

Utility-scale solar deployment

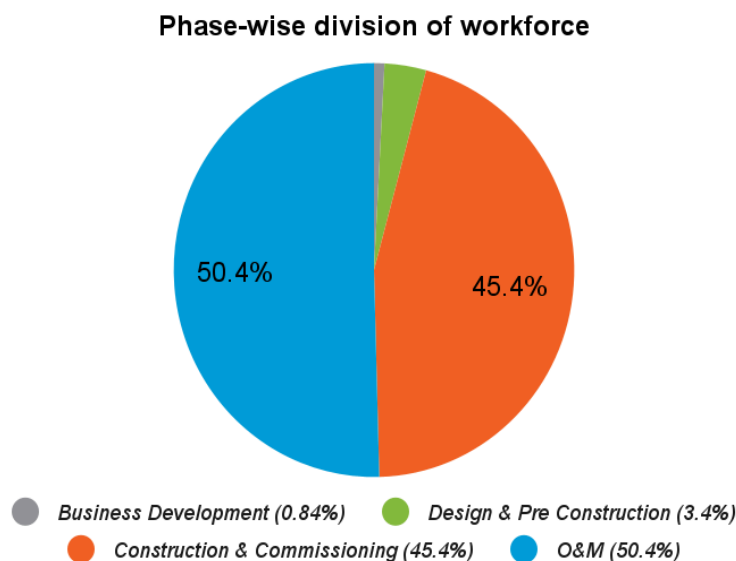
The Ministry of New and Renewable Energy (MNRE) assessed the technical potential of solar energy is 25 GW, assuming 3 per cent land utilisation (MNRE 2024). With higher land utilisation¹, this goes up to 149 GW (Singh et al. 2023) in Odisha. This presents a humongous opportunity to meet the Central RPO target of 43.33 per cent by 2030 (Ministry of Power, 2022) and ensure energy security. Odisha currently relies heavily on imports to meet its renewable energy target with 58 per cent of electricity generated from solar contracts and 436 MW of solar installed capacity within the state (DoE, 2023). This shows that there is a large need for greater solar generation and sizable available technical potential in the state.

Opportunities for 2030

Jobs overview

- Based on CEEW employment coefficients (Neeraj et al. 2017), it is estimated that If Odisha installs ~7,970 MW of utility-scale solar capacity by 2030, it can generate **6,940 FTE jobs**²

Figure 1: Phase-wise division of workforce



Source: Authors analysis adapted from Kuldeep et al. 2017

¹ MNRE/NISE assumes 3 per cent waste land utilisation while Singh et al., 2023 assumes higher utilisation of 50 to 10 percent in five key wasteland categories of open scrub, mining wasteland, industrial wasteland, dense scrub and rocky/stony land.

² Annexure

Market opportunity

- The market opportunity³ in the year 2030 in terms of revenue accruals from the sale of electricity is **INR 2,700 crore (USD 330 mn)**⁴
- **High potential districts: Koraput and Gajapati** are the high-impact districts for ground-mounted solar (as per NISE and Singh et al., 2023). Koraput and Gajapati account for 7 per cent of the wasteland share as per iForest in Odisha with high assessed potential and experience substantially higher insolation⁵ as compared to the average insolation received by the state⁶.

Investment opportunity

- The investment opportunity by 2030 is **INR 40,000 crore (USD 4,900 mn)**⁷.

Why should Odisha invest in utility-scale solar deployment?

