**Performance assessment of grid-interactive solar photovoltaic projects under India’s national solar mission**

Ishan Purohita and Pallav Purohitb[[1]](#footnote-1)

aInternational Finance Corporation (IFC), World Bank Group, New Delhi, India

bInternational Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria

**Table S.1. Annual Global Horizontal Irradiance over the locations of select solar PV power projects under NSM Phase-I**

|  |  |  |  |
| --- | --- | --- | --- |
| **Projects**  | **Nearest IMD****location** | **Nearest NIWE****location** | **Annual GHI (kWh/m2) through**  |
| **NIWE**  | **IMD** | **NASA** | **NREL** | **SWERA** | **Meteonorm 7.0** | **Meteonorm 7.1** | **SolaGIS** |
| 1. **Batch – I Projects**
 |
| 1. Aftaab Solar Pvt Ltd | Ranchi | Simliguda | 2135 | 1717 | 1817 | 2014 | 2009 | 1824 | 1884 | 1877 |
| 2. Alex Spectrum Radiation Pvt Ltd | Jodhpur  | Bodana | 1941 | 2017 | 1826 | 2082 | 2084 | 1896 | 1899 | 1955 |
| 3. Amrit Energy Pvt Ltd | Jodhpur  | Jodhpur | 1737 | 2017 | 1863 | 2162 | 2207 | 1968 | 1970 | 1928 |
| 4. Azure Power (Rajasthan) Pvt Ltd  | Jodhpur  | Mathania | 2175 | 2017 | 1953 | 2179 | 2086 | 2032 | 2033 | 1995 |
| 5. CCCL Infras. Ltd | Chennai | Ramnathpr | 2087 | 1957 | 1930 | 2161 | 2170 | 1972 | 1973 | 1982 |
| 6. DDE Renewable Energy Pvt Ltd | Jodhpur  | Amarsagar | 2379 | 2017 | 1868 | 2101 | 2134 | 1978 | 1980 | 1987 |
| 7. Mahindra Solar One Pvt Ltd | Jodhpur  | Jodhpur | 1737 | 2017 | 1839 | 2088 | 2063 | 1967 | 1970 | 1928 |
| 8. SaiSudhir Energy Ltd | Hyderabad | Kadapa | 2179 | 2070 | 1856 | 2112 | 1994 | 1905 | 1907 | 1985 |
| 9. Welspun Solar AP Pvt Ltd | Hyderabad | Kadapa | 2179 | 2070 | 1856 | 2125 | 2239 | 1946 | 1942 | 2006 |
| 10. Khaya Solar Pvt Ltd | Jodhpur  | Mathania | 2175 | 2017 | 1862 | 2134 | 2145 | 2032 | 1950 | 2020 |
| 11. Green Tech Power Pvt Ltd | Jodhpur | Bodana | 1941 | 2017 | 1862 | 2134 | 2173 | 1896 | 1943 | 2021 |
| 12. Vasavi Solar Power Pvt Ltd | Jodhpur  | Amarsagar | 2379 | 2017 | 1862 | 2133 | 2167 | 1978 | 1950 | 2020 |
| 13. Newton Solar Pvt Ltd | Jodhpur | Amarsagar | 2379 | 2017 | 1862 | 2133 | 2111 | 1978 | 1951 | 2022 |
| 14. Finehope Allied Engg. Pvt Ltd | Jodhpur  | Amarsagar | 2379 | 2017 | 1862 | 2133 | 2111 | 1978 | 1951 | 2022 |
| 15. Electromech Maritech Pvt Ltd | Jodhpur  | Amarsagar | 2379 | 2017 | 1862  | 2133  | 2111  | 1978 | 1951  | 2022  |
| 1. **Batch – II Projects**
 |
| 1. Welspun Solar AP Pvt Ltd | Jodhpur  | Jodhpur | 1737 | 2017 | 1826 | 2098 | 2098 | 1967 | 1978 | 1953 |
| 2. Welspun Solar AP Pvt Ltd | Jodhpur  | Jodhpur | 1737 | 2017 | 1826 | 2098 | 2098 | 1967 | 1978 | 1953 |
| 3. Welspun Solar AP Pvt Ltd | Jodhpur  | Jodhpur | 1737 | 2017 | 1956 | 2118 | 2103 |  1967 | 1937 | 1947 |
| 4. Symphony VyapaarPvt Ltd | Jodhpur  | Jodhpur | 1737 | 2017 | 1901 | 2098 | 2144 | 1903 | 1905 | 1973 |
| 5. Essel MP Energy Ltd | Pune | Osmanabad | 2277 | 1971 | 1901 | 2098 | 2144 | 1903 | 1905 | 1973 |
| 6. Sai Maithili Power Company | Jodhpur  | Phalodi | 2343 | 2017 | 1856 | 2138 | 2239 | --\* | 1972 | 1989 |
| 7. Mahindra Surya Prakash Pvt Ltd | Jodhpur  | Jodhpur | 1737 | 2017 | 1856 | 2125 | 2239 | 1953 | 1942 | 2006 |
| 8. Mahindra Surya Prakash Pvt Ltd | Jodhpur  | Jodhpur | 1737 | 2017 | 1856 | 2125 | 2239 | 1953 | 1942 | 2006 |
| 9. Saisudhir Energy Ltd | Hyderabad | Kadapa | 2179 | 2070 | 1856 | 2112 | 1994 | 1905 | 1907 | 1985 |
| 10. Fonroche Raajhans Energy Pvt Ltd | Jodhpur  | Pokhran | 2284 | 2017 | 1953 | 2179 | 2086 | 2041 | 2033 | 1995 |
| 11. Fonroche Saaras Energy Pvt Ltd | Jodhpur  | Pokhran | 2284 | 2017 | 2169 | 2096 | 2101 | 1956 | 1959 | 1989 |
| 12. Azure Solar Power Pvt Ltd | Jodhpur  | Mathania | 2175 | 2017 | 1856 | 2138 | 2239 | 1972 | 1956 | 2017  |
| 13. Azure Solar Power Pvt Ltd | Jodhpur  | Mathania | 2175 | 2017 | 1856 | 2138 | 2239 | 1972  | 1956 | 2017  |
| 14. Shree Saibaba Green Pvt Ltd | Pune | Osmanabd | 2277 | 1973 | 1930 | 2095 | 2098 | 1967 | 1971 | 1938 |
| 15. Lexicon VanijyaPvt Ltd | Jodhpur  | Jodhpur | 1737 | 2017 | 1856 | 2138 | 2239 | 1972  | 1956 | 2017  |
| 1. **Migration Projects**
 |
| 1. Astonfield Solar (Raj.) Pvt Ltd | Jodhpur  | Jodhpur | 1737 | 2017 | 1856 | 2138 | 2239 | 1981 | 1972 | 2041 |
| 2. Comet Power Pvt Ltd | Jodhpur  | Jodhpur | 1737 | 2017 | 1862 | 2133 | 2111 | 1989 | 1951 | 2039 |
| 3. Swiss Park VanijyaPvt Ltd | Jodhpur  | Jodhpur | 1737 | 2017 | 1856 | 2138 | 2239 | 1992 | 1972 | 2040 |
| 4. Videocon Industries Ltd | Pune | Osmanabd | 2277 | 1973 | 1930 | 2095 | 2098 | 1967 | 1971 | 1938 |
| 5. Moser Baer Photovoltaic Ltd | Jodhpur  | Jodhpur | 1737 | 2017 | 2169 | 2096 | 2101 | 1989 | 1959 | 2039 |
| 1. **IREDA Projects**
 |
| 1. RV Akash Ganga InfraLtd | Delhi | Dehradun | 1241 | 1862 | 2172 | 2105 | 2112 | 1977 | 1957 | 1949 |
| 2. Citra Real Estate Ltd | Pune | Wardha | 1541 | 1971 | 1973 | 1874 | 1874 | 1918 | 1740 | 2048 |
| 3. C&S Electric Ltd | Delhi | Sonipat | 1854 | 1862 | 1856 | 2138 | 2239 | 1979 | 2041 | 1972 |
| 4. Zamil ND Infra Pvt Ltd | Jodhpur  | Jodhpur | 1737 | 2017 | 1973 | 1874 | 1874 | 1918 | 1740 | 2040 |

