

Evaluating the impact of BII's investment in C&I power in India Insights from FPEL

Report

Authors: Edward Hedley and Rene Kim

Date: November 2025

Acknowledgements

Itad and Steward Redqueen would like to extend our sincere gratitude to the staff of British International Investment (BII) for generously providing their time and information in support of this research. We would also like to thank Fourth Partner Energy for their participation in the research process and for supplying the data that underpins this report. Their cooperation and openness have been greatly appreciated.

Disclaimer

The views expressed in this report are those of the evaluators. They do not necessarily represent those of British International Investment or any individuals and organisations referred to in the report.

Suggested citation

Itad (2025) 'Evaluating the impact of BII's investment in C&I power in India Insights from FPEL'. Brighton: Itad.

Copyright

© Itad 2025



This is an Open Access paper distributed under the terms of the Creative Commons Attribution 4.0 International licence (CC BY), which permits unrestricted use, distribution and reproduction in any medium, provided the original authors and source are credited and any modifications or adaptations are indicated.

Contents

1	Introduction.....	10
2	Sector impact framework.....	13
3	Methodology	14
4	Market and regulatory context for C&I in India	18
5	FPEL's client base and product offering	22
6	Reasons why FPEL clients adopt renewable C&I power	26
7	Climate and economic impact.....	31
8	Broader strategic lessons	33
9	Conclusions and recommendations	35
	Annex I World Bank Enterprise Survey analysis results	37
	Annex II Model used to estimate value addition from increased electricity usage and data.....	39
	Annex III Summary of datasets and sources used in modelling	46

List of figures

Figure 1 Timeline of investments in FPEL	12
Figure 2 Impact framework for power	13
Figure 3 Reasons for adopting renewable C&I power	27
Figure 4 Electricity imports, exports and surplus	28
Figure 5 Transmission and distribution losses	29
Figure 6 Companies self-reporting outage.....	29

List of tables

Table 1 Research questions and data sources/approach	14
Table 2 FPEL-installed open access capacity	23
Table 3 FPEL-installed capacity, estimated power production and CO ₂ avoidance	31
Table 4 Lost time and lost sales as a result of outages by sector (WB Enterprise Survey)	37
Table 5 Lost time and sales due to outages by state (WB Enterprise Survey)	38
Table 6 Regression results and value added per kWh (by sector)	44
Table 7 Regression results and value added per kWh (by state)	45

Acronyms and abbreviations

ADB	Asian Development Bank
BESS	battery energy storage systems
BII	British International Investment
C&I	commercial and industrial
CERC	Central Electricity Regulatory Commission
CES	constant elasticity of substitution
DEG	German Development Finance Institution
DFI	development finance institution
DISCOM	state-owned distribution company
ESG	environmental, social and governance
EV	electric vehicle
FPEL	Fourth Partner Energy
GE0A	Green Energy Open Access
GHG	greenhouse gas
GNA	General Network Access
GW	gigawatt
IFC	International Finance Corporation
IFI	international finance institutions
IPP	independent power producers
kWh	kilowatt hour
MW	megawatt
MWh	megawatt hour
PPA	Power Purchase Agreement
PV	photovoltaic
WBES	World Bank Enterprise Survey

Executive summary

Investment context and purpose

This study examines the growth and development impact of commercial and industrial (C&I) renewable power in India, focusing on British International Investment's (BII) investment in Fourth Partner Energy (FPEL), India's leading renewable energy solutions company. It was undertaken as part of a broader evaluation of BII's infrastructure portfolio by Itad and Steward Redqueen, designed to strengthen BII's evidence base on the role of infrastructure investments in delivering climate and economic outcomes.

It explores how FPEL has expanded since BII's initial support and how BII's financial and non-financial inputs have contributed to this growth. The report provides broader insights into how C&I energy solutions can support India's clean energy transition and the strategic implications for investors aiming to deliver climate and economic benefits through this type of investment.

Founded in 2010 and headquartered in Hyderabad, FPEL offers integrated clean energy solutions including rooftop and ground-mounted solar, open access solar and wind, wind-solar hybrids, battery energy storage systems (BESS) and electric vehicle (EV) charging infrastructure. It has executed over 3,000 projects and manages a 1.2 gigawatt (GW) portfolio across distributed and open access platforms, making it one of the top three players in India's C&I renewable energy market.

BII has supported FPEL through two debt investments: USD 33 million (₹250 crore) in 2021 to finance 217 MW of greenfield renewable projects, followed by a USD 47 million (₹350 crore) facility in 2022 to support 295 megawatt (MW) of additional capacity across India and other Asian markets.

The results

The C&I sector is emerging as a major driver of renewable energy growth in India and is playing a critical role in the country's energy transition.

The C&I sector accounts for around 50% of India's total electricity consumption and is undergoing a major shift in sourcing patterns – from grid and captive fossil-based supply to renewable solutions. Renewable C&I generation remains a small but rapidly expanding share of total C&I demand.

Rapid growth in renewable C&I is driven by the expansion of 'open access' renewable C&I solutions, underpinned by a series of enabling conditions in the India market.

Open access renewable C&I¹ has expanded rapidly in India in recent years due to a combination of high growth in electricity demand, a maturing and much more reliable national grid, and a series of enabling regulatory reforms. These include: i) Green Energy Open Access Rules (2022), which decoupled generation from consumption and allowed cross-state power sales; ii) waivers of interstate transmission charges; and iii) the General Network Access (GNA) framework (2022), which improved project viability and investment confidence. Together, these factors have created a highly permissive environment for open access C&I renewables and have supporting the rapid

¹ Open access C&I solutions refer to renewable C&I energy which is generated 'offsite' and transmitted to the consumer via the public transmission and distribution grid under PPAs or bilateral arrangements. Because such generation is not constrained by location at the consumption point, open access arrangements can permit much larger scale installations, offer cost advantages through scale and serve large energy consumers with higher demand.

expansion of FPEL's open access portfolio, which now represents 94% of its total generation, supporting its growth to become one of India's top three providers of renewable C&I power.

Consistent with this overall picture, FPEL's clients cite environmental and cost considerations, rather than reliability, as the main reasons for adopting renewable C&I solutions.

Analysis of 62 FPEL clients with publicly available statements shows that 76% cite environmental goals and 66% cite cost reduction as their main motivations, while only 16% mention reliability. Most clients have publicly stated sustainability targets, including net-zero or emissions reduction commitments, and view renewable C&I power as a key means to achieve them. Cost advantages are also strong: FPEL's tariffs average a 30–50% cost saving over the average industrial tariff. The cost of grid access by FPEL is unknown for the purposes of this study, although providers of renewable open access C&I electricity have until recently benefited from grid tariff wavers.

Among FPEL's clients, the switch to renewable C&I power has avoided an estimated 3.23 million tonnes of CO₂ emissions annually.

Using FPEL's portfolio data and harmonised default grid emission factors, the study estimates that FPEL's solar, wind-solar hybrid and rooftop projects together avoid approximately 3.23 million tonnes of CO₂ per year. When valued at a shadow carbon price of USD 100 per tCO₂, this represents around USD 323 million in annual climate benefits.

Lower-cost renewable electricity has increased firms' output, generating an estimated USD 344 million (₹29.6 billion) in additional value added annually.

Modelling based on World Bank Enterprise Survey (WBES) data and sectoral production functions indicates that a 30% reduction in electricity price increases industrial power consumption by 18.9%. This translates into USD 344 million (₹29.6 billion) in additional value added each year for FPEL's clients, equivalent to around 3% of their total annual output.

Open access C&I renewables offer a relatively efficient method of decarbonising India's power system, offering rapid payback and measurable emissions benefits.

Analysis suggests that FPEL's open access renewable C&I solutions have an economic payback period of around 5.4 years based on value added gains alone and 2.8 years when including the monetised carbon benefits from avoided emissions. Compared to other solutions, such as large-scale independent power producer (IPP) projects, this suggests that open access C&I is a relatively efficient pathway for grid decarbonisation, achieving rapid cost recovery and easily traceable abatement.² Payback periods were calculated using estimated levelised capital costs for installing FPEL's open access solar and wind capacity, based on forward-looking overnight costs per megawatt derived from industry benchmarks.³

BII's investment played an important role in supporting FPEL's rapid expansion into open access renewable C&I and in bridging to additional institutional finance.

BII provided two mezzanine debt facilities (USD 33 million (₹250 crore) in 2021 and USD 47 million (₹350 crore) in 2022) that together supported over 500 MW of new capacity. These investments were timed at a critical juncture as FPEL pivoted from smaller-scale rooftop C&I solutions into open access C&I. By bridging the financing gap between equity and conventional debt, BII's capital enabled an early scale-up of the open access model and signalled confidence

² In a study of independent power producers (IPP) by the same evaluation team, payback times were found to range from substantially longer than 10 years to less than a year in places with many power outages. Refer to: [Kalra, P., Meinderts, H., and Kim, R. 2025. Economic and Climate Impact of Power Investments Across Six African Countries. Steward Redqueen, 11 August 2025.](#)

³ These estimates reflect the total investment required to develop equivalent renewable generation capacity rather than the company's actual financing structure. We did not use FPEL's 'capital stack' given that information to isolate the share of total capital specifically invested in open-access C&I projects was not available.

to other investors, including a consortium of the International Finance Corporation (IFC), Asian Development Bank (ADB) and the German Development Finance Institution (DEG). This consortium committed an equity investment of USD 275m in 2024 to support FPEL's planned expansion across verticals and geographies. Alongside financial support, BII's support in strengthening FPEL's environmental and social management systems, corporate governance and risk management frameworks is cited by the company as having supported its growth and ability to attract further international capital.

Method

The study applied a light-touch methodology combining secondary data analysis, investee data and targeted interviews. It used FPEL's operational data on installed capacity and tariffs, complemented by national datasets from the International Energy Agency and the WBES to analyse trends in grid reliability and firm-level power use. Quantitative modelling was applied to estimate avoided greenhouse gas (GHG) emissions and to assess the additional economic value generated by cheaper electricity. This modelling combined assumptions from academic literature (including electricity price elasticity for industrial users in India) with production function analysis to estimate the increase in output attributable to FPEL's lower tariffs. While access to FPEL clients was not possible, triangulation with public statements and secondary datasets provided a robust and replicable approach to estimate climate and economic impacts.

Recommendations

1. Continue to scale C&I investments in comparable markets through client-led regional partnerships.

BII should leverage its strong track record in India to deepen its support for scalable, commercially viable C&I platforms in countries with similar enabling conditions – particularly in Southeast Asia, South Africa and other more developed emerging markets. Replication can be accelerated through client-led regional partnerships that leverage relationships with multinational clients operating across multiple countries. These partnerships can help de-risk early market entry in contexts with evolving regulation but strong corporate sustainability demand.

2. Maintain a flexible investment strategy that responds to local policy and grid contexts.

Experience from India shows that the fragmented but rapidly evolving nature of energy policy and grid infrastructure demands a flexible investment strategy, rather than a one-size-fits-all approach. BII should be able to tailor its support to relevant solutions, ranging from rooftop solar to open access and hybrid solar-BESS systems, and pursue opportunities in niche segments where BII can continue to play an innovative role. In this context, BII should seek partners with deep regulatory understanding and strong local presence.

3. Use mezzanine finance strategically to sustain growth and unlock commercial capital.

Institutional capital by development finance institutions (DFIs) has been catalytic to FPEL's growth, with BII making an important contribution through several channels, including the provision of mezzanine capital at a time when such financing was not commercially available in the Indian market. This flexible form of capital enabled FPEL to maintain its rapid growth trajectory while bridging to a subsequent equity raise and contributed to unlocking additional commercial capital. BII's non-financial support, particularly in strengthening FPEL's environment, social and governance (ESG) systems and policies, further supported the company in meeting the requirements of subsequent institutional investors.

4. Explore targeted, resilience-focused solutions in frontier markets.

In markets where grid infrastructure remains weak, BII should explore firm-level interventions using onsite applications, including rooftop solar and solar-BESS hybrid systems for clients with strong ESG commitments and high reliability needs.

5. Quantify climate and economic outcomes where feasible.

This study demonstrates that robust estimates of impact can be developed using investee data and recent secondary data sources (including the most recent WBES), even where direct access to end users is limited. BII can replicate this modelling approach to assess climate and economic outcomes for clean power investments in other contexts where electricity displaces more carbon-intensive grid supply.

1 Introduction

1.1 Study context and purpose

This study examines the development and impact of commercial and industrial (C&I) renewable power in India,⁴ focusing on British International Investment's (BII) investment in Fourth Partner Energy (FPEL), one of the country's leading distributed energy providers. It explores how FPEL has expanded since BII's initial support and how BII's financial and non-financial inputs have contributed to this growth. The report provides broader insights into how C&I energy solutions can support India's clean energy transition and the strategic implications for investors aiming to deliver climate and economic benefits through this type of investment.

The report focuses on three main lines of inquiry:

1. It draws on secondary data and publicly available information to analyse how and why India's C&I renewable energy sector has evolved over time (see Section 4).
2. It focuses on FPEL's client base and sectoral reach and examines the reasons that FPEL's clients are increasingly adopting renewable power solutions (see Sections 5 and 6).
3. Building on this analysis, the report uses data provided by the investee to estimate the climate and economic impacts of this shift – specifically by modelling avoided greenhouse gas (GHG) emissions and quantifying the additional economic value generated through access to lower-cost, clean energy (see Section 7).

The study is designed to generate learning for both BII and FPEL. It discusses the strategic implications of the analysis presented in the report and provides practical lessons for scaling similar investments, especially in emerging markets with enabling grid and policy conditions (see Section 8).

