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# Gujarat's Electricity Sector

## *The Fairy Tale Revival*

*Debajit Palit*

## *Introduction*

Gujarat has long been considered a progressive province of the Indian union. Situated on the western coast of the Indian peninsula, Gujarat, with a geographical spread of 196,244 km, is the sixth-largest state in India in terms of area and ninth-largest by population.[1] The state's economy has been growing consistently during the last two decades, and the state has been a leading business-friendly environment. The state's gross domestic product (GDP) registered a compounded annual growth rate (CAGR) of 9.9 percent and contributed almost 8 percent to India's total GDP between 2010–2011 and 2018–2019.[2] The state's per capita gross state domestic product (GSDP) grew at a CAGR of 8.6 percent from, INR 87,481 to INR 131,583, during the same period. Over a period of time, the state has diversified its industrial base.[3] Being a leading industrial state in India, Gujarat's electricity demand has also grown at a CAGR of 6.1 percent annually between 2008–2009 and 2018–2019, and over the years, it has also undergone massive transformation. The transformative change introduced in the electricity sector was accompanied by a significant change in energy consumption and increased efficiency in the agricultural sector. Despite a considerable part of Gujarat falling under arid, semi-arid, and dry sub-humid climatic zones, the state had the highest decadal rate of growth in the agricultural sector from 2000–2001 to 2009–2010, reaching nearly 11 percent.[4] Table 1 gives a snapshot of Gujarat's demographics and economic profile.

1. Ministry of Power (MoP), *24x7 Power for All – A joint initiative of Government of India and Government of Gujarat,* (New Delhi: 2016), https://powermin.nic.in/sites/default/files/uploads/joint_initiative_of_govt_of_india_and_Gujarat.pdf.
2. Tim Buckley and Kashish Shah, *Gujarat's electricity sector transformation: A role model of India's electricity transition* (Lakewood, OH: Institute for Energy Economics and Financial Analysis, 2019), https://ieefa.org/wp-content/uploads/2019/08/Gujarat-Electricity-Sector-Transformation_Final_August-2019.pdf.
3. MoP, 24x7 Power for All.
4. ET Bureau, "Gujarat records highest decadal agricultural growth rate of 10.97%," *Economic Times*, July 16, 2011, https://economictimes.indiatimes.com/news/economy/agriculture/gujarat-records-highest-decadal-agricultural-growth-rate-of-10-97/articleshow/9243480.cms.

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**Table 1: Demographics and Economic Profile of Gujarat**

| | |
|---|---|
| **POPULATION AND DEMOGRAPHICS (CENSUS 2011)** | Total population: 60.44 million<br>▪ Rural: 57 percent; Urban: 43 percent<br>▪ Decadal growth in population: 19.3 percent<br>▪ Literacy - ~78 percent<br>Total households: 9,643,989 (61 percent rural; 39 percent urban) |
| **AREA** | 196,024 $km^2$ (6.19 percent of country) |
| **STATE GDP** | INR 10,335.73 billion at current prices in FY 2016–2017 |
| **PER CAPITA INCOME** | INR 156,526 at current prices in FY 2016–2017 |

Sources: Census 2011. Registrar General of India, Ministry of Home Affairs, Government of India; and Directorate of Economics and Statistics, Profile of Gujarat State, 2018–19 (Gandhinagar: Government of Gujarat, 2019).

In 2001, Gujarat's electricity sector was in dismal condition. The Gujarat Electricity Board (GEB) put a strain on the state's finances and development, and the organization was disliked by customers and farmers alike. However, the state gradually carried out sweeping reforms in the power sector, and the GEB transformed itself into a profitable and efficient public utility in less than a decade. Since then, it has won many awards for its innovation and customer services. The state reformed the entire sector—generation, transmission, and distribution—and achieved the status of power surplus in 2009 (Table 2).

**Table 2: Power Supply Scenario in Gujarat**

| PERIOD/ITEMS | 2008–2009 | 2009–2010 | 2010–2011 | 2011–2012 | 2012–2013 | 2013–2014 | 2014–2015 |
|---|---|---|---|---|---|---|---|
| PEAK DEMAND (MW) | 12,294 | 10,848 | 11,296 | 11,401 | 12,348 | 12,577 | 14,005 |
| PEAK MET (MW) | 9,437 | 9,883 | 10,461 | 11,209 | 12,348 | 12,577 | 14,005 |
| PEAK DEFICIT/SURPLUS (MW) | −2,857 | −965 | −835 | −192 | 0 | 0 | 0 |
| PEAK DEFICIT/SURPLUS (%) | −23 | −9 | −7 | −2 | 0 | 0 | 0 |
| ENERGY REQUIREMENT (MU) | 68,188 | 68,131 | 67,065 | 72,836 | 80,575 | 79,338 | 90,998 |
| ENERGY AVAILABILITY (MU) | 62,214 | 75,737 | 83,974 | 96,538 | 115,233 | 116,746 | 120,543 |
| ENERGY DEFICIT/SURPLUS (MU) | −5,974 | 7,606 | 16,909 | 23,702 | 34,658 | 37,408 | 29,545 |
| ENERGY DEFICIT/SURPLUS (%) | −10 | 10 | 20 | 25 | 30 | 32 | 25 |

Source: Gujarat State Power Utilities cited in Ministry of Power (MoP), 24x7 Power for All – A joint initiative of Government of India andGovernment of Gujarat, (New Delhi: 2016), https://powermin.nic.in/sites/default/files/uploads/joint_initiative_of_govt_of_india_and_Gujarat.pdf.

In addition to the surplus power scenario, all villages and households in rural areas of Gujarat are also provided with uninterrupted electricity services, with substantially higher per capita electricity consumption than the national average.[5] The aggregate technical and commercial (AT&C) loss stands at 8.86 percent and is substantially lower than the all-India average of 19.01 percent in 2019–2020.[6]

5. Ministry of Power, *Lok Sabha Unstarred Question No 4202 (Answered on 18.07.2009) – Electrification of Villages.* (New Delhi: 2019), https://powermin.nic.in/sites/default/files/uploads/LS18072019_Eng.pdf.
6. Ujwal DISCOM Assurance Yojana (UDAY), "AT&C Loss (Aggregate Technical and Commercial Loss)," Ministry of Power, 2020, https://www.

Collection efficiency of revenues, including in rural areas, is close to 100 percent, with the state electricity distribution companies (DISCOMs) ranking as the best for resolving customers' complaints in time. The AT&C loss is low both in the state's two private DISCOMs, largely serving urban areas, as well as in the four public DISCOMs that were set up as part of the restructuring of the electricity sector.

A few years ago, Sarangi et al. (2019) conducted an evaluation study to understand the sustainability of the electricity sector in India and observed that Gujarat (along with Punjab, Uttar Pradesh, and Rajasthan) showed a steady growth in sustainable outcomes across all three studied dimensions of sustainable development.[7] However, the analysis for Gujarat, as part of the same study, also showed existence of unevenness and dissimilar growth patterns for individual dimensions of different sustainable outcomes. Nevertheless, coupled with its achievement in managing the utility finances and in expanding rural electrification, the case of Gujarat might indeed be instructive of how factors constraining development of the electricity sector in other states could be overcome.

Yet, the institutional structure is no different in Gujarat than other states. This suggests that problems that have been chronic to the sector, such as an inability to overcome political interference, might simply have played out in a manner leading to more positive outcomes in Gujarat as compared to other states. . The state has been able to achieve the growth with a mix of steps that have both commercial and social overtones, with stress on credible implementation and realization of rational user charges. The political will along with the turnaround strategy have materialized into expected benefits.

This paper details the major steps taken by the Gujarat government to bring about the transformation in the rural electricity sector and provides a learning opportunity to other sector stakeholders from India and overseas. It is an exciting story of political will and the government's pledge to empower the voters. How did an inefficient state electric utility transform itself into one of India's most high-performing electricity distribution companies? What are the factors that worked and what were those conditions that enabled the government to succeed in Gujarat? Are the benefits uniformly distributed, or do urban customers reap more at the cost of rural customers, owing to the present configuration of incentives and institutional structure?

