy. The vertical difference between these two prices represents the per-unit government subsidy. This creates an incentive for producers to increase the supply of renewable energy, while the lower market price can encourage greater consumption. Consequently, the quantity of renewable energy supplied and demanded increases from Q_0 to Q_1.

From a welfare perspective, the purpose of such an intervention is not simply to increase production, but to address an existing market distortion. Renewable energy can generate positive externalities through reduced air pollution, lower greenhouse gas emissions, improved public health, and potential technological spillovers. Because these benefits may not be fully reflected in the market price, the free market may produce less renewable energy than the socially desirable level. A subsidy can therefore encourage greater production and consumption by bringing private incentives closer to their wider social benefits. (Greenlaw et al., 2022)

However, the diagram represents the theoretical mechanism rather than proving that allocative efficiency has actually been achieved. For a subsidy to fully correct a positive externality, its value would ideally reflect the marginal external benefit generated by renewable energy. If the subsidy is too small, output may remain below the socially optimal level; if it is too large, it may result in overproduction and an inefficient use of government resources. Therefore, while subsidies can potentially improve allocative efficiency, their actual effectiveness depends on their size, targeting, duration, and implementation. The theoretical model shows that a subsidy can move output toward the socially optimal quantity when it accurately reflects the relevant external benefit.

1.4 Positive Externalities of Renewable Energy

While government intervention in India's solar energy market primarily seeks to address the negative externalities associated with coal-based electricity generation, solar energy itself may generate positive externalities. Positive externalities occur when the production or consumption of a good creates benefits for third parties that are not fully reflected in market prices. (Greenlaw et al., 2022)

Renewable energy technologies can provide a range of external benefits, including improved air quality, reduced greenhouse gas emissions, improved public health outcomes, and environmental benefits. In addition, investment in renewable energy may generate technological spillovers, whereby knowledge and innovations developed through research and investment benefit other firms or industries beyond the original investor. Such spillovers are a recognized example of positive externalities because the full benefits of innovation may not be captured by the individual producer making the investment. (Greenlaw et al., 2022)

Because producers and consumers may not capture the full value of these social benefits, the market may underproduce or under consume renewable energy relative to the socially optimal level. In economic terms, the marginal social benefit (MSB) exceeds the marginal private benefit (MPB). This creates a divergence between the market outcome and the socially efficient outcome. Government support, such as subsidies, can therefore be used to encourage activities that generate positive externalities and move market output closer to the socially desirable level. (Greenlaw et al., 2022)

This provides a second economic justification for government intervention in renewable energy markets. Intervention can potentially address the negative externalities associated with fossil-fuel-based electricity while simultaneously encouraging the positive externalities generated by renewable energy. However, whether government intervention actually achieves these objectives depends on the design and scale of the policies implemented, which will be examined in the following sections.

MARKET FAILURE IN INDIA'S ENERGY SECTOR

2.1 India's Dependence on Coal

India's rapid economic development and increasing electrification have resulted in a sustained rise in electricity demand. Electricity consumption increased by 5.8% in 2024, following an 8.3% increase in 2023, while peak electricity load rose from 148 GW in 2014 to 250 GW in 2024. The International Energy Agency (IEA) expects India's electricity demand to continue growing strongly, projecting average annual growth of approximately 6.4% between 2026 and 2030. This continuing increase in electricity demand creates a significant challenge for India, as the country must expand its electricity supply while simultaneously attempting to reduce its dependence on fossil fuels. (International Energy Agency [IEA], 2026)

Despite the rapid expansion of renewable energy, coal remains the dominant source of electricity generation in India. According to the Central Electricity Authority (CEA), coal and lignite accounted for approximately 73.01% of utility electricity generation in 2024–25, producing 1,331,867 GWh out of a total 1,824,214 GWh. Renewable energy sources excluding hydroelectricity accounted for approximately 13.98%, while hydroelectricity contributed a further 8.15%. (Central Electricity Authority [CEA], 2025)

The continued importance of coal can also be observed over a longer period. According to the IEA, coal accounted for approximately 76% of India's electricity generation in 2015, compared with around 71% in 2025. Although this represents a gradual decline in coal's share, the relatively small reduction over a decade demonstrates that the expansion of renewable energy has not yet resulted in a fundamental shift away from coal in India's electricity generation. In absolute terms, coal therefore remains central to meeting India's electricity requirements. (IEA, 2026)

One reason for this continued dependence is the role of coal-fired power plants in providing reliable and dispatchable electricity. Unlike solar and wind generation, which depend on weather conditions and therefore vary throughout the day, coal-fired generation can be adjusted according to electricity demand. This is particularly significant for India as peak electricity demand continues to increase. The IEA notes that India's peak load increased by 68% between 2014 and 2024, driven by factors including industrial development, greater electricity access, agriculture, and increasing use of air conditioning and household appliances.

At the same time, India has experienced substantial growth in renewable energy investment and capacity. In 2024, 83% of investment in India's power sector went towards clean energy, with solar photovoltaic technology representing a major component of this expansion. Nevertheless, the continued dominance of coal in actual electricity generation indicates that installed renewable capacity alone does not immediately translate into an equivalent reduction in coal-based generation. (IEA, 2025)

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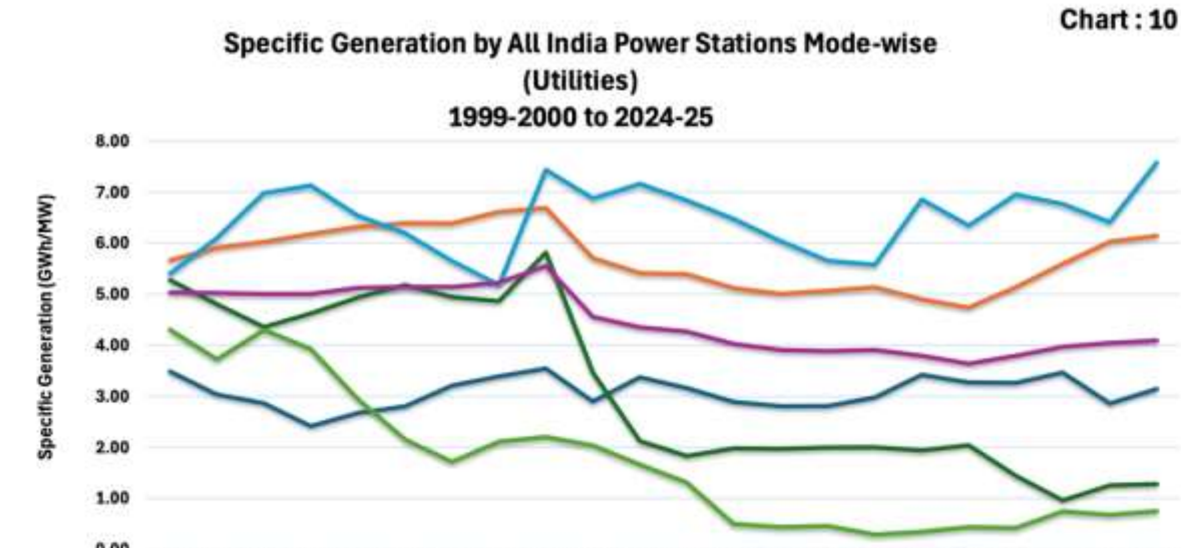
Figure 3: Specific Generation by All India Power Stations, Mode-wise, 1999–2000 to 2024–25
Source: Central Electricity Authority (CEA), Government of India, 2025.