While originally designed to include interviews with FPEL clients, the study adapted its methodology to rely on secondary data and stakeholder interviews with FPEL and BII. Despite this shift, the report provides a robust assessment of FPEL's climate and economic impacts, drawing on firm-level data to estimate avoided emissions and value added, and offering practical lessons for scaling similar investments in emerging markets with enabling grid and policy conditions.

1.2 Strategic relevance to BII

This study forms part of a broader evaluation of BII's infrastructure portfolio, conducted by Itad and Steward Redqueen. In Phase 1 of the evaluation, a comprehensive review of BII's infrastructure investments and existing evidence base was undertaken. The evidence review identified priority areas where BII has significant investments and where further evidence would add value.⁵ Phase 2 of this evaluation, of which this study forms part, aims to support BII to deepen its understanding of the impact it is having within these strategic areas and to communicate this to a wider audience.

Within BII's overall portfolio, infrastructure represents approximately 36% of all investments, of which 59% comprises investments in the power sub-sector. Within the power portfolio, 54% of investments are in independent power producers (IPP), with the next largest segments being C&I

⁴ Commercial and industrial (C&I) renewable power refers to electricity generated from renewable sources, such as solar, wind or hybrid systems, that is supplied directly to business consumers rather than households or the public grid. In India, this is typically done through on-site rooftop solar installations or through off-site 'open access' projects, where firms contract power directly from renewable developers under long-term agreements.

⁵ Kim, R., Sutherland, Z., Verhoeven, S., Binet, S., Düring, N., Barnett, C., Lemma, A., and Beckmann, L. 2022. Final Report: Evaluating the Impact of British International Investment's Infrastructure Portfolio. e-Pact consortium: Itad, Steward Redqueen, Overseas Development Institute.

and off-grid power investments and home solar.⁶ Although C&I investments constitute a relatively small share of the overall portfolio, Phase 1 of the evaluation identified C&I power as a priority area to study further given the growing demand for reliable and affordable energy in the commercial and industrial sector and its potentially significant role in supporting the energy transition.

1.3 Background to the investment being studied

Profile of Fourth Partner Energy

Fourth Partner Energy (FPEL), founded in 2010, is one of India's leading renewable energy companies serving the C&I sectors. The company offers integrated clean energy solutions including rooftop and ground-mounted solar systems, open access solar farms, wind-solar hybrids, battery storage and electric vehicle (EV) charging infrastructure. It has executed over 3,000 projects and currently manages a portfolio of 1.2 GW⁷ across its distributed and open access platforms.⁸

Headquartered in Hyderabad, FPEL has a pan-India presence with offices in 13 cities including Pune, Gurgaon, Bengaluru and Chennai. Norfund is the single largest investor in FPEL to date, alongside the International Finance Corporation (IFC), the Asian Development Bank (ADB), the Germany's development finance institution DEG, and BII.⁹ FPEL is recognised as one of the top three players in India's distributed C&I renewable market¹⁰.

Investment by British International Investment

BII has supported FPEL through two investments. In April 2021, BII committed ₹250 crore¹¹ (approximately USD 33 million) mezzanine financing to support the development of approximately 217 MW of greenfield renewable power projects in India.¹² These projects were expected to displace primarily fossil-based electricity and reduce an estimated 258,000 tonnes of CO₂ emissions annually.¹³

In April 2022, BII made a follow-on investment of ₹350 crore¹⁴ (approximately USD 47 million, debt) to support the construction of an additional 295 MW of renewable capacity across India, Sri Lanka, Bangladesh, Indonesia and Vietnam. These projects were projected to avoid nearly 326,000 tonnes of CO₂ emissions annually, with the majority of the mitigation expected in India. BII's investments can be considered significant to the growth trajectory of FPEL, providing growth capital at a stage when such financing was otherwise difficult to access, as well as giving confidence to follow-on investors (See Section 5.3).

Other institutional investors in FPEL

FPEL has attracted several other institutional investors. TPG's involvement began with a USD 70 million investment by The Rise Fund in 2018, which enabled the company's early scale-up.¹⁵ In June 2021, Norfund invested USD 100 million in the company, joined by a further USD 25 million

⁶ Kim, R., Hedley, E., and Romme, M. 2025. Final Synthesis Report: Evaluating the Impact of British International Investment's Infrastructure Portfolio. e-Pact consortium: Itad and Steward Redqueen. (Publication forthcoming).

⁷ Total operating and under construction capacity as at June 2025.

⁸ <https://www.fourthpartner.co/>

⁹ <https://www.ifc.org/en/pressroom/2024/fourth-partner-energy-secures-275-million-equity-investment-from-ifc-adb-deg-consortium>

¹⁰ https://www.investec.com/en_in/capabilities/latest-transactions/norfund-and-tpg-invest-into-fourth-partner-energy.html

¹¹ ₹2,500,000,000 (Indian Rupees)

¹² Refer to BII website: <https://www.bii.co.uk/en/our-impact/search-results?inv-name=fourth%20partner>

¹³ <https://www.bii.co.uk/en/news-insight/news/cdc-group-announces-250-cr-investment-into-fourth-partner-energy>

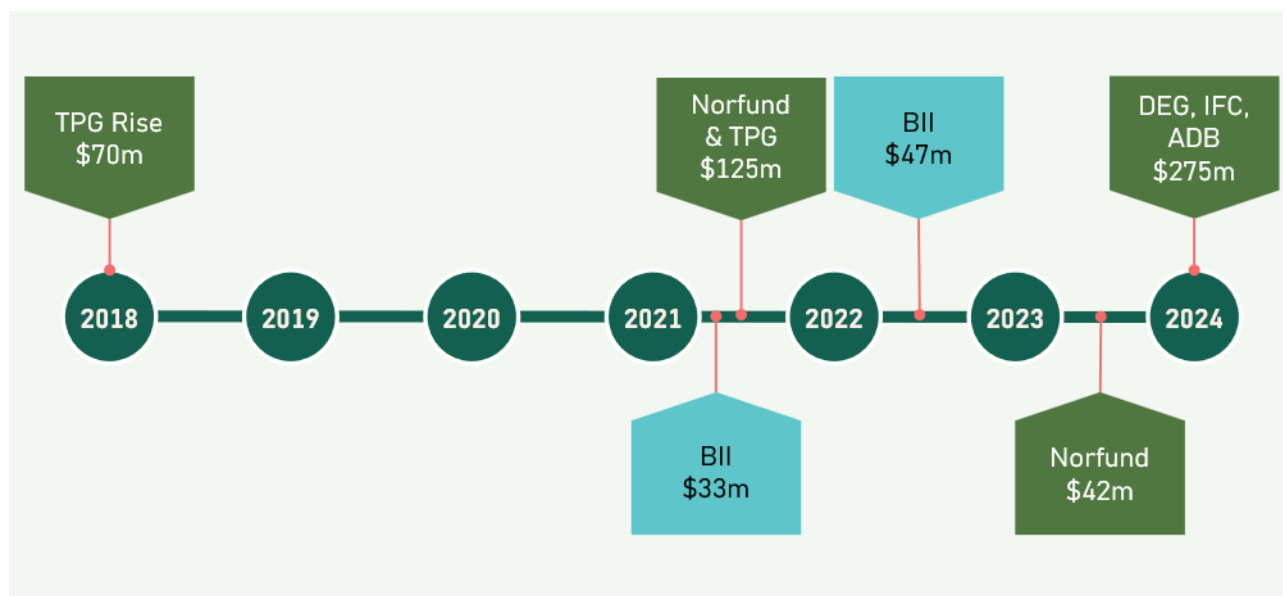
¹⁴ ₹3,500,000,000 (Indian Rupees)

¹⁵ <https://therisefund.com/portfolio/fourth-partner-energy> (accessed September 2025)

equity commitment from TPG Rise.¹⁶ Norfund followed this with an additional ₹350 crore (approximately USD 42 million) investment in August 2023 to support FPEL's continued expansion in India.¹⁷

In August 2024, FPEL secured a USD 275 million equity investment from a consortium led by IFC, along with ADB and DEG. IFC contributed USD 125 million, ADB USD 100 million, and DEG USD 50 million. The capital will support FPEL's growth strategy, which includes reaching 3.5 gigawatt (GW) of renewable capacity by 2026.¹⁸

Figure 1 Timeline of investments in FPEL



¹⁶ https://www.investec.com/en_in/capabilities/latest-transactions/norfund-and-tpg-invest-into-fourth-partner-energy.html (accessed September 2025)

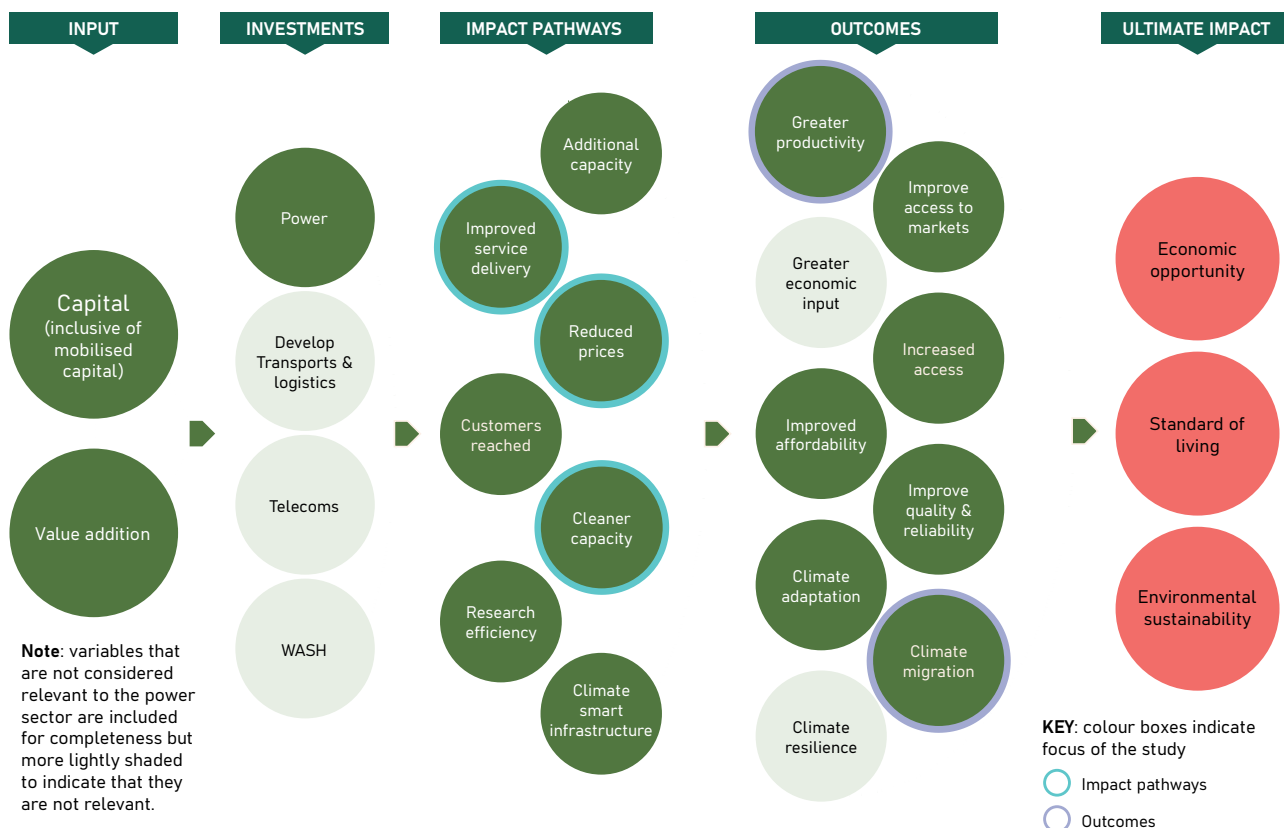
¹⁷ <https://solarquarter.com/2023/08/14/norfund-pours-rs-350-crore-into-fourth-partner-energys-renewable-vision/>

¹⁸ <https://www.ifc.org/en/pressroom/2024/fourth-partner-energy-secures-275-million-equity-investment-from-ifc-adb-deg-consortium>

2 Sector impact framework

This study is framed by BII's sector impact framework for the power sector (Figure 2). This framework outlines the key impact pathways through which investments in power generation are expected to produce outcomes for stakeholders and, ultimately, impacts for end beneficiaries.

Figure 2 Impact framework for power



The specific research questions covered by this study are introduced in Section 3.2. In relation to the impact framework, the focus is two-fold:

- Which of the impact pathways help to explain the reasons why firms adopt renewable C&I power in the India context?** In particular, the study looks at three explanations (highlighted on the framework in green). Do firms adopt renewable C&I because it offers: (a) an improved service (in this context defined as the ability to overcome grid outages and improve reliability); (b) reduced prices (versus the grid); (c) a cleaner alternative to the grid and/or 'traditional' C&I solutions such as diesel generators and captive thermal power plants?
- What is the outcome of firms adopting renewable C&I?** The study focuses on two main outcomes (highlighted in blue on the impact framework): (a) greater productivity as a result of either more reliable or cheaper power; and (b) GHG emissions avoided.¹⁹

¹⁹ Lower input costs can also have other important firm-level effects. Even if productivity (defined as output per unit of input) does not change, reduced energy costs can increase profits, be passed on as lower prices to customers, or enable higher wages. Given the data available, this study is not able to observe or quantify such outcomes and the analysis is therefore limited to productivity and avoided GHG emissions.

3 Methodology

3.1 Overview of the methodology

The approach adopted for this study combines a desk review of publicly available information sources on the Indian C&I sector, a review of internal documentation and data from BII and FPEL, interviews with representatives of FPEL and BII and an analysis of secondary data from the World Bank and the International Energy Agency on grid reliability and outages.