The aforementioned questions are answered in the following sections, with the remainder of Section 1 outlining the methodology followed. Section 2 discusses the structure of the Gujarat electricity sector and is followed by a discussion of the turnaround of the electricity sector in Section 3. Section 4 showcases two programs contributing to the turnaround: the Jyoti Gram Yojana, a scheme for continuous three-phase electricity provision for all villages, and Suryashakti Kishan Yojana, which is a solar-based irrigation scheme. Section 5 concludes the paper by discussing the lessons learned, present challenges, and the way forward.

## *Methodology*

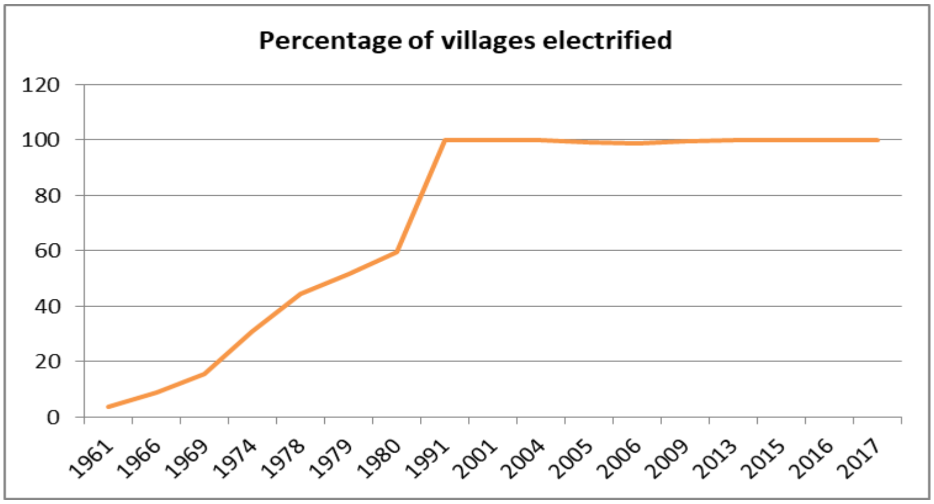
This paper is based on an extensive review of available literature (scholarly and gray) as well as a selection of background reading materials. The reading materials were gathered using keyword searches on the internet and a search of document records in various databases. Various journals' databases as well as professional and practice-based research materials were searched. Search queries included words and word combinations such as "Jyotigram," "Jyoti Gram Yojana," "Suryashakti Kishan Yojana," "electricity access in Gujarat," "turnaround of Gujarat electricity sector," "rural energy in Gujarat," "rural electrification in Gujarat," "solar PV in Gujarat," "decentralized solar in Gujarat," and "solar pump in Gujarat," among others. The literature gathered was reviewed to explore contextual information, best practices, challenges in financing, and the political economy. A synthesis of the reviewed documents forms the basis of information for the present study. Additionally, a few consultations were also undertaken via tele/

uday.gov.in/atc_india.php; and Ujwal DISCOM Assurance Yojana (UDAY), "Gujarat Dashboard," Ministry of Power, 2020, https://www.uday.gov.in/state.php?id=2&code=gujarat.

videoconferencing with some stakeholders.

## *The Structure of the Gujarat Electricity Sector*

The Gujarat Electricity Board (GEB) was set up along with the formation of the state of Gujarat in 1960. The GEB started functioning with a generation capacity of 315 MW and 1.40 million customers.[8] As in other Indian states, during the 1970s and 1980s, electricity supply to rural areas was a major thrust. Because of the GEB's steady focus on electrifying rural areas, Gujarat became the first Indian state to achieve almost 100 percent village electrification by 1991, extending the central grid to 17,940 of its 18,028 villages (Figure 1).




Source: Debajit Palit and Kaushik Ranjan Bandyopadhyay, "Rural electricity access in India in retrospect: A critical rumination," Energy Policy 109 (October 2017), doi:10.1016/j.enpol.2017.06.025.

In line with the country's broad economic agenda of liberalization in the early-1990s, the electricity-sectorreforms were started across different states.[9] Though the corporatization of Gujarat's electricity sector was initiated in 1993 with the setting up of the Gujarat State Electricity Corporation Limited (GSECL) and Gujarat Energy Transmission Corporation Limited (GETCO) a year later, the financial position of the sector was not improving, and the GEB reported a loss of INR 22.46 billion in 2000–2001 on revenues of INR 62.80 billion.[10] Power theft (between 20 percent in urban areas to 70 percent in rural areas) coupled with unmetered electricity supply due to high AT&C losses (to the tune of 35.27 percent) and frequent brownouts and blackouts. The utility had neither the funds to install new generation plants, nor was it able to attract private investments for power generation in Gujarat.

The GEB's poor financial position prompted the enactment of the Gujarat Electricity Industry (Reorganization and Regulation) Act in 2003 to reorganize the electricity sector in Gujarat and establish a State Electricity Regulatory Commission. At the time of enactment, the electricity and energy portfolio was held by the chief minister, indicating the political commitment to turnaround the sector. As per

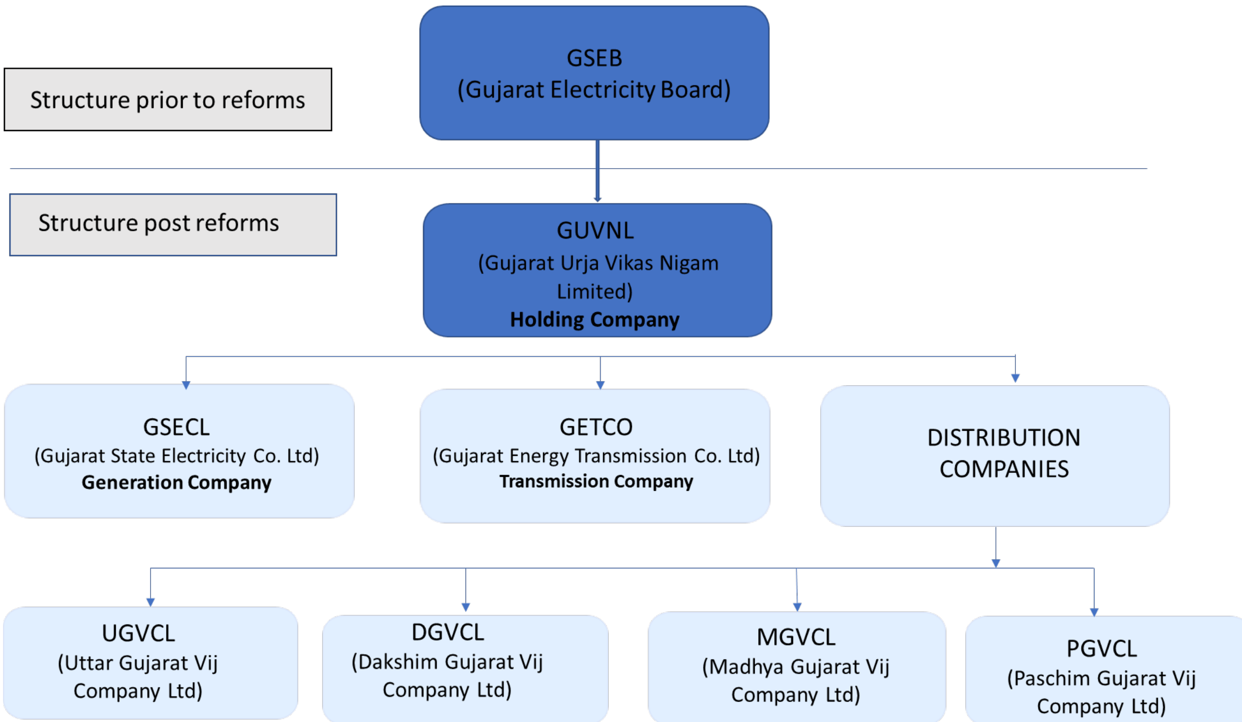
8 Vaibhav Vish, *Power distribution reforms in Gujarat* (2009), https://www.academia.edu/15595989/Power_distribution_reforms_in_Gujarat_Power_distribution_reforms_in_Gujarat.

