LEDS GLOBAL PARTNERSHIP

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# Gujarat state:
## Pioneering and scaling up solar energy in India

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"I saw more than glittering panels—I saw the future of India and the future of our world. I saw India's bright creativity, ingenuity and cutting edge technology."

UN Secretary General Ban Ki-moon, at inauguration of canal-top solar energy plant in Vadodara, Gujarat[1]

## Key messages

- For nearly 40 years, Gujarat state has been an innovative leader in low emission development strategies. From small scale technologies such as solar cookers to larger projects including photovoltaic rooftops, solar parks, and canal-top solar power, the state has pioneered renewable energy projects and programs that have later been rolled out to other states and at national level. While remaining within the overall ambit of India's national policy, Gujarat state has led the nation and other states in solar power policies and initiatives.
- Gujarat's 2009 Solar Power policy, the first comprehensive solar policy in India, offered incentives to investors over a 25 year period. The robust policy framework, financing mechanism, and incentives contributed to creating an enabling green investment climate in the state and led to ambitious targets for grid connected solar power being achieved. By 2013, Gujarat had over 50% of the share of solar power capacity in the country.
- The Jawaharlal Nehru National Solar Mission, established in 2010, helped to align state and national initiatives and has led to major successes in solar power deployment at both state and national levels.
- The capacity of grid connected solar power in India has increased from 20 MW in 2010 to over 5,500 MW in 2016.
- The experience of Gujarat state shows how subnational governments can proactively lead and inform national policy and raise national government ambitions for more aggressive greenhouse gas mitigation commitments.
- Gujarat's success is due to several enabling factors: a very high solar power potential, availability of wasteland, good connectivity, transmission and distribution infrastructure, and efficient utilities—complemented by a strong political will and an investment friendly climate.

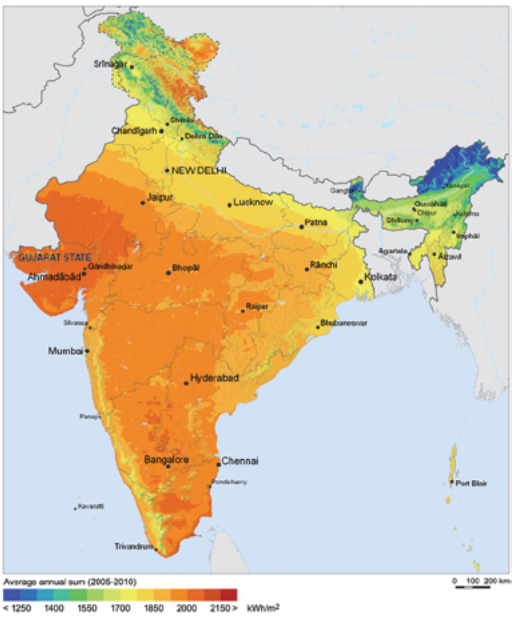
The **LEDS GP Subnational Integration Working Group** strives to accelerate climate resilient LEDS by supporting the coordination and vertical integration of climate action between national and subnational governments. Contact: sniwg@ledsgp.org

- With its successful track record, the state has the potential to go even further through continued efforts and stakeholder involvement, delivering inclusive green growth benefits.

## Renewable energy in Gujarat state

Located in western India, Gujarat is one of India's most industrialized states. With a share of 7.5%, the state is the fourth largest contributor to national GDP. It has a population of around 60 million and is among India's most prosperous states with a per capita GDP higher than the national average. Since the 1960s, the state has witnessed rapid industrial growth and has established leadership in several industrial sectors. Gujarat also has abundant solar resource potential, receiving 5.5–6 kW/m$^2$ per day with over 300 days of sunshine.

**Figure 1. Solar resource map of India[2]**




## Gujarat Energy Development Agency

As early as the 1970s, the state government of Gujarat initiated a program to promote renewable energy technologies and energy efficiency. At the time, the global oil crisis had affected several national economies. The uncertainty over global oil prices was an important driver for deployment of renewable energy and energy efficiency at the national level, which in turn reverberated down to subnational and local levels. One of the Gujarat government's first actions was to create the Gujarat Energy Development Agency (GEDA) in 1979, with the high level goal of achieving energy self-sufficiency.

> "An ambitious, proactive initiative by the state government, complemented by the national policy framework, has led to the remarkable success of solar power in the country"
>
> Mr S.B. Patil, Deputy Director, GEDA

GEDA later became the first state nodal agency for the MNRE—the first national–subnational institutional arrangement for implementation of energy programs in the country (see Box 1). The state nodal agencies coordinate with the MNRE to enhance renewable energy deployment. While the programs were announced at the center, they were implemented at subnational level through state agencies. This included decisions over targets and financial transfers. For instance, subsidies announced by MNRE would be transferred by GEDA to the developers. Similarly, within the national rules and guidelines, the state regulatory body determined tariffs and incentives to attract developers.