The methodology is somewhat similar to the economic analysis used in the IPP study in six African countries produced by the same team of evaluators.²⁰ The main difference is that in the IPP study, the power system of a country needed to be modelled to derive how the entire system had changed in terms of power costs and GHG level when additional capacity was inserted into it (in effect a modelled system-wide counterfactual). In this case, we have direct information on how much electricity firms switch from the grid to FPEL and the prices they pay. We use this information along with a series of assumptions (based on production function analysis – see below) to understand how these firms would have behaved if they hadn't accessed lower-cost electricity from FPEL (in effect a modelled econometric counterfactual of firm behaviour).

In the case of the IPP study, the study demonstrated that the impact upon firms of improved reliability of electricity was many times greater than the impact of slightly decreasing grid electricity costs. A significant difference in this study is that firms do not experience increased reliability from using FPEL electricity, but do experience a large reduction in costs (–30%) (see Sections 4 and 6).

3.2 Research questions

Table 1 Research questions and data sources/approach

Research questions	Data sources/approach	Section
Understanding the context of the power and C&I sectors in India		4
How significant is the C&I sector in India?	Desk research	
How has the C&I sector in India evolved over time?	Desk research	
What factors underpin the evolution of the sector?	Desk research	
Understanding the context of the investment and BII's role		5
How many clients does FPEL serve and what power solutions does it offer?	FPEL data	
Where does FPEL operate and in what sectors?	FPEL data	
How has FPEL's service offering developed over time?	FPEL data/interviews with FPEL representatives	
How has BII supported FPEL's growth?	Interviews with FPEL representatives	
Exploring the reasons firms choose C&I power		6
Why do FPEL customers choose C&I for their energy needs?	Analysis of public statements	

²⁰ Kalra, P., Meinderts, H., and Kim, R. 2025. *Economic and Climate Impact of Power Investments Across Six African Countries*. Steward Redqueen, 11 August 2025.

	Interviews with FPEL representatives on FPEL tariffs	
What does secondary data reveal about the importance of power reliability and price to businesses operating in India?	Analysis of World Bank/ International Energy Agency datasets	
Exploring the impact of FPEL customers choosing C&I power		7
What is the impact on GHG emissions avoided?	Modelling based on FPEL data	
What is the impact on economic output?	Modelling based on FPEL data	
Strategic discussion around the role of C&I		8
What does the study indicate about renewable C&I's role in the green transition?	N/A	
What does FPEL's experience suggest in terms of scaling up renewable C&I in other countries?	N/A	

3.3 Secondary data points accessed and analytical approach

The secondary data analysis covered two major areas:

Drivers of adoption: grid reliability and firm-level outages and impacts

Data from the International Energy Agency and India's Central Electricity Authority was used to analyse national trends in electricity supply, transmission and distribution losses, and improvements in grid reliability over the past decade.

This grid-level data was complemented by firm-level data from the World Bank Enterprise Survey (WBES) panel dataset (2014 and 2022 rounds), which includes responses from over 4,000 firms across Indian states.²¹ This analysis provided insight into the frequency and economic impact of power outages at the firm level – including lost production time and sales – and how these have changed over time.

Taken together, this analysis provides additional context (alongside public statements by FPEL clients) to assess the key drivers behind the adoption of renewable C&I. In particular, it enables a deeper understanding of the role of grid reliability as a driver for adoption.

Emissions and economic modelling

This study demonstrates how the climate and economic impact of C&I energy investments can be modelled using standard methodologies, publicly available data and sectoral benchmarks, with only limited data required of the investee. This makes it a potentially replicable tool for assessing the climate and economic effects of distributed renewable energy investments in other contexts where data is limited and where direct access to the clients of investees is not feasible.

To quantify the impact of firms adopting cheaper renewable energy provided by FPEL, two modelling approaches were applied to estimate: (1) GHG emissions avoided; and (2) increased economic value addition as a result of access to cheaper electricity. Both approaches draw on widely available secondary data sources and apply standard techniques widely used in development finance.

1. GHG emissions avoided result from FPEL clients substituting more carbon-intensive grid electricity with clean FPEL C&I power. To estimate this impact, data provided by FPEL on installed capacity (MW) by production type (open access solar, wind-solar hybrid and

²¹ The panel data set covers 4,063 companies. The 2022 survey encompasses over 9,300 companies of which sufficient data for the economic analysis was available for 4,029.

onsite solar) is multiplied by capacity utilisation factors²² to estimate total power production (MWh). This is combined with a default emission factor for the Indian electricity grid of 951 gCO₂/kWh to estimate total CO₂ avoidance (tCO₂eq). The default emission factor is based on the Harmonised International Finance Institutions (IFI) Default Grid Factors (2021).²³

2. Increased economic output results from FPEL clients switching from grid power to cheaper electricity provided by FPEL. This methodology used to estimate this impact is based on production function analysis with capital, labour, electricity and intermediary materials as inputs. A production function essentially predicts how firms' output responds to changes in inputs (costs). Production functions for different sectors and/or states can be derived by drawing on data from secondary datasets and assumptions in published literature. The methodology is described in detail in Annex II, including the inputs and assumptions used; results are discussed in Section 7.2. The model uses a three-step modelling approach as follows:

Step 1: Cheaper electricity encourages firms to use more power

The model draws on information provided by FPEL to compare FPEL's average electricity price to the national average for industrial users. FPEL's power is priced around 30% lower, once upfront equity contributions are taken into account. To estimate how firms might respond to this lower price, the study applied a widely used estimate of industrial electricity price elasticity from academic literature.²⁴ This was used to calculate how much additional electricity FPEL clients are likely to consume as a result of the cost savings. For example, with a price elasticity of -0.63, a 10% reduction of electricity price results in a 6.3% increase of electricity consumed and a 30% price reduction thus results in an 18.9% increase.

Step 2: Firms generate more output when they use more electricity

To understand how electricity contributes to business output, the study used data from the WBES, which includes detailed information on costs, production and electricity use for thousands of Indian firms. The analysis used this dataset to estimate how much economic value different types of firms typically produce per unit of electricity consumed. This analysis was cross-checked against a client breakdown by sector and state provided by FPEL.

Step 3: This additional electricity use leads to increased economic output

The model combined the estimated increase in electricity use (from Step one) with the productivity of electricity use (from Step 2). It also factored in the additional materials firms would require as output rises, and adjusted for the lower cost of electricity under FPEL contracts. Drawing on data on power sold (MWh) by sector provided by FPEL, this allowed the study to estimate the net increase in value added that could be linked to access to cheaper renewable energy.

3.4 Interviews conducted

Interviews were conducted with representatives of BII and FPEL on the context of the investment and BII's role vis-à-vis other investors. The purpose of these discussions was to assess the extent to which BII's partnership with FPEL has added value, in terms of FPEL's growth and aspects of strategy development, environmental, social and governance (ESG) and corporate governance, etc. These interviews provided a deeper understanding of FPEL's operational

²² 20% for solar and 40% for wind-solar hybrid. These are recognised utilisation factors for renewables, recognising that these energy sources are intermittent and do not produce electricity at 100% utilisation rates. This equates to 8,760 hours/year.

²³ IFI Default Grid Factors (2021). Sourced from: <https://unfccc.int/climate-action/sectoral-engagement/ifi-harmonization-of-standards-for-ghg-accounting/ifi-twg-list-of-methodologies>

²⁴ Tran, N D., Sahu, N. C. and Kumar, P. 2023. *The Electricity Journal*.

dynamics and contextual factors. Interviews were also conducted with FPEL on the reasons their clients cite in choosing FPEL for their energy needs, the typical costs savings they achieve when choosing FPEL and the typical percentage of their energy needs they derive from FPEL. These interviews supported the secondary data analysis and helped to collect information to ground truth assumptions in this analysis.

3.5 Limitations

While the study draws on secondary data and academic literature to present plausible estimates of the economic and climate benefits associated with FPEL's renewable power solutions, several limitations should be acknowledged:

Lack of direct access to FPEL clients

This study adopts an approach based primarily on secondary data analysis and economic modelling, which is less invasive for investee businesses and clients. This design reflects the anticipated challenges of collecting firm-level primary data from FPEL's clients within the resource envelope available. In principle, a statistically representative assessment of impacts would require primary data collection on firms' electricity consumption, production output, energy costs and investment decisions – information that is often commercially sensitive. Conducting such a survey would require a substantial number of client participants willing to share data or participate in structured interviews. Following discussions with FPEL, this was assessed to be challenging within the timeframe and scope of the study, and given the limited incentives for clients to engage and the concerns about confidentiality. As a result, the study instead draws on secondary data sources, including FPEL's portfolio data, publicly available client statements and national datasets, complemented by economic modelling to estimate results at scale.

Analysis of client motivations to adopt renewable C&I energy draws on public statements and on insights drawn from FPEL case studies, cross-checked through interviews with FPEL representatives. The public statements made by clients may reflect marketing or reputational considerations and should be interpreted as indicative rather than representative. These statements are triangulated with reference to wider literature and analysis of secondary data sets to mitigate this risk.

Modelling economic impact using secondary data

The economic analysis relies on secondary data from the WBES, rather than on firm-specific data from FPEL clients. The WBES data is mapped by sector and state to align as closely as possible with FPEL's client base. However, this introduces a degree of uncertainty, as client-specific differences in size, efficiency or energy-use patterns are not captured. Key modelling assumptions are documented in Annex II. Sensitivity analysis was also undertaken to test the robustness of the results to variations in key parameters, including the elasticity of industrial electricity demand and the assumed capacity utilisation rates for solar and hybrid generation. This analysis confirms that the overall direction and magnitude of results are robust to reasonable changes in these inputs.

4 Market and regulatory context for C&I in India

This section sets out the market and policy environment shaping the expansion of C&I renewable energy solutions in India. It provides an overview of recent trends in the power sector, including growing electricity demand from industry, the diversification of the generation mix, and the rapid rise of distributed renewables.

The section draws on desk-based research to highlight how improvements in infrastructure and the introduction of supportive policies, such as open access reforms, tariff waivers, group captive models and financing innovations, have enabled the growth of renewable C&I power.

This context sets the stage for the analysis in Section 6, which explores further why FPEL clients are adopting renewable C&I power, and in Section 8, which considers the strategic potential of this model in supporting the clean energy transition.

4.1 Evolution of India's power sector

India is one of the world's largest and fastest-growing electricity markets. Although previously dominated by fossil fuels, renewables are growing rapidly.

India ranks as the world's third-largest producer and consumer of electricity, with total installed generation capacity reaching approximately 475 GW as of March 2025.²⁵ While the generation mix has traditionally been dominated by thermal power (primarily coal) the grid is witnessing a significant shift to non-fossil sources of electricity generation. Coal's share of installed capacity has declined to around 46.7 % as of 2025, with the remaining ~250 GW composed of renewable, hydro and nuclear sources. Renewable capacity has seen roughly a three-fold increase since 2014; solar photovoltaic (PV) now stands at over 110 GW installed capacity and wind at ~51 GW.

²⁶ The government aims to reach 500 GW of non-fossil-fuel capacity by 2030, supported by deployment of BESS and continued grid integration reforms enabling greater renewable penetration.²⁷

Grid reliability has dramatically improved due to strategic national initiatives

The Indian electricity grid has seen remarkable improvements in reliability over the past decade: energy shortages have plummeted from 4.2% in 2013–14 to just 0.1% in 2024–25,²⁸ with peak demand shortages also reducing significantly.²⁹ This enhanced reliability is largely attributable to substantial additions in generation and transmission capacities, coupled with strategic initiatives

²⁵ Press Information Bureau (PIB), Government of India, 2025. Energizing the Future: POWERup Q1 2025. Retrieved from: <https://www.pib.gov.in/FactsheetDetails.aspx?Id=149218>

²⁶ Data sourced from the Ministry of New and Renewable Energy, Government of India, retrieved at: <https://mnre.gov.in/en/physical-progress/>

²⁷ Ministry of New and Renewable Energy 2025, Press Release. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2120729>

²⁸ Energy shortage calculated as a percentage of energy deficit in the total energy requirement (i.e. in 2013–14 for every 100 units of electricity needed, 4.2 units were not available).

²⁹ SolarQuarter. 2025, India's Power Sector In FY 2024–25: Milestones, Reforms, And The Path To A Sustainable Future. Retrieved from: <https://solarquarter.com/2025/01/02/indias-power-sector-in-fy-2024-25-milestones-reforms-and-the-path-to-a-sustainable-future/>

like 'One Nation, One Grid' through which all regional electricity grids have been interconnected, effectively creating a unified national power grid operating at a single frequency.³⁰

4.2 Overview of the C&I sector in India

The C&I sector is a major electricity consumer with growing demand

The C&I sector accounts for a substantial share (estimates range between 40 and 50%³¹) of India's total energy demand. Major industrial consumers include energy-intensive sectors like cement, pharmaceuticals, metals, mining, textiles and chemicals. Commercial segments like data centres and large commercial buildings are also rapidly growing electricity consumers. Electricity demand in the sector is growing quickly, at an annual rate of approximately 10% per annum,³² driven by industrial expansion and urbanisation.

Shifting to renewables in the C&I sector is crucial to national climate goals

Given its significant consumption, achieving a shift towards renewable energy in the C&I sector is key to India achieving its wider climate targets and to enhance overall energy security. Historically, most electricity demand in the sector was met through grid purchases from distribution companies, predominantly supplied by coal-fired thermal power plants. Many large industrial units operate their own captive power plants to ensure reliable and cost-effective power (fuelled traditionally by coal or natural gas). While these conventional sources still dominate, the sector is increasingly shifting to renewable energy in line with broader national trends.