	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Hydro	3.49	3.03	2.86	2.41	2.67	2.80	3.21	3.39	3.54	2.90	3.37	3.16	2.89	2.80	2.81	2.97	3.42	3.27	3.26	3.46	2.86	3.14
Coal/Lignite	5.66	5.91	6.02	6.18	6.32	6.39	6.39	6.61	6.69	5.71	5.41	5.39	5.12	5.00	5.07	5.14	4.90	4.74	5.14	5.59	6.03	6.14
Gas/Liquid	5.28	4.80	4.36	4.62	4.94	5.18	4.94	4.86	5.82	3.46	2.13	1.83	1.98	1.97	2.00	2.00	1.94	2.04	1.45	0.96	1.26	1.28
Nuclear	5.40	6.10	6.98	7.13	6.54	6.20	5.65	5.18	7.44	6.88	7.16	6.84	6.47	6.04	5.66	5.58	6.85	6.35	6.95	6.76	6.41	7.58
Diesel	4.30	3.72	4.30	3.93	2.95	2.16	1.72	2.11	2.20	2.04	1.66	1.31	0.50	0.44	0.46	0.29	0.35	0.44	0.42	0.75	0.68	0.75
All Types	5.03	5.02	5.01	5.00	5.12	5.14	5.14	5.23	5.55	4.56	4.35	4.27	4.03	3.91	3.89	3.91	3.79	3.64	3.79	3.97	4.04	4.09

The data show that coal/lignite-based power stations have consistently recorded relatively high levels of specific generation over the period shown. In 2024–25, coal/lignite recorded 6.14 GWh/MW, compared with 4.09 GWh/MW for all electricity-generation sources combined. This indicates that the existing coal-based generating capacity continues to be used intensively within India's electricity system. Although nuclear power records a higher specific generation value in the latest year, coal/lignite remains particularly significant because of the much larger scale of coal-based generating capacity in India.

This continued reliance on coal is economically significant because the market price of coal-generated electricity does not necessarily incorporate its full social cost. Producers consider their private costs, such as fuel, labour, maintenance and capital expenditure, when making production decisions. However, society also bears costs associated with air pollution, health impacts and greenhouse-gas emissions. Therefore, the marginal social cost (MSC) of coal-based electricity is greater than its marginal private cost (MPC).

As established in the theoretical framework, when producers respond primarily to private costs, the market may generate a quantity of coal-based electricity above the socially optimal level. The resulting divergence between private and social costs represents a negative production externality, creating allocative inefficiency and a potential welfare loss. Therefore, India's continued dependence on coal provides a relevant real-world context in which the theoretical concept of market failure can be applied.

At the same time, the data also highlight why replacing coal cannot occur immediately. Coal-based generation represents a substantial part of India's established electricity infrastructure, while electricity demand continues to grow. Consequently, policies encouraging solar and other renewable sources must not only reduce environmental externalities but also provide a sufficiently reliable alternative to existing coal-based generation. This creates the basis for examining the environmental and economic costs associated with coal and the extent to which government intervention in the solar market can correct this market failure.

2.2 Environmental and Social Costs of Coal-Based Electricity

The continued dependence on coal becomes an economic concern because the market price of coal-based electricity does not fully reflect the costs imposed on third parties. Coal-fired electricity generation produces negative externalities in the form of air pollution, greenhouse-gas emissions and associated health and environmental damage. These costs are not fully borne by electricity producers or consumers, meaning that the private cost of coal-based generation can be lower than its true social cost.

Coal combustion releases carbon dioxide (CO_2), as well as pollutants including sulphur dioxide (SO_2), nitrogen oxides (NO_x) and particulate matter. These pollutants contribute to air pollution and can impose costs on households and the wider economy through adverse health effects and environmental damage. The International Energy Agency identifies coal as a major source of both CO_2 and local air pollutants and notes that moving away from unabated coal generation is important for reducing emissions. (IEA, 2025)

The economic significance of these effects is that they represent external costs. A coal-fired power producer considers its own costs, such as fuel, labour, maintenance and capital expenditure, when determining whether to generate electricity. However, the costs associated with pollution and environmental damage may be experienced by individuals who are not directly involved in the transaction. For example, households may experience health-related costs from poorer air quality, while the wider society bears costs associated with environmental degradation and climate change.

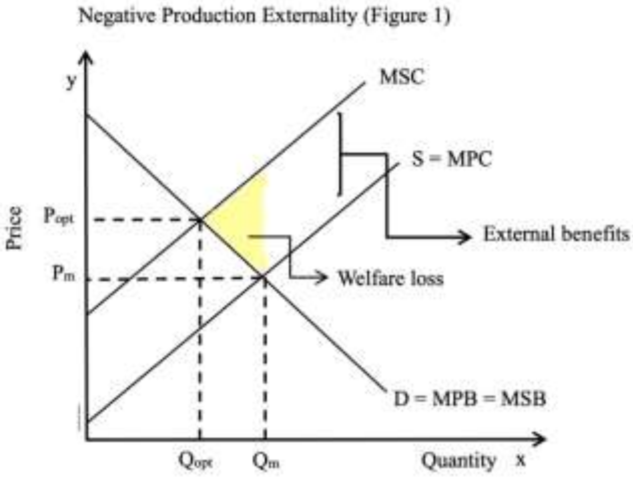
Therefore, the marginal social cost (MSC) of coal-based electricity is greater than its marginal private cost (MPC):

MSC = MPC + Marginal External Cost (MEC)

The marginal external cost represents the additional cost imposed on society by producing one additional unit of coal-based electricity. Since this cost is not fully incorporated into the market price, the price paid for electricity can underestimate its true social cost. The Energy and Resources Institute (TERI) similarly finds that the financial cost of electricity does not represent its full social cost when environmental and health impacts are excluded.

This creates a divergence between the private and social incentives facing producers. If electricity producers respond primarily to their private production costs, coal-based electricity can remain more attractive than it would be if the full environmental and health costs were incorporated into the price. Consequently, the market may allocate too many resources towards coal-based generation relative to the socially efficient level.

Figure 1: Negative Production Externality in Coal-Based Electricity Generation



Looking back at Figure 1, it demonstrates this relationship. The MPC curve represents the private cost faced by producers, while the MSC curve incorporates the external costs imposed on society. Since MSC lies above MPC, the market equilibrium quantity of coal-based electricity is greater than the socially optimal quantity. The difference between the two quantities represents the extent of overproduction resulting from the negative production externality. The associated area between MSC and MPC represents the potential welfare loss arising from production beyond the socially efficient level.

The scale of the environmental externality is particularly important for India because coal remains the dominant source of electricity generation. Although India's electricity-sector emissions intensity is expected to decline as low-emission sources expand, the IEA projects that coal will remain the dominant source of electricity supply through the latter part of the decade. This means that the external costs associated with coal cannot be considered a minor or temporary issue; they remain economically relevant while coal continues to provide a large proportion of India's electricity.

There are also important social costs associated with air pollution. The IEA has highlighted the close relationship between India's energy system, air pollution and public health, particularly because coal-intensive electricity generation contributes to emissions of SO_2, NO_x and particulate matter. The IEA also reports that many Indian thermal power plants have faced difficulties in meeting increasingly stringent air-pollution standards. (IEA, 2021)

However, this does not mean that all coal generation is economically inefficient or that coal can immediately be eliminated. As established in Section 2.1, India faces rapidly increasing electricity demand and coal provides a significant source of reliable generation. The economic issue is therefore not simply the existence of coal generation, but the fact that the market does not fully account for the external costs associated with it.

This creates a clear case of market failure. When the external costs of coal-based electricity are excluded from private decision-making, the market equilibrium may result in excessive production relative to the socially optimal level, causing allocative inefficiency and welfare loss. This provides the economic rationale for policies that either reduce the external costs of fossil-fuel generation or encourage the expansion of lower-externality alternatives such as solar energy.