1. Energy security for the state - Since Odisha imports a majority of its RE requirement from other states wherein, in 2021-22, 58 per cent of contracted electricity from solar and 100 per cent of contracted electricity from wind was installed outside the state. With the elapsing of ISTS⁸ waiver being offered by the Government of India for projects commissioned post 2025, procuring RE from other states will be more expensive and thus, this threatens not just energy security but also industrial growth in the state due to increasing costs to commercial and industrial consumers. Therefore, it is important to build internal RE capacity within the state to safeguard from such risks and secure energy security.
2. Attract investment, generate employment and arrest migration - As per a 2014 study (Sharma et al. 2014) 30 per cent of households in Odisha have one or more members migrating for work. A more recent estimate of 2022 (Johnson et al. 2022) shows that 18-31 percent of households have at least one person migrating for work. Deploying utility-scale solar can help arrest migration since it has huge employment potential. Further, ~50 per cent of jobs are created in the operations and maintenance phase which indicates high potential for creation of permanent, resilient jobs which do not depend on the year-on-year fluctuations in installed capacity. Additionally, ~45 per cent jobs are created during construction & commissioning, which are temporary in nature (~4-5 months). Thus, it becomes important to have a sustained deployment trajectory to ensure constant employment.

³ A majority of these plants will be deployed by private sector players/central PSU developers and thus, this revenue will not be accruing to Odisha alone

⁴ Annexure

⁵ Insolation - Extent of exposure to sun's rays

⁶ Koraput district is a highly industrial area and a potential manufacturing hub (The New Indian Express 2022) as well while Gajapati is highly agrarian and can potentially house certain socio-economic conflicts. We have not considered factors like land prices, conflicting land use in the analysis currently.

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⁸ Inter State Transmission System

3. Industrial growth and prosperity - Deployment of RE technologies and manufacturing of associated equipment go hand in hand. Maintaining a sustained deployment trajectory is one of the key requirements for manufacturers to set up facilities. Thus, having a focused target for deployment and a constant trajectory will help the evolution of the ecosystem for manufacturing of RE equipment in the state and creation of a local supply chain.

Inspiration from a success story



The Pavagada Solar Park is the second largest solar park in India commissioned in 2019 which spreads over ~13,000 acres in the Pavagada Taluk of Tumkur district in Karnataka with an installed capacity of 2,000 MW (NS Energy, 2020). It successfully showcases the land lease model and developer contribution to local villages. The project was managed by the Karnataka Solar Power Development Corporation (KSPDCL), a joint venture between the

state renewable energy development agency (KREDL) and SECI, specifically created for the park to ensure smooth land procurement and efficient park management. It successfully implemented the land leasing model of land procurement wherein an initial annual rent of INR 21,000 per acre with a 5 per cent escalation amount every two years was offered to ~2,300 farmers from whom the land was leased for 28 years (Government of Karnataka). This arrangement helped the drought-hit area wherein they experienced droughts in 54 of the last 60 years (Blackridge Research, 2023). Further, as per MNRE guidelines, 1 per cent of the total investment made for setting up the park (~INR 1 billion) was contributed to a local area development fund (LADF) (KSPDCL, 2018) which was used to develop local infrastructure in the form of streetlights, local schools, healthcare equipment and infrastructure, etc. (KSPDCL, 2018).

Who could support in scaling utility-scale solar deployment?

1. Role of departments:

- a. GRIDCO Odisha - GRIDCO, as the Nodal agency to look into timely tendering of projects, ensuring participation from private sector and timely clearances. GRIDCO Odisha could also look into scaling large-scale storage systems such as battery energy storage systems (BESS), plan for flexible thermal generation along with OERC and other generation companies, and build capacities to undertake robust demand and generation forecasting to prepare the grid for intermittency.
- b. Department of Energy (DoE): Department of Energy to play an important role in setting targets for solar deployment and estimating a trajectory of deployment. Land may be made available to developers for ease of deployment, and DoE, GRIDCO, Revenue Department and IPICOL to ensure responsible practices in land procurement to reduce delays in commissioning.