The renewable C&I sector is small but rapidly scaling

Although still representing approximately 6–8% of the C&I sector's total energy consumption, adoption of renewable C&I solutions is growing quickly. By early 2024, the renewable C&I sector had approximately 35 GW of installed capacity.³³

Solar PV dominates C&I renewables

- **Onsite** installations (located on customer premises) had reached around 15.76 GW cumulative installed capacity in India by December 2024.³⁴ An estimated 70% of this capacity serves the C&I sector.
- **Open access** installations, which are located away from customers' premises (offsite) transmit electricity via the national grid, accounted for approximately 20.2 GW installed capacity by December 2024. The majority of this capacity also serves the C&I sector. The open access solar segment is growing especially fast, with 6.9 GW added in 2024 – a 77% increase from the 3.8 GW added in 2023.³⁵

³⁰ The synchronous National Grid was formally established in December 2013 with the commissioning of the 765 kV Raichur–Solapur transmission line, which interconnected the Western and Southern regional grids. The aims of 'One Nation, One Grid' are to enhance grid stability and reliability, facilitate the efficient evacuation and integration of diverse power sources, optimise resource utilisation by allowing states with surplus power to transfer it to deficit states, and foster a more efficient and competitive electricity market.

³¹ Energetica India, 2025. Retrieved from: <https://www.ecofy.co.in/sites/default/files/2025-02/Energetica%20Coverage%20-%20Kailash%20Rathi.pdf>

³² Energetica India, 2025. Retrieved from: <https://www.ecofy.co.in/sites/default/files/2025-02/Energetica%20Coverage%20-%20Kailash%20Rathi.pdf>

³³ Renewable Watch India. <https://renewablewatch.in/2024/12/30/power-pathways-opportunities-challenges-and-way-forward-for-indias-renewable-open-access-market/>

³⁴ Energetica India, 2025. Retrieved from: <https://www.ecofy.co.in/sites/default/files/2025-02/Energetica%20Coverage%20-%20Kailash%20Rathi.pdf>

³⁵ Mercom India Research, 2025, figures sourced from: <https://www.mercomindia.com/product/q4-2024-mercom-india-solar-open-access-market-report>

Wind-solar hybrid and storage technologies complement solar and reduce intermittency

Wind power also plays a notable role in the C&I open access segment, concentrated in states with abundant wind resources such as Tamil Nadu, Gujarat and Rajasthan. Recent trends also include the growth of storage and hybrid solutions, which aim to address intermittency challenges and provide dispatchable power; these include a recent trend towards wind-solar hybrid projects and the integration of BESS, both of which support the growth of 'round-the-clock' power solutions that cater to the reliability needs of industrial processes.

4.3 Factors driving the recent growth in open access C&I

A permissive regulatory environment is driving enhanced economic viability

Open access renewables are now cheaper than grid electricity. The levelised cost of solar and wind generation has fallen sharply in the past decade, allowing open access generators (such as FPEL) to offer long-term contracts to C&I clients at lower tariffs than those charged by state-owned distribution companies ('DISCOMs'). Industrial grid tariffs remain relatively high because they incorporate cross-subsidy charges that support other customer groups such as urban households and rural consumers.

Introduction of time-of-day tariffs creates incentives to switch to open access renewables: higher peak-hour charges introduced in India in 2020 to manage demand.³⁶ This provides a strong incentive for C&I customers to procure renewable energy, especially when paired with storage, to reduce consumption during expensive peak periods.

Waiver of interstate transmission system charges has improved interstate project viability: the development of open access solar has been given a significant boost through a waiver of interstate energy transmission charges for renewable energy projects. This increases the viability of open access projects which sell to customers located in other states. A 100% waiver (for 25 years) is available to solar and wind projects commissioned before 30 June 2025 and, for BESS, before June 2028.^{37, 38}

New Green Energy Open Access rules have lowered access thresholds: in 2020 the Ministry of Power lowered the minimum eligibility threshold for open access from 1 MW to 100 kW.³⁹ This has opened the market to a much wider array of C&I consumers, including to smaller industries and medium and small enterprises. The rules also aimed to streamline the application and approval process.

Changes under the General Network Access (GNA) framework and complementary reforms to open access rules have enabled wider interstate project expansion. A more unified and streamlined system for interstate transmission access has been introduced through the GNA framework, introduced by the Central Electricity Regulatory Commission (CERC) in October 2022. In parallel, complementary reforms under the Green Energy Open Access (GEOA) rules removed procedural bottlenecks for interstate open access and clarified the process for supply to new customer segments – both have enabled an expansion of interstate electricity supply from open access sites. While these regulatory shifts have significantly improved market

³⁶ Press Information Bureau (PIB), Government of India. 2023. *Central Government Amends Electricity (Rules, 2020) by Introducing Time of Day (ToD) Tariff and Simplification of Smart Metering rules*. Retrieved from <https://www.pib.gov.in/PressReleaseFramePage.aspx?PRID=1934673>

³⁷ Tapered waiver rates are available for projects commissioned after these dates to 30 June 2028. Co-located BESS projects commissioned on or before 30 June 2028 receive a 100% waiver for 12 years, provided the power is consumed outside the state where they are commissioned.

³⁸ The cost of grid access by FPEL is unknown for the purposes of this study, although providers of renewable open access C&I electricity have until recently benefited from grid tariff waivers.

³⁹ Press Information Bureau (PIB). 2022. *Ministry of Power notifies Green Energy Open Access Rules to promote generation, purchase and consumption of green energy*. Available at: <https://www.pib.gov.in/PressReleaseFramePage.aspx?PRID=1842737>

viability, the GNA framework imposes 15-minute scheduling requirements and disallows banking for interstate supply.⁴⁰

A more mature market has opened new financing models and boosted developer confidence

Improved access to finance supports project development: the open access market has matured with increasingly accessible financing avenues from financial institutions and non-banking financial companies in India, making it easier for developers to secure funding.⁴¹

Larger IPP are moving into the C&I market: with fewer large state tenders for utility-scale renewable projects, many IPP are pivoting towards the high-growth, high-return C&I open access segment.

The 'group captive' model is driving growth: the more recent development of this model, in which C&I consumers invest equity in renewable projects alongside the developer, is another significant recent growth driver.⁴² These models are often exempt from cross-subsidy surcharges and the additional surcharge, making them the most financially viable option in many states. FPEL's open access projects use this approach.

Sustainability and ESG commitments are accelerating the shift

Corporate decarbonisation targets are pushing renewable procurement: an increasing number of C&I entities, especially large corporations, are setting ambitious decarbonisation targets. Open access renewable energy provides a direct and verifiable way to achieve these sustainability goals and enhance their ESG credentials. This is explored further in Section 7.

⁴⁰ Under India's GNA framework, interstate open access transactions must be scheduled in 15-minute blocks, with no provision for 'banking' unused renewable energy for later use. This rule is intended to maintain grid stability and ensure accurate scheduling of variable renewable generation. This favours larger clients with steady, predictable demand profiles because they can more easily match contracted generation with consumption. Smaller firms, whose electricity demand is more variable and intermittent, face higher risks of mismatch and penalties for deviations.

⁴¹ Institute for Energy Economics and Financial Analysis (IEEFA). (2022, February). Renewable Energy Financing Landscape in India. Available at: https://ieefa.org/wp-content/uploads/2022/01/Renewable-Energy-Financing-Landscape-in-India_February-2022.pdf

⁴² CareEdge Ratings. 2023. *Group Captive Mode to Drive Installations in FY24-FY25*. Available at: https://img.saurenergy.com/2023/08/gc_mode_to_drive_installations_careedge_report.pdf

5 FPEL's client base and product offering

This section presents an overview of FPEL's portfolio, examining how its installations are distributed across states and sectors and tracing the evolution of FPEL's service offering – highlighting shifts from onsite to open access (offsite) generation, the growing adoption of hybrid solutions, and the underlying factors driving these changes. The section draws on data shared by FPEL and insights from interviews with company representatives, with additional research.

5.1 Portfolio overview

FPEL has built one of India's largest portfolios of C&I renewable energy projects, serving a wide-ranging and geographically diverse client base. FPEL serves over 350 clients and has a strong presence across a diverse range of sectors, including automotive, industrial and manufacturing, consumer goods and retail, healthcare, and IT and financial services.

The company offers a suite of clean energy solutions, which can be tailored to meet specific installation requirements and client needs. FPEL's main services are onsite solar, covering rooftop, ground-mounted and floating installations, and open access (offsite) solar and wind, provided through long-term Power Purchase Agreements (PPAs) using an open access model. More recently, FPEL has introduced hybrid solutions to clients seeking 'firmer' renewable energy supply. These solutions include wind-solar hybrid and BESS, and are currently relatively few in number.

5.2 Initial offering: onsite/rooftop solar solutions

Onsite solar was the first renewable energy solution offered by FPEL and laid the foundation for its early growth. Through onsite installations, FPEL serves C&I clients with available rooftop space and who want to partially offset their grid power consumption with clean energy. These installations directly connect to the consumer's premises and typically fulfil 10–30% of a client's total electricity needs, depending on rooftop capacity and load profile.

The rooftop portfolio tends to serve businesses with medium-scale, regular daytime power needs. In many cases, onsite solar is pursued as a first step towards renewable energy adoption, driven by cost savings and corporate sustainability goals.

In recent years, as energy demand and climate targets have grown, clients have increasingly looked to open access, or to combine rooftop systems with open access.

Onsite installations can be suitable in states that still have regulatory hurdles to the adoption of open access solutions. FPEL pursues such projects where regulatory constraints make them more suitable than open access; for example in Telangana, which has especially high grid access charges, making open access projects less attractive.⁴³

⁴³ For example, access charges are INR 1.5/KWh in Uttarakhand. Data retrieved from: <https://goldisolar.com/challenges-of-implementing-open-access-oa-in-india>

5.3 Rapidly expanding offering: open access solar and wind

Open access has become the dominant model in FPEL's portfolio and a key driver of its recent growth. Open access allows renewable energy to be generated offsite and transmitted to clients through the grid, enabling much larger volumes than rooftop installations. Under this model, FPEL supplies solar, wind or hybrid solutions to C&I clients, typically fulfilling up to 60–65% of their total electricity needs – rising even higher in some cases with storage integration. A breakdown of total installed open access capacity by generation type is provided in Table 2.

Table 2 FPEL-installed open access capacity

Generation type	Total installed capacity (MW)
Solar	875,268
Wind-solar hybrid	362,150
Total installed capacity (MW)	1,237,418

Open access projects primarily serve large-scale energy consumers seeking cost savings and support for their energy transition targets. These include firms in sectors such as industrial gases, manufacturing and industry – particularly those with export-facing value chains or corporate mandates for 100% renewable sourcing. Many of these clients are multinational or supply to multinational customers, who are increasingly requiring renewable procurement from their vendors.

The financial model for open access typically involves equity contributions from clients and long-term contracts. Around 95% of FPEL's open access clients use a group captive model, under which they contribute equity to the project – typically ₹30 lakh/MW for solar and ₹70 lakh/MW for wind. In return, they receive power at a preferential tariff rate. Clients without equity contributions can access a third-party supply model but face higher tariffs due to additional levies and charges.

Equity contributions are also a condition of FPEL's funding structure – projects without them are not typically eligible for the firm's primary sources of capital.

Recent changes to national regulation and access to finance have underpinned the rapid scale-up of FPEL's open access model. The model has benefited from some of the recent changes to regulation discussed in Section 4.3, in particular the introduction of the Green Energy Open Access Rules (2022) and the waiver of interstate transmission charges for open access solar. These reforms have enabled FPEL to build larger centralised projects and improved the commercial viability of supplying power across state borders, eliminating the need to construct multiple smaller plants in each state. This has improved efficiency and reduced costs. Interstate sale also enables FPEL to supply clean energy to states that do not have the resources to generate RE optimally.

Increased access to long-term capital from institutional and development finance investors has also played a key role in the expansion of the model. This began with an equity investment by TPG's Rise Fund of \$70 million in 2018. In 2021, BII provided an initial mezzanine facility of \$33 million, alongside a simultaneous equity investment of c. \$100 million from Norfund and a further USD 25 million equity commitment from TPG Rise. BII's facility was subsequently extended in 2022–23 to reach \$78 million in total. Building on this foundation, in 2024 a consortium of IFC, ADB and DEG committed US \$275 million in equity.

In this journey, FPEL recognises BII's innovative mezzanine finance facility as playing an important role in enabling it to maintain its growth trajectory. Structured as a seven-year mezzanine facility, it provided growth capital at a stage when such financing was otherwise

difficult to access. This instrument helped FPEL bridge the gap between equity and conventional debt, enabling it to fund project development and supporting the successful expansion into large-scale open access projects, as well as giving confidence to follow-on investors, including by a consortium of IFC, ADB and DEG (see Section 1.3 for further information).

Beyond capital, BII's role extended into non-financial support. Alongside Norfund, it required and supported the establishment of an independent ESG department in 2021, oversaw the development of an Environmental and Social Management System aligned with IFC Performance Standards and helped formalise risk management and business integrity frameworks. BII staff also provided hands-on guidance and training, joined ESG board subcommittees and helped strengthen governance and policies across the company. This combination of financial innovation and technical engagement was central to strengthening FPEL's ESG profile and credibility with subsequent DFI investors.