2.3 Underpricing of Externalities and Welfare Implications

The environmental and social costs associated with coal-based electricity create a divergence between the private cost of electricity generation and its full social cost. In a competitive market, producers respond primarily to the costs that they directly incur. However, when the costs of air pollution, health impacts and environmental damage are not fully incorporated into the price of electricity, the market price does not reflect the complete cost to society. The Energy and Resources Institute (TERI, 2018) similarly highlights that the financial cost of electricity can underestimate its social cost when environmental and health impacts are excluded.

This can be represented as underpricing of the negative externality. In economic terms, the marginal private cost (MPC) of coal-based electricity is below its marginal social cost (MSC), because.

MSC = MPC + Marginal External Cost (MEC)

The marginal external cost represents the additional damage imposed on third parties by producing one additional unit of coal-based electricity. Since this cost is not fully reflected in the market price, consumers and producers may have insufficient economic incentives to reduce coal-based electricity generation. Consequently, the market equilibrium can occur at a quantity greater than the socially optimal level.

As shown in Figure 1 above, the market equilibrium occurs where MPC = MPB, resulting in the market quantity (Q_m). However, the socially efficient equilibrium occurs where MSC = MSB, resulting in the lower quantity (Q_{opt}). The difference between (Q_m) and (Q_{opt}) represents the potential overproduction resulting from the negative production externality. The welfare loss shown in the diagram represents the net social benefits that are lost because resources are allocated towards coal-based electricity beyond the socially optimal level.

The existence of this welfare loss indicates allocative inefficiency. At the market equilibrium, the marginal social cost of producing additional coal-based electricity exceeds the marginal social benefit obtained from it. In other words, society is bearing additional costs for units of electricity whose total social cost is greater than their social benefit. This is a key characteristic of market failure (Mankiw, 2021).

However, the economic evaluation must also recognize that coal provides benefits that are not captured by the negative-externality analysis alone. India has rapidly increasing electricity demand, and coal remains an important source of reliable electricity supply. The International Energy Agency (IEA, 2025) notes that coal remains important to India's power system because of its availability and its role in meeting electricity demand, even as renewable energy expands.

Therefore, the economically efficient solution is not necessarily to eliminate coal completely, but rather to reduce production to a level where marginal social benefit equals marginal social cost. This distinction is important when evaluating India's renewable-energy policies. The purpose of government intervention should not simply be to maximize solar generation or minimize coal generation. Instead, intervention should aim to internalize the external costs associated with energy production and move the electricity market closer to the socially efficient allocation of resources.

One possible approach is to introduce policies that make producers or consumers account for the external costs created by fossil-fuel generation, such as environmental regulations or carbon-related charges. Another approach is to support cleaner alternatives that generate positive externalities, such as solar power. By encouraging renewable energy, the government can alter relative incentives and help shift electricity production towards technologies with lower environmental externalities.

Nevertheless, government intervention is not automatically efficient. If subsidies for renewable energy are poorly targeted or significantly exceed the external benefits generated, government expenditure may itself create an inefficient allocation of resources. This introduces the possibility of government failure, which becomes particularly important when evaluating whether India's solar-energy policies have generated a net welfare gain.

Therefore, the success of government intervention should ultimately be judged by whether it produces net social welfare gains, rather than simply by the increase in renewable-energy capacity. The intervention must be sufficiently large to address the market failure, but not so large that the costs of intervention outweigh its benefits.

Overall, India's dependence on coal demonstrates a significant case of market failure because important environmental and social costs are not fully reflected in private market decisions. The resulting divergence between MPC and MSC can lead to overproduction of coal-based electricity and allocative inefficiency. This provides the economic justification for examining the government's intervention in the solar-energy market and whether these policies have actually moved India closer to the socially optimal allocation of energy resources.

GOVERNMENT INTERVENTION IN INDIA’S SOLAR ENERGY MARKET

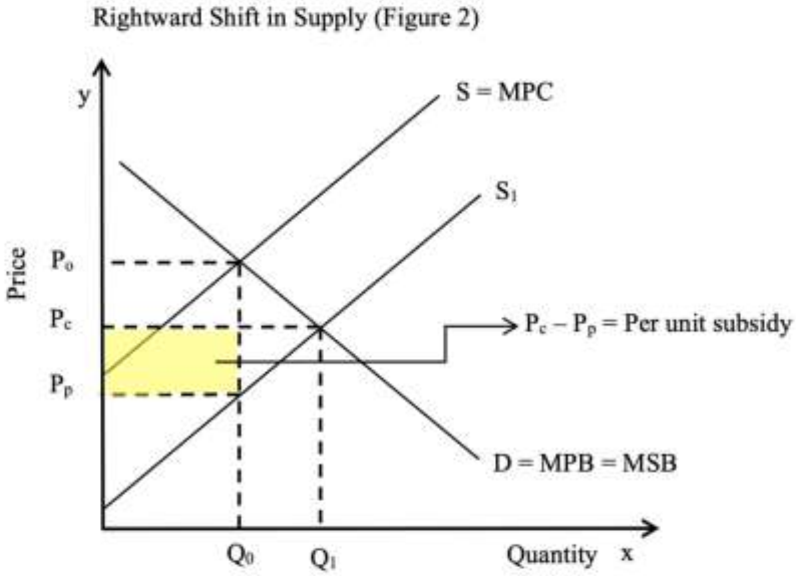
3.1 Capital Subsidies and Financial Support

The Government of India has introduced various financial incentives to encourage the adoption of solar energy and reduce the financial barriers associated with renewable-energy investment. These interventions are particularly relevant because solar energy can generate positive externalities through lower greenhouse-gas emissions, reduced air pollution and improved environmental outcomes. Since these wider benefits are not fully reflected in the private returns received by individual consumers and producers, the free market may result in a level of solar investment below the socially optimal level.

One important form of government intervention is the provision of capital subsidies, where the government contributes towards the initial cost of installing solar-energy infrastructure. This is particularly relevant for rooftop solar systems, where the relatively high upfront cost can discourage households from investing even when the technology may provide financial benefits over its lifetime. The Government of India introduced the PM Surya Ghar: Muft Bijli Yojana in 2024 to accelerate residential rooftop solar adoption by providing financial assistance to eligible households (Ministry of New and Renewable Energy [MNRE], 2024).

Under the scheme, households receive Central Financial Assistance (CFA) towards the installation of rooftop solar systems. The subsidy is structured to provide greater financial support for the initial portion of installed capacity, with additional support available for systems with higher capacity. According to MNRE, the scheme has an overall financial outlay of ₹75,021 crore and aims to support the installation of rooftop solar systems in one crore households (MNRE, 2024).

Figure 2: Impact of a Government Subsidy on Renewable Energy Production



From a microeconomic perspective, this intervention reduces the effective cost of adopting solar energy. This can be represented using Figure 2, where a subsidy causes the supply curve to shift downwards from (S) to (S_1), reducing the market price paid by consumers and increasing the equilibrium quantity from (Q_0) to (Q_1).

In the case of rooftop solar, the subsidy therefore reduces the financial barrier faced by households and increases the incentive to invest in renewable energy. The resulting increase in solar adoption can generate additional social benefits that would not necessarily have occurred under the original market equilibrium. In this sense, the policy attempts to bring private incentives closer to the wider social benefits associated with renewable-energy consumption.

However, the presence of a subsidy does not automatically mean that allocative efficiency has been achieved. The theoretically optimal subsidy would reflect the marginal external benefit (MEB) generated by solar energy. If the subsidy is lower than the external benefit, solar adoption may remain below the socially optimal level. Conversely, if the subsidy is greater than the additional social benefit generated, resources may be allocated inefficiently and the government may incur unnecessary expenditure.