9 Debajit Palit and Kaushik Ranjan Bandyopadhyay, "Rural electricity access in India in retrospect: A critical rumination," *Energy Policy* 109 (October 2017), doi:10.1016/j.enpol.2017.06.025.

10 PricewaterhouseCoopers (PwC), *Best practices and strategies for distribution loss reduction–Final Report* (London: 2016), http://www.forumofregulators.gov.in/Data/study/11.pdf.

the restructuring exercise, the vertically integrated GEB was restructured with effect from April 1, 2005, into seven companies—one for generation, one for transmission, four companies for the distribution of electricity to the entire state, and a holding company called Gujarat Urja Vikas Nigam Limited (GUVNL) (Figure 2). GUVNL acted as the planning and coordinating agency at the time of sector reformation. Distribution in the cities of Ahmedabad and Surat has historically been the responsibility of a private-sector entity, Torrent Power, through its fully-owned subsidiaries—Ahmedabad Electricity Company and Surat Electricity Company—and they continue to operate in their respective areas.

**Figure 2: Restructuring of the Gujarat Electricity Board**




Source: Author's compilation/creation.

**<u>Power Sector Organizations in Gujarat</u>**

**Gujarat Electricity Regulatory Commission (GERC)**

*The GERC, constituted in November 1998, is responsible for regulating and determining tariffs; issuing licenses; specifying the grid code; specifying and enforcing standards for quality and reliability, among other areas, at the intra-state level; promoting cogeneration and generation of electricity from renewable sources of energy; and adjudicating on the disputes between the licensees and generating companies, and refer to any dispute for arbitration.*

**Gujarat Urja Vikas Nigam Limited (GUVNL)**

*The GUVNL is engaged in the business of bulk purchase and sale of electricity as well as the supervision, coordination, and facilitation of the activities of its six subsidiary companies. It is the single bulk buyer of power in the state as well as the bulk supplier to distribution companies.*

**Gujarat State Electricity Corporation Limited (GSECL)**

*After the Electricity Act of 2003, the GEB was unbundled in 2005, and the GSECL was given the responsibility of electricity generation and undertaking new power projects in the state. It currently accounts for 31 percent (6,132 MW) of the total installed conventional capacity of the state.*

**Gujarat Energy Transmission Corporation Limited (GETCO)**

*Started in 1999, GETCO builds, operates, and maintains state transmission networks in the state. The company has made significant progress in network capacity addition, transmission asset management, state grid operation, smart grid solutions, and human resource development.*

**Distribution Licensees in Gujarat**

*Licensees undertake the electricity distribution and retail supply in Gujarat. The state is served by six distribution licensees—two privately owned (Ahmedabad Electricity Co. and Surat Electricity Co.) and four state-owned companies (Uttar Gujarat Vij Company Ltd., Dakshim Gujarat Vij Company Ltd., Madhya Gujarat Vij Company Ltd., and Paschim Gujarat Vij Company Ltd.). These companies were serving about 15.5 million electricity consumers, including 1.185 million consumers under the agriculture category, during 2014–2015.*

## Gujarat Electricity Sector: The Turnaround Story

The technical loss of GEB in 1992–1993 and in 1996–1997 was low at 21.1 percent and 18.2 percent respectively. At the same time, the employee productivity was reasonably good at 2.5 and 1.9 employees per million kWh of energy sold during these years,, Considering these parameters, the GEB appeared to be functioning very well in the 1990s.[11] However, the utility reported huge financial losses despite the rosy story of its overall performance. The sector regulator, the GERC, which was newly formed at that time, critically examined the books of the GEB in 2000, before its unbundling, and discovered a huge inconsistency between the utility's claimed technical losses (~20 percent) and the value determined by the regulatory authority, which was around 34 percent. The difference, as pointed out by the GERC, was due to a large quantity of energy consumption for agricultural purposes. Since it was difficult to estimate the illegal use of electricity resulting from theft and hooking, this illegal consumption was simply added into the agricultural category.

Thus, to lessen the utility's liability on the state's finances, Gujarat's government went ahead with major reforms in the electricity sector. The Gujarat Electricity Act was passed during the same year to reorganize

11. Siddharth Sareen, "What Powers Success on the Ground? The Gradual Reform of Electricity Distribution in Gujarat," Mapping Power Project, Centre for Policy Research and the Regulatory Assistance Project, 2017, https://www.raponline.org/wp-content/uploads/2017/04/rap-india-mappingpower-gujarat-2017-april2.pdf.

the sector, as mentioned in Section 2. The focused reform included steps such as process strengthening, administrative initiatives, network strengthening, and redesign. The reform, however, did not immediately reduce the prevailing subsidy on electricity for agricultural use. Instead, various steps were implemented to address the theft and pilferage of electricity, which also included segregation of feeders for agricultural use (see Section 3.1).

To secure buy-in from the staff associations that mostly opposed the restructuring of the organization, a "change management program" was implemented from the very beginning. This ensured full cooperation from the staff and convinced them that the government and the GEB did not have any covert agenda behind the restructuring exercise. The Gujarat government, GEB, and all the staff associations signed a tripartite agreement, and a "Reform Progress Management Group" (RPMG) was set up. The group was constituted with officials from different departments of the GEB, including Finance, Engineering, Transmission and Distribution (T&D), and Human Resources (HR), and was tasked with the responsibility of coordinating and maintaining cordial relations between the different companies that were set up as part of the restructuring exercise as well as the resolution of HR-related concerns. The group was also responsible for devising financial improvement plans.

Effective and continued communication between different stakeholders also helped the GEB handle the transformation process more effectively. Strong internal communication was established to inspire the employees toward reform, which led to the success of the restructuring exercise and helped avoid any commotion. The diligently planned communication strategy included meetings with senior management every week, identification and implementation of key performance indicators, and monitoring of revenue collection, among other goals. "Reform Champions" from within the organizations were appointed to create a sense of ownership for the reformation and to have better clarity behind the change. Their sensitization to the reform and capacity building created a healthy competition between different divisions and brought out a positive attitudinal change in the workforce.[12]

A Financial Restructuring Plan (FRP) was worked out by the state government, and consequently, the GEB's losses were inherited by GUVNL so that the newly formed electric utility could start its operation with a clean balance sheet.[13] The government assumed responsibility of the debt payment liability of the GEB and settled the unpaid dues of INR 162.77 billion payable to Central Public Sector Units (CPSUs). Further, the Gujarat government converted its loan to the GEB, aggregating to INR 62.3 billion, into equity in the GUVNL. A moratorium period of six years for payment of interest on the remaining outstanding loan of INR 84.2 billion was also allowed.

## *Impact of Distribution Reforms in Gujarat*

The wide-ranging steps undertaken to unbundle the GEB into multiple agencies, focusing on generation, transmission, and distribution, led to significant lowering of T&D losses, lowered the cost of supply, and ensured technical improvements. Such steps resulted in noteworthy growth in revenues and, eventually, cash flows. These efforts finally bore fruit in 2005–2006 when the combined utilities recorded their first profit of INR 20.3 billion, after tax.[14] In 2010–2011, the GEB's net profit had risen to INR 53.3 billion, while its distribution line losses had come down to 20.13 percent. The distribution reforms focused on reducing the technical and commercial losses while improving the consumer services. The details are discussed in

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12. Rakesh Mohan Joshi, "Gujarat Electricity Board's turnaround: Complete Rural Electrification in Gujarat," London Business School, 2008, https://www.academia.edu/819255/Gujarat_Electricity_Board_s_Turnaround.
13. MoP, *24x7 Power for All*.
14. Anamika Gupta, "Price of Development in Gujarat under Narendra Modi," European Peace University, 2013, https://www.academia.edu/4917530/Price_of_Development_in_Gujarat_under_Narendra_Modi.