State-level regulatory and policy differences play a central role in determining where and how FPEL operates open access projects. The type of solution offered in each state is shaped by local grid tariffs, open access policies and banking regulations. In Karnataka and Maharashtra, for example, high commercial tariffs and streamlined policies make large-scale solar projects financially attractive. In Uttar Pradesh, a new solar policy featuring wheeling and transmission waivers and land leasing has helped draw open access investment. Tamil Nadu, a long-time frontrunner in open access solar, combines open access and onsite installations supported by a multi-year tariff framework.⁴⁴

Residual challenges continue to shape the implementation of the open access model. While national-level reforms have improved project viability, several states maintain more restrictive policies that limit deployment by FPEL. Practical barriers also continue to impose challenges, including delays in project approvals, difficulties in land acquisition (for example, compliance with ESG requirements, while ultimately supportive in enabling access to DFI finance, can add procedural complexity at the acquisition stage), and continuing grid transmission bottlenecks, which can restrict the pace at which large projects can be connected and commissioned. Open access is also skewed to larger clients with consistent and high electricity demand, such as larger manufacturing and industrial firms, as a result of the requirement under the national GNA framework that interstate open access projects must follow 15-minute scheduling blocks with no banking provisions.

5.4 Latest offering: hybrid solutions including battery storage

Hybrid renewable energy solutions, including wind-solar hybrids and BESS, represent FPEL's most recent and advanced offerings. These models are designed to enable clients to achieve higher levels of renewable energy penetration. While both types of hybrid systems offer enhanced power reliability, only those including BESS enable true round-the-clock clean energy supply.

Wind-solar hybrid projects are supported by states with specific enabling policies and are designed to improve the consistency of renewable generation. FPEL's Gondal park in Gujarat,⁴⁵ for example, has been implemented under the state's wind-solar hybrid policy, which allows solar and wind installations to share the same sites and to make use of the same infrastructure, including transmission lines, while also providing financial incentives⁴⁶ to hybrid projects. The

⁴⁴ Information drawn from customer case studies published by FPEL (including: https://www.fourthpartner.co/wp-content/uploads/2025/01/Fourth-Partner-Energy_Kosmo-One_Case-Study.pdf) and additional research (including: <https://jmkresearch.com/uttar-pradesh-issues-new-solar-policy-targets-22-gw-of-solar-power-by-2026-27>)

⁴⁵ See also Fourth Partner Energy Case Study, 'FILATEX INDIA'S FOCUS ON ADOPTION OF RENEWABLE ENERGY', Available at: https://www.fourthpartner.co/wp-content/uploads/2025/01/Fourth-Partner-Filatex_Case_Study.pdf

⁴⁶ Including concession on wheeling charges and a reduction in the Cross Subsidy Surcharge, and more flexible banking provisions.

policy aims to encourage developers to combine the generation profiles of solar and wind to provide a more stable and predictable power supply, without relying on storage.

BESS is currently used by a small number of clients seeking near-total renewable energy replacement. BESS in combination with renewables enables clients to meet 97–98% of their electricity needs. Such projects are especially capital intensive as a result of the high cost of batteries.

6 Reasons why FPEL clients adopt renewable C&I power

This section examines the key factors driving the adoption of renewable C&I power solutions among FPEL's clients. The analysis draws on three main sources:

1. A search of publicly available statements made by FPEL clients describing their reasons for adopting C&I power (drawing on FPEL case studies, company websites, press releases and news pages).
2. An analysis of available secondary datasets on grid performance, including firm-level data on outages from the WBES and grid-wide data on production and reliability from the World Bank and the International Energy Agency.
3. Insights from interviews with FPEL representatives.

The search of publicly available statements by FPEL clients on their reasons for adopting renewable C&I power is based on a sample of 62 unique India-based FPEL clients drawn from a client list provided by FPEL and supplemented by a series of eight client case studies produced by FPEL.⁴⁷ Of these 62 clients, public statements were identified for 29 companies. This search provides a broad view of motivations for adopting C&I across multiple power solutions (open access, onsite and battery backup) and covers a wide variety of sectors. Nevertheless, it is important to note that this approach has limitations; it is based on self-reporting by firms (and hence potentially biased) and should be interpreted as indicative rather than truly representative or exhaustive.

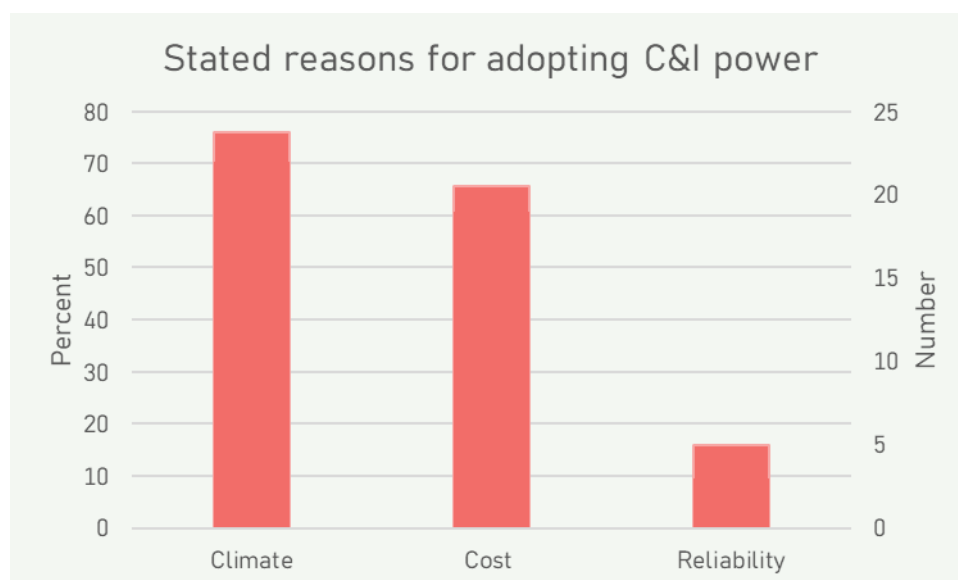
To mitigate the potential limitations of this approach, this study triangulates and supplements the search of public statements with detailed analysis of available secondary datasets from the World Bank and the International Energy Agency. Together, these sources provide a plausible snapshot of the motivations behind the uptake of FPEL's renewable C&I power solutions.

This research into drivers for adopting renewable C&I power solutions provides critical context for the quantitative assessment of climate and economic impacts in Section 7, and also informs the discussion in Section 8 on the strategic role of C&I in accelerating clean energy transitions.

Meeting climate goals, followed by cost, are the primary reason for FPEL clients to adopt renewable C&I

Drawn from the results of the internet search, Figure 3 highlights the main stated reasons why FPEL clients adopt renewable C&I power. The principal reasons fall into three main categories: (a) meeting corporate climate goals and targets; (b) opportunities to reduce the cost of electricity vis-à-vis the grid; and (c) opportunities to improve the reliability of electricity supply.

⁴⁷ Case studies retrieved from: <https://www.fourthpartner.co/case-studies/>

Figure 3 Reasons for adopting renewable C&I power⁴⁸

Meeting climate goals is identified as a key driver for the adoption of renewable C&I power by 76% of firms for which public statements were identified (22 out of 29 firms), closely followed by cost. These results are consistent across power solution type and sector (although some variation is observed with regard to reliability, as discussed below).

This is an interesting finding given that reliability is typically seen as a key motivation for firms to adopt 'traditional' C&I power solutions – such as diesel generators or captive thermal plants. Nevertheless, this fits recent trends in the C&I sector in India presented in Section 4, which describes how a desire by C&I customers to achieve sustainability goals and enhance their ESG credentials is driving a wholesale shift to renewable forms of C&I power.

Given that FPEL's clients are typically larger domestic companies and multinational corporates, these clients are likely to be in the vanguard of this change. While the results are not exhaustive, it is noticeable that the vast majority of firms for which public statements were found have concrete climate-related targets, typically either to reduce their GHG emissions by a certain percentage or to reach net zero by a certain date.

Given that climate goals are a key driver in firms' adopting C&I, this study estimates the impact of this switch to renewable power by FPEL customers in terms of GHG avoidance in Section 7.1.

Cost reduction is also a major motivation for FPEL clients to adopt renewable C&I

Alongside climate goals, cost is cited by FPEL clients as a key reason for adopting renewable C&I power. As Figure 3 highlights, 66% of firms for which public statements are available (19 out of 29 firms) identified cost as a key reason for adopting renewable power. Indeed, firms typically cite both reasons together (cost and climate) as their key reasons for adopting C&I power.

The issue of cost as a driver for C&I adoption was explored further with representatives of FPEL. They confirm that FPEL is able to offer power at a significant discount to grid tariffs, which provides a significant motivation to firms to adopt.

This cost advantage reflects several structural factors, including the lower cost of renewable generation, driven by falling equipment prices, economies of scale in utility-scale solar and wind, and zero fuel costs compared to volatile coal prices, together with the avoidance of DISCOM cross-subsidies typically levied on C&I consumers, long-term PPAs that provide price certainty

⁴⁸ Percentages do not equal 100 as firms may cite more than one reason for adoption.

relative to annually revised grid tariffs and a range of regulatory concessions such as transmission charge waivers (as discussed further in Section 4.3).

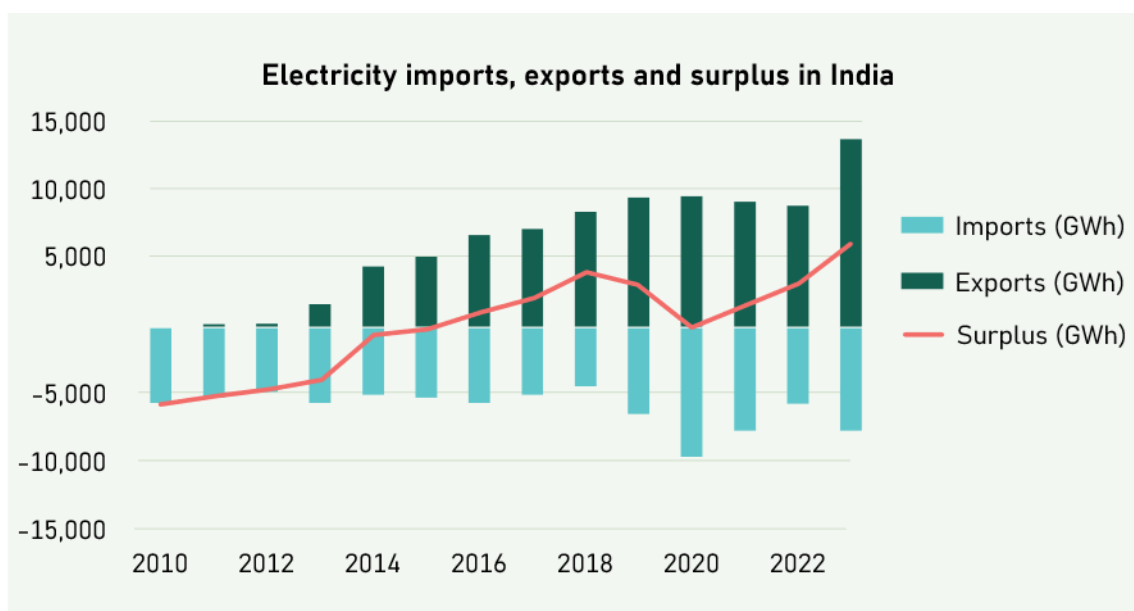
Given that cost of electricity supply is a significant motivation for firms to adopt renewable C&I power, the economic impact of this decision-making is explored further in section 7.2. This section explores the impact of C&I power on economic output as firms adapt to cheaper power by scaling up production. The analysis in this section assumes FPEL's electricity is offered at a 30–50% discount over average industrial electricity tariffs and taking into account equity contributions by FPEL clients within long-term PPAs in the group captive model that has been adopted.⁴⁹

Reliability is a much less significant driver of adoption as the national grid in India is becoming more reliable

Firms have traditionally adopted C&I solutions in India to improve the reliability of their electricity supply – especially backup diesel generators and captive thermal power plants.⁵⁰ This is changing with the adoption of renewable sources of C&I power; only 16% of firms for which public statements on motivations were identified cited reliability as a driver (Figure 3). To understand why this might be the case we analysed recent grid-level and firm-level data on the reliability of the electricity grid in India.

Data from the International Energy Agency and the World Bank shows that the reliability of the electricity grid in India has improved significantly in the last 15 years and power outages have become much less common. As highlighted in Figure 4, significant investments in generation capacity have resulted in a 'deficit' situation being transformed into one of electricity surplus between 2010 and 2022, with exports of electricity exceeding imports for the first time.