### 1980s—solar cooker program

GEDA's earliest initiative was the solar cooker, the first renewable energy based consumer product available in Gujarat state. GEDA marketed the solar cooker through advertising in local media and newspapers, promotional leaflets, and hoardings, complemented by market research studies and user feedback surveys. Following its launch in 1979, GEDA's solar cooker became a prototype for India's National Solar Cooker Promotion Program, which began in 1982. When the cooker was initially launched nationally, Gujarat was the only state in a position to manufacture and market it, and had already sold nearly 4,000 cookers within the state. By 1984–85 the cumulative national sales of solar cookers passed the 25,000 mark, with 8,000 of those sold by GEDA.[3] GEDA received a National Award in 2007 for its outstanding promotion of solar cookers. GEDA had also simultaneously

## Box 1 India's national renewable energy policy

The oil shocks of the 1970s were the impetus for India's introduction of national policies and programs with two objectives: improving national energy security; and providing clean energy options to rural populations faced with high energy prices and depleting local resources. Throughout the 1990s, India's economic growth was accompanied by a rapid increase in energy demand. Global attention to renewable energy and national programs shifted the focus to look at alternative, cleaner energy sources. Given India's development concerns, policymakers attempted to focus on the dual goals of energy access and sustainable development. In the 1980s and 1990s, national policies and programs were introduced to achieve these interrelated goals (detailed in Figure 2). The programs included both supply side and demand side policies, and created implementation architecture that targeted local resources by introducing improved cooking stoves, family and community level biogas plants, biomass gasifiers for local electricity generation, solar street lighting for villages, and more efficient irrigation pumps. In 1990, 32 MW of electricity was generated from renewable energy sources nationally. However, this was a very small proportion of the 62,000 MW total national power generation capacity.

The Indian government's resolve to promote renewable energy in India has been evident since the 2000s, most notably in the passing of the Electricity Act and the activities of the Ministry of New and Renewable Energy (MNRE; see Figure 2). The MNRE decides overall national targets, aggregate funding, and distribution of targets and finances at the national level. The MNRE is mainly responsible for the promotion of both grid connected and off grid renewable energy, and works closely with the 28 state nodal agencies, the first of which was the Gujarat Energy Development Agency (GEDA). State nodal agencies work with local administration and NGOs at district and village levels to implement programs and policies in urban areas and villages.

In addition, implementation of renewable energy programs also entails coordination among the national and state electricity regulatory authorities. The Central Electricity Regulatory Commission (CERC) at the national level lays down the norms for setting tariffs. The State Electricity Regulatory Commission (SERC) frames state level guidelines aligned with the directives issued by the CERC.

initiated other renewable energy programs including grid connected wind farms, solar water heating systems, bioenergy, and energy conservation programs.

### 1990s–2000s—renewable energy promotion policies

Recognizing the success of earlier decentralized renewable energy programs, Gujarat continued to make efforts towards promoting renewable energy. Given the increasing focus of national policies on energy security (Box 1), Gujarat aimed to move from energy deprivation and dependence to energy security. This was complemented by the fact that the state had very high potential for solar, biomass, and wind energies. In the years that followed, renewable energy was given a major thrust as the state enacted ambitious renewable energy promotion policies, including incentives for wind energy in 1993 and 2002, and subsequently the country's first wind power policy in 2007.[4] The success of these policies was also due to the fact that Gujarat had an investment friendly climate that attracted entrepreneurs and investors. Despite this, solar power generation did not achieve the desired penetration due to its low level of cost effectiveness relative to conventional energy. In 2009 the price of solar power was over five times that of conventional electricity.

### 2009—Gujarat Solar Power Policy

In 2009, Gujarat became the first state to announce its Solar Power Policy, with a view to generating new jobs and progress in the less developed areas. The policy specified a minimum capacity of 5 MW for solar photovoltaic (PV) and solar thermal. The major fiscal incentives provided were exemption from electricity duty, 80% accelerated depreciation in the first year, and a power purchase agreement at a fixed level tariff for 25 years under which the solar energy generated would be sold (Table 1).