This creates an important opportunity cost for the government. Public funds used to subsidise rooftop solar cannot simultaneously be used for other purposes such as healthcare, education, infrastructure or alternative energy investments. Therefore, the economic effectiveness of the intervention depends not only on whether solar adoption increases, but also on whether the social benefits generated by the additional adoption justify the fiscal resources committed to the scheme.

Capital subsidies can therefore be understood as an attempt to address the positive externalities associated with renewable energy by reducing the private cost of adopting solar technology. However, whether this intervention has actually improved overall allocative efficiency depends on the magnitude of the resulting environmental and economic benefits relative to the fiscal cost of the policy. This question will be examined more closely in the later welfare-analysis section.

3.2 Production-Linked Incentive (PLI) Scheme

Another major government intervention in India's solar-energy market is the Production-Linked Incentive (PLI) Scheme for High Efficiency Solar PV Modules. Unlike capital subsidies, which primarily reduce the cost of solar adoption, the PLI scheme focuses on increasing the domestic supply and manufacturing capacity of solar photovoltaic (PV) modules. The scheme was introduced because India's solar expansion had historically depended substantially on imported solar cells and modules, creating concerns regarding import dependence and the development of domestic manufacturing capacity (Ministry of New and Renewable Energy [MNRE], 2026).

The PLI scheme provides financial incentives to selected solar PV manufacturers based on the production and sale of high-efficiency solar PV modules. Incentives are provided for five years after manufacturing plants are commissioned, with the scheme designed to encourage manufacturers to establish integrated or partially integrated production facilities within India. The overall scheme has an approved outlay of ₹24,000 crore, implemented through two tranches. Tranche I received an allocation of ₹4,500 crore, while Tranche II received ₹19,500 crore (MNRE, 2026).

The first tranche resulted in Letters of Award being issued to three successful bidders for 8,737 MW of fully integrated solar PV manufacturing capacity. Under the second tranche, 11 bidders were awarded capacity to establish 39,600 MW of fully or partially integrated solar PV manufacturing. This demonstrates that the intervention is aimed not merely at increasing the number of solar installations, but at developing the supply-side capacity required to support India's longer-term expansion of solar energy (MNRE, 2026).

From an economic perspective, the PLI scheme can influence the supply side of the solar-energy market. By reducing the effective cost or increasing the profitability of domestic solar manufacturing, the incentive encourages firms to enter or expand production. In the longer term, greater domestic production may generate economies of scale, technological learning and productivity improvements, potentially lowering the cost of solar equipment. The scheme also explicitly aims to encourage higher module efficiency, greater domestic value addition and technological development (MNRE, 2026).

The intervention also has a strategic economic dimension. Greater domestic manufacturing can reduce India's dependence on imported solar equipment and therefore reduce exposure to international supply disruptions and changes in global prices. This is particularly relevant because solar energy expansion requires substantial quantities of photovoltaic modules and related components. The government therefore views domestic manufacturing as a means of strengthening the resilience of India's renewable-energy supply chain (MNRE, 2026).

However, the PLI scheme also involves a significant opportunity cost. The ₹24,000 crore allocated to the programme represents public resources that could otherwise be used for alternative investments. Furthermore, encouraging domestic production does not necessarily mean that Indian manufacturers will immediately produce solar equipment at the lowest possible cost. If domestic manufacturing remains more expensive than imported alternatives, government support could increase the cost of solar deployment in the short run. This creates an important trade-off between dynamic benefits, such as technological development and energy-security benefits, and static efficiency, where resources are allocated towards the lowest-cost producer.

Therefore, the PLI scheme should not be evaluated solely according to whether it increases domestic manufacturing capacity. Its effectiveness ultimately depends on whether the benefits generated through technological development, economies of scale, employment, reduced import dependence and greater energy security outweigh the fiscal cost and any additional production costs created by the intervention. This distinction becomes particularly important in the later evaluation of whether government intervention has generated a net improvement in economic welfare.

3.3 Renewable Purchase Obligations (RPOs)

Another important form of government intervention in India's renewable-energy market is the Renewable Purchase Obligation (RPO). Unlike capital subsidies and the Production-Linked Incentive (PLI) scheme, which primarily influence the financial incentives of consumers and producers, RPOs use regulation to create demand for renewable electricity. Under the RPO framework, designated electricity distribution companies, open-access consumers and certain captive power consumers are required to obtain a specified proportion of their electricity consumption from renewable energy sources (Ministry of Power, 2022).

The purpose of RPOs is to ensure that renewable energy receives a guaranteed level of demand within the electricity market. In a completely market-driven system, renewable-energy producers may face difficulties competing with established conventional sources such as coal, particularly because coal-based power benefits from existing infrastructure and can provide dispatchable electricity. At the same time, the positive externalities associated with renewable energy are not fully reflected in its private market value. RPOs therefore attempt to overcome this market limitation by requiring electricity purchasers to include renewable energy within their energy procurement.

From a microeconomic perspective, an RPO can be viewed as a government-created demand mechanism. By requiring electricity suppliers or other obligated entities to purchase a certain proportion of renewable electricity, the government increases the effective demand for renewable energy. This provides renewable-energy producers with a more predictable market and can encourage investment in additional generation capacity.

The Indian government has progressively increased the importance of renewable-energy obligations. The Ministry of Power's RPO trajectory for 2024–25 to 2029–30 establishes increasing renewable-energy procurement requirements, with the overall RPO rising from 29.91% in 2024–25 to 43.33% by 2029–30. The framework also includes separate requirements for different renewable sources, including wind, hydro and distributed renewable energy (Ministry of Power, 2022).

This increasing obligation can create a stronger incentive for investment in renewable generation. As the required share of renewable electricity rises, obligated entities need to secure additional renewable power either through direct procurement or through mechanisms such as Renewable Energy Certificates (RECs). This creates a market-based mechanism through which renewable-energy generation receives additional demand beyond what would necessarily occur under unrestricted market conditions.

RPOs can therefore contribute to correcting the underproduction associated with the positive externalities of renewable energy discussed in Section 1.4. If the social benefits of renewable electricity exceed the private benefits perceived by market participants, the free-market equilibrium may result in a quantity below the socially optimal level. By artificially increasing demand for renewable electricity, an RPO can move the market towards a higher level of renewable-energy production.

However, the effectiveness of RPOs depends on their implementation and enforcement. If obligated entities fail to comply with the requirements, or if renewable-energy supply is insufficient, the policy may not produce the intended increase in renewable generation. Furthermore, forcing electricity purchasers to procure renewable energy can increase their procurement costs if renewable electricity is more expensive than alternative sources. This creates a potential trade-off between allocative efficiency and policy objectives: while renewable procurement may generate environmental and social benefits, the additional private cost must be considered when assessing the overall welfare effect.

Therefore, RPOs represent an important complement to financial incentives such as subsidies and PLI. Rather than directly reducing the cost of solar technology, they create a regulatory demand for renewable electricity, encouraging investment and expanding the market for renewable producers. Whether this intervention has actually improved allocative efficiency depends on whether the additional social benefits generated by renewable-energy consumption outweigh the costs imposed on electricity purchasers and the wider economy.

3.4 Tax Incentives and Other Government Support

In addition to direct subsidies and production incentives, the Government of India has used a range of tax and financial measures to encourage investment in renewable energy. These policies aim to reduce the effective cost of renewable-energy projects and improve their financial viability, particularly during the initial stages of investment. Such measures complement capital subsidies and the PLI scheme by addressing different financial barriers within the solar-energy market.