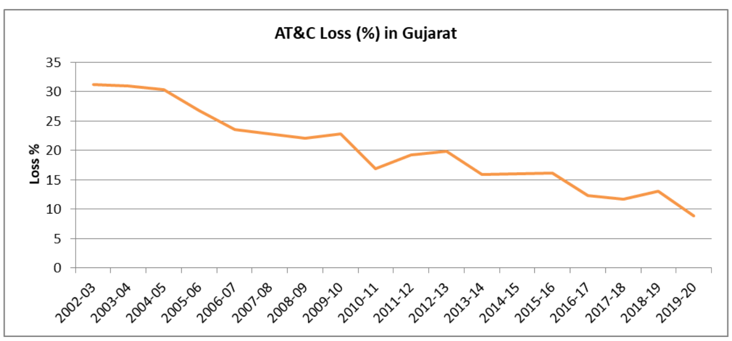
the subsequent segments of this study.

## *Reduction in T&D losses*

The state first concentrated on reducing line losses through a combination of measures such as implementation of technology, strict measures to check theft and pilferage, strengthening of the distribution grid network, and the changing of operational processes and procedures. The measures taken to tackle the T&D losses included a stringent anti-theft policy. As part of the policy, a senior police officer was placed in each of the DISCOMs and made responsible to stop thefts with the help of installation-checking squads. Theft-prone areas were identified, and massive anti-theft drives were organized with the assistance of police teams. The theft cases dropped by almost 29 percent from 107,985 registered in 2003–2004 to roughly 77,000 four years later. Additionally, 8.3 million electricity connections were checked over the period.

As part of the governance framework, audit committees/cells were set up and feeder managers were appointed to monitor the losses and take appropriate action. Aerial bunched cables began being employed to reduce the instances of power theft by unauthorized connections. These comprehensive measures led to a huge reduction of around 25 percent in T&D losses in a span of five years, from 31.24 percent in 2002–2003 to 22.81 percent in 2007–2008.[15] The losses have further reduced since, and currently the average for the four state-owned distribution companies stands at 8.86 percent (Figure 3). Further, the state also upgraded the sub-transmission and distribution systems, including improving the high-tension (HT) and low-tension (LT) ratio under the federal government's Accelerated Power Development and Reforms Programme (APDRP). As a result, reliability of power in most areas Gujarat has improved to 99 percent, with less than 5 percent transformer burn rate. As of December 31, 2019, the state had achieved 100 percent metering at the feeder and distribution transformer levels, in both urban and rural areas, and energy accounting at all rural feeders is being done as per provisions under Ujwal DISCOM Assurance Yojana (UDAY).[16]

**Figure 3: Gradual Reduction of AT&C Loss in Gujarat Electricity Distribution Companies**




Source: PFC, Performance Report of State Power Utilities, (New Delhi: Power Finance Corporation Limited, nd.). https://www.pfcindia.com/Home/VS/29.

## *Cost Reduction and Improvement in Revenues*

15. PFC, *Performance Report of State Power Utilities* (New Delhi: Power Finance Corporation Limited, nd.), https://www.pfcindia.com/Home/VS/29.
16. Ministry of Power, *Lok Sabha Unstarred Question No 4202*; and UDAY, "AT&C Loss (Aggregate Technical and Commercial Loss)."

On the one hand, the average cost for supplying electricity to customers declined from INR 4.15 per kWh in 2003–2004 to INR 3.63 per kWh in 2006–007. On the other hand, the average revenue realization went up from INR 3.49 to INR 3.70 per kWh during the same time. Thus, the shortfall of INR 0.66 per kWh in 2003–2004 was turned around to a surplus of INR 0.06 per kWh in 2006–2007. In 2019–2020, the difference of average revenue requirement (ARR) and average cost of supply (ACS) was INR 0.03 per KWh. Some of the actions implemented to increase the revenue include 100 percent consumer metering, automated meter reading, handheld devices for energy billing, replacement of all the non-functional meters, and Management Information System (MIS)-based regular reporting for all feeders. Additionally, tie-ups with post offices and banks were made, mobile collection vans were mobilized, operation hours for cash collection counters were increased, and customer-friendly measures with internal targets were ensured to increase revenue. It is worthwhile to mention here that the financial turnaround was achieved without any large increase in electricity charges during the initial years of reformation.

## *Improvement in Consumer Services*

The premise of Gujarat's efforts in reforming the electricity sector and improving consumer services lies in the state's all-inclusive measures, going beyond electricity distribution related challenges to understand and address the main reasons for the GEB's poor performance. The state followed a detailed strategy, including focusing on the energy-water-food nexus, addressing the challenges of complete electrification of rural areas, and improving the service delivery systems for customers so as to turn the sector around within a given time period. Some of these strategies and schemes are described below.

**Jyoti Gram Yojana (Rural Lighting Scheme):** An ambitious program, Jyoti Gram Yojana(JGY), was initiated immediately after the reforms began in the state, with the aim of segregating rural feeders by putting in place parallel distribution lines for uninterrupted, three-phase electricity supply to domestic users and ensuring rationed power supply to agricultural users to operate water pumps. The JGY assured a 24-hour, quality power supply to all villages in the state. The JGY was implemented with the objective of reducing losses from theft, increasing social inclusion in terms of providing quality electricity, and enhancing revenue generation from rural areas. The scheme worked very well, yielding efficiency gains and becoming a model that was eventually adopted by the federal government for nationwide replication in 2014. A decade after the start of the JGY, Gujarat's electricity sector transformation was praised as an excellent example that exemplified political will, an all-inclusive agenda, decisive leadership, and a strategy that drove changes as a socio-technical process through the contextualized execution of feeder reforms. Under the JGY, 18,065 villages received 24-hour power supply. The villages which could not be covered under the JGY were provided with solar energy-based electrification. The execution of the program was completed within a short period of 2.5 years, with an expenditure of around INR 11.70 billion. Impact studies on the JGY indicate that the scheme has resulted in a significant improvement of power supply in villages in Gujarat resulting in improved prosperity and an improvement in the quality of life.[17] However, the state continued with the recurring power subsidies for agricultural sector, which is now being addressed through implementation of grid connected solar pump program. The JGY is discussed in more detail in Section 3.1.

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17. Tushaar Shah and Shilp Verma, "Co-management of electricity and groundwater: an assessment of Gujarat's Jyotigram Scheme," *Indian Economic & Political Weekly* 43, no. 7 (2008): 59–66, https://www.jstor.org/stable/40277613?seq=1; and Tushaar Shah et al., "Groundwater governance through electricity supply management: Assessing an innovative intervention in Gujarat, western India," *Agricultural Water Management* 95, no. 11 (2008): 1233–1242, doi:10.1016/j.agwat.2008.04.006.

**Micro-irrigation Scheme:** While the JGY was focused on improving electricity distribution, the reforms also targeted the water use in the agricultural sector so as to reduce the reliance on groundwater for irrigation. The agricultural sector has been a major energy-consuming sector, using almost 45 percent of the total share of electricity consumption in Gujarat in 2000–2001.[18] An analysis of the electricity consumption data for two decades starting from 1980 indicated increasing agricultural use and shrinking industrial consumption until 2002–2003.[19] Additionally, over 95 percent of the electricity sales to the agricultural sector were unmetered during this period. The areas of north Gujarat, Kutch, and Saurashtra, which were predominantly agriculture-based during that time, are also the most rain deficient, and thus groundwater extraction to support farming practices was done with unrestrained electricity use. All these factors contributed to an increased dependency on groundwater-based irrigation, thus increasing the GEB's burden to provide subsidized electricity. This put an immense strain on the state's finances and siphoned off electricity supply from other economic sectors. This led to more pressure on industrial tariffs, which usually cross-subsidize other sectors, and simultaneously made the quality and reliability of electricity supply unsatisfactory for all customer categories.