\*Not available

**Table S.2. Month wise actual capacity utilization factor of select solar PV power projects under NSM Phase-I**

|  |  |  |  |
| --- | --- | --- | --- |
| **Projects**  | **Capacity (MW)** | **CUF (%) of the projects in the month of**  | **Annual CUF** **(%)** |
| **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| **A. Batch – I Projects**  |
| 1. Aftaab Solar Pvt Ltd
 | 5 | 20.7 | 23.2 | 21.8 | NA | 21.0 | 19.0 | 13.1 | 15.3 | 16.6 | 20.0 | 19.1 | 18.3 | 18.92 |
| 1. Alex Spectrum Rad. Pvt Ltd
 | 5 | 20.6 | 19.3 | 22.4 | 24.3 | 23.5 | 23.5 | 21.7 | 21.4 | 21.7 | 19.7 | 18.5 | 15.7 | 21.03 |
| 1. Amrit Energy Pvt Ltd
 | 5 | 15.7 | 22.2 | 25.1 | 25.4 | 24.7 | 23.9 | 17.7 | 16.9 | 20.4 | 21.4 | 20.3 | 19.6 | 21.12 |
| 1. Azure Power (Raj) Pvt Ltd
 | 5 | 17.1 | 20.8 | 23.3 | 23.9 | 23.9 | 23.6 | 19.9 | 18.8 | 22.6 | 19.7 | 18.5 | 17.3 | 20.79 |
| 1. CCCL Infras. Ltd
 | 5 | 16.8 | 18.4 | 21.9 | 19.8 | 17.8 | 20.2 | 19.8 | 19.3 | 19.9 | 15.4 | 14.1 | 13.6 | 19.33 |
| 1. DDE RE Ener. Pvt Ltd
 | 5 | 18.6 | 18.9 | 20.9 | 20.2 | 21.2 | 19.6 | 17.9 | 19.2 | 19.1 | 19.0 | 19.1 | 18.4 | 20.11 |
| 1. Mahindra Solar One Pvt Ltd
 | 5 | 17.2 | 19.9 | 24.3 | 27.2 | 26.6 | 25.4 | 23.3 | 23.3 | 18.5 | 19.9 | 18.3 | 17.1 | 20.36 |
| 1. SaiSudhir Energy Ltd
 | 5 | 17.2 | 25.4 | 23.1 | 22.7 | 23.0 | 21.2 | 16.1 | 17.5 | 18.1 | 20.4 | 19.8 | 19.6 | 20.64 |
| 1. Welspun Solar AP Pvt Ltd
 | 5 | 22.3 | 22.9 | 22.8 | 22.8 | 21.6 | 20.6 | 0.0 | 18.6 | 19.1 | 19.4 | 18.7 | 18.3 | 22.15 |
| 1. Khaya Solar Pvt Ltd
 | 5 | 17.7 | 19.9 | 24.2 | 24.5 | 26.8 | 26.9 | 22.7 | 24.1 | 22.8 | 19.7 | 19.0 | 17.4 | 22.19 |
| 1. Green Tech Power Pvt Ltd
 | 5 | 11.2 | 22.6 | 24.4 | 25.0 | 24.4 | 22.7 | 22.4 | 22.5 | 19.5 | 18.5 | 17.8 | 16.9 | 18.07 |
| 1. Vasavi Solar Power Pvt Ltd
 | 5 | 16.1 | 20.0 | 24.2 | 24.3 | 26.6 | 27.2 | 22.8 | 24.7 | 22.8 | 21.0 | 19.1 | 17.4 | 21.75 |
| 1. Newton Solar Pvt Ltd
 | 5 | 16.5 | 18.7 | 20.7 | 19.9 | 21.2 | 20.8 | 18.4 | 19.7 | 19.6 | 19.0 | 19.0 | 17.9 | 19.26 |
| 1. Finehope Allied Eng. Pvt Ltd
 | 5 | 15.6 | 20.0 | 21.9 | 22.5 | 26.3 | 24.5 | 18.7 | 20.0 | 19.1 | 18.6 | 19.4 | 17.9 | 20.33 |
| 1. ElectromechMarit. Pvt Ltd
 | 5 | 17.9 | 19.4 | 22.2 | 21.1 | 22.3 | 21.4 | 19.0 | 19.8 | 20.1 | 19.8 | 19.7 | 18.8 | 18.91 |
| **B. Batch – II Projects**  |
| 1. Welspun Solar AP Pvt Ltd
 | 20 | 16.7 | 20.3 | 22.7 | 23.4 | 21.5 | 21.5 | 20.4 | 20.5 | 20.9 | 20.4 | 19.1 | 17.9 | 20.42 |
| 1. Welspun Solar AP Pvt Ltd
 | 15 | 19.1 | 21.3 | 23.1 | 24.9 | 23.1 | 23.5 | 23.4 | 22.4 | 22.5 | 21.6 | 20.4 | 18.4 | 21.97 |
| 1. Welspun Solar AP Pvt Ltd
 | 15 | 19.4 | 20.9 | 24.8 | 25.6 | 23.2 | 24.1 | 24.7 | 22.7 | 22.7 | 22.2 | 18.9 | 18.7 | 22.33 |