Tax incentives can reduce the tax burden associated with investment in renewable-energy infrastructure, thereby increasing the expected return to firms undertaking solar projects. This can encourage greater private investment by making renewable-energy projects relatively more financially attractive compared with alternative investments. From an economic perspective, reducing the effective cost faced by producers can increase the incentive to expand renewable-energy supply and accelerate the adoption of solar technology.

Another important form of government support is Viability Gap Funding (VGF). VGF provides financial assistance to infrastructure projects that are considered economically or socially desirable but may not be financially viable on their own. In the renewable-energy sector, such support can help large-scale projects overcome the gap between their expected revenues and the costs required to establish the project. The Ministry of New and Renewable Energy has used VGF as part of its support for renewable-energy development, including large-scale solar projects (Ministry of New and Renewable Energy [MNRE], 2024).

The economic rationale for such intervention is similar to that of subsidies. If the social benefits generated by renewable energy exceed the private benefits received by investors, the market may result in insufficient investment in renewable-energy capacity. Financial support can therefore reduce the private cost of investment and encourage production towards a level closer to the socially desirable outcome.

However, these incentives also create a potential government failure. Financial support requires public funds or reduces government tax revenue, creating an opportunity cost. If projects would have been undertaken even without the incentive, the government may effectively be subsidising investment that would have occurred under market conditions. Similarly, if financial incentives remain in place for too long, producers may become dependent on government support rather than becoming competitive through technological improvements and economies of scale.

Therefore, the effectiveness of tax incentives and other financial support should be assessed not simply by the amount of renewable-energy investment they generate, but by whether the additional investment and associated social benefits exceed the fiscal cost of the intervention. This becomes particularly important when evaluating the long-term sustainability of India's renewable-energy policies.

Taken together, capital subsidies, the PLI scheme, RPOs and other financial incentives demonstrate that the Indian government has adopted a multi-dimensional approach to promoting solar energy. These policies address different market barriers: subsidies encourage adoption, PLI strengthens domestic supply, RPOs create demand, and additional financial support improves project viability. The next section therefore examines the resulting growth of India's solar sector and considers whether this expansion provides evidence that government intervention has successfully influenced the energy market.

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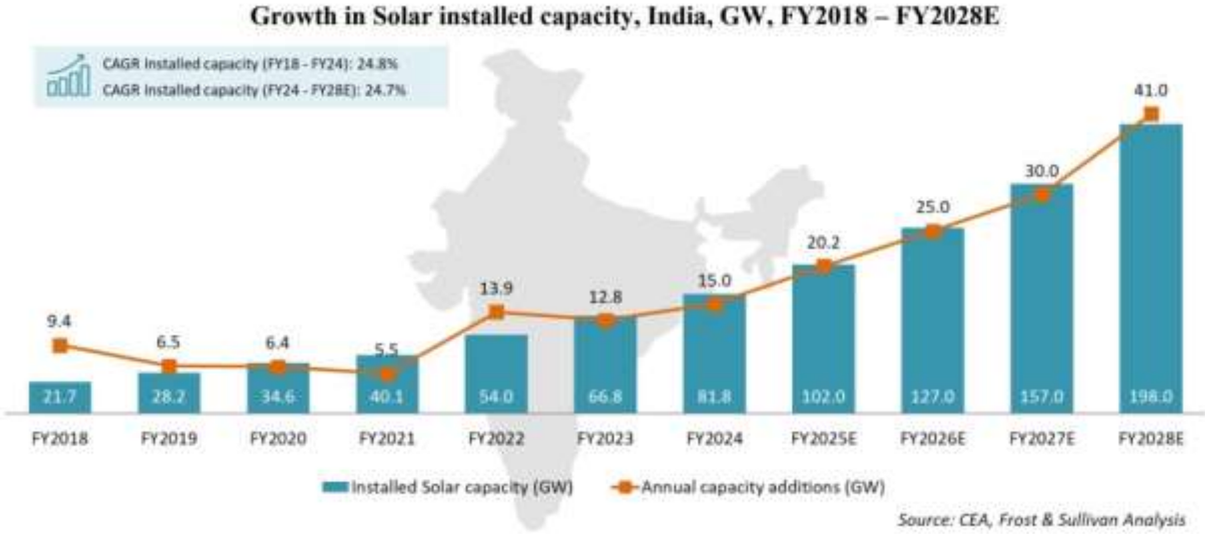
3.5 Growth of India's Solar Energy Sector

The various government interventions discussed above have been accompanied by a substantial expansion of India's solar-energy sector. This growth is important because it provides an initial indication of whether government policies and other market developments have successfully encouraged the adoption and production of renewable energy. However, an increase in solar capacity alone does not necessarily demonstrate an improvement in allocative efficiency. The economic impact of this growth must therefore be considered alongside changes in costs, electricity generation and the overall energy mix.

India's installed solar capacity has increased significantly over the past decade. According to the Ministry of New and Renewable Energy (MNRE), solar power capacity reached approximately 140.6 GW by January 2026, compared with less than 3 GW around a decade earlier (MNRE, 2026). This represents a substantial structural expansion of solar within India's electricity system and reflects the combined influence of government policies, technological development and falling costs of solar photovoltaic technology.

Figure 4: Growth in Installed Solar Capacity and Annual Capacity Additions in India, FY2018–FY2024

Source: Central Electricity Authority (CEA) and Frost & Sullivan, reproduced in Mint (Bhambhani, 2024).



The data demonstrate the rapid expansion of India's solar sector, with installed capacity increasing from 21.7 GW in FY2018 to 81.8 GW in FY2024. The accompanying projections suggest that this expansion is expected to continue, with installed capacity estimated to reach 198 GW by FY2028. This substantial increase indicates that government policies and declining solar technology costs have strengthened incentives for renewable-energy investment. However, capacity growth alone does not establish that the negative externalities associated with coal have been fully corrected, since installed capacity does not directly measure actual electricity generation or the extent to which coal-based generation has been displaced.

MICROECONOMIC WELFARE ANALYSIS

4.1 Effect of Government Subsidies on Solar Supply and Output

Government subsidies can influence the market for renewable energy by reducing the effective cost of production faced by producers. As established in Section 1.3, a producer subsidy shifts the supply curve downwards/rightwards because producers are willing to supply a greater quantity at each market price. This increases equilibrium output and lowers the price paid by consumers, while producers receive a higher effective price once the subsidy is taken into account.

Figure 2 therefore provides a theoretical representation of how India's support for renewable energy can increase the supply of solar electricity. The movement from Q_0 to Q_1 represents the increase in renewable-energy output resulting from the reduction in producers' effective costs. In economic terms, this intervention attempts to alter the incentives faced by producers so that the market allocates more resources towards an activity associated with positive externalities.

The Indian case is particularly relevant because government support has operated alongside substantial reductions in the cost of solar technology. The Economic Survey notes that solar power costs in India have fallen sufficiently for renewable electricity to become competitive with fossil-fuel generation in a number of circumstances. It also reports recent Solar Energy Corporation of India (SECI) auction prices for interstate-connected solar PV projects in the range of approximately ₹2.60–₹2.74 per kWh in 2024.

This suggests that the increase in solar supply cannot be attributed to subsidies alone. Government intervention has worked together with technological improvements, economies of scale, increased deployment and declining capital costs. The IEA similarly identifies supportive policies, cheaper financing, increased deployment, economies of scale and technological improvements as factors contributing to declining renewable-energy costs.

The outcome can be observed in India's rapid expansion of installed solar capacity discussed in Section 3.5. The increase in capacity indicates that the combination of government incentives and improving project economics has successfully encouraged producers and investors to allocate greater resources towards solar energy. However, this should not be interpreted as proof that the subsidy itself has produced the entire increase. Causation is more complex, since falling technology costs have simultaneously made solar projects increasingly attractive.