- c. Odisha Power Transmission Corporation Limited (OPTCL) - OPTCL under the Odisha Distribution System Strengthening Project (ODSSP) (OERC 2015) to look into building transmission and distribution networks in prospective areas.
 - d. Odisha Electricity Regulatory Commission (OERC) - OERC to work closely with Odisha Renewable Energy Development Agency (OREDA) to set ambitious RPO targets for the state and ensure adherence and implementation.
 - e. Ministry of New and Renewable Energy (MNRE): MNRE could ensure manufacturing uptake of solar components and lower costs via R&D incentives like capital expenditure subsidy, and incentivise higher adoption of indigenous products across the value chain. Further, the Department of Science and Technology could invest in R&D in the sector and lead industry-academia collaborations.
2. **Role of local administration and civil society organisations (CSOs)** - Local administration like the gram panchayat and CSOs like Gram Vikas can enable responsible practices to be undertaken during deployment of utility scale solar. This includes facilitating skill development of local communities, working with developers for local area development, acting as a link between the community and solar developers, etc.
 3. **Role of the private sector** - Private sector to work closely with academic institutions, think tanks and research organisations for R&D to improve module manufacturing technology and invest to develop capacity for upstream components of solar modules like wafers and ingots to reduce costs and increase generation capacity. Further, developers' to ensure responsible deployment of renewable energy to minimise delays in project deployment and maximise social and economic benefits. This includes ensuring responsible land procurement practices, providing jobs to local communities and conducting local area development works, etc.

Overcoming challenges to scale utility-scale solar deployment

1. Challenges related to land procurement

- a. Land procurement and acquisition is one of the largest challenges for utility-scale solar in India due to reasons like competing land uses, land disputes, socio-cultural norms of land ownership and administrative processes, identifying suitable land parcels and acquiring them (Gagal 2022a). Specifically in Odisha, due to competing demands from sectors like agriculture and urbanisation, lack of suitable land for solar is a key issue (Kharvi A.S. 2023).

To overcome this, it becomes important to employ a host of strategies and suitably apply them as per local needs. To minimise social risk to investment, developers should deploy solar projects in a responsible and socially inclusive and equitable manner. This includes undertaking private land leasing instead of land acquisition (Rai 2023), deploying projects in zones of low socio-economic conflicts through proper siting (Deshmukh et al. 2017), undertaking stakeholder consultations to

understand the impact on local communities and establishing a mitigation strategy (WRI 2021), ensuring mutual consent and principles of participatory governance, consensus building and Free, Prior and Informed Consent (FPIC) are undertaken. Further, Odisha can also pilot utilising mining wastelands for utility-scale solar projects to understand the alternative uses of mining land given India's commitment to energy transition. However, the feasibility and applicability of doing so will need to be assessed in more detail.

2. Need for facilitating infrastructure

- a. Grid integration and maintaining stability is a key challenge due to the intermittent nature of solar energy and the problem of load balancing (Kulkarni, P). To address this challenge, technical and regulatory interventions such as strengthening transmission infrastructure, deploying utility-scale storage capacity and making thermal generation flexible become important (Aggarwal et al. 2019). Deploying battery energy storage solutions along with utility-scale solar not only enables maintaining grid stability but also addresses the loss of solar generation during non-peak hours and helps tackle the issue of variability in generation. Further, demand forecasting and generation forecasting is essential to aid advance planning for grid strengthening and balancing.
- b. Development of transmission infrastructure in line with development of the renewable sector is also extremely important to ensure robustness and handle the variable and intermittent nature of solar energy. If existing substations need to be augmented or new substations need to be built, it usually leads to a delay of 18 - 22 months in project execution timeline (Selna et al 2019). Further, weak transmission grid leads to challenges related to transmission line overloading, losses of electricity transmission, frequency and voltage issues, etc (Gagal 2022b).

Thus, a strong transmission infrastructure should be a key priority of states. To ensure the development of the transmission system, adequate interventions are required to address challenges related to Right of Way (ROW) for power transmission. These interventions include undertaking socially beneficial measures under CSR for those impacted by transmission line construction to reduce local resistance, adapting new innovative technologies like a compact tower design and increasing utilisation of existing lines through Update and Upgrade, etc (Gupta et al. 2022).