| 1. Symphony VyaparPvt Ltd
 | 10 | 19.9 | 21.4 | 23.6 | 24.0 | 22.3 | 22.4 | 19.8 | 20.8 | 21.3 | 21.2 | 20.5 | 19.7 | 21.41 |
| 1. Essel MP Energy Ltd
 | 20 | 16.5 | 18.6 | 18.6 | 9.4 | 11.5 | 14.7 | 10.0 | 13.0 | 14.1 | 16.2 | 15.4 | 15.2 | 14.42 |
| 1. Sai Maithili Power Company
 | 10 | 17.8 | 20.4 | 20.4 | 23.8 | 18.9 | 18.4 | 18.5 | 19.1 | 17.2 | 15.5 | 16.0 | 18.1 | 18.66 |
| 1. Mahindra S. Pvt Ltd
 | 20 | 19.1 | 21.8 | 23.3 | 24.1 | 23.9 | 24.8 | 23.0 | 22.5 | 21.8 | 20.5 | 21.1 | 19.7 | 22.12 |
| 1. Mahindra S. Pvt Ltd
 | 10 | 19.4 | 21.8 | 21.8 | 23.3 | 24.8 | 24.7 | 23.0 | 23.1 | 22.4 | 20.5 | 21.1 | 19.9 | 22.16 |
| 1. Saisudhir Energy Ltd
 | 20 | 21.1 | 25.1 | 23.6 | 23.0 | 23.4 | 21.8 | 17.4 | 19.4 | 20.1 | 22.3 | 21.2 | 19.6 | 21.49 |
| 1. Fonroche R. Energy Pvt Ltd
 | 5 | 17.9 | 17.9 | 29.5 | 24.6 | 26.1 | 26.2 | 23.7 | 23.7 | 24.6 | 22.8 | 21.1 | 18.1 | 23.01 |
| 1. Fonroche S. Energy Pvt Ltd
 | 15 | 16.3 | 22.6 | 25.2 | 27.6 | 26.5 | 26.9 | 24.3 | 24.2 | 25.4 | 23.4 | 21.6 | 18.6 | 23.55 |
| 1. Azure Solar Power Pvt Ltd
 | 20 | 16.8 | 21.8 | 21.8 | 23.9 | 24.9 | 24.7 | 21.0 | 19.8 | 23.4 | 20.6 | 19.6 | 16.9 | 21.28 |
| 1. Azure Solar Power Pvt Ltd
 | 15 | 16.8 | 21.7 | 21.7 | 24.2 | 25.0 | 24.7 | 20.9 | 19.7 | 23.5 | 20.7 | 19.3 | 17.1 | 21.27 |
| 1. Shree S. GreenpowerPvt Ltd
 | 5 | 16.5 | 23.7 | 23.6 | 24.1 | 23.9 | 22.1 | 16.9 | 18.7 | 20.5 | 22.4 | 20.8 | 18.8 | 21.00 |
| 1. Lexicon VanijyaPvt Ltd
 | 10 | 18.1 | 21.6 | 23.6 | 24.1 | 22.7 | 22.6 | 19.9 | 21.0 | 21.2 | 21.3 | 20.4 | 19.8 | 21.35 |
| **C. Migration Projects**  |
| 1. Astonfield Solar (Raj.) Pvt Ltd
 | 5 | 20.1 | 22.4 | 22.9 | 22.4 | 19.4 | 18.5 | 19.0 | 18.8 | 17.1 | 14.4 | 20.1 | 22.4 | 19.33 |
| 1. Comet Power Pvt Ltd
 | 5 | 25.1 | 26.5 | 24.0 | 24.4 | 20.6 | 20.4 | 21.2 | 23.9 | 22.9 | 21.4 | 25.1 | 26.5 | 22.17 |
| 1. Swiss Park VanijyaPvt Ltd
 | 5 | 18.3 | 22.2 | NA | NA | NA | 17.1 | 18.2 | 19.6 | 18.0 | 20.6 | 18.3 | 22.2 | 18.41 |
| 1. Videocon Industries Ltd
 | 5 | 23.5 | 23.0 | 21.8 | 17.3 | 17.2 | 16.1 | 21.9 | 21.5 | 21.3 | 21.5 | 23.5 | 23.0 | 20.65 |
| 1. Moser Baer Photovoltaic Ltd
 | 5 | 22.2 | 24.8 | 24.2 | 23.4 | NA | 19.6 | 20.7 | 22.0 | 20.4 | 18.6 | 22.2 | 24.8 | 20.84 |
| **D. IREDA Projects**  |
| 1. RV Akash Ganga InfraLtd
 | 5 | 9.1 | NA | 19.4 | 21.2 | 20.5 | NA | NA | 15.9 | 17.0 | 15.1 | 15.1 | 11.0 | 16.03 |
| 1. Citra Real Estate Ltd
 | 5 | 17.7 | 14.8 | 20.4 | NA | 19.9 | NA | NA | NA | 16.4 | 18.2 | 19.8 | 21.0 | 18.52 |
| 1. C&S Electric Ltd
 | 5 | 12.0 | 16.5 | 19.5 | 19.9 | 17.4 | 18.2 | 15.6 | 5.2 | 17.5 | 17.2 | 15.8 | 13.1 | 15.66 |
| 1. Zamil ND Infra Pvt Ltd
 | 5 | 15.2 | 22.1 | 15.6 | 18.0 | 17.0 | 16.1 | 15.2 | 15.9 | 18.1 | 17.6 | NA | 15.2 | 16.91 |

