| Cover Page