**Figure 2. Timeline of national and Gujarat state renewable energy policies and programs**

| National policies and programs | Year | Initiatives in Gujarat |
|---|---|---|
| | 1979 | Solar Cooker Promotion Program |
| | | Formation of Gujarat Energy Development Agency (GEDA) |
| Commission for Additional Sources of Energy (CASE) formed | 1981 | Energy Conservation Program and awareness drives |
| Department of Non-Conventional Energy Sources (DNES) formed | 1982 | |
| DNES promotes solar cookers | | |
| | 1990 | Outstanding performance in Solar Thermal Program |
| Ministry of Non-Conventional Energy Sources (MNES) formed | 1992 | |
| Electricity Act | 2003 | Awards for overall best performance in Solar Cookers Program (2002–07) |
| Integrated Energy Policy | 2006 | |
| MNES renamed Ministry of New and Renewable Energy (MNRE) | | |
| National Action Plan on Climate Change (NAPCC) | 2008 | Discussions and feedback on draft State Solar Policy |
| National Solar Mission Approved | 2009 | Gujarat Solar Policy 2009 |
| Jawaharlal Nehru National Solar Mission announced | 2010 | Renewable purchase obligation for Gujarat |
| | | Renewable energy certificates |
| | 2012 | India's first Canal-top Solar Power Plant and largest Solar Park |
| | | Solar PV rooftop scheme launched |
| MNRE announces rooftop program | 2013 | State capacity is 57% of total national capacity |
| Target 1,000 MW; achievement exceeds target | | First prize awarded by MNRE as best nodal agency for achieving maximum solar water heating systems installation during 2012–13 |
| Solar Cities Program | 2014 | Solar Rooftop program in second city |
| Cumulative capacity crosses 5,000 MW | 2015 | Gujarat Solar Power Policy 2015 |
| Central financial assistance for grid-connected solar rooftop plants | | |

At the time, there was uncertainty regarding the technical and financial viability of solar power. State efforts towards raising awareness through training programs and stakeholder meetings helped overcome initial barriers and stimulate a green investment climate in the state.

**Table 1. Tariffs for solar power generation under Gujarat Solar Power Policy 2009 (US$/kWh at current prices)**

| Projects commissioned before: | Solar photovoltaic | | Solar thermal | |
|---|---|---|---|---|
| | 1–12 years | 13–25 years | 1–12 years | 13–25 years |
| December 1, 2010 | 0.28 | 0.07 | 0.22 | 0.07 |
| March 31, 2014 | 0.26 | 0.07 | 0.20 | 0.07 |

### 2010—Jawaharlal Nehru National Solar Mission

Recognizing the large potential for solar power in India, the National Solar Mission was announced as one of eight National Missions under the National Action Plan on Climate Change (NAPCC).

With a goal to achieve grid tariff parity by 2022, the National Solar Mission aims to accelerate investment and reduce the cost of solar power by establishing supportive long term policies and specific implementation targets, focusing on domestic manufacturing and solar research and development, to develop a comprehensive solar ecosystem in the country. The national target was to achieve a total of 20,000 MW of grid connected solar power capacity by 2022, with a vision to establish India as the global leader in solar energy. (This target was revised in 2015 to 100,000 MW.) The National Solar Mission document (2010)[7] also indicates that the Tariff Policy 2006 would be modified to mandate that state electricity regulators would fix a percentage for purchase of solar power. The Mission outlines that the solar Renewable Purchase Obligation (RPO) will be an important driver for promoting utility scale solar power generation. RPOs are the minimum amount of solar energy that distribution companies have to deliver or consume as share of the total electricity. The National Tariff Policy was amended in January 2011 to prescribe a solar specific RPO in line with the NAPCC. Subsequently, the State Electricity Regulatory Commissions (SERCs) defined their respective RPO regulations. However, given the mismatch of resources among states, the Renewable Energy Certificates (RECs) were introduced as a market based instrument to promote renewable energy and promote compliance with RPOs by the utilities. Each REC represents 1 MWh of power produced from a renewable energy source and is tradable at power exchanges. The initiative made it possible for solar deficient states to meet their RPO obligations by purchasing RECs from solar surplus states.[8] The RPO for states can be initiated at 0.25% in Phase I (by 2013) rising to 3% by 2022. In 2012, Gujarat set a solar RPO target (1%) which went beyond the Tariff Policy targets and was the highest among states. The REC market faces challenges of oversupply, and inconsistent demand and noncompliance by states. Despite this, the REC market has seen significant growth. From 10 solar RECs in 2012, over 90,000 RECs were redeemed In February 2016.[9] The new RPO targets in the amended National Tariff Policy in 2016 specify a target of 8% of electricity consumption (excluding solar power) to come from solar by March 2022.[10]