**Table S.3. Technical losses associated with energy yield estimation using PVSYST software**

|  |  |  |  |
| --- | --- | --- | --- |
| **Technical Loss** | **Range (%)** | **Definition** | **Remarks** |
| 1. Incident angle modifier (IAM) | 2.0-3.5 | The incidence angle loss accounts for radiation reflected from the front glass when the light striking it is not perpendicular. | Location/design specific and determined through sun-earth geometry by PVSYST |
| 2. Soiling loss  | 1.5-2.0  | Losses due to soiling (dust and bird droppings) depend on the environmental conditions. | Location specific and taken into account through review of O&M (cleaning) approach of the contractor |
| 3. Near shading loss | 1.0-1.5 | Shading losses occur due to mountains or buildings on the far horizon, mutual shading between rows of modules and near shading due to trees, buildings, pylons or overhead cabling. | Location specific and design specific. Optimized through inter row spacing. Could be carried out separately or using PVSYST  |
| 4. Loss due to irradiance level  | 0.5-0.75  | The conversion efficiency of a PV module generally reduces at low light intensities. This causes a loss in the output of a module compared with the STC (i.e. 1,000W/m2). This *low irradiance loss* depends on the characteristics of the module and the intensity of the incident radiation. | Location and irradiance specific and estimated through PVSYST |
| 5. Loss due to temperature  | 6.0-10.0 | The characteristics of a PV module are determined at standard temperature conditions of 25˚C. For every degree rise in oC above this standard, crystalline silicon or thin film modules reduce in efficiency, generally by around 0.5%. | Depends on technology and location. Estimated through PVSYST |
| 6. Module quality loss | -0.8-0.0 | Most PV modules do not exactly match the manufacturer’s nominal specifications. Modules are sold with a nominal peak power and a guarantee of actual power within a given tolerance range. | Depends on technology and location. Estimated through PVSYST |
| 7. Module array mismatch loss  | 0.5-1.0 | Losses due to mismatch are related to the fact that the real modules in a string do not all rigorously present the same current/voltage profiles; there is a statistical variation between them which gives rise to a power loss. This loss is directly related to the modules power tolerance. | Depends on technology and location. Estimated through PVSYST |
| 8. Ohmic wiring losses  | 1.0-1.5  | Electrical resistance in the cable between the modules and the input terminals of the inverter give rise to Ohmic losses. These losses increase with temperature. | Could be calculated from actual design using PVSYST |
| 9. Light induced degradation (LID)  | 1.0-2.0 | The performance of a PV module decreases with time. Different for crystalline and thin Films  |  |
| 10. Inverter loss  | 1.4-2.0 | Inverters convert current from DC into AC with an efficiency that varies with inverter load. The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the MPP voltage. Different inverters do this with varying efficiency. | Depends on the model/manufacturer. Estimated through PVSYST  |
| 11. AC Ohmic wiring losses  | 1.0-1.5  | AC cable losses are the Ohmic losses in the AC cabling. This includes all cables post inverter up to the metering point. | Depends on the distance from power plant to grid substation (metering point) and voltage level etc.  |
| 12. Transformer loss | 1.5-2.5  | Transformer losses are usually quantified in terms of iron and resistive/inductive losses, which can be calculated based on the transformer’s no-load and full-load losses. | Depends on the configuration and need to done separately |
| 13. Auxiliary consumption  | 0.50-0.75 | Power may be required for electrical equipment within the plant. This may include security systems, tracking motors, monitoring equipment and lighting. | Taken as per best industrial practices in India  |
| 14. First year degradation  | 0.65-0.70 | The performance of a PV module decreases with time | As per manufacturer’s opinion, references from R&D institutions etc. 0.65% for crystalline and 0.70% for thin films |
| 14. Plant availability  | 0.50-1.0 | As per the O&M contract i.e. plant availability guaranteed by O&M contractor  | Plant specific and taken from best industrial practices in India  |
| 15. Grid availability  | 0.50-1.0 | Taken from the transmission network owner (CTU/STU) for the grid availability of specific voltage network | Location/state specific and taken from best industrial practices in India |

Source: World Bank (2015)