From a welfare perspective, the increase in solar output can potentially improve resource allocation because solar electricity generates benefits that are not fully captured by the private market. These include lower local air pollution and lower greenhouse-gas emissions relative to fossil-fuel generation. Therefore, increasing solar production can reduce the relative dependence on an electricity source associated with significant external costs while increasing the production of a technology with positive external benefits.

However, the theoretical diagram also highlights an important limitation. A subsidy increases output, but the socially optimal quantity is not automatically achieved simply because output increases. For allocative efficiency to be achieved, the marginal social benefit of additional solar generation must equal its marginal social cost. If the subsidy is smaller than the relevant external benefit, solar production may remain below the socially optimal level. Conversely, if the subsidy exceeds the external benefit, resources could be pushed towards excessive solar production, creating a new inefficiency.

There is also an important distinction between the private cost of solar generation and its system-wide economic cost. Although solar PV has become highly competitive on an LCOE basis, LCOE does not capture every cost associated with integrating variable renewable electricity into the electricity system. India's Economic Survey specifically cautions that LCOE does not incorporate the costs associated with intermittency and dispatchability. This means that a simple comparison of the cost of generating one unit of solar electricity with one unit of coal electricity may not represent the complete social cost of supplying reliable electricity.

Therefore, the effect of subsidies should be evaluated as a movement towards improved allocation rather than proof of complete allocative efficiency. Government intervention appears to have strengthened incentives for solar investment and increased renewable-energy supply, but whether this has moved India's electricity market all the way towards the socially optimal outcome depends on the external benefits generated, the costs of integrating renewable electricity, and the extent to which solar generation actually displaces electricity from coal.

Overall, the evidence supports the conclusion that government intervention has partially corrected the original market distortion by increasing the supply of renewable energy and improving incentives to account for environmental benefits. However, the existence of rapidly growing solar capacity alone is insufficient to conclude that the market failure has been completely eliminated. The next stage of the analysis therefore requires comparing the cost competitiveness of solar and coal and considering the resulting welfare implications.

4.2 Solar Energy Compared with Coal: Cost Competitiveness

A key factor in evaluating the effectiveness of government intervention is whether solar energy has become sufficiently cost-competitive with conventional electricity generation. If solar can increasingly compete with coal on the basis of its generation cost, the need for continued financial support may decrease over time. This is particularly relevant to allocative efficiency because resources should ideally be directed towards the energy source that provides the greatest overall social benefit relative to its cost.

One commonly used measure for comparing different electricity-generation technologies is the Levelized Cost of Electricity (LCOE). LCOE represents the average cost of generating one unit of electricity over the lifetime of a power-generation project. It incorporates major costs such as capital expenditure, operation and maintenance, fuel costs where applicable, and the amount of electricity expected to be generated over the project's lifetime. This makes it useful for comparing the underlying generation costs of solar and coal.

The cost competitiveness of solar energy in India has improved substantially over the past decade. According to the Government of India's Economic Survey, solar power costs have fallen significantly as technological improvements, economies of scale and increased deployment have reduced the cost of photovoltaic generation. Recent SECI auctions for interstate-connected solar PV projects recorded tariffs of approximately ₹2.60–₹2.74 per kWh in 2024, demonstrating the increasingly competitive cost of utility-scale solar generation (Government of India, 2024).

This decline in solar costs is economically significant because it suggests that the expansion of solar energy is no longer driven exclusively by government financial support. As the private cost of solar generation falls, producers have a greater incentive to invest even without an equivalent increase in subsidies. Government intervention may therefore have contributed to a dynamic efficiency effect, where early support encouraged investment and deployment, which in turn contributed to economies of scale, technological learning and lower future costs.

However, a direct comparison between the LCOE of solar and coal has limitations. Solar generation is dependent on sunlight and is therefore variable, whereas coal-fired power plants can generally provide electricity when required. Consequently, the cost of generating electricity from solar panels does not capture all of the costs associated with ensuring a reliable electricity supply. Additional investment in energy storage, transmission infrastructure and grid balancing may be required as the proportion of intermittent renewable generation increases.

The Economic Survey similarly highlights that LCOE does not fully capture the costs associated with the intermittency and dispatchability of renewable electricity (Government of India, 2024). Therefore, even if solar has a lower LCOE than coal, this does not necessarily mean that solar has a lower total social cost in every situation. For an allocative-efficiency analysis, the relevant comparison must consider not only the private cost of generation but also the external environmental costs associated with each technology.

This creates an important distinction between private cost competitiveness and social cost competitiveness. Coal may have a relatively competitive private generation cost, but its production generates external costs through air pollution, health impacts and greenhouse-gas emissions. These costs increase its marginal social cost above its marginal private cost. Solar, in contrast, has relatively low environmental costs during operation and therefore may have a lower social cost than its private cost alone would suggest.

Consequently, the increasing competitiveness of solar can strengthen the economic case for government intervention. If solar becomes increasingly inexpensive while simultaneously generating positive environmental externalities, shifting resources towards solar can potentially generate both private economic benefits and wider social welfare gains. However, government support must still be proportional to the additional social benefits generated. Once solar becomes commercially competitive, excessive subsidies could distort resource allocation rather than correct it.

This also creates a potential transition problem for government policy. Financial support that is necessary to establish an emerging technology may become less economically justified once that technology reaches cost competitiveness. Continuing the same level of support indefinitely could result in government resources being allocated towards projects that would have occurred without intervention. Therefore, the effectiveness of solar policy should be judged not only by whether it reduced the cost of solar electricity, but also by whether the government can gradually reduce support as the technology becomes more commercially viable.

Overall, the falling cost of solar energy provides evidence that India's interventions may have contributed to a movement towards a more efficient energy allocation. Nevertheless, LCOE alone cannot establish allocative efficiency because it does not fully account for external environmental costs, intermittency, storage and grid-integration requirements. The comparison therefore supports a partial rather than definitive conclusion: solar has become substantially more economically competitive, strengthening the case for shifting electricity production away from coal, but the extent of the resulting welfare improvement must be assessed by considering both the benefits and the remaining costs of this transition.

4.3 Has Government Intervention Improved Allocative Efficiency?

The ultimate measure of the effectiveness of government intervention is not simply whether solar energy production has increased, but whether resources within India's electricity market are being allocated closer to the socially optimal level. As established in the theoretical framework, allocative efficiency occurs when marginal social benefit (MSB) is equal to marginal social cost (MSC). In the case of electricity generation, this requires the environmental and health costs associated with different sources of electricity to be considered alongside their private production costs.

Before government intervention, the presence of negative externalities from coal means that the marginal social cost of coal-based electricity is greater than its marginal private cost. Producers respond primarily to their private costs and therefore have an incentive to produce more coal-based electricity than would be socially desirable. This creates a welfare loss because some of the additional units of electricity generated impose social costs greater than the benefits received from their consumption.

Government support for solar energy can potentially improve this allocation by increasing the supply and consumption of a technology with substantially lower operational environmental externalities. Policies such as capital subsidies, PLI incentives and RPOs alter the relative incentives facing producers and consumers, encouraging resources to move towards renewable electricity. If this results in solar generation replacing electricity that would otherwise have been produced using coal, the external costs associated with electricity generation can be reduced.

The expansion of solar capacity discussed in Section 3.5 provides evidence that these interventions have successfully influenced the allocation of investment within the electricity sector. However, capacity expansion alone cannot demonstrate that allocative efficiency has been achieved. The socially optimal level depends on the marginal social benefits and marginal social costs of renewable generation, rather than simply the amount of installed capacity. Furthermore, because solar generation is intermittent, increasing solar capacity does not necessarily result in an equivalent reduction in coal-based electricity generation.