Figure 4 Electricity imports, exports and surplus⁵¹



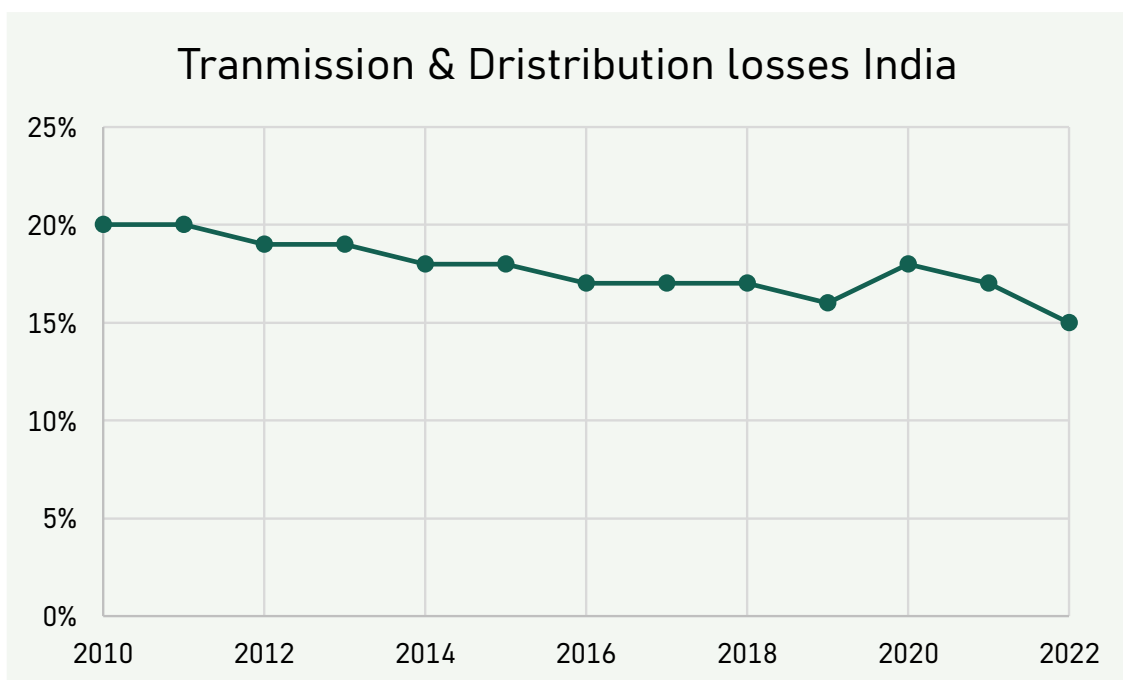
⁴⁹ Confidential tariff data provided by FPEL were used in the underlying analysis to estimate the additional production resulting from access to lower-cost electricity supplied by FPEL. These data have been removed from this public report, but the assumptions presented here remain consistent with the original analysis.

⁵⁰ Singh, A., Joshi, A., Pope, F. D., Singh, B., Khare, M., Kota, S. H., and Radcliffe, J. (2024). Evaluating alternative technologies to diesel generation in India using multi-criteria decision analysis. *Cleaner Energy Systems*, 9, 100133. Elsevier.

⁵¹ Source: International Energy Agency

At the same time, as illustrated in Figure 5, network losses across the grid have decreased substantially, reducing from 20% in 2010 to 15% in 2022.

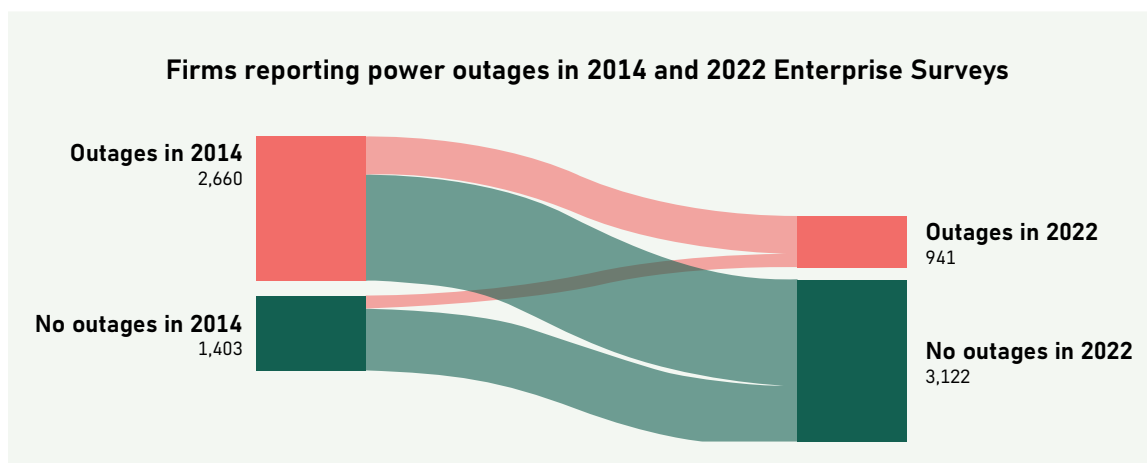
Figure 5 Transmission and distribution losses⁵²



This picture of a more productive and reliable grid is supported by analysis of firm-level data on outages reported through the WBES of India.

Figure 6 presents results from the WBES panel dataset covering 4,063 firms throughout India surveyed in 2014 and 2022.⁵³ In 2014, 2,660 (65%) surveyed firms reported suffering from outages, but this had fallen significantly to 941 (23%) in 2022. Most firms which reported outages in the 2014 survey (1,957) did not report outages when interviewed again in 2022. Only 703 firms reported outages in both 2014 and 2022.

Figure 6 Companies self-reporting outages



⁵² Source: World Bank Development Indicators

⁵³ This is a subset of the full World Bank Enterprise Survey, covering a panel of firms which were interviewed in both of the most recent survey rounds, in 2014 and 2022.

Data from the 2022 WBES of India is also helpful in estimating the residual impact for firms of grid outages. In the 2022 survey, firms reported losing on average only 0.31% of production time (around six hours per year) due to outages, with average sales losses of 0.87%. Of the firms that reported experiencing outages, this resulted in 1.44% of lost time and 4.12% of sales. This data further underlines the finding that grid reliability is not driving the adoption of renewable C&I. As such, it is not included in the modelling of economic impact in Section 7.2.

Sectoral and geographic differences still shape how some firms experience and respond to outages, despite overall improvements in grid reliability

While the national picture points to fewer disruptions, firm-level data from the 2022 WBES shows that some sectors and states continue to face greater exposure to power outages. For example, food producers report the highest levels of sales losses, while firms in Jammu and Kashmir, Punjab, and Tamil Nadu face longer average outage durations and greater sales impacts.

Table 4 and Table 5 in Annex I provide a full breakdown by sector and state. In addition, the 2022 survey finds that firms with diesel generators are actually more likely to report production or sales losses.

This points to the importance of sector-specific factors in meeting reliability concerns. In particular, sectors like food processing and retail are much more vulnerable to inventory or operational loss due to power outages, which cannot be fully mitigated by traditional backup power systems. Concerns around reliability are a reason for some FPEL clients to adopt hybrid C&I solutions. For example, one large retail firm with grocery operations is the first adopter of FPEL's hybrid rooftop and BESS, which guarantees '24/7 power for critical operations'. This solution also allows the company to bypass regulatory constraints around net metering in Karnataka by fully disconnecting the firm from the grid. In addition, clients in the data centre and textile sectors are also adopting FPEL's wind-solar hybrid solution for reliability reasons as the solution provides 'firmer', more reliable power without the need for battery storage.

7 Climate and economic impact

This section quantifies the principal benefits of adopting FPEL's renewable C&I solutions. It builds on the analysis of the key drivers for adopting FPEL's renewable energy explored in Section 6. Based on the main reasons for adopting renewable C&I power, two key benefits are quantified: (a) avoided GHG emissions (stated by FPEL customers as the primary reason for switching to FPEL energy); and (b) increased output and value addition as a result of lower tariffs when switching to FPEL energy (a significant secondary reason customers cite for switching to FPEL energy).

7.1 Climate impact: avoided emissions

FPEL's solar and hybrid power generation solutions avoid an estimated 3.22 million tonnes of CO₂ annually, with a value of USD 322 million

These figures are calculated using: (a) the IFI harmonised default emission factor (operating margin) for India of 951gCO₂eq/kWh; (b) capacity utilisation of 20% for solar and 40% for wind-solar hybrid⁵⁴; and (c) a shadow price of US\$ 100 per tCO₂eq a year.⁵⁵

This calculation suggests that total emissions avoided per year are substantial. When valued at USD 100 per tCO₂eq, CO₂ avoided amounts to USD 322 million, which is similar to the estimated USD 344 million of additional economic output derived from firms using cheaper electricity supplied by FPEL (see Section 7.2). A breakdown of CO₂ avoided per FPEL C&I solution is provided in Table 3.

Table 3 FPEL-installed capacity, estimated power production and CO₂ avoidance

Solution	Installed capacity (MW)	Power production (MWh)	CO ₂ avoidance (tCO ₂ eq)
Solar	647	1,130,806	1,075,396
Wind-solar hybrid	591	2,064,402	1,963,246
Onsite solar	111	193,871	184,371
Total	1348	3,389,078	3,223,014

7.2 Economic Impact: Increased output and value added

This section quantifies the economic impact of firms switching to using cheaper renewable energy provided by FPEL. It does this through a number of steps: (a) calculating the increased use of electricity by firms switching to FPEL as they capitalise on cheaper electricity tariffs; (b) calculating the value of output (before switching to FPEL); (c) modelling the new value of output (after switching to FPEL); and (d) estimating the total value addition which is attributable to firms switching to FPEL. This section provides key highlights from the analysis; a full description

⁵⁴ These are recognised utilisation factors for renewables, that is, recognising that they are intermittent and do not produce electricity at 100% utilisation rates. This equates to 8,760 hours/year.

⁵⁵ The range of realistic carbon prices is wide and differs by institution. The price of USD 100 is close to the current market price in the EU ETS, the largest carbon market in the world (EUR 78 per tCO₂eq, i.e. US\$ 92, expected to rise to EUR 85, i.e. USD 100 by year end 2025).

of the model used and data tables developed through the analysis are provided in Annex II. Note that this analysis is based on data on electricity generation provided by FPEL and secondary data from the WBES for India. It has not been possible to ground truth this analysis directly with FPEL clients.

Cheaper power from FPEL leads to increased electricity consumption by clients of approximately 18.9%

This result is based on an elasticity for electricity in India of -0.63 , which is derived from peer-reviewed academic literature on electricity pricing in India⁵⁶ and reflects how C&I energy users adjust consumption in response to changes in electricity cost.⁵⁷

Based on FPEL's electricity being on average 30% cheaper than the grid,⁵⁸ the model predicts that client electricity consumption increases by approximately 18.9%.

This increased consumption translates into USD 344 million in value added annually, which is directly attributable to FPEL's cheaper power

By mapping FPEL's sectoral client base onto the WBES data, and running log-linear regression analysis, value addition per kWh is derived on a sector-by-sector basis. The analysis makes use of the Cobb-Douglas production function to develop factor shares, including for electricity.

The situation pre- and post-connection to FPEL is analysed. The situation post-connection to FPEL takes into account the higher consumption of electricity, reduced unit cost of energy (owing to the lower tariffs) and an increased cost of materials as firms (which scale in proportion to the increased consumption of electricity).

The analysis estimates that FPEL's offsite clients produce approximately USD 12 billion in value added in total annually using the energy provided by FPEL. Of this, a net value added (or GDP) gain of USD 344 million (₹29.6 billion) annually is attributable to the incremental increase in power use after connection to FPEL. To put this into perspective, we can estimate the 'economic' payback time of FPEL. The average overnight cost of solar and wind-solar hybrid plants is approximately USD 1,500 per kWh.⁵⁹ This means that the capital costs of the 1,247 MW FPEL wind and wind-solar hybrid capacity (see Table 3) is approximately USD 1,856 million. Dividing the capital costs by the GDP contribution of USD 344 million yields an economic payback time of 5.4 years. When also accounting for the CO₂ avoidance of the offsite power production valued at USD 100 per tCO₂eq, the economic payback time decreases to 2.8 years.⁶⁰

The final value added per kWh among FPEL clients is estimated at USD 4.26 (₹366), substantially higher than the Indian economy-wide average of USD 3.11 (₹268).⁶¹ This analysis is based on open access generation only, which accounts for 94% of FPEL's total electricity supply and reflects the most scalable part of its operations.

⁵⁶ Tran, N D., Sahu, N. C. and Kumar, P. 2023. *The Electricity Journal*.

⁵⁷ Annex II contains a sensitivity analysis for price elasticity: halving the price elasticity reduces value added results by 36%.

⁵⁸ Refer to Annex II for the assumptions underpinning this analysis. Confidential tariff data provided by FPEL were used in the underlying analysis to estimate the additional production resulting from access to lower-cost electricity supplied by FPEL. These data have been removed from this public report, but the assumptions presented here remain consistent with the original analysis.

⁵⁹ EIA, *Capital cost and performance characteristics for utility-scale electric power generating technologies*, 2024. This report states on-shore wind to be USD 1,489 per kWh and solar PV at 1,274. The cost for wind-solar hybrid is likely within this range. Allowing for some interest cost and noting that mentioned prices are in the US, we deem a capital cost of USD 1,500 per kWh defensible.

⁶⁰ The carbon avoidance of the offsite capacity in Table 3 is 3,038,642 tCO₂eq, which is valued at USD 304 million.

⁶¹ Based on the most recent government data on India's GDP and electricity use.

8 Broader strategic lessons

This section outlines the broader lessons emerging from the recent growth of the renewable energy segment within India's C&I sector. It draws together insights from Section 4 on national trends, along with the specific experiences of FPEL and its clients detailed in Sections 5 to 7. It also incorporates additional reflections shared by FPEL representatives during interviews, and considers the potential relevance of this model for other markets, particularly those in Southeast Asia and other regions of strategic interest.

India's C&I power sector is playing a pivotal role in advancing the country's energy transition, led by the private sector. India's C&I sector accounts for roughly half of the country's electricity demand and has emerged as a key engine for renewable energy adoption. FPEL's rapid growth illustrates how a viable, private sector-led model can deliver large-scale decarbonisation. Over the past decade, the C&I segment has undergone a substantial transformation driven by large industrial clients with ambitious decarbonisation goals and is enabled by the ability of developers like FPEL to deliver commercially competitive, scalable power solutions across a wide industrial base.

Four core enablers have underpinned the rapid growth of renewable C&I power in India.

1. Robust demand from India's industrial economy. India's strong industrial growth (averaging over 10% annual increase in electricity demand for the C&I sector), together with an increasing focus on environmental targets, has created a large market for low-cost, low-carbon alternatives to traditional grid supply.