**Table S.4. Actual and estimated CUF and LCOE of select Solar PV projects under NSM Phase-I through various solar databases**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **NSM Phase – I projects** | **Actual CUF****(%)** | **Actual LCOE****(INR/kW)** | **Capacity utilization factor through solar radiation database (%)** | **Levelized cost of electricity through solar radiation database (INR/kWh)** |
| **NASA** | **NREL** | **SWERA** | **Meteonorm 7.0** | **Meteonorm 7.1** | **Solar GIS** | **NASA** | **NREL** | **SWERA** | **Meteonorm 7.0** | **Meteonorm 7.1** | **Solar GIS** |
| **A. Batch-I Projects** |
| 1. Aftaab Solar Pvt Ltd
 | 18.9% | 5.7 | 17.9% | 19.8% | 19.8% | 17.6% | 18.2% | 18.4% | 6.0 | 5.4 | 5.5 | 6.1 | 5.9 | 5.9 |
| 1. Alex Spectrum Rad. Pvt Ltd
 | 21.0% | 5.1 | 20.4% | 23.6% | 23.7% | 21.1% | 21.3% | 22.0% | 5.3 | 4.6 | 4.6 | 5.1 | 5.1 | 4.9 |
| 1. Amrit Energy Pvt Ltd
 | 21.1% | 5.1 | 17.5% | 20.3% | 20.8% | 18.5% | 18.4% | 17.7% | 6.2 | 5.3 | 5.2 | 5.8 | 5.9 | 6.1 |
| 1. Azure Power (Raj) Pvt Ltd
 | 20.8% | 5.2 | 18.5% | 20.6% | 20.0% | 19.4% | 19.2% | 21.8% | 5.8 | 5.2 | 5.4 | 5.6 | 5.6 | 5.0 |
| 1. CCCL Infras. Ltd
 | 19.3% | 5.6 | 20.2% | 22.6% | 22.6% | 20.8% | 20.6% | 18.9% | 5.4 | 4.8 | 4.8 | 5.2 | 5.3 | 5.7 |
| 1. DDE RE Ener. Pvt Ltd
 | 20.1% | 5.4 | 20.6% | 23.4% | 22.5% | 21.7% | 21.8% | 22.1% | 5.2 | 4.6 | 4.8 | 5.0 | 5.0 | 4.9 |
| 1. Mahindra Solar One Pvt Ltd
 | 20.4% | 5.3 | 19.0% | 22.0% | 22.0% | 20.6% | 20.6% | 20.4% | 5.7 | 4.9 | 4.9 | 5.3 | 5.3 | 5.3 |
| 1. SaiSudhir Energy Ltd
 | 20.6% | 5.2 | 17.8% | 20.6% | 19.9% | 18.2% | 18.1% | 19.3% | 6.1 | 5.3 | 5.4 | 5.9 | 6.0 | 5.6 |
| 1. Welspun Solar AP Pvt Ltd
 | 22.2% | 4.9 | 17.7% | 20.5% | 20.5% | 18.7% | 18.4% | 17.3% | 6.1 | 5.3 | 5.3 | 5.8 | 5.9 | 6.2 |
| 1. Khaya Solar Pvt Ltd
 | 22.2% | 4.9 | 17.8% | 20.8% | 20.9% | 19.7% | 18.7% | 17.7% | 6.1 | 5.2 | 5.2 | 5.5 | 5.8 | 6.1 |
| 1. Green Tech Power Pvt Ltd
 | 18.1% | 6.0 | 17.6% | 20.6% | 21.0% | ----- | 18.9% | 19.5% | 6.1 | 5.3 | 5.2 | -----  | 5.7 | 5.5 |
| 1. Vasavi Solar Power Pvt Ltd
 | 21.8% | 5.0 | 17.8% | 20.8% | 20.9% | 19.7% | 18.7% | 17.7% | 6.1 | 5.2 | 5.2 | 5.5 | 5.8 | 6.1 |
| 1. Newton Solar Pvt Ltd
 | 19.3% | 5.6 | 17.8% | 20.8% | 20.9% | 19.7% | 18.7% | 17.7% | 6.1 | 5.2 | 5.2 | 5.5 | 5.8 | 6.1 |
| 1. Finehope Allied Eng. Pvt Ltd
 | 20.3% | 5.3 | 17.8% | 20.8% | 20.9% | 19.7% | 18.7% | 17.7% | 6.1 | 5.2 | 5.2 | 5.5 | 5.8 | 6.1 |
| 1. ElectromechMarit. Pvt Ltd
 | 18.9% | 5.7 | 17.8% | 20.8% | 20.9% | 19.7% | 18.7% | 17.7% | 6.1 | 5.2 | 5.2 | 5.5 | 5.8 | 6.1 |
| **B. Batch-II Projects** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Welspun Solar AP Pvt Ltd
 | 20.4% | 5.29 | 18.6% | 21.6% | 21.6% | 20.1% | 20.2% | 19.8% | 5.8 | 5.0 | 5.0 | 5.4 | 5.4 | 5.5 |
| 1. Welspun Solar AP Pvt Ltd
 | 22.0% | 4.93 | 18.6% | 21.7% | 21.7% | 20.1% | 20.2% | 19.8% | 5.8 | 5.0 | 5.0 | 5.4 | 5.3 | 5.4 |
| 1. Welspun Solar AP Pvt Ltd