**The eight National Missions under the NAPCC are:**

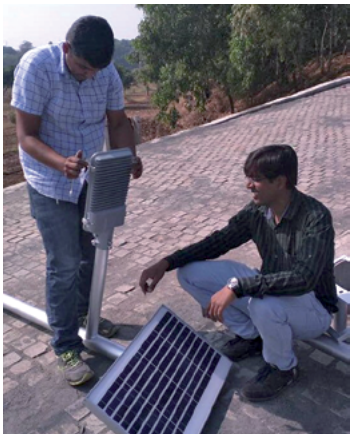
- Solar
- Enhanced Energy Efficiency
- Sustainable Habitat
- Water
- Sustaining the Himalayan Ecosystem
- 'Green' India
- Sustainable Agriculture
- Strategic Knowledge for Climate Change

The announcement of targets under the Jawaharlal Nehru National Urban Renewal Mission helped initiate solar power investments in several states. In Gujarat, this further propelled investments between 2010 and 2012. In 2012, power purchase agreements for 971.5 MW were signed by the Gujarat government. An assessment showed that grid connected solar power contributed to annual savings of 0.7 MT of coal and 1.1 MT of $CO_2$ emissions in Gujarat in 2012.[11]

## Innovative low emission developments in Gujarat

MNRE provides guidelines for grid connected rooftop solar PV power generation plants with a maximum capacity of 500 kilowatts peak (kWp) per project/system.[12] In order to achieve rapid diffusion, the national program is designed to be implemented through the state nodal agencies, the Solar Energy Corporation of India, and government organizations including public sector units and local government. Projects may be installed on net metering or feed-in tariff, to be decided by regulators, distribution companies, or distribution licensees in consultation with the implementation agencies. A 30% subsidy is provided for noncommercial and nonindustrial rooftop solar PV plants. For industrial and commercial installations, incentives include concessions on custom and excise duties, accelerated depreciation, and fiscal and other concessions from state governments.

**Kilowatts peak (kWp) is the power generated by a solar module at peak performance, for example at noon on a sunny day (under standard conditions).**



*Solar lighting for a farmhouse in Gujarat state*
*(Photo credit: Su-Kam Solar)*

## Solar Rooftop Program

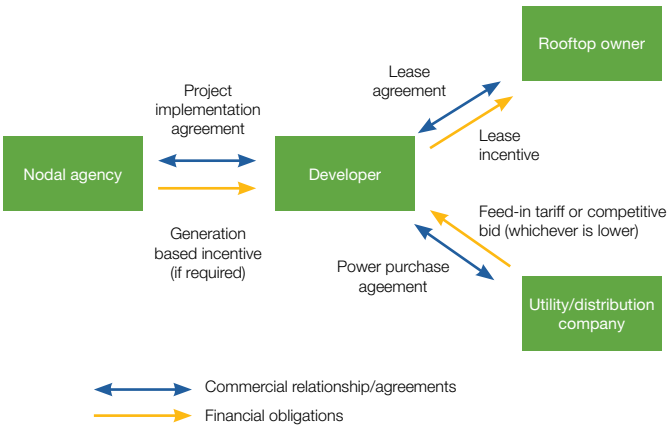
Aligned with the national agenda for promoting rooftop solar, a 5 MW solar PV Rooftop Program was initiated in the city of Gandhinagar in 2012. The International Finance Corporation (IFC) of the World Bank was appointed to provide advisory services including technical, legislative, analytical, and marketing support. The aim is to generate solar power by setting up grid interactive rooftop solar PV systems connected to the grid.[14] Known as the 'Rent a Roof' project, the program seeks to extend the installation of solar panels to people who own roof space.

The Gandhinagar Photovoltaic Rooftop Program is the first of its kind in India and brings together a partnership between the government, solar power generators, regulators, home owners, and utilities (Figure 3). The program works in collaboration with private solar companies selected through a competitive bidding process. These companies rent the roofs on public and private buildings, receiving $0.05 (Rs3) per unit produced. The program is now generating 5 MW of power and saving over 7 MT of greenhouse gas emissions annually. Its success has led to its replication in Vadodara city in Gujarat, and it has been scaled up to four further cities in the state—Bhavnagar, Mehsana, Rajkot, and Surat.[15]

GEDA has facilitated solar panel installation on hospitals and educational institutions, among others. For example, a solar panel installation that is a joint effort of GEDA, the National Solar Mission, the state government's Public Implementation Unit, and the Civil Hospital produces 1,200 kW an hour, resulting in significant energy savings for the hospital.[16] The solar panels on the rooftop of St Xavier's college in Ahmedabad city have resulted in over 90% reduction in the monthly electricity bill.