2. Targeted regulatory reform has created an enabling environment for renewable energy adoption. India has implemented a suite of national policy reforms that have overcome regulatory hurdles and improved the economics of renewable energy. These include the GEOA rules, the waiver of interstate transmission system charges, and the GNA framework. These measures have enabled the rise of large-scale, centralised open access renewable projects that supply customers across state lines, significantly lowering costs and complexity for developers like FPEL.

3. Increased access to long-term capital has supported a shift to open access models and rapid scale-up. As the market has matured, access to capital (including from institutional investors) has played a critical role in financing the transition from rooftop systems to large-scale open access projects. FPEL's own growth has been enabled by mezzanine debt from BII, which has in turn helped to unlock further investment from other DFIs.

4. Grid improvements are the bedrock to the expansion of large-scale open access projects. Significant public investment in India's national electricity grid over the past decade has enhanced grid reliability, reduced technical losses and enabled full national integration.

FPEL's success underscores the need for flexible, locally specific strategies. India's fragmented regulatory landscape means that no single model fits all geographies. FPEL has had to tailor its offerings (including onsite rooftop, offsite open access and hybrid models) to fit the specific rules, tariffs and grid conditions in each state. This experience highlights the importance of regulatory familiarity and business flexibility. It also reinforces the idea that successful replication in other markets will require similar adaptability to local policy and infrastructure contexts.

Renewable C&I power has strong potential for replication in other mature emerging markets, especially in Southeast Asia. FPEL is already testing its model in Southeast Asia, beginning with rooftop installations for multinational clients in Vietnam, Indonesia and Bangladesh. Southeast

Asian markets are particularly promising given their large industrial bases, improving grid infrastructure, carbon-intensive grids and growing emphasis on climate targets. FPEL's early projects leverage relationships with existing global customers seeking consistent sustainability standards across operations and are focused on onsite installations which are easier to execute and require fewer regulatory clearances. This early experience highlights the need for a deep knowledge of the local regulatory landscape and a need to build strong local partnerships.

Opportunities to replicate the open access model in Alpha and Beta countries may be more limited for now. In less developed markets, particularly in sub-Saharan Africa and frontier markets, the core enabling conditions for the open access model often do not yet exist. Weak or unreliable grid infrastructure, more limited access to finance and regulatory hurdles limit scalability. However, there may still be near-term opportunities for tailored solutions. For example, FPEL's development of hybrid solar-BESS systems for clients in India demonstrates a potential model for targeted applications to individual companies. These solutions are capital intensive, however, and are likely to be more suitable to larger firms with a particular focus on reliability of supply and decarbonisation targets.

9 Conclusions and recommendations

Conclusions

The C&I sector is emerging as a major driver of renewable energy growth in India and is playing a critical role in India's national energy transition.

India's C&I sector accounts for over 50% of the country's electricity demand and is transitioning rapidly to renewable energy. The C&I sector has seen a dramatic shift in power sourcing over the past decade (from grid and captive fossil-based supply to a growing portfolio of renewable solutions). This transformation has been largely private sector-led and enabled by developers like FPEL, which have built scalable, commercially viable solutions tailored to India's industrial base and policy environment.

FPEL's shift from rooftop to open access has enabled rapid scale-up, made possible by access to finance and grid integration.

FPEL's growth in recent years mirrors the wider transition of the sector in India. Since BII's initial investment, FPEL has expanded from decentralised rooftop systems to large-scale open access and hybrid projects. This transition has been enabled by stronger grid infrastructure, policy reform and the availability of BII's mezzanine finance, which provided growth capital at a stage when such financing was otherwise difficult to access and gave confidence to follow-on investors including Norfund, IFC, ADB and DEG. The regulatory landscape in India varies by state, and FPEL has adopted a flexible approach to adapt to these local realities.

FPEL's clients are adopting C&I power primarily to meet climate goals and reduce costs – resulting in substantial environmental and economic impact.

Public statements show that 76% of FPEL's clients adopt renewable C&I primarily to meet corporate decarbonisation targets, followed closely by cost savings of around 30–50% compared to grid power. The study estimates that FPEL's power solutions avoid 3.23 million tonnes of CO₂ annually and generate USD 344 million in additional value added (or GDP) each year through cheaper electricity and higher productivity. Considering the capital cost of the installed renewable capacity, this means an economic payback time of 5.4 years when only considering the value added contribution and 2.8 years when valuing the carbon emissions avoided at USD 100 per tCO₂eq.

Renewable C&I can drive the electricity transition elsewhere but success depends on the presence of four enabling conditions: electricity demand, (especially from low-carbon sources), enabling policies, grid reliability and access to finance.

Replication of this model is most viable in mature emerging markets, particularly in Southeast Asia, where industrial demand is rising and infrastructure is improving. Full-scale open access models are less likely to succeed in countries where grid reliability and regulatory hurdles remain major challenges. In these contexts, for example in Nigeria, onsite solutions including rooftop solar and onsite solar-BESS hybrid solutions are more feasible since they don't rely on power being wheeled over the grid. These solutions are likely most applicable to larger firms with strong ESG mandates.

Recommendations

1 Continue to scale C&I investments in comparable markets through client-led regional partnerships.

BII should leverage its strong track record in India to deepen its support for scalable, commercially viable C&I platforms in countries with similar enabling conditions – particularly in Southeast Asia, South Africa, and other more developed emerging markets. Replication can be accelerated through client-led regional partnerships that leverage relationships with multinational clients operating across multiple countries. These partnerships can help de-risk early market entry in contexts with evolving regulation but strong corporate sustainability demand.

2 Maintain a flexible investment strategy that responds to local policy and grid contexts

Experience from India shows that the fragmented but rapidly evolving nature of energy policy and grid infrastructure demands a flexible investment strategy, rather than a one-size-fits-all approach. BII should be able to tailor its support to relevant solutions, ranging from rooftop solar to open access and hybrid solar-BESS systems, and pursue opportunities in niche segments where BII can continue to play an innovative role. In this context, BII should seek partners with deep regulatory understanding and strong local presence.

3 Use mezzanine finance strategically to sustain growth and unlock commercial capital.

Institutional capital by DFIs has been catalytic to FPEL's growth, with BII making an important contribution through several channels, including the provision of mezzanine capital at a time when such financing was not commercially available in the Indian market. This flexible form of capital enabled FPEL to maintain its rapid growth trajectory while bridging to a subsequent equity raise and contributed to unlocking additional commercial capital. BII's non-financial support, particularly in strengthening FPEL's ESG systems and policies, further supported the company in meeting the requirements of subsequent institutional investors.

4 Explore targeted, resilience-focused solutions in frontier markets.

In markets where grid infrastructure remains weak, BII should explore firm-level interventions using onsite applications, including rooftop solar and solar-BESS hybrid systems for clients with strong ESG commitments and high reliability needs.

5 Quantify climate and economic outcomes where feasible.

This study demonstrates that robust estimates of impact can be developed using investee data and recent secondary data sources (including the most recent WBES), even where direct access to end users is limited. BII can replicate this modelling approach to assess climate and economic outcomes for clean power investments in other contexts where electricity displaces more carbon-intensive grid supply.

Annex I World Bank Enterprise Survey analysis results

Table 4 Lost time and lost sales as a result of outages by sector (WB Enterprise Survey)

	Average of Lost time	Average of sales lost (%R)
Basic Metals	0.35%	0.60%
Chemicals and Chemical Products	0.33%	0.86%
Construction	0.37%	1.07%
Fabricated Metal Products	0.41%	1.25%
Food	0.47%	1.36%
Garments	0.27%	0.94%
Hotels	0.25%	0.78%
IT & IT Services	0.27%	0.70%
Machinery & Equipment	0.28%	0.72%
Motor Vehicles	0.38%	1.09%
Non-Metallic Mineral Products	0.27%	0.75%
Other Manufacturing	0.29%	0.71%
Other Services	0.23%	0.82%
Restaurants	0.28%	0.92%
Retail	0.28%	0.80%
Textiles	0.23%	0.71%
Wholesale	0.30%	0.93%
Grand Total	0.31%	0.87%

Table 5 Lost time and sales due to outages by state (WB Enterprise Survey)

	Average of Lost time	Average of sales lost (%R)
Andhra Pradesh	0.07%	0.39%
Arunachal Pradesh, Nagaland	0.02%	0.36%
Assam	0.01%	0.06%
Bihar	0.12%	0.18%
Chhattisgarh	0.00%	0.22%
Delhi	0.02%	0.03%
Goa	0.14%	1.24%
Gujarat	0.03%	0.06%
Haryana	0.05%	0.27%
Himachal Pradesh	0.79%	1.03%
Jammu & Kashmir (union territory)	1.27%	2.46%
Jharkhand	0.08%	0.24%
Karnataka	0.54%	1.88%
Kerala	0.55%	2.46%
Madhya Pradesh	0.05%	0.29%
Maharashtra	0.10%	0.43%
Odisha	0.00%	0.00%
Punjab	1.59%	2.73%
Rajasthan	0.05%	0.07%
Tamil Nadu	1.17%	3.52%
Telangana	0.25%	0.47%
Uttar Pradesh	0.13%	0.80%
Uttarakhand	0.07%	0.76%
West Bengal	0.19%	0.32%
Grand Total	0.31%	0.87%

Annex II Model used to estimate value addition from increased electricity usage and data

To estimate the value add associated with the consumption of lower-priced power generated by Fourth Partner from firm-level data in the World Bank Enterprise Survey requires the following steps:

1. Estimate the increase of physical power consumption (ΔE_{kWh}) resulting from the lower price (ΔP) of Fourth Partner-generated power as well as the associated change of power costs (ΔE)
2. Estimate the increase of economic output (ΔY) resulting from the increased power consumption (ΔE_{kWh}) per economic sector or per state
3. Translate economic output (Y) and the costs of intermediary materials (M) and power (Y) costs into value added per kWh (VA_{kWh})
4. Calculate total value added per sector or state by multiplying the value added per kWh results with the kWh generated by Fourth Partner in that sector or state

Step 1: Estimating additional electricity consumption due to lower prices

This step gives the basis for estimating how much more electricity FPEL clients will use as a result of cheaper power.

Average electricity price for industrial users in 2022 was ₹8/kWh. Fourth Partner estimates that it offers clients a 30–50% lower price for power (₹4.0–4.5/kWh stated during interviews with FPEL staff).

On top of the energy price there is also an equity contribution which depends on the length of the contracts and not on energy use. The estimations made in this study use a conservative figure of 30% lower price, i.e. ₹5.6/kWh. This means that the equity contribution paid to Fourth Partner is equal to approximately ₹1.1–1.6/kWh, which agrees with estimations provided by Fourth Partner staff.

The change of the kWh power consumed, ΔE_{kWh} is a function of the price elasticity of demand, ε , the relative change of price P and the current kWh power consumption E_{kWh}

$$\Delta E_{kWh} = -\varepsilon \cdot \frac{\Delta P}{P} \cdot E_{kWh}$$

A price elasticity of -0.63 for industrial electricity demand in India is used in this report⁶² and reflects how firms adjust electricity consumption when prices change.⁶³ With the relative change of price of 30%, this means that power consumption increases by $0.189 \cdot E_{kWh}$. In monetary terms, total power costs change as follows:

$$(E_{kWh} + \Delta E_{kWh}) \cdot (P + \Delta P) - E_{kWh} \cdot P = 1.189 \cdot (1 - 30\%) \cdot E_{kWh} \cdot P = 0.832 \cdot E_{kWh} \cdot P$$

This means that while firms consume 30% more power, they spend 16.8% less on power.

Step 2: Estimating increased economic output from increased power consumption

Absent access to Fourth Partner client data, the second step uses firm-level data from the WBES to estimate how economic output changes in response to increased power consumption. Although the WBES has panel data in India for a limited number of firms, the panel only consists of the years 2014 and 2022. Because of the changes in India's manufacturing and electricity

⁶² Tran, N. D., Sahu, N. C. and Kumar, P. Estimation of income and price elasticities of Indian electricity demand, *The Electricity Journal* 36(5), 2023

⁶³ This is a short-run response based on the current fixed assets.

sector, as well as to increase the sample size, we decided to only use the 2022 data. In the analysis hereafter, that means we deploy a cross-sectional rather than a longitudinal analysis.

In this analysis we assume a Cobb-Douglas production function:

$$Y = A \cdot K^{\alpha} L^{\beta} M^{\gamma} E^{\delta}$$

Y = Firm output (₹)

A = Total factor productivity

K = Capital (₹)

L = Labour cost (₹)

M = Material costs (₹)

E = Electricity cost (₹)

Greek letters = Factor shares

More complex forms of production functions (e.g. the constant elasticity of substitution (CES) function) are available to overcome some of the constraints of the Cobb-Douglas production, namely perfect substitutability of inputs and absence of technological interaction between inputs.⁶⁴ But absent panel data of sufficient quality, the reduced estimation complexity and superior interpretability of the Cobb-Douglas function make it a reliable workhorse of micro-economic analysis of firm behaviour.⁶⁵ Importantly, as will be shown in the results, the Cobb-Douglas production function describes decreasing marginal returns to the use of inputs, which is important for the analysis here. The factors in the Cobb-Douglas production function should ideally be stated in unit rather than monetary terms, in order to see the technological relationships more directly. In practice, this introduces issues of comparability between sectors (e.g. different types of labour, very many different types of intermediary materials, etc.⁶⁶ And while in longitudinal analysis the relationships could be affected by price changes, in the cross-sectional approach taken here, that is not so much of an issue. Finally, data is hardly ever available in terms of units, and the WBES data used here indeed only captures monetary data.