 | 22.3% | 4.85 | 18.9% | 20.5% | 20.3% | 18.7% | 18.6% | 18.9% | 5.7 | 5.3 | 5.3 | 5.8 | 5.8 | 5.7 |
| 1. Symphony VyaparPvt Ltd
 | 21.4% | 5.05 | 21.3% | 24.0% | 21.3% | 21.4% | 21.4% | 22.6% | 5.1 | 4.5 | 5.1 | 5.1 | 5.1 | 4.8 |
| 1. Essel MP Energy Ltd
 | 14.4% | 7.44 | 21.3% | 24.1% | 24.7% | 21.5% | 21.4% | 22.2% | 5.1 | 4.5 | 4.4 | 5.0 | 5.1 | 4.9 |
| 1. Sai Maithili Power Company
 | 18.7% | 5.78 | 17.8% | 20.7% | 21.4% |  | 18.9% | 19.2% | 6.1 | 5.2 | 5.1 | -----  | 5.7 | 5.6 |
| 1. Mahindra S. Pvt Ltd
 | 22.1% | 4.9 | 18.6% | 21.8% | 23.1% | 19.7% | 19.6% | 21.8% | 5.8 | 5.0 | 4.7 | 5.5 | 5.5 | 5.0 |
| 1. Mahindra S. Pvt Ltd
 | 22.2% | 4.89 | 21.8% | 23.0% | 23.0% | 19.4% | 19.5% | 20.6% | 5.0 | 4.7 | 4.7 | 5.6 | 5.5 | 5.3 |
| 1. Saisudhir Energy Ltd
 | 21.5% | 5.04 | 18.1% | 19.2% | 19.5% |  | 19.2% | 18.0% | 6.0 | 5.6 | 5.6 | -----  | 5.6 | 6.0 |
| 1. Fonroche R. Energy Pvt Ltd
 | 23.0% | 4.71 | 20.4% | 22.8% | 22.2% | 21.4% | 21.1% | 21.2% | 5.3 | 4.8 | 4.9 | 5.1 | 5.1 | 5.1 |
| 1. Fonroche S. Energy Pvt Ltd
 | 23.6% | 4.61 | 20.0% | 19.3% | 19.4% | 17.9% | 17.9% | 18.0% | 5.4 | 5.6 | 5.6 | 6.0 | 6.0 | 6.0 |
| 1. Azure Solar Power Pvt Ltd
 | 21.3% | 5.08 | 17.8% | 20.7% | 21.4% |  | 18.9% | 19.2% | 6.1 | 5.2 | 5.1 | -----  | 5.7 | 5.6 |
| 1. Azure Solar Power Pvt Ltd
 | 21.3% | 5.09 | 18.5% | 21.9% | 22.8% | 19.9% | 20.0% | 20.7% | 5.8 | 5.0 | 4.8 | 5.4 | 5.4 | 5.2 |
| 1. Shree S. GreenpowerPvt Ltd
 | 21.0% | 5.15 | 18.6% | 20.2% | 20.2% | 18.0% | 18.7% | 18.6% | 5.8 | 5.4 | 5.4 | 6.0 | 5.8 | 5.8 |
| 1. Lexicon VanijyaPvt Ltd
 | 21.4% | 5.07 | 17.9% | 22.0% | 23.1% | 20.0% | 20.1% | 20.9% | 6.0 | 4.9 | 4.7 | 5.4 | 5.4 | 5.2 |
| **C. Migration Projects** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Astonfield Solar (Raj.) Pvt Ltd
 | 19.3% | 5.6 | 17.0% | 21.7% | 20.3% | 22.8% | 21.4% | 19.9% | 6.3 | 5.0 | 5.3 | 4.8 | 5.1 | 5.4 |
| 1. Comet Power Pvt Ltd
 | 22.2% | 4.9 | 17.7% | 22.0% | 20.7% | 20.0% | 18.8% | 20.5% | 6.1 | 4.9 | 5.2 | 5.4 | 5.7 | 5.3 |
| 1. Swiss Park VanijyaPvt Ltd
 | 18.4% | 5.9 | 17.4% | 22.0% | 20.5% | 22.9% | 21.4% | 20.9% | 6.2 | 4.9 | 5.3 | 4.7 | 5.1 | 5.2 |
| 1. Videocon Industries Ltd
 | 20.7% | 5.2 | 19.7% | 22.0% | 20.5% | 23.1% | 21.6% | 20.2% | 5.5 | 4.9 | 5.3 | 4.7 | 5.0 | 5.4 |
| 1. Moser Baer Photovoltaic Ltd
 | 20.8% | 5.2 | 22.2% | 23.0% | 21.5% | 23.0% | 21.5% | 21.1% | 4.9 | 4.7 | 5.0 | 4.7 | 5.0 | 5.1 |
| **D. IREDA Projects**  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. RV Akash Ganga Infra Ltd
 | 16.0% | 6.7 | 21.0% | 19.4% | 19.4% | 20.4% | 18.0% | 17.9% | 5.2 | 5.6 | 5.6 | 5.3 | 6.0 | 6.0 |
| 1. Citra Real Estate Ltd
 | 18.5% | 5.8 | 20.8% | 18.7% | 18.7% | 19.2% | 17.0% | 16.5% | 5.2 | 5.8 | 5.8 | 5.6 | 6.4 | 6.5 |
| 1. C&S Electric Ltd
 | 15.7% | 6.9 | 18.2% | 19.6% | 19.3% | 18.8% | 18.7% | 17.3% | 5.9 | 5.5 | 5.6 | 5.7 | 5.8 | 6.2 |
| 1. Zamil ND Infra Pvt Ltd
 | 16.9% | 6.4 | 18.2% | 21.6% | 22.6% | 19.7% | 19.6% | 20.7% | 5.9 | 5.0 | 4.8 | 5.5 | 5.5 | 5.2 |