> "The rooftop solar panels have not only reduced our monthly electricity bills by a huge amount, they have brought in greater awareness and sustainability thinking within our institution and other similar educational institutions in the city. Encouraged by this, we plan to install additional solar systems at the university."
>
> Father Robert A., Principal, St Xavier's college, Ahmedabad

**Figure 3. Implementation structure for rooftop programs in Gujarat[13]**




Gujarat state leads the country in rooftop solar power generation capacity. In March 2015, Gujarat accounted for over 23% of the total rooftop solar power generated in India. In 2016, the national government announced a scale-up of the budget from US$90 million to over $750 million for implementation of grid connected rooftop systems over a period of 5 years up to 2019–20 under the National Solar Mission.[18] In order to reduce ambiguity and speed up implementation of solar rooftop projects, in 2016 the Gujarat government issued a notice indicating the key steps, authorities involved, and timelines.[19]

### Solar Park

Under its Solar Power Policy, the Gujarat Solar Park is an innovative concept of the state government to promote solar installations. The first solar park was commissioned at Charanka village in Gujarat for installation of solar PV and concentrated solar power plants. For developers wanting to set up solar plants in India, land acquisition posed a major hurdle. In the case of the solar park, the state government earmarked land in Charanka and acquired the land through a consultative process. The state allocated developed land for solar power generation to the project developers, with infrastructure, including power transmission, roads, and water for commissioning of the power project put on fast track. With land acquisition a potential problem for private investors, this was seen as a welcome move. The park received financial assistance of US$75 million from the Asian Development Bank (ADB) for laying down the transmission infrastructure.[20]

The state utility has signed a solar power purchase agreement with solar power developers for a 25 year period. This includes a tariff of Rs15 (about US$0.29) for the first 12 years and Rs5 (US$0.08) from the 13th year onwards. With a capacity of 590 MW and spread over 2,000 hectares, this was also Asia's largest solar park. The project is designed to allow multiple investors to set up solar power generating units at a single location, with state of the art infrastructure, to benefit from economies of scale and further reduce costs.

There was apprehension among locals about the impact of the project on their land and livelihoods. The state conducted an educational campaign to inform local residents about the benefits of solar power and the livelihood opportunities that the project will create. In addition, the ADB has funded vocational courses to train women on solar power under the Gujarat Solar Vocational Training and Livelihoods Project.[21]

### Canal Solar Power Project

In 2012, a 1 MW Canal Solar Power Project was installed on top of a 750 meter stretch of canal in Gujarat state—the first of its kind in India. The project was implemented by a private firm, SunEdison, with support from Gujarat State Electricity Corporation Ltd. The objective was to demonstrate an innovative solar power generation project using the canal top, thus avoiding any land requirement. This innovative project has generated clean energy and contributed to state renewable energy targets, providing two major environmental co-benefits—avoiding land acquisition, and potentially will save 90,000 liters annually by blocking the evaporation of water. Operating at cooler temperatures than conventional land based systems, the panels can generate more energy.


*The inauguration of Gujarat's Canal Solar Power Project (Photo credit: Hitesh vip)*

The successful installation and operation of this plant led to the commissioning of another 10 MW plant in 2014. The state government invested $18.3 million including 25 years' operation and maintenance. The plant has saved 16 hectares of land, and potentially will save 90 million liters of water annually. Following the successful implementation of the canal-top solar plants in Gujarat, the states of Haryana, Odisha, Maharashtra, and several others are planning similar projects.[22] In 2015, the national government sanctioned US$38 million to promote 50 MW canal-top and canal-bank projects in the country.[23]

## Gujarat Solar Power Policy 2015

Encouraged by the success of the 2009 Solar Power Policy, and in line with national targets, Gujarat's 2015 Solar Power Policy has revised the state ambition.[24] Before announcing the policy, the state invited various stakeholders, including government and industry, to brainstorm on aspects of the new policy that covered determination of tariffs, investment opportunities and challenges, technological aspects, commercial issues, land issues, and encouragement for manufacturing/assembling units.

The state policy, to 2020, encourages investments in both large megawatt-scale projects under solar PV and solar thermal technologies, and smaller kilowatt-scale solar projects including solar rooftop systems. Solar power generators installed and commissioned during the operative period would be eligible to receive incentives for a period of 25 years from the date of commissioning. The policy outlines provisions and incentives provided for rooftop solar PV systems with net metering for different categories, including government and residential, industrial and commercial consumers, and captive consumers.

Gujarat state is an integral part of the National Solar Mission and will be a major contributor to helping the Mission meet its goals. Recognizing that solar power is still expensive compared with conventional sources (US$0.07/KWh for solar compared with $0.03/kWh for conventional power generation), the 2015 policy maintains that increasing the share of renewable energy should be done in a manner that does not place an undue burden on consumers. The policy is expected to generate a new round of private investment in the state and to help meet the national target.

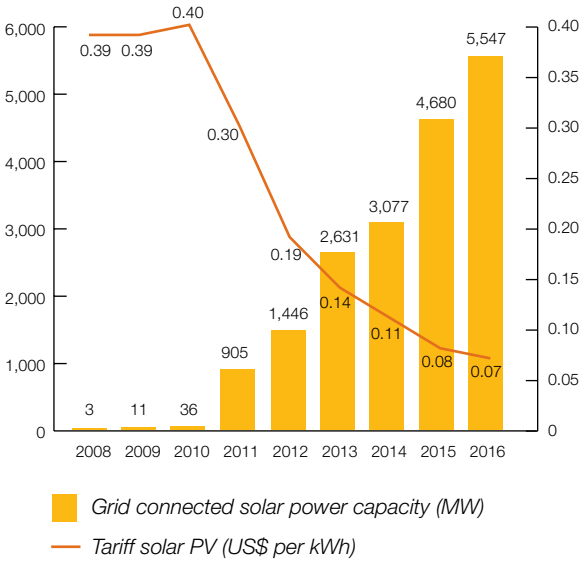
> Gujarat has demonstrated mother industry status for solar PV, unmatched by any other Indian state, for the benefit of the nation.
> Mr Bhargav Mehta, Consultant, SunEdison Energy India

## Impacts

### Major increase in solar capacity

What began with small, state level initiatives for clean energy has resulted in Gujarat state's becoming the driving champion of solar capacity at national level. The state's efforts for promotion of solar energy have now spanned three decades, including several firsts for India—the formation of GEDA, the state solar policy, and the canal-top power project, solar park, and solar rooftop programs. A clear policy framework has incentivized private investments, which further helped enhance solar capacity in the state. The Gujarat Policy in 2009 led to a capacity addition of over 1,000 MW. By March 2013, of the 1,440 MW of total installed capacity in the country, Gujarat had a share of 57%, making the state first in the country in installed solar capacity.

**Figure 4. Cumulative grid connected solar power in India and tariff per kWh[25]**




Post-2010, the incentives under the National Solar Mission, complemented by state level initiatives, resulted in rapid development with India's solar power capacity increasing from 20 MW in 2010 to over 5,500 MW in 2016. During this period, the price of solar power dropped from US$0.39/KWh to under $0.07/KWh.[26] In recent bidding for grid-connected solar PV power plants under the National Solar Mission, the lowest bid was $0.06.[27]

The installed capacity for the first phase of the National Solar Mission (1,684 MW) went well beyond the specified target of 1,100 MW. Efforts are now under way to meet the targets for the second phase (Table 2). Technological developments, and a drop in the price of solar cells and panels globally and nationally, are expected to bring solar power at grid parity in 2017, 5 years before the announced timeline of 2022.[28]

### Savings in $CO_2$ emissions

Solar power generation in Gujarat has resulted in significant savings in greenhouse gas emissions, in addition to co-benefits of reduced air pollution and health benefits from avoided fossil fuel consumption. The 590 MW Charanka solar park project alone has generated 342,400 tons of carbon emission reductions,[29] one of the highest contributions in the renewable energy sector. It has been recognized as the nation's most innovative and environment friendly project by the Confederation of Indian Industry.

**Table 2. Target and achievements for development of solar energy under the Jawaharlal Nehru National Solar Mission**

| Application | Target for Phase I 2010–13 | Achievement for Phase I | Cumulative target for Phase II 2013–17 | Cumulative target for Phase III 2017–22 |
|---|---|---|---|---|
| Grid solar power including rooftop and distributed small grid connected plants (MW) | 1,100 | 1,466[a] | 4,000<br>10,000[b] | 20,000 |
| Off grid solar applications (MW) | 200 | 223 | 1,000 | 2,000 |
| Solar thermal collectors (million $m^2$) | 7 | 6.92 | 15 | 20 |

a Including those under state initiative.

b With mandatory RPO obligations, international finance, and technology.

### Social and environmental benefits

Solar power projects in Gujarat have generated a number of green jobs in the state. The Charanka solar park has generated a number of local jobs for unskilled workers and led to local area development in the catchment region. Training programs were organized to build the capacity of local youths to encourage their employment in the solar park. This also led to productive use of wasteland in the state, with socioeconomic benefits.

The innovative installation of canal-top power plants in Gujarat and other states has reduced the requirement for land acquisition and generated co-benefits of water savings. Local area development due to additional infrastructure, including roads, has enhanced economic opportunities for locals.

The initiatives in Gujarat have led to replication in several states, generating green growth benefits at national level. A noteworthy benefit is the impact on national energy security through reduced fossil based generation and greenhouse gas mitigation.

## Lessons learned

### National–subnational integration

The establishment of India's National Solar Mission under the NAPCC was a significant event that marked the scale up of solar power in the country. The proactive lead taken by Gujarat state under the solar policy and initiatives created a positive investment climate for solar in the state as well as the nation.

The 2009 Gujarat Solar Policy was implemented to initiate the solar market in the state. While the state had already begun to implement solar power projects, the announcement of the National Solar Mission further helped align state and national ambitions, and the subsequent state initiatives supported meeting the Mission's goals. For instance, the MNRE subsidy for rooftop programs was complemented by a financial incentive from the state to attract investment in rooftop power projects.

The scale of solar power purchase agreements in Gujarat informed the establishment of the National Solar Mission; and the announcement of the Mission sent an encouraging signal to investors, further aiding investments in the state and leading to more ambitious, bolder state initiatives.

*Preparations for the opening of Gujarat Solar Park (Photo credit: DeshGujarat)*

Post-2010, policies and incentives originating at the national level aligned with state initiatives, further improving investor confidence and making a strong business case for solar in Gujarat. The national government was receptive to ideas and initiatives from Gujarat state informing national policy and targets, with the intention of contributing to global efforts for climate action. State representatives were invited to share their experience at national events discussing issues and challenges for large scale solar deployment in India.

After the successful implementation of the solar park at Gujarat, MNRE announced a scheme for development of solar parks and Ultra Mega Solar Power projects with a target to achieve 20,000 MW of installed capacity in 5 years, starting in 2014.[30] Under this scheme, states can designate an agency to develop a solar park which would be eligible for central financial assistance for project development and additional assistance after partial completion of the project. The implementing agency formulates a recovery model through sale/lease of land to developers, putting in some of its own equity and raising loans, and through registration fees.[31]

Between 2010 and 2015, a cumulative capacity of over 5,000 MW grid connected solar power was installed in the country. Following on from the success of solar initiatives in India, in 2015 the national solar target was raised from 20,000 MW to 100,000 MW by 2022. This will include 40,000 MW rooftop and 60,000 MW through large and medium scale grid connected solar power projects. Support for these projects from the national government includes fiscal incentives such as accelerated depreciation, concessional customs duty, excise duty exemptions, an income tax holiday for 10 years, loans, and subsidies.[32]

## Enabling factors in Gujarat

### Attractive financial incentives for private investors

Initially, as grid connected solar power was less competitive relative to coal, the Gujarat state solar policy was complemented by a range of attractive financial incentives. This included financial incentives such as subsidies and tax rebates. Feed-in tariffs and long term power purchase agreements helped build investor confidence.

Under the state power policy, the 25 year power purchase agreement offered a stable policy environment for investors. This included an initial feed-in tariff of US$0.22/kWh for the first 12 years, followed by US$0.07/kWh for the subsequent years. The announced fixed tariff turned out to be one of the most influential factors for developers' preference to invest in grid connected solar plants under the state policy (Figure 4).[33] The success of early initiatives and public–private partnerships established the attractiveness of Gujarat as an investment destination for solar power projects, and post-2010 a large number of companies began to show interest in setting up solar plants in the state.

Several other initiatives of the state government made projects attractive for investors. The offer of developed land and infrastructure support in the case of Charanka also contributed to the dramatic rise in grid connected installed capacity in the state. For projects outside the solar park, the state government assisted fast-track approvals and facilitated land acquisitions. Clear guidelines were issued to the collectors to expedite conversion so that investors would not suffer delays.

The solar rooftop project in Gandhinagar demonstrates that effective public–private partnerships for pilot projects can speed up implementation, creating a strong evidence base. This helps inform policies that can facilitate broader scale implementation.

### Coordination among state institutions

The success of solar power in Gujarat was facilitated by seamless coordination among state institutions. The state government identified three agencies to turn its solar vision into reality: GEDA, Gujarat Power Corporation Ltd, and the Gujarat Electricity Regulatory Commission. In addition, Gujarat Urja Vikas Nigam Ltd is an umbrella company with six subsidiary companies engaged in trading, generation, and distribution of power in the state. The solar policy laid down the overarching framework and direction under which these companies worked in coordination with the local planning authorities to expedite the process of clearances and implementation of solar power projects in the state. State projects were financed through subsidies from state budgets and national subsidies were channeled through state agencies or public–private partnerships.

### Effective communication with private investors

The state government also ensured effective and transparent communication with private investors. After power purchase agreements were signed for setting up solar projects, the state government held regular meetings with private investors to iron out implementation issues up to the completion of the projects. The financial incentives announced under the state solar policy, and the credibility of the state in implementing projects, made Gujarat an attractive destination for private investors.

In fewer than 5 years, solar projects in the country had moved from demonstration scale to mainstream power generation. After Gujarat, several states introduced policies, feed-in tariffs, and new business models. While this success was aided by the global developments in the solar industry, initiatives by the state government have definitely accelerated the developments beyond business as usual.

The second phase of the National Solar Mission, from 2013 to 2017, set the tariff at US$0.08 per unit, with some financial support from the government in the form of viability gap funding. Over time, new business models evolved and the competition further brought down prices, leading to increasing financial viability and reduced need for government support.

The Gujarat Solar Policy 2015[34] highlights the objective of enhancing solar capacity without adding undue financial burden, and made efforts to include the interests of all its stakeholders: investors, developers, technology providers, power utilities, grid operators, and consumers. Long before the revised state solar policy was announced in 2015, the state made efforts to engage stakeholders based on their past experience and suggestions as to what should be included. This helped achieve greater buy-in from investors and other departments and agencies of the state government. Recent projects, for instance the rooftop projects in Gandhinagar, have been initiated through attractive and effective business models that improve competition, bring down prices, and benefit consumers.

## Replicating Gujarat's success

Solar PV versus conventional power as a business model in Gujarat came to fruition following the state's 2009 solar policy. Since then, the state has provided some innovative ideas for solar projects in the country. The solar initiative of the Gujarat government has helped make a strong business case in both the state and the country.

Several initiatives of Gujarat state have been replicated in other states and fed into national programs and policies. The success of the public–private partnership model for the rooftop PV program in Gandhinagar city led to increased ambition, and the government of Gujarat decided to replicate and scale up the rooftop solar PV initiative across the state through the development of similar pilot projects in five large cities.[35] The generation

based incentives offered to rooftop owners were effective for replication. Similarly, the canal-top power project and solar park implementation in Gujarat led the way for similar projects in other states, also leading to national targets for canal-top and canal bank power projects. Initial success in Gujarat led to more ambitious targets announced by the state as well as national targets for solar power generation.

Gujarat's success is due to several enabling factors including a very high solar power potential, availability of wasteland, good connectivity, transmission and distribution infrastructure, and efficient utilities. Historically, growth in Gujarat has been driven by significant industrial investment and the state has developed an investment friendly reputation. The financial credibility of Gujarat Urja Vikas Nigam Ltd was an important factor for stimulating investment. For instance, bankability of power purchase agreements was demonstrated first in Gujarat. A strong political will to advance solar energy by incentivizing the private sector was also a key factor in advancing solar power capacity in Gujarat.

## The way forward

Gujarat's phenomenal success has helped replication and scale up of solar power generation in India. And the state has the potential to expand its solar power even further. The Gujarat Solar Policy 2015 lays down ambitious targets.[36] Further scaling up solar in Gujarat will require addressing technical challenges, financial barriers, and public acceptance. Technical challenges include dealing with the problems of grid integration that a large amount of intermittent solar energy would bring about. Early experience from the rooftop projects shows that project implementation is fraught with challenges.  This includes challenges of securing private rooftops through awareness programs as well as support to reduce investor risk.

Promoting a long term and sustainable future for solar energy in India will require a comprehensive renewable energy roadmap supported by technological advances in grid modernization. Given that each state has its own policy, national state coordination will be increasingly important in determining tariffs, financing mechanisms not only for solar but also for strengthening the overall electricity market. It is important to create domestic industry for low carbon technologies. A clearer focus on local research and development will reduce the reliance on imported technologies and solar panels.

Gujarat's solar success story in the next few years may not necessarily follow business as usual trends. The pace of replication is still highly dependent on reducing uncertainty through access to finance and innovative business models. Continued efforts will be needed to develop innovative projects and financing mechanisms, and to enhance awareness. Improved technical support to local entrepreneurs can help technology adaptation and better service support for users, as well as creating local job opportunities. Ensuring transparency and fairness in awarding contracts will maintain the credibility of state agencies, enhancing investor confidence.

Gujarat's success with solar power demonstrates that subnational governments can catalyze ambitious initiatives while remaining within the overall ambit of national governments. Sustainability initiatives are further advanced if there is a strong business case and this ensures that environmental objectives are met while the local economy also benefits through increased job opportunities.

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### LEDS GP

The Low Emission Development Strategies Global Partnership (LEDS GP) was founded in 2011 to enhance coordination, information exchange and cooperation among countries and international programmes working to advance low emission, climate resilient growth. LEDS GP currently brings together LEDS leaders and practitioners from more than 120 countries and international institutions through innovative peer-to-peer learning and collaboration via forums and networks. For the full list of participants and more information on partnership activities, see **www.ledsgp.org**

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