3. Supply chain challenges

- a. Post introduction of the Production Linked Incentive (PLI) scheme for integrated solar manufacturing in 2021, India is set to achieve 100 GW of module capacity by 2026 (Bloomberg 2023). However, it still relies 100 per cent on China for import of wafers, polysilicon and other backward linkages (Gulia et al. 2022). Further, 56 per cent and 66 per cent of cells and modules respectively are imported from China as of FY24

(CID 2024). This creates a huge risk for Indian supply chain stability and poses a threat to energy security. It is important to incentivise domestic manufacturing, especially creating the space for more backward linkages through upgradation of infrastructure facilities and setting up integrated platforms for raw material suppliers, undertaking skill development measures⁹, etc.

Risk-proofing the scale-up of utility-scale solar deployment

1. Environmental and social risks

- a. An average of four to five acres of land is required for deployment of one megawatt of solar energy (MNRE 2016). This leads to various concerns regarding food security and biodiversity related issues. The Nature Conservancy (TNC) found that over 85 per cent of solar projects in India were built on land cover types that could create potential biodiversity and food security related conflicts with 67.6 per cent agricultural land and 18.7 per cent of natural habitat (Shivaprakash, 2022). Major concerns include impact on agricultural production, effect on local natural resources like soil, groundwater, natural habitat, socio-economic concerns arising from loss of agricultural income, loss of grazing land, etc (World Resources Institute, 2021).

Mitigation: Developers may conduct environmental and social assessments including stakeholder discussions once land is identified and before procurement of the land. Concerns arising out of the assessment may be rectified, or plan for mitigation may be developed (Davis et al., 2020).

- b. Further, there are risks related to intensive water use associated with solar panel operation and maintenance wherein ~24,000 litres of water are required for a 1 MW solar park per wash (once a week) (Renewable Watch, 2022). Typically during O&M phase, 60 per cent of water for cleaning comes from the ground through borewells whereas the remaining 40 per cent from surface water sources like rivers, canals, etc (WRI 2021). This leads to water- related conflicts with local communities who are dependent on the sources of water for their livelihood.

Mitigation: To overcome concerns related to water use, newer technology technologies like robotic dry cleaning of modules are being used by developers (Bureau DQI, 2022), which helps increase efficiency of panels and avoids large- scale usage of water. It is important to invest in such technologies and encourage R&D to ensure further adaptation and increased affordability.

- c. Solar panels have a lifespan of 25-30 years and the International Renewable Energy Agency (IRENA) estimates that global PV waste will touch 7-8 million tonnes by 2050 with India being one of the top five PV waste creators (Ali et al., 2016). Further, the expected cumulative waste from existing and new capacity in India is 600 kilotonnes

⁹ More details on incentivising domestic manufacturing for renewable energy equipments is mentioned in the separate note on Renewable Energy Manufacturing

by 2030 and 19,000 kilotonnes by 2050 (MNRE and CEEW 2024). PV module waste is a huge risk given that they contain various hazardous toxins.

Mitigation: - PV module waste disposal management and recycling is important to ensure sustainable and environment- friendly deployment of utility- scale solar keeping in mind end of life challenges. Steps like second-life use of sub-standard modules, incentives like green certifications to promote recycling, (Tyagi and Kuldeep, 2021), building waste management infrastructure for solar modules and research and investment in recycling technologies should be undertaken to ensure circularity in solar deployment (MNRE and CEEW 2024).

Annexure

Scoping of the solar deployment value chain

The solar value chain consists of several segments: 1) mining, raw materials extraction and processing, 2) component manufacturing, 3) deployment, and 4) end-of-life-cycle management.

In this section we estimate jobs and market only for the ‘deployment’ segment of the solar value chain. The deployment segment of the solar value chain further consists of four phases: 1) business development, 2) design and pre-construction, 3) construction and commissioning, and 4) operations and maintenance. All these sub-phases have been considered for jobs estimation.