**Table S.5. Solar PV project cost consideration for economic analysis [69]**

|  |  |  |
| --- | --- | --- |
| **Particulars** | **Capital cost (Million INR/MW)** | **% of Total cost** |
| PV modules | 32.84 | 61.96 |
| Land cost | 2.50 | 4.70 |
| Civil and general works | 3.50 | 6.60 |
| Mounting | 3.50 | 6.60 |
| Power conditioning unit | 3.50 | 6.60 |
| Evacuation cost up to interconnection point (cables and transformers) | 4.40 | 8.30 |
| Preliminary and pre-operative expenses including Interest during construction and contingency | 2.76 | 5.21 |
| Total cost | 53.00 | 100 |

**Table S.6. Key technical and economic parameters considered for tariff determination**

|  |  |  |
| --- | --- | --- |
| **Parameter**  | **Unit**  | **Value**  |
| Installed power generation capacity | MW | 1.0  |
| Useful life | years | 25  |
| Power plant cost | Million INR/MW | 53.0  |
| Annual degradation\*  | % | 0.65 |
| % | 0.70 |
| Debt: Equity ratio | % | 70:30 |
| Repayment period (including moratorium) | year | 12  |
| Interest rate | % | 12.76 |
| MAT rate | % | 21.34 |
| Income tax rate | % | 34.61 |
| Depreciation (for first 12 years) | % | 5.83 |
| Depreciation (13th year onwards) | % | 1.54 |
| Operation and maintenance (O&M) charges | month | 1  |
| Maintenance spares (% of O&M expenses) | % | 15 |
| Interest on working capital | % | 13.26 |
| Plant O&M cost | Million INR/MW | 0.7 |
| O&M expense escalation | % | 5.72 |

\* Annual degradation is taken to be 0.65% for multi-crystalline and 0.70% for thin film based modules

**Table S.7. MPE between actual and estimated CUF and LCOE of select solar PV projects under NSM Phase-I through various SRDBs**