Thus, in order to moderate the electricity use for agriculture and reduce farmers' dependence while increasing agricultural production through the adoption of scientific water management techniques, an ambitious drip irrigation scheme was started in the state in the mid-2000s. To speed up the scheme, the Gujarat government in 2005 also allowed the farmers to opt for any area, any crop, and any micro-irrigation system. Though the micro-irrigation policy has been in the state since the 1980s, it was not properly implemented until the mid-2000s. However, it was not an easy task for the state government to persuade the farmers to participate in the micro-irrigation scheme, as they were demanding more electricity supply for their irrigation needs. The farming community was thus asked to adopt farming techniques that helped to conserve water and to tap surface water to reduce their dependence on electricity. To make the scheme more popular, electricity connections began to be prioritized for those farmers who adopted micro-irrigation systems for their agricultural lands. Further, to promote the adoption of micro-irrigation in dark-zone blocks (i.e., areas with severe water shortage), the government withdrew the restriction on electricity connections for agricultural purposes, and from 2012, it was mandatory for farmers to adopt micro-irrigation systems in order to get new electricity connections. In addition to grid electricity, solar pumps were also promoted in those areas where the electricity grid was unavailable.

In May 2005, the Gujarat Green Revolution Company (GGRC) was established to act as the nodal agency for promotion of micro-irrigation systems. The company started implementing the micro-irrigation scheme through reputed firms that would supply and install the irrigation systems and provide necessary agricultural services. Soon, favorable results began to show, and from its inception until 2018–2019, the scheme benefitted 1,100,556 farmers with coverage of 1,781,279 hectares of land. The scheme benefitted small and marginal famers considerably, who constitute roughly 63 percent of total farm holdings in Gujarat. Of the different capacities of pumps that were implemented, a majority were 5–10 HP (37.15 percent) and 10–15 HP (59.38 percent) in capacity.

An impact analysis carried out for the micro-irrigation scheme by researchers indicated that the rate of adoption of micro-irrigation had been quite significant across farm-size classes, agro-climatic regions, and water-stressed regions in the state, including with tribal farmers.[20] Along with a reduction of water

18. Directorate of Economics and Statistics, *Social Economic Review – Gujarat State 2007–08* (Gandhinagar: Government of Gujarat, 2008), http://14.139.60.153/bitstream/123456789/10528/1/Socio-Economic%20Review.%20Gujarat%20State%202007-2008.pdf.
19. Guruprasad Mohapatra, "Management of change A critical evaluation of power sector reforms and restructuring of Gujarat electricity board GEB" (Ph D thesis submitted to Maharaja Sayajirao University of Baroda, 2010), http://hdl.handle.net/10603/58099.
20. Chandra Sekhar Bahinipati and P.K. Viswanathan, "Adoption and Diffusion of Micro irrigation Technologies in Gujarat, Western India: Do Institutions

consumption, the impact analysis also reported that savings of electricity across the sampled zones varied, with average savings of 39.92 percent. While electricity was used for around 6.78 hours before the implementation of micro-irrigation systems, that value has reduced to 4.07 hours per day by adopting micro-irrigation techniques.21 Some researchers observed that metered connections along with the adoption of micro-irrigation contributed to a significant reduction in groundwater use.22 A study by the Associated Chambers of Commerce of India (ASSOCHAM) indicates that, in Gujarat, around 1.5 million hectares of arid and semi-arid lands could be converted for farming practices because of innovative water-use methods such as the focus on small, minor irrigation projects, which lead to higher crop output.23 Despite the adoption of micro-irrigation, some researchers also observed that between 2005 and 2015, the aggregate level of adoption was still low in terms of total farmers and coverage area, with only around 14 percent of total farmers having adopted micro-irrigation systems for 11 percent of the total potential area. Thus, there is a remarkable potential for adopting micro-irrigation techniques and reducing electrical energy consumption in the state.

The scheme was subsumed into and made one of the key components of the Pradhan Mantri Krishi Sinchayee Yojana in 2015–2016. In line with the requirement of the new national-level scheme, in 2017, the GGRC developed the Agro Smart Digital Technology Platform for effective monitoring and evaluation of work and management of the transfer of assets to the right beneficiary.24  A notable feature of the Agro Smart Digital Technology Platform is the registration of beneficiary application on the farm site itself. Further, geofencing has been implemented with the use of GPS-based perimeter waypoint-fetching devices. The cost evaluation and design preparation are done on computer-aided design software using the waypoints and populating the area in which micro-irrigation systems are to be installed on farmers' fields. A geofencing map is then linked to a Google/Bhuvan Map to get the exact field periphery as well as elevation to synchronize with the actual field geography.

The Agro Smart Digital Technology Platform has helped the GGRC in identifying the right beneficiary with pace and precision. It has also assisted in authenticating the identity of the farmer by taking biometric parameters, thus ensuring the authenticity of the applicant. This platform also provides for quick processing of the application form from field-level registration and design preparation to disbursement of the subsidy. This technology platform has enabled the GGRC to cross-verify the pre-geotagged locations with post-installed geotagged photographs so as to ensure the right location for transferring the asset to the genuine beneficiary. The Agro Smart Digital Technology Platform has helped cover 202,222 hectares, benefitting 125,000 farmers during 2015–2016 alone.

Sujalam Sufalam (Water Harvesting) Scheme: Around the same time, another scheme, called the Sujalam Sufalam scheme, was also launched to increase the surface and shallow water availability for irrigation by building small dams and excavating water bodies to reduce famers' dependency on electricity to draw water, increasing reliance on surface water instead. This scheme was started with two objectives: (1) the provision of a sustainable solution to the recurring water problem in drought-prone areas and (2) the

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and Policies Matter?," in *Global Change, Ecosystems, Sustainability: Theory, Methods, Practice*, P. Mukhopadhyay, N. Nawn, and K. Das (New York: SAGE Publications, 2017).

21. Global Agri System, *National Mission on Micro Irrigation – Impact Evaluation Study* (New Delhi: Government of India: Ministry of Agriculture, Department of Agriculture & Cooperation, 2014), https://pmksy.gov.in/microirrigation/Archive/IES-June2014.pdf.

22. Chandra Sekhar Bahinipati and P.K. Viswanathan, "Can micro-irrigation technologies resolve India's groundwater crisis? Reflections from dark-regions in Gujarat," *International Journal of the Commons* 13, no. 2 (2019): 848–858, https://www.thecommonsjournal.org/articles/10.5334/ijc.888/.

23. MoP, *24x7 Power for All*.

24. Government of India, *Digital Irrigation in Gujarat, New Beginning – Book-on-Innovations* (New Delhi: Department of Administrative Reforms & Public Grievances, Ministry of Personnel, Public Grievances and Pensions, 2017), https://darpg.gov.in/sites/default/files/Book-on-Innovations-released-by-Hon'ble-PM-on-CSD,2017.pdf.

conservation of electricity by reducing the peak load. During the 2000s, around 105,000 check dams were built by the government in a participatory manner, with farmers contributing between 10 and 15 percent of the cost by way of labor. In the districts of north and central Gujarat, where constructing check dams was difficult, 18,100,000 farm ponds were built in 10 years. These farm ponds were located in parts of farms where rainwater collection happens naturally. This could be considered a paradigm shift from the national strategy which began in the mid-1960s that focused mainly on groundwater-based irrigation.[25] The scheme not only helped in reducing the electricity demand for agriculture but also improved the groundwater table in the state. A 2009 study found that the water table in more than half of the 112 blocks which were considered semi-critical to overexploited had regained their normal state.[26]

Apart from the previously mentioned ways, other measures were also taken to achieve universal rural electrification. For instance, to bridge the gap in terms of electricity access between rich and poor households, the state government rolled out a series of schemes targeting slums and rural households, including hutments. Thus, the Kutir Jyoti Yojana (Hutment Electrification Scheme), electrification of scheduled caste habitations, and the Tribal Sub-Plan (TSP) focused on specific segments and geographies where the poor resided. To encourage these poor households to shift from traditional kerosene lamps to electric lighting, the power tariff was appropriately customized as well.[27]

## *Case Studies*

This section discusses the two most prominent electricity schemes in the state of Gujarat and the lessons learned from them: Jyoti Gram Yojana and Suryashakti Kishan Yojana.