The factor shares are determined through log-linear regression analysis of 4,029 Indian companies from the WBES 2022: for (a) all companies in an industrial sector; and (b) all companies within a state. The results are shown in Table 6 and Table 7. Note that the estimations at the sector level are all highly statistically significant (p-values < 0.01), whereas the results at the state level are much less so. This is because the heterogeneity between firms in a sector is much less than the heterogeneity of all firms within a state.

By taking the derivative of the Cobb-Douglas function with respect to a change to E , the increase of output ΔY is obtained:

$$\Delta Y = \delta \cdot \frac{\Delta E}{E} \cdot Y$$

Because of the cross-sectional nature of the regression and by assuming that all firms in the WBES sample paid the same price P (₹8/kWh), ΔY can be written in physical unit (kWh) terms:

$$\Delta Y = \delta \cdot \frac{\Delta E_{kWh}}{E_{kWh}} \cdot Y = 0.189 \cdot \delta \cdot Y$$

Finally, when output increases, the demand for intermediary materials increases proportionally:

⁶⁴ Another example is given by J. Colmer, D. Lagakos and M. Shu, *Is electricity sector a weak link in development?* LSE, 2024.

⁶⁵ Balk, B. M., Why is the Cobb-Douglas production function so popular? *Evolutionary and Institutional Economics Review* 21, 2024

⁶⁶ Using physical units renders any production function dimensionally inconsistent. In monetary terms, the Cobb-Douglas function is dimensionally meaningful, provided that economies of scale remain constant (i.e. the sum of factor shares equals 1).

$$\Delta M = \frac{\Delta Y}{Y} \cdot M = 0.189 \cdot \delta \cdot M$$

The reason that factor share γ does not feature in this equation, unlike δ , is because intermediary demand is driven by the increase of output, whereas an increase of electricity consumption drove the increase of output.⁶⁷

Step 3: Deriving value added results per kWh of electricity consumed

The value added of a firm is equal to its income on capital and labour, which is equal to its output minus intermediary materials and electricity. For all WBES companies in a sector or a state, the value added that firms produce per kWh can be determined as:

$$VA_{kWh} = \frac{Y - M - E}{E_{kWh}} = \frac{Y - M - E}{E/P}$$

where Y , M and E are the observations in the WBES. This step gives estimates (by specific industrial sector and by state) of economic productivity per unit of electricity. In the analysis, electricity was priced at ₹8.0/kWh to reflect average grid conditions without connection to FPEL. Results by sector and state are presented in Table 6 and Table 7.

Driven by the increased use of electricity, output and (proportionally) intermediary material use increases, resulting in a change of value added per kWh:

$$VA_{kWh} + \Delta VA_{kWh} = \frac{(Y + \Delta Y) - (M + \Delta M) - (E_{kWh} + \Delta E_{kWh}) \cdot P_{kWh} \cdot 70\%}{(E_{kWh} + \Delta E_{kWh})}$$

in which the Δ terms have been defined in the sections above:

$$VA_{kWh} + \Delta VA_{kWh} = \frac{Y \cdot (1 + 0.189 \cdot \delta) - M \cdot (1 + 0.189 \cdot \delta) - 0.832 \cdot E}{1.189 \cdot E_{kWh}}$$

The results are again presented in Table 6 and Table 7. As can be seen, $VA_{kWh} + \Delta VA_{kWh} < VA_{kWh}$. This is as expected because of diminishing returns.

Step 4. Quantification of total value addition with and without connection to FPEL

The last step is to combine the FPEL kWh consumption per sector with the value added per kWh results derived in the previous step. The pre- and post-FPEL situations are given by:

$$VA^{\text{pre FPEL}} = VA_{kWh} \cdot E_{kWh}^{\text{pre FPEL}} = VA_{kWh} \cdot \frac{E_{kWh}^{\text{FPEL}}}{1.189}$$

$$VA^{\text{post FPEL}} = (VA_{kWh} + \Delta VA_{kWh}) \cdot E_{kWh}^{\text{FPEL}}$$

where E_{kWh}^{FPEL} expresses the amount of electricity (kWh) consumed by all companies in a sector.

The logic here is that as the lower prices incurred after becoming an FPEL customer, electricity consumption increased by a factor 1.189 x. The pre-FPEL situation thus is calculated by dividing by that factor. The difference between the post- and pre-FPEL situation is the value added that is attributable to the increased electricity consumption due to FPEL's lower prices:

$$VA^{\text{FPEL}} = VA^{\text{post FPEL}} - VA^{\text{pre FPEL}}$$

When applied across FPEL's estimated electricity supply and mapped to sectors in the WBES analysis, the total additional value added attributable to increased power usage due to lower price is: ₹29.6 billion (USD 344 million).

⁶⁷ Intermediary material is included in the regression model to get a more reliable estimate of the factor share of electricity.

Total value added per kWh is ₹370⁶⁸ (USD 4.26) per kWh, which is, as expected, higher than the ₹268 (USD 3.11) per kWh for the entire Indian economy, which includes household consumption. Note that analysis is undertaken for open access generation only (which is 94% of FPEL electricity production).

Qualitative and quantitative assessment of the main assumptions

The methodology described above relies on several assumptions:

- i. Use of cross-sectional secondary rather than longitudinal primary data
- ii. Price elasticity used
- iii. Use of the Cobb-Douglas production function to quantify the factor elasticity of electricity.

We qualitatively and quantitatively assess the validity of those assumptions below.

Cross-sectional secondary data

Absent primary ex ante and ex post production data of FPEL clients, the use of secondary data is inevitable. This means that each of FPEL's clients is assumed to behave like the average of the sector it is classified in. The more granular the sector classification, the less restricting this assumption is, especially when considering a portfolio of clients which allows for averaging out of unbiased individual estimation errors. The WBES is focused on manufacturing clients, and the 10 sectors used to map FPEL clients is in our opinion sufficiently granular.

In estimating production functions, one ideally uses longitudinal data over cross-sectional regression because it tracks the same firms or units over time, allowing for the identification of dynamic effects and causal relationships rather than mere associations. This approach also helps control for unobserved heterogeneity, reducing bias and improving the reliability of the estimated elasticities. The WBES would allow for longitudinal regression based on only two years, 2014 and 2022, and for a significantly smaller sample of firms. Because of the large changes in the Indian economy (production technologies, prices of inputs, etc.) over this long period between the observations, we preferred the larger sample of just the 2022 survey.

Price elasticity

Price elasticity is an estimate at one point in time: it depends on the shape of the demand curve for electricity as well as on the current price. It amalgamates the different price sensitivity of individual firms and thus masks underlying heterogeneity and unobserved behaviour of firms. To test the sensitivity of this assumption, we performed the calculation with a price elasticity twice as small as the currently used -0.63 .⁶⁹ This causes the value added attributable to FPEL's cheaper electricity to reduce by 36%. Reductions per sector range from 22% to 40%. The fact that the value added results go down less than the price elasticity is because of the diminishing marginal returns on greater use of inputs.

Factor share of electricity

The last factor to discuss is the estimation of the factor share of elasticity δ . In addition to the previously mentioned assumption on cross-sectional estimation, the regression also assumes

⁶⁸ ₹ 1,070,967 million divided by 2,890,825 MWh equals ₹370 per kWh.

⁶⁹ The elasticity used in this analysis (-0.63) is within the range applied in other empirical work. For example, Zhang et al. (2024) estimate an energy price elasticity of 0.54 for emerging economies (*Environmental Science and Pollution Research*, <https://doi.org/10.1007/s11356-024-35423-y>), which is comparable to the value used here.

the parametric form of the Cobb–Douglas production function, which was discussed before. The factor share for electricity in the Cobb–Douglas function might be estimated too high due to multicollinearity with other inputs, particularly capital, as their high correlation can make it difficult to disentangle the individual contributions of each factor from output. However, the use of the Cobb–Douglas function with cross-sectional regression is common. For example, Saliola and Seker used this approach to analyse total factor productivity across emerging markets.⁷⁰ The values we find for the factor shares for capital, labour, electricity and intermediary materials correspond well with those found in that report. In addition, the estimations are all highly statistically significant, as indicated by the p-value δ column in Table 6 being well below 0.01 (except for the sector Garments, which is not used in the results). We nevertheless tested the sensitivity of the results to the electricity factor share δ by assuming they are half the values indicated in Table 6. This causes the value added attributable to FPEL’s cheaper electricity to reduce by 43%. Reductions per sector range from 29% to 48%.

⁷⁰ Saliola, F. and Seker, M. Total Factor Productivity across the developing world. *Enterprise Note 23*, World Bank, 2011

Table 6 Regression results and value added per kWh (by sector)

Sector	δ	p-value δ	γ	p-value γ	#	Y (₹ million)	E (₹ million)	M (₹ million)	VA _{kWh} (₹ / kWh)	VA _{kWh} + Δ VA _{kWh} (₹ / kWh)
Basic Metals	0.110	0.000	0.633	0.000	384	342,732	3,377	193,760	345	297
Chemicals & Chemical Products	0.150	0.000	0.543	0.000	293	284,570	2,105	158,604	451	409
Fabricated Metal Products	0.080	0.001	0.557	0.000	396	196,823	1,562	111,666	428	367
Food	0.086	0.000	0.575	0.000	343	149,424	1,604	90,266	287	247
Garments	0.073	0.013	0.507	0.000	369	182,364	1,208	99,955	538	460
Machinery & Equipment	0.125	0.000	0.505	0.000	298	181,792	2,583	103,730	234	203
Motor Vehicles	0.080	0.004	0.621	0.000	254	211,294	1,525	122,751	456	391
Non-Metallic Mineral Products	0.139	0.000	0.464	0.000	330	170,935	2,610	90,953	237	206
Other Manufacturing	0.081	0.000	0.586	0.000	810	443,808	5,075	239,268	314	270
Textiles	0.110	0.000	0.498	0.000	420	162,706	1,182	92,257	469	404
All sectors	0.104	0.000	0.548	-	4029	2,360,571	23,141	1,321,284	351	302

Table 7 Regression results and value added per kWh (by state)

State	δ	p-value δ	γ	p-value γ	#	Y (₹ million)	E (₹ million)	M (₹ million)	VA _{kWh} (₹ / kWh)	VA _{kWh} + Δ VA _{kWh} (₹ / kWh)
Andhra Pradesh	0.303	0.000	0.513	0.000	122	15,589	398	6,836	168	151
Arunachal Pradesh, Nagaland, Mani	0.097	0.148	0.586	0.000	75	8,847	87	4,255	415	357
Assam	0.156	0.000	0.616	0.000	189	81,134	1,637	29,625	244	212
Bihar	0.074	0.091	0.495	0.000	115	22,801	93	14,758	682	583
Chhattisgarh	0.160	0.000	0.579	0.000	142	70,660	295	49,273	573	498
Delhi	0.058	0.061	0.734	0.000	152	30,447	429	14,495	289	247
Goa	0.053	0.178	0.513	0.000	103	88,444	2,224	61,071	90	78
Gujarat	0.202	0.000	0.569	0.000	219	174,718	882	109,491	584	511
Haryana	- 0.113	n/a	0.684	0.000	117	65,079	673	28,662	425	351
Himachal Pradesh	0.052	0.080	0.805	0.000	145	360,191	1,296	205,548	947	805
Jammu & Kashmir (union territory)	0.111	0.002	0.823	0.000	55	82,855	429	50,051	604	520
Jharkhand	0.141	0.000	0.612	0.000	164	45,036	364	28,653	352	305
Karnataka	0.051	0.055	0.561	0.000	203	48,023	778	24,949	229	196
Kerala	0.074	0.125	0.501	0.000	126	65,941	1,572	30,573	172	148
Madhya Pradesh	0.130	0.005	0.553	0.000	145	40,129	666	13,104	316	274
Maharashtra	0.121	0.000	0.465	0.000	340	106,876	662	65,965	486	420
Odisha	0.117	0.000	0.675	0.000	177	65,760	220	43,017	821	707
Punjab	- 0.017	n/a	0.828	0.000	213	273,762	2,127	171,776	376	316
Rajasthan	0.071	0.010	0.665	0.000	213	131,975	2,235	75,603	194	166
Tamil Nadu	0.372	0.000	0.248	0.000	123	52,332	877	5,699	417	377
Telangana	- 0.025	n/a	0.320	0.000	120	20,576	179	6,514	620	520
Uttar Pradesh	0.077	0.000	0.813	0.000	265	260,932	2,008	129,333	516	442
Uttarakhand	0.164	0.000	0.637	0.000	153	205,192	2,903	120,295	226	197
West Bengal	0.078	0.002	0.576	0.000	238	43,271	107	31,738	855	731

Annex III Summary of datasets and sources used in modelling

1. Data provided by FPEL

Installed capacity (MW) – disaggregated by solution type and state

Estimated electricity supply (kWh) – disaggregated by sector

Average tariff offered to clients (₹/kWh)

Breakdown of client sectors – mapped to WBES sectors

2. Secondary datasets used

World Bank Enterprise Survey (WBES), 2014 and 2022, including panel dataset

National industrial electricity tariff data (source: Indian state electricity regulatory commissions and CERC reports)

IFI Harmonised Default Grid Emission Factor for India (source: IFI Harmonised Framework for GHG Accounting, 2022 update)

World Bank electricity sector diagnostics

International Energy Agency data on grid performance and losses

India Central Electricity Authority data on grid performance



We provide expert monitoring, evaluation, learning and strategy services to help build a more equitable and sustainable world for all.

itad.com

[X @ItadLtd](#)

[in Itad](#)

mail@itad.com

Itad Ltd

International House
Queens Road
Brighton, BN1 3XE
United Kingdom

Tel: +44 (0)1273 765250

Itad Inc

c/o Open Gov Hub
1100 13th St NW, Suite 800
Washington, DC, 20005
United States