|  |  |  |
| --- | --- | --- |
| **Projects** | **MPE (%) w.r.t. Actual CUF** | **MPE (%) w.r.t. Actual LCOE** |
| **NASA** | **NREL** | **SWERA** | **Meteonorm 7.0** | **Meteonorm 7.1** | **Solar GIS** | **NASA** | **NREL** | **SWERA** | **Meteonorm 7.0** | **Meteonorm 7.1** | **Solar GIS** |
| **A. Batch – I Projects** |
| 1. Aftaab Solar Pvt Ltd
 | -5.6% | 4.9% | 4.4% | -7.0% | -3.8% | -2.6% | 5.8% | -4.6% | -4.0% | 7.4% | 3.9% | 2.6% |
| 1. Alex Spectrum Rad. Pvt Ltd
 | -2.8% | 12.3% | 12.5% | 0.1% | 1.2% | 4.8% | 2.9% | -10.7% | -10.7% | 0.0% | -1.2% | -4.5% |
| 1. Amrit Energy Pvt Ltd
 | -17.3% | -3.8% | -1.8% | -12.4% | -12.8% | -16.4% | 20.5% | 3.9% | 1.8% | 13.9% | 14.3% | 19.1% |
| 1. Azure Power (Raj) Pvt Ltd
 | -11.2% | -0.8% | -4.0% | -6.7% | -7.7% | 4.7% | 12.3% | 0.8% | 4.0% | 6.9% | 8.3% | -4.4% |
| 1. CCCL Infras. Ltd
 | 4.4% | 16.8% | 17.1% | 7.6% | 6.6% | -2.2% | -3.9% | -14.0% | -14.2% | -6.8% | -5.9% | 2.3% |
| 1. DDE RE Ener. Pvt Ltd
 | 2.5% | 16.2% | 12.0% | 7.9% | 8.3% | 10.0% | -2.4% | -13.6% | -10.4% | -7.1% | -7.5% | -8.8% |
| 1. Mahindra Solar One Pvt Ltd
 | -6.6% | 7.9% | 7.9% | 1.2% | 1.2% | 0.0% | 7.0% | -7.2% | -7.2% | -1.1% | -1.1% | 0.0% |
| 1. SaiSudhir Energy Ltd
 | -13.9% | -0.3% | -3.8% | -11.7% | -12.2% | -6.3% | 15.7% | 0.2% | 3.8% | 13.0% | 13.6% | 6.5% |
| 1. Welspun Solar AP Pvt Ltd
 | -20.3% | -7.3% | -7.3% | -15.8% | -16.8% | -21.7% | 24.7% | 7.8% | 7.8% | 18.2% | 19.6% | 27.0% |
| 1. Khaya Solar Pvt Ltd
 | -19.8% | -6.4% | -6.0% | -11.4% | -15.9% | -20.3% | 24.0% | 6.8% | 6.4% | 12.3% | 18.4% | 24.8% |
| 1. Green Tech Power Pvt Ltd
 | -2.6% | 14.0% | 16.2% | 0.0% | 4.7% | 7.8% | 2.5% | -12.1% | -13.7% | --- | -4.5% | -7.2% |
| 1. Vasavi Solar Power Pvt Ltd
 | -18.2% | -4.6% | -4.1% | -9.6% | -14.2% | -18.7% | 21.5% | 4.6% | 4.2% | 10.2% | 16.1% | 22.3% |
| 1. Newton Solar Pvt Ltd
 | -7.6% | 7.8% | 8.3% | 2.1% | -3.1% | -8.2% | 8.0% | -7.0% | -7.3% | -2.0% | 3.2% | 8.8% |
| 1. Finehope Allied Eng. Pvt Ltd
 | -12.4% | 2.1% | 2.6% | -3.3% | -8.2% | -13.0% | 13.7% | -2.1% | -2.4% | 3.2% | 8.7% | 14.5% |
| 1. ElectromechMarit. Pvt Ltd
 | -5.9% | 9.8% | 10.3% | 4.0% | -1.3% | -6.5% | 6.0% | -8.8% | -9.1% | -3.9% | 1.2% | 6.7% |
| **B. Batch – II Projects** |
| 1. Welspun Solar AP Pvt Ltd
 | -9.2% | 6.0% | 6.0% | -1.7% | -1.1% | -3.1% | 9.8% | -5.5% | -5.5% | 1.7% | 1.1% | 3.2% |
| 1. Welspun Solar AP Pvt Ltd
 | -15.3% | -1.2% | -1.2% | -8.7% | -7.9% | -9.7% | 17.7% | 1.2% | 1.2% | 9.1% | 8.3% | 10.3% |
| 1. Welspun Solar AP Pvt Ltd
 | -15.4% | -8.2% | -8.9% | -16.4% | -16.9% | -15.5% | 17.7% | 8.9% | 9.5% | 19.2% | 19.8% | 17.7% |
| 1. Symphony VyaparPvt Ltd
 | -0.5% | 12.1% | -0.5% | 0.1% | -0.2% | 5.7% | 0.6% | -10.5% | 0.6% | 0.0% | 0.2% | -5.2% |
| 1. Essel MP Energy Ltd
 | 48.0% | 66.9% | 71.2% | 49.0% | 48.5% | 53.9% | -31.9% | -39.4% | -40.9% | -32.3% | -32.1% | -34.4% |
| 1. Sai Maithili Power Company
 | -4.8% | 11.0% | 14.8% | 0.0% | 1.5% | 3.0% | 5.0% | -9.7% | -12.6% | --- | -1.4% | -2.8% |
| 1. Mahindra S. Pvt Ltd
 | -15.8% | -1.3% | 4.3% | -11.2% | -11.5% | -1.6% | 18.2% | 1.2% | -4.1% | 12.2% | 12.5% | 1.4% |
| 1. Mahindra S. Pvt Ltd
 | -1.8% | 3.8% | 3.8% | -12.4% | -11.9% | -7.2% | 1.6% | -3.7% | -3.7% | 13.7% | 13.1% | 7.6% |
| 1. Saisudhir Energy Ltd
 | -15.8% | -10.7% | -9.4% | 0.0% | -10.7% | -16.1% | 18.3% | 11.5% | 10.1% | --- | 11.5% | 18.5% |
| 1. Fonroche R. Energy Pvt Ltd
 | -11.6% | -0.7% | -3.7% | -7.2% | -8.3% | -8.0% | 12.7% | 0.9% | 3.8% | 7.6% | 8.9% | 8.5% |
| 1. Fonroche S. Energy Pvt Ltd
 | -15.0% | -18.0% | -17.8% | -24.0% | -24.0% | -23.6% | 17.1% | 21.3% | 21.0% | 30.6% | 30.6% | 29.9% |
| 1. Azure Solar Power Pvt Ltd
 | -16.5% | -2.7% | 0.7% | 0.0% | -11.0% | -9.7% | 19.5% | 2.8% | -0.6% | --- | 12.2% | 10.6% |
| 1. Azure Solar Power Pvt Ltd
 | -13.1% | 2.8% | 7.3% | -6.5% | -6.2% | -2.5% | 14.7% | -2.8% | -6.7% | 6.7% | 6.3% | 2.4% |
| 1. Shree S. GreenpowerPvt Ltd
 | -11.5% | -3.9% | -3.8% | -14.2% | -11.1% | -11.5% | 12.6% | 3.9% | 3.9% | 16.1% | 12.0% | 12.6% |
| 1. Lexicon VanijyaPvt Ltd
 | -16.2% | 3.2% | 8.2% | -6.4% | -6.0% | -2.1% | 18.7% | -3.0% | -7.5% | 6.5% | 6.3% | 2.0% |
| **C. Migration Projects**  |
| 1. Astonfield Solar (Raj.) Pvt Ltd
 | -12.0% | 12.2% | 4.9% | 18.1% | 10.5% | 3.1% | 13.4% | -10.6% | -4.5% | -14.3% | -9.1% | -2.9% |
| 1. Comet Power Pvt Ltd
 | -20.0% | -0.7% | -6.6% | -9.6% | -15.0% | -7.4% | 24.1% | 0.6% | 6.8% | 10.2% | 17.2% | 7.6% |
| 1. Swiss Park VanijyaPvt Ltd
 | -5.6% | 19.3% | 11.6% | 24.2% | 16.1% | 13.4% | 5.8% | -15.9% | -10.2% | -19.1% | -13.7% | -11.6% |
| 1. Videocon Industries Ltd
 | -4.6% | 6.4% | -0.5% | 11.8% | 4.6% | -2.3% | 4.6% | -5.9% | 0.4% | -10.3% | -4.4% | 2.1% |
| 1. Moser Baer Photovoltaic Ltd
 | 6.5% | 10.3% | 3.1% | 10.4% | 3.2% | 1.3% | -6.0% | -9.1% | -2.9% | -9.3% | -3.1% | -1.2% |
| 1. **IREDA Projects**
 |
| 1. RV Akash Ganga Infra Ltd
 | 30.7% | 21.2% | 21.2% | 27.3% | 12.0% | 11.8% | -23.1% | -17.1% | -17.1% | -21.0% | -10.6% | -10.4% |
| 1. Citra Real Estate Ltd
 | 12.5% | 1.1% | 1.1% | 3.6% | -8.5% | -11.0% | -10.8% | -1.0% | -1.0% | -3.4% | 9.1% | 12.2% |
| 1. C&S Electric Ltd
 | 16.1% | 25.3% | 23.0% | 20.2% | 19.2% | 10.5% | -13.6% | -19.8% | -18.4% | -16.5% | -15.7% | -9.3% |
| 1. Zamil ND Infra Pvt Ltd
 | 7.6% | 27.5% | 33.8% | 16.7% | 16.1% | 22.5% | -7.1% | -21.2% | -24.8% | -14.1% | -13.7% | -18.1% |

1. Corresponding author: Tel: +43-2236807-336; Fax: +43-2236807-533; E-mail: purohit@iiasa.ac.at [↑](#footnote-ref-1)