## *Jyoti Gram Yojana (JGY)*

Jyoti Gram means "village of lights." Though almost all villages in the state have been equipped with electricity connection since the 1990s, the quality of power being supplied was poor. This was attributed to the large-scale illegal use of power, resulting in frequent transformer failures, poor voltage stability, and blackouts and brownouts. Concurrently, there was a large increase in electricity demand in rural Gujarat, especially for agricultural use. In this backdrop, in September 2003, the government of Gujarat started the JGY as a demonstration program in eight districts, aiming to supply uninterrupted, quality power to villages that had poor electricity services. This scheme was part of the larger goal of facilitating rural economic prosperity in the state. In view of the success of the demonstration program, by November 2004, the JGY was expanded to cover all other villages in the state.

Before the JGY, 11 kV feeders were used to serve clusters of two to five villages with all types of connection (domestic, agricultural, and commercial). However, with the implementation of the JGY, these 11 kV feeders were segregated into agricultural and non-agricultural feeders.[28] Thus, certain feeders started to serve only farm customers, and the rest catered to the needs of domestic and commercial customers. Meters on agricultural feeders were installed to identify the source of any greater-than-expected demand. This rewiring of rural Gujarat resulted in two main outcomes: (1) villages started to get daily-uninterrupted

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25. Palit and Bandyopadhyay, "Rural electricity access in India in retrospect."

26. Uday Mahurkar, "A green rising," *India Today*, April 16, 2020, https://www.indiatoday.in/magazine/states/story/20100614-a-green-rising-743111-2010-06-04.

27. Planning Commission, *Evaluation Report on Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) [PEO Report No. 224]* (New Delhi: Programme Evaluation Organisation, Planning Commission, Government of India, 2014), https://niti.gov.in/planningcommission.gov.in/docs/reports/peoreport/peo/peo_rggvy3107.pdf.

28 Shilpi Verma and Tushaar Shah, "Co-management of electricity and groundwater: an assessment of Gujarat's Jyotirgram Scheme," *Economic & Political Weekly* 43, no. 7 (2008): 59-66, https://www.epw.in/journal/2008/07/special-articles/co-management-electricity-and-groundwater-assessment-gujarats.

electricity supply for domestic and industrial, including schools, hospitals, and other public institutions, and (2) farmers began to be provided with eight hours of quality power supply every day based on a pre-announced schedule.

Within a short span of just 3.5 years, the JGY covered 17,839 villages by laying a parallel rural electric network comprised of 78,454 km of electric lines, 2,257 JGY feeders, 18,724 additional transformer centers, and 4,530 special designed transformers at an investment of around INR 12 billion.[29]

The JGY turned out to be a win-win solution for all stakeholders in the electricity sector. Pre-JGY, the state's village industries were made to pay for the faults of those who were inefficiently using groundwater for irrigation, even though they were paying the commercial electricity tariff based on consumption recorded in the meters. All customers requiring three-phase supply were connected to the same feeders, and it was not possible for the electric utility to regulate power for tube wells by not doing the same for non-farm commercial users in such villages. The JGY addressed this issue and provided a strong impetus to all non-farm productive units for creating new livelihoods and jobs. The cost for non-farm enterprises such as flour and rice mills were reduced as they started producing the same output but consumed less power due to proper voltage and an uninterrupted three-phase power supply. The provision of quality electricity supply in rural areas has fostered the uptake of mechanization in rural livelihoods clusters. For example, in the pottery clusters of Gujarat, the state government has distributed pottery wheels and pug mills that are operated using electricity.[30]

An Asian Development Bank study reported that the JGY is gender-neutral, with all categories of customers—domestic, agricultural, industrial, and commercial—deriving benefits.[31] The study reported an increase in availability and reliability of power supply, namely an increase in per capita consumption from 817 kWh in 2002 to 1,313 kWh in 2006. Other benefits reported include: (1) an increase in industrial productivity, (2) new employment opportunities due to additional power supply, (3) a reduction in the failure of farmers' motor sets due to improvement in power quality leading to savings on recurring maintenance costs, (4) an enhanced exposure of the rural population through electronic media, and (5) an improvement in the standard of living in rural areas on account of more access to a wide variety of goods and appliances. Yet in another study conducted in early 2007, the International Water Management Institute (IWMI) undertook a quick assessment of the implications of the JGY in 55 villages spread over 10 districts, with particular emphasis on its impact on Gujarat's groundwater situation. The study noted that by far the most significant impact of the JGY has been in the area of improving the quality of life of rural people, who had never experienced uninterrupted 24-hour, three-phase power supply, in all of the 55 villages. Below are some of the prominent effects seen as a result of the implementation of this scheme.

**Improved Standard of Living:** The freedom from pre-announced power outages, voltage fluctuations, and frequent tripping was found to improve the well-being of rural people everywhere in the state. The study further noted that the JGY had led to a substantial improvement in the standard of living of the people in rural areas, as they were able to access and use a wider variety of goods and appliances. Rural women were finding it easier to organize their daily lives. Before the JGY, livestock keepers were obliged to complete the milking and feeding of cattle very early in the morning before the power supply was withdrawn.

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29. Rutam Vora, "How Gujarat became a power surplus State," *Hindu Business Line*, November 27, 2014, https://www.thehindubusinessline.com/news/national/How-Gujarat-became-a-power-surplus-state/article20796535.ece; and PwC, *Best practices and strategies for distribution loss reduction*.
30. "Electric Potter Wheel and Pug Mill Scheme," Gujarat Matikam Kalakari & Rural Technology, 2020, http://www.rtigujarat.org/electric-potter-wheel-pug-mill.html.
31. Asian Development Bank, *Gujarat Power Sector Development Program* (Manila: 2008), https://www.adb.org/sites/default/files/project-document/67829/29694-ind-pcr.pdf.

After the JGY, they enjoyed greater convenience and flexibility in performing these tasks. Schoolteachers and students could use laboratory equipment, computers, and television sets more frequently than they could before due to long and frequent interruptions in rural power supply. Especially during Gujarat's hot summer, the inability to operate ceiling fans made the afternoon heat insufferable in schools, shops, workshops, homes, and rural hospitals. The JGY improved this situation drastically.

**Development of Small-scale Industries:** The JGY was also instrumental to the growth of rural industries because of the improved availability and quality of power supply. Many of the diamond-polishing units relocated to villages so as to reduce their expenditure on renting spaces, which resulted in an increase in labor demand. Flourmills that were running on expensive diesel started using electric engines. The businesses (especially the ones dealing in perishable food products), public telephone booths, and computer-training centers, all of which had previously needed to invest in invertors or diesel generators, stopped doing so because of the new availability on uninterrupted power supply. The study observed that the JGY stimulated growth in jobs and wages in different trades such as diamond polishing, tailoring, knitting, vending, welding, and small oil mills. Women, who had typically been unable to travel to towns and cities for diamond-polishing work, started joining the newly opened diamond-cutting/polishing units near their homes. Electronic and electrical repair shops in most districts also started to work with more efficiency because of improvements in power supply.

**Reduced Migration from Rural Areas:** The improvement in village economies helped in creating more job opportunities, thereby reducing migration from villages. Better and uninterrupted power supply enabled improvements in public facilities such as hospital services, drinking water and sanitation, street lighting, and telecommunication. The temptation to migrate to urban areas, especially among the young, started to decline with more comfort being guaranteed in villages after the implementation of the JGY. Reduced migration to urban areas also helped the cities and towns by considerably reducing the load on their electricity infrastructure.

## *Suryashakti Kishan Yojana (SKY)*

The Gujarat government launched the pilot project of a scheme called Suryashakti Kishan Yojana (SKY) in July 2018. The scheme could be called an ultra-mega solar initiative but at a distributed scale. SKY aimed for farmers to generate electricity from solar energy for self-use in farms and irrigation purposes and sell the surplus power to state-owned electric utilities. The lower prices of solar panels, coupled with Gujarat having more than 300 sunny days and high insolation, offered a viable clean energy solution for irrigation pumping while generating clean electricity for utilities.