There is therefore an important distinction between increasing renewable-energy output and correcting market failure. Government intervention can move the market towards greater efficiency by increasing the production of solar energy and reducing reliance on electricity associated with negative externalities. However, complete allocative efficiency would require the additional social benefits of renewable generation to equal its additional social costs. These costs include not only the private costs of producing solar electricity but also the infrastructure, transmission, storage and grid-balancing requirements associated with integrating increasing quantities of renewable energy.

The presence of positive externalities further strengthens the potential welfare gains from solar energy. Reduced air pollution, lower greenhouse-gas emissions and technological spillovers create benefits for third parties that are not necessarily captured by individual producers or consumers. Consequently, the market may initially underprovide solar energy relative to the socially optimal quantity. Government intervention can therefore improve allocation from both directions: reducing the excessive production associated with coal's negative externalities while encouraging the underproduction of renewable energy associated with positive externalities.

Nevertheless, intervention can also create a new source of inefficiency if policies are poorly calibrated. A subsidy that is smaller than the marginal external benefit may fail to bring solar output to the socially optimal level. Conversely, a subsidy that is excessively large may encourage investment beyond the economically efficient level and impose unnecessary costs on taxpayers. Similarly, RPOs may increase renewable-energy procurement but can impose additional costs on obligated electricity suppliers if renewable electricity is more expensive or difficult to integrate.

Therefore, the evidence suggests that government intervention in India's solar market has moved the electricity sector in the direction of improved allocative efficiency, but cannot be considered to have completely achieved it. The rapid expansion of solar energy, declining generation costs and increasing renewable procurement indicate that government policies have helped correct part of the original market distortion. However, continued dependence on coal, the intermittency of solar generation, infrastructure requirements and the fiscal costs of intervention indicate that the socially optimal allocation has not necessarily been reached.

The intervention can therefore be characterised as a partial correction of market failure rather than a complete solution. Its success should ultimately be judged by whether the social benefits created by additional renewable generation continue to exceed the economic and fiscal costs of achieving it. This provides the basis for examining the welfare gains and potential government failures associated with India's solar-energy policies.

4.4 Welfare Effects of Government Intervention

The effectiveness of government intervention can ultimately be assessed by considering its impact on overall social welfare. In the case of India's electricity market, welfare is not determined solely by the private benefits received by electricity producers and consumers. It also depends on the external costs and benefits associated with different methods of electricity generation. Therefore, increasing solar-energy production can potentially create welfare gains if it reduces the external costs associated with coal-based electricity.

One major source of welfare gain is the reduction in negative externalities. Coal-based electricity generation creates costs through air pollution, adverse health effects and greenhouse-gas emissions. These costs are not fully reflected in the market price of electricity and are therefore not considered by producers when determining their private level of output. If government policies successfully encourage solar generation and cause some coal-based generation to be displaced, the external costs imposed on society may decrease. This represents a potential increase in social welfare because fewer resources are required to deal with the consequences of pollution and environmental damage.

Solar energy can also generate positive externalities, as discussed in Section 1.4. Improvements in air quality, reductions in greenhouse-gas emissions and technological spillovers can create benefits for individuals and industries beyond the immediate producers and consumers of solar electricity. Since these benefits may not be fully captured through the market price, government support can increase solar production towards a level that more closely reflects its wider social value. In this sense, intervention can improve welfare by addressing both the negative externality associated with coal and the positive externality associated with renewable energy.

However, government intervention itself involves an economic cost. Subsidies, financial incentives and other forms of government support require public funds that could alternatively be allocated to other areas such as healthcare, education, infrastructure or other public services. This creates an opportunity cost of government intervention. Therefore, the welfare gain from reducing environmental externalities should be compared with the resources used to achieve that reduction.

The size of the subsidy is particularly important. If government support is too small, solar production may remain below the socially optimal level and the positive externalities associated with renewable energy may continue to be underprovided. However, if subsidies are excessively large, they may encourage investment in solar projects beyond the economically efficient level. In this situation, the government may spend public resources generating additional solar capacity whose social benefits are smaller than its additional cost. The intervention could therefore create a new source of allocative inefficiency.

There are also costs associated with integrating large amounts of solar generation into the electricity system. Solar power is intermittent because generation depends on sunlight, meaning that additional investment in transmission networks, grid management and energy storage may be required as its share of electricity generation increases. These costs are important when assessing total welfare because the social cost of increasing solar generation is not limited to the cost of installing photovoltaic capacity alone.

Therefore, the welfare effects of India's solar policies are mixed but potentially positive. On one hand, government intervention can generate significant welfare gains by reducing the negative externalities associated with coal and encouraging an energy source with positive environmental and technological externalities. On the other hand, these gains must be weighed against the fiscal cost of subsidies, opportunity costs and the additional infrastructure required to integrate renewable electricity.

Overall, government intervention appears to have improved social welfare by moving resources towards cleaner electricity generation, but the magnitude of this improvement cannot be assumed from solar-capacity growth alone. The intervention is most economically efficient when the additional social benefits generated by solar energy exceed the additional social costs of producing and integrating it. This suggests that India's policies have contributed to a partial correction of the original market failure, while the extent of the welfare improvement depends on how effectively government support is targeted and adjusted as solar technology becomes increasingly competitive.

EVALUATION: MACROECONOMIC AND LONG-RUN CONSIDERATIONS

The microeconomic analysis suggests that government intervention has helped move India's electricity market towards a more efficient allocation of resources. However, evaluating the long-term effectiveness of solar-energy policies requires consideration of factors beyond individual markets. The fiscal implications of government support, energy security, international trade, and the long-term sustainability of renewable-energy investment can affect whether these policies remain economically desirable over time. Therefore, the success of solar intervention should be evaluated not only through its effect on market failure, but also through its wider macroeconomic consequences.

5.1 Fiscal Burden and Opportunity Cost

Government support for solar energy involves a financial cost. Capital subsidies, production-linked incentives and other forms of public support require government expenditure, creating an opportunity cost because the same funds could alternatively be allocated towards other public priorities. For example, the PLI scheme for high-efficiency solar PV modules has a total approved outlay of ₹24,000 crore, demonstrating the scale of public resources committed to developing domestic solar manufacturing capacity (Ministry of New and Renewable Energy [MNRE], 2026).

However, government spending on renewable energy should not automatically be interpreted as a welfare loss. Public support can generate longer-term benefits through technological development, domestic manufacturing, employment and reduced environmental damage. The IEA reports that 83% of India's power-sector investment went towards clean energy in 2024, illustrating the increasing importance of renewable energy within India's investment landscape (International Energy Agency [IEA], 2025).

Therefore, the relevant economic comparison is between the cost of intervention and the wider social benefits generated by it. A subsidy that is necessary during the early development of a technology may become less necessary as production expands, technological costs decline and economies of scale develop. If government support remains excessive after solar becomes commercially competitive, public resources could potentially be used to encourage investment that would have occurred without intervention.

This creates an important policy trade-off. The government must provide sufficient support to overcome market barriers while avoiding excessive or permanent subsidies. As solar technology becomes increasingly competitive, gradually reducing reliance on direct financial support could allow the sector to become more self-sustaining.

5.2 Energy Security and Import Dependence

Solar expansion also has important implications for India's energy security. India's rapidly increasing electricity demand makes diversification of the power-generation mix increasingly important. The IEA notes that India is promoting renewable and nuclear investment partly to diversify its electricity mix while meeting sharply rising electricity demand (IEA, 2025).

Increasing domestic renewable-energy generation can reduce exposure to international fossil-fuel prices and potential disruptions in global energy supply. Greater use of domestic solar resources therefore provides a potential long-term energy-security benefit, particularly because solar generation does not require imported fuel for each additional unit of electricity produced.