Mining, raw materials extraction and processing has been excluded since the production of minerals such as cobalt, copper, etc. needed for low-carbon technologies are concentrated in a handful of countries such as China, South Africa, etc (CEEW 2023). In addition, mining and raw material extraction caters to diverse sectors and cannot be attributed to clean technologies alone.

We have excluded component manufacturing as it has been covered as a subpart of RE manufacturing. End-of-life-cycle management is largely looked at under circular economy, although not as a part of this report.

Jobs and market estimation

Jobs estimation:

Total number of jobs that can be created through solar deployment in Odisha by 2030 is calculated using phase-wise full-time equivalent (FTE) per MW coefficients and potential market size.

Table 1: The phase-wise FTE considered are as follows:

Table 1

Sl. No.	Phase	FTE/MW
1.	Business Development	0.05
2.	Design and Pre-Construction	0.2
3.	Construction and Commissioning	2.7
4.	Operations and Maintenance	0.5
5.	Total	3.45

Source: Kuldeep et al., 2017

The first three phases of project deployment (i.e. business development, design and pre-construction, as well as construction and pre-commissioning) create one-time jobs whereas in

the last phase of the project (i.e. operations and maintenance), the employment generated lasts for the lifetime of the project.

A linear trajectory of solar deployment is assumed and jobs are calculated in a manner that the workforce employed in one year will be reabsorbed in deployment of solar energy in the next year for the first three phases of project deployment. This would help avoid double counting of jobs and align with the aim of creation of a renewable energy workforce that can offer sustained employment by accelerated deployments.

Market sizing (in units):

India’s 2030 target for cumulative solar is ~292 GW, which will enable India to meet its 2030 NDC target (CEA 2023). The share of rooftop solar out of this cumulative target in 2030 is ~61 GW (refer to the rooftop solar note for elaboration on the methodology). Thus, ground mount, large-scale solar amounts to 231 GW by 2030, assuming that it will form the remainder of the 2030 target.

Odisha’s technical potential for solar, as assessed by National Institute of Solar Energy, is ~3.44 per cent of India’s total solar potential. Assuming that the distribution of 2030 targets to states is as per the share of technical potential, Odisha’s 2030 target is derived from the total utility-scale solar target of 231 GW.

Market opportunity (in value) estimation

The market value of solar deployment through an ambitious scenario set for Odisha, has been estimated through forecasting the revenue generated from the sales of power in 2030. In order to convert MW ambitious scenario to MWh in terms of electricity generation, the following formula was used:

$$Capacity\ Utilisation\ Factor\ (CUF) = \frac{Injected\ energy\ (MWh)}{Project\ capacity\ (MW) \times 8766} \times 100$$

$$Revenue\ potential = Tariff\ rate\ (USD/kWh) \times Injected\ energy\ (kWh)^{10}$$

Further, a degradation rate and performance ratio has also been applied to account for the decline in performance with age.

The input values taken and rationale for each parameter are mentioned below:

Table 2

Sl. No.	Parameter	Value	Rationale
1.	CUF	20 per cent	CUF taken from Indian Technology Catalogue by CEA (CEA 2022)

¹⁰ 1 USD = INR 80

2.	Project capacity (MW)	19,500	Built as per the the scenario mentioned
3.	Tariff rate (INR/kWh)	2.63	An average of the tariff of two projects contracted in Odisha in 2022-23

Source: Authors' analysis

Investment opportunity estimation

To arrive at the investment opportunity when deploying the ambitious target for solar in Odisha by 2030, we multiplied the capital cost of utility scale solar per MW by the total additional capacity to be installed¹¹.

¹¹ As per the Indian Technology Catalogue by CEA, the capital cost of photovoltaics in large scale utility systems is INR 5.4 Cr per MW as on 2020

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