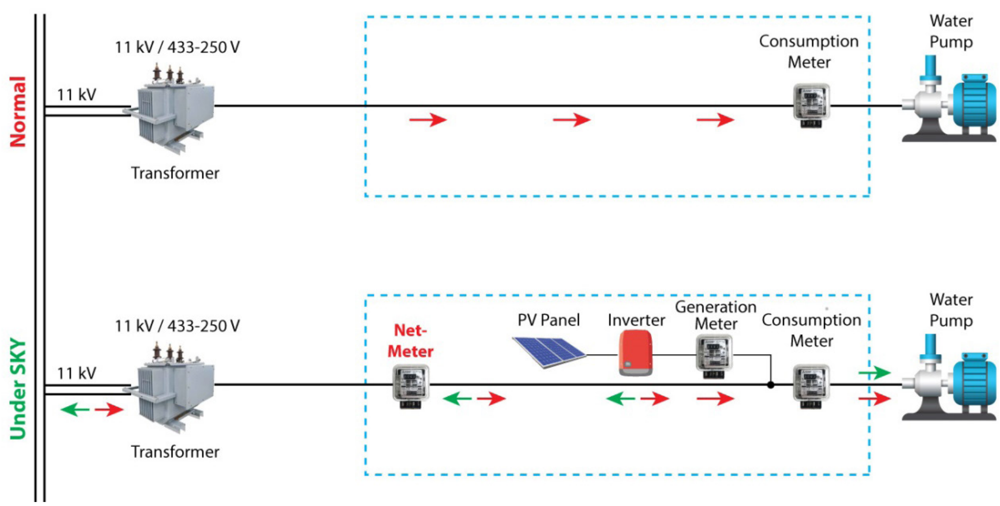
The consumption of electricity for agricultural use in Gujarat constituted around 21.46 percent in 2017–2018.[32] Though the share has substantially reduced from around 45 percent, recorded at the start of electricity reforms in the state, the revenue from the sector was less than 5 percent during the year, with the difference paid for through government direct subsidy and cross-subsidy from the industrial sector. Thus, the scheme aimed to provide a cleaner source of generation to farmers in their own fields to reduce their dependence on electricity from the grid while earning additional revenue. Further, it was also envisaged that if farmers started generating their own power, the DISCOMs would not have to look for other costly sources to meet the shortfall in energy supply that had started to

32. Government of Gujarat. *Profile of Gujarat State, 2018–19*.

happen due to the inability of some private generating units to keep their commitment to supply power. At the same time, with power consumption for agricultural use from the state electricity grid expected to come down, it could also save the government subsidy. The scheme thus targeted only the farmers who already had grid connections for agricultural use, and it aimed to include the maximum number of farmers on a given agricultural feeder. Farmers covered under the scheme were provided with a grid-tied photovoltaic (PV) system (1.25 kW per HP for each pump connected), and the installation was carried out through empaneled installers at competitive rates (Figure 5). The initial plan was to solarize 137 feeders covering 12,400 farmers from 33 districts, and the cost was pegged at INR 8.70 billion, with a targeted installation capacity of 175 MW.[33]

With respect to funding, a farmer joining SKY is required to contribute only 5 percent of the cost for implementing the PV plant, which also includes the inverters. The federal and state government will contribute 30 percent each as a subsidy. The farmer can take a loan for the remaining 35 percent with the duration for repayment fixed at seven years. Farmers can utilize solar electricity and feed any surplus generated into the grid. The revenue to the farmer is decided on the net energy fed and used at the end of each billing period. The surplus electricity fed to the electric grid is purchased at a rate of INR 7 per kWh. Of this, INR 3.50 is the feed-in-tariff (FiT) from electric utilities, and INR 3.50 per kWh is provided by the Gujarat government as an evacuation-based incentive (EBI) (Table 3). This amount, however, is paid after deducting the loan installment and is remitted directly into the farmer's bank account.

**Figure 5: SKY Schematic**




*Source: The graphic is based on the scope of the scheme. Author's own compilation/creation.*

The direct benefit for farmers is daytime grid-quality power for almost eight hours and relief from monthly electricity bills. Further, the sale of surplus electricity provides additional income. This way farmers become capable of owning the PV system after loan repayment. With a seven-year performance guarantee and insurance on the PV system, the risk of non-performance has also been taken care of and factored in. The land under solar panels can also be used to grow crops, with the

33. Maulik Pathak, "Gujarat farmers can now produce, sell solar power under Suryashakti Kishan Yojana," Live Mint, June 23, 2018, https://www.livemint.com/Industry/Yo4kUy3NeBkdU293IJ3rMO/Gujarat-farmers-can-now-produce-sell-solar-power-under-Sury.html.

option to increase the height of the panels. While the effective period of SKY is seven years, after which the government will withdraw its support and farmers will be paid INR 3.5 per kWh, as per the 25-year power purchase agreement signed with electric utilities, it might still be considered beneficial. The debt component will be over in seven years, after which no amount would get deducted from the farmer's earnings, thereby offsetting the loss of the tariff. While large-scale empirical studies have not yet been done on the project, selected anecdotal cases report that, as producers, farmers are earning double what they previously earned from their produce before the implementation of the scheme.[34]

| FINANCIAL INSTRUMENT | DETAILS | BENEFITS TO FARMERS |
|---|---|---|
| **CAPITAL COST SUBSIDY** | ▪ Government provides a 60 percent subsidy on solar pumps.<br>▪ Farmers pay 5 percent of capital cost and 35 percent is repaid as debt (within seven years). | ▪ Provision of the subsidy covers the high price of PV pumps and makes them financially affordable. |
| **FEED-IN-TARIFF (FIT)** | ▪ Farmers receive INR 3.5 per kWh as an FiT for electricity fed back into the grid.<br>▪ Evacuation-based incentive (EBI) received for initial seven years. | ▪ Provision of an FiT and EBI serves as an additional income source for farmers to repay their debt. |
| **PERFORMANCE GUARANTEE AND INSURANCE** | ▪ Performance guarantee offered as applicable on the solar PV provid-ed.<br>▪ Government provides insurance on solar PV panels for the initial seven years | ▪ Performance guarantee and insurance ensure free and responsive maintenance of PV panels for the first seven years. |

Source: A. Pruthi and T. Singh, "Learning from practice: Deploying innovative financial interventions at scale," Energy and Resources Institute, Mitigation Talks 2, no. 2–3, 2019, https://www.teriin.org/projects/nfa/files/mitigation-talk2019-vol2-issue2-3.pdf.

For the state government, some of the benefits expected from the scheme, going beyond low-carbon electricity development, include not needing large plots of land to set up utility-scale solar power plants, improvements in water utilization efficiency, lower T&D losses, and optimal use of the electricity grid network. With more and more farmers signing up for SKY, cross-subsidization is expected to fall, including subsidy expenditure for the state government.

Notably, about three years before the launch of SKY, a solar cooperative named the Dhundi Solar Pump Irrigators' Cooperative Enterprise (SPICE) was started in the Anand District as a pilot with nine farmers to explore the viability of solar pumps. The model sought to make solar pumps affordable for farmers by providing a 90 percent capital cost subsidy. To enhance framers' income streams, the project helped farmers form cooperatives and sell surplus electricity back to the grid at a fixed FiT to the Madhya Gujarat Vij Company under a 25-year power purchase agreement. To encourage efficient utilization of resources, SPICE also included a provision for bonuses for producing green energy and conserving water.

The pilot was successful and led to a decline in energy consumption and an increase in farmers' income. Thus, the Dhundi pilot helped in understanding the market growth potential of solar pumps in the state, as well as their possible advantages for the agricultural, energy, and water sectors, and subsequently led

34. Rutam Vora, "In Gujarat, solar energy is helping farmers double their income," *Hindu Business Line*, December 17, 2019, https://www.thehindubusinessline.com/economy/agri-business/in-gujarat-solar-energy-is-helping-farmers-double-their-income/article30322713.ece.

to the launch of SKY. The SPICE pilot also indicated the opportunity for lenders to incentivize farmers to efficiently manage resources through provision of resource conservation incentives, replicated in the form of EBI and FiT in the case of SKY. The success of SPICE and SKY also led to the replication of the concept with some local adaptation in the states of Maharashtra and Andhra Pradesh as well as at the national level KUSUM Yojana in 2019.

Notwithstanding the benefits under SKY, there are also challenges, and it may not be that easy to implement the scheme on a larger scale, as observed by some reports.[35] Considering the challenges, the scheme was scaled down by the Gujarat government to set up 50 feeders covering around 2,000 farmers.[36] The biggest obstacle is the farmers' refusal to change to a situation where the tariff for agricultural power is INR 0.5 per kWh. It may therefore not be easy to persuade the farmers to give up the subsidized power that they are getting currently and invest in a separate solar project. Additionally, average feeder losses have been assumed at 5 percent when real agricultural feeder losses are more than 15 percent, thereby impacting the net earnings of the farmer. Further, farmers signing up for SKY are required to form a group for each feeder, which might need social mobilization efforts by DISCOMs, which again is not their forte. There could be challenges to making farmers in a particular area agree to set up PV plants in their land.

Although the scheme targets have been scaled down, there are some lessons that are worth highlighting for replication. A proper design of sustainable finance models is paramount to addressing specific financial barriers. The SKY financial model is designed in such a way that makes it viable and sustainable for all stakeholders involved. The provision of government subsidies makes adoption of solar PV pumps more acceptable to the farming community while giving them a climate-friendly reliable source of irrigation in their own fields. The provision of FiTs and EBIs further provides incentives to farmers to effectively utilize resources. Therefore, the model offers a tangible solution to restrict possible groundwater exploitation as it motivates the farmer to use, sell, and save, thus ensuring profitability and sustainability through the system. It also opens up an avenue for farmers to supplement their income by pooling surplus solar power, making it a profitable option. The farmer cooperatives, as seen in SPICE, can enable demand aggregation and pooling of resources to collectively access and manage finances at better terms. This is expected to ensure improvement in the ability of vulnerable groups such as small and marginal farmers to further invest in climate-friendly farm equipment and technologies and help prepare to collectively manage the impact of extreme climatic events.

## *Conclusion and the Way Forward*

Reformation in the Gujarat electricity sector is a case where reforms were undertaken in a politically sensitive sector in a way that turned out to be a win-win case for all key stakeholders. It was a political determination, coupled with people's participation, which steered the reforms and made "development" a major election issue, helping the political party, which initiated the power sector reforms in the state, to win the state elections again and again. Due to the well-timed and appropriately planned reforms and holistic measures, including feeder segregation as well as focus on water-use efficiency, the rural electricity distribution sector in Gujarat underwent a complete overhaul.

Specifically, the Jyoti Gram Yojana (JGY) helped in the simultaneous management of electricity use and groundwater irrigation in the state to extricate the electricity supply to residential and commercial customers from a perverse political economy of power subsidies to the agriculture sector. The stimulus

35. Saur Energy International, *Gujarat's Troubles with SKY Scheme a Lesson For all State Governments* (New Delhi: Saur Energy International, March 2019), https://www.saurenergy.com/solar-energy-news/gujarats-troubles-with-sky-scheme-a-lesson-for-all-state-governments.
36. Maulik Pathak, "Cloud over SKY: Gujarat scales down pilot solar project," *Times of India*, March 15, 2019, https://timesofindia.indiatimes.com/city/ahmedabad/cloud-over-sky-state-scales-down-pilot-solar-project/articleshow/68416667.cms.

that the JGY gave to the rural industries is also clear, and this is expected to become stronger over time. A stable political environment and emphasis on good governance also helped the electric utilities capitalize and perform steadily post-reforms. The peak power deficit in the state, which had reached a worrisome 25 percent in 2004, completely changed, with zero deficits during the last few years. The surplus power scenario also became the pump-primer of Gujarat's economic success. There is probably no other Indian state that can boast such a healthy financial situation for its electricity distribution sector.[37]

Notwithstanding the positives of the rural electricity sector in the state, there are a few areas where the government should focus to further strengthen the sector.

First, with infrastructure delivery moving toward universal electricity access and the uninterrupted "power for all" goal already achieved, the monitoring matrix should graduate to electricity use, reliability, and quality, amongst other issues. In addition to the feeder meters and household-level smart meters that have been installed or are being installed for energy accounting, the electricity distribution companies may also consider putting up electrical network health monitoring systems and equipment to measure electricity supply interruptions, voltage drops, and power factors at the 11 kV rural feeders and low-tension distribution network. This would ensure real-time data recording and feeding to a central station to strengthen the outage management system and feed-forward mechanism. This will lead to further improvement in network system efficiency and help lower energy consumption, thereby contributing to low-carbon development pathways. Moreover, as India is planning for increasing use of artificial intelligence (AI) systems across all sectors, data robustness will be critical to their success as AI depends on past data to design future systems. Gujarat can take a lead in this sector in India.

Second, it would also be prudent for state utilities to explore low-carbon power generation opportunities at the substation level, going beyond the solarization of agricultural feeders. For example, by solarizing rural domestic feeders, DISCOMs can provide daytime supply to households and enhance the reliability and quality of the electricity supply. DISCOMs can install sub-MW or MW-scale solar plants to solarize domestic feeders, preferably along with a battery energy storage system (BESS). This would ensure reliability of energy supply as well as the improvement of power quality in terms of voltage and frequency at the last mile during the daytime and reduce pressure during peak hours. During nighttime, when rural industrial feeders take up significantly lower levels of energy, the same could be supplied to domestic customers. A pilot study could be conducted to establish the viability of this model, which will allow for private entrepreneurs and electricity distribution franchisees to take up ownership and handle network operations and maintenance of solarized rural feeders and the LT infrastructure.

Third, each of the LT feeders may be considered a distributed microgrid platform that can transform the grid by utilizing the existing infrastructure as well as complementing it with climate-smart technologies such as solar. The installation of smart devices with digital connection, which allows the microgrid operators to understand and control supply and demand, further making it possible for customers to control their energy use and spend over a smart device, and peer-to-peer trading by those who can install rooftop solar systems would take the electricity distribution companies to the next level of service delivery. Smart contracts could be developed to manage the commercial exchange between utility, prosumers, and customers.

Fourth, small and marginal farmers can be supported by maximizing the power supply when demand for irrigation reaches the peak and reducing the supply during off-peak periods. Farmers require electricity for

37. SSEF and MP Ensystems Advisory Private Limited, *Analysis of Financial Health of DISCOMs and its Link with End-use Efficiency Implementation* (New Delhi: Shakti Sustainable Energy Foundation (SSEF), 2018), https://shaktifoundation.in/wp-content/uploads/2018/10/Analysis-of-Financial-Health-of-DISCOMs-16Oct18.pdf.

irrigation for a maximum of 30 to 40 days a year, especially during the dry season. A farm power schedule that can provide electricity for agriculture on those strategically selected days and ration the power supply during remainder of the year to around four to five hours is likely to benefit the farmers considerably more than the current practice of providing eight hours of daily supply in all seasons.[38] Additionally, the tube well owners who spend in recharging groundwater could be rewarded, and those who excessively extract groundwater could be penalized. Further, the efficiency of those water pumps that have already been installed must be improved to lower consumption and encourage greater sales or self-consumption for uses other than the agricultural load.

And finally, the state should roll out a "solar for public services" program by using grid-compatible PVs plus storage for powering the schools and health clinics in the state. This would not only help in increasing the energy resilience of these public institutions but also augment the use of renewable energy in the state. The government of Gujarat can offer support toward the capital cost, and with minimal maintenance requirements and no fuel cost, the departments overseeing the schools and health clinics could save money toward recurring electricity charges and divert these to other pressing needs the public institutions.

***Debajit Palit*** *is a senior fellow with the Energy and Resources Institute in New Delhi. He holds a PhD in energy policy. He can be reached at debajitp@teri.res.in.*

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38. Shah et al., "Groundwater governance through electricity supply management."