However, the transition towards solar does not completely eliminate external dependence. Solar expansion requires photovoltaic modules, manufacturing equipment, batteries and other components, and global clean-energy supply chains remain highly concentrated. The IEA reports that China continues to be the dominant producer across the solar PV supply chain, accounting for particularly high shares of global production capacity for wafers and other components (IEA, 2026).

This creates a potential contradiction within India's energy-security strategy. Greater domestic solar generation can reduce dependence on imported fossil fuels, while dependence on imported solar equipment can create a different form of external vulnerability. India's PLI scheme attempts to address this issue by developing domestic high-efficiency solar PV manufacturing and reducing import dependence (MNRE, 2026).

Therefore, the energy-security benefits of solar depend not only on increasing installed capacity but also on developing a sufficiently resilient domestic and international supply chain.

5.3 Trade and Balance-of-Payments Implications

The expansion of renewable energy can also influence India's international trade position. Reducing dependence on imported fossil fuels could potentially reduce expenditure on energy imports and decrease the economy's exposure to international fuel-price fluctuations. Over the long term, replacing some imported fossil-fuel consumption with domestically generated solar electricity could therefore improve India's external position.

However, this benefit must be considered alongside imports of solar modules, cells, batteries and critical minerals. The IEA identifies the concentration of clean-energy technology manufacturing as a significant supply-chain vulnerability, with China remaining the dominant supplier across several stages of solar PV production (IEA, 2026).

India has nevertheless made progress in developing domestic solar manufacturing capacity. MNRE reports that India's solar PV module manufacturing capacity increased from approximately 2.3 GW in 2014 to around 172 GW by March 2026, while solar-module imports also declined substantially during the same period (MNRE, 2026).

This suggests that government intervention may have a dual economic effect: in the short run, policies supporting domestic manufacturing can require substantial investment and financial assistance, but in the longer run they may reduce import dependence and strengthen India's domestic industrial base.

5.4 Government Failure and Policy Risks

Although government intervention is intended to correct market failure, it can itself create inefficiencies. This is known as government failure. In India's solar market, one potential risk is over-subsidisation. If financial incentives remain too generous after solar becomes increasingly cost-competitive, resources may be diverted towards solar projects beyond the socially efficient level.

Another risk is policy uncertainty. Renewable-energy projects require substantial upfront investment and generally operate over long periods. Changes in subsidies, regulations or renewable-energy obligations can therefore affect investor expectations and project economics. The IEA identifies financing conditions, off-taker risk and inadequate transmission infrastructure among the challenges affecting renewable-energy investment in India (IEA, 2025).

There is also a risk of focusing excessively on installed capacity rather than actual electricity generation and system reliability. Solar capacity does not automatically translate into an equivalent reduction in coal generation because solar generation is variable and depends on weather and time of day. The IEA's analysis shows that, despite rapid growth in renewable generation, coal still accounted for around 71% of India's electricity generation in 2025 (IEA, 2026).

Therefore, government intervention should not be judged simply by whether solar capacity targets are achieved. Its effectiveness depends on whether renewable generation can actually contribute to a reliable electricity system while reducing the external costs associated with fossil-fuel generation.

5.5 Long-Run Sustainability

The long-term effectiveness of India's solar policies ultimately depends on whether the sector can continue expanding without requiring permanently increasing government support. Falling solar costs and economies of scale suggest that the technology is becoming increasingly commercially viable. This strengthens the argument for gradually shifting policy support away from broad financial assistance towards policies that address remaining market failures and infrastructure constraints.

However, the intermittency of solar energy remains a significant long-run challenge. Solar generation varies according to sunlight, while electricity demand must be met continuously. Greater reliance on solar therefore requires investment in energy storage, transmission networks and grid management. The IEA notes that inadequate transmission infrastructure has already constrained the integration of renewable capacity in India (IEA, 2025).

This means that India's long-term energy transition cannot depend on solar capacity alone. A sustainable strategy requires complementary investment in grid infrastructure, storage and other sources of electricity so that increasing renewable capacity can translate into reliable electricity generation.

Overall, the macroeconomic analysis demonstrates that government intervention in India's solar market produces both benefits and trade-offs. Solar expansion can improve energy security, reduce exposure to fossil-fuel prices and potentially reduce environmental costs, while domestic manufacturing can create industrial and trade benefits. However, subsidies impose fiscal costs, imported components can create supply-chain vulnerabilities, and large-scale renewable integration requires additional infrastructure.

Therefore, the long-term success of government intervention depends on whether policy support evolves alongside the market. Temporary and targeted intervention can help overcome market failures and establish renewable energy, but permanent or excessive subsidies may create government failure of their own. India's challenge is consequently not simply to increase solar capacity, but to achieve a transition that is economically efficient, fiscally sustainable and sufficiently reliable to meet growing electricity demand.

RESEARCH METHODOLOGY

This study uses a qualitative and analytical research approach based on secondary data and published literature. Government reports, institutional publications, peer-reviewed academic studies and energy-sector data are analysed using microeconomic concepts of externalities, allocative efficiency, welfare economics and government intervention. The study compares theoretical predictions with developments in India's solar and electricity markets to evaluate the extent to which government intervention has corrected the identified market failure.

CONCLUSION

This paper has examined whether government intervention in India's solar energy market has effectively corrected market failure and improved allocative efficiency. The analysis shows that the original market failure arises largely from the negative externalities associated with coal-based electricity generation. Because environmental and health costs are not fully reflected in the private costs faced by producers, coal-based electricity can be produced beyond the socially optimal level, resulting in allocative inefficiency and welfare loss.

Government intervention through solar subsidies, production-linked incentives, Renewable Purchase Obligations and other policy measures has helped alter these market incentives. The rapid expansion of India's solar sector and the significant decline in solar-generation costs indicate that these policies, alongside technological progress and economies of scale, have successfully encouraged greater investment in renewable energy. Solar energy also generates positive externalities through reduced pollution and greenhouse-gas emissions, providing an additional economic justification for intervention.

However, the analysis does not support the conclusion that market failure has been fully corrected. Although solar capacity and generation have increased substantially, coal remains a major component of India's electricity supply. Furthermore, increased solar capacity does not automatically imply that the socially optimal level of electricity generation has been achieved. The costs of grid integration, energy storage and intermittency must also be considered when determining the true social cost of renewable electricity.

The intervention also creates wider macroeconomic trade-offs. Government subsidies and incentives involve fiscal costs and opportunity costs, while India's dependence on imported solar equipment and critical minerals can create new external vulnerabilities. At the same time, greater domestic renewable generation can strengthen energy security, reduce exposure to fossil-fuel price fluctuations and potentially reduce dependence on imported fuels. The long-term success of the policies therefore depends on India's ability to develop domestic manufacturing, reliable infrastructure and a renewable-energy system that can operate with decreasing dependence on government support.

Overall, government intervention in India's solar energy market can be considered a partial but significant correction of market failure. In the short run, intervention has improved incentives for renewable-energy investment and helped shift resources towards a cleaner source of electricity. In the long run, however, continued policy effectiveness will depend on whether subsidies become increasingly targeted and whether solar energy can be integrated reliably and economically into India's electricity system. Therefore, rather than completely eliminating market failure, government intervention has moved India closer towards a more socially efficient allocation of energy resources, while leaving significant economic and structural challenges to be addressed.

Final judgement: India's solar policies have improved allocative efficiency and generated welfare gains, but have not yet achieved complete allocative efficiency. The strongest evidence of success is the rapid growth and declining cost of solar energy; the strongest limitation is the continued dominance of coal and the additional fiscal, infrastructural and supply-chain challenges associated with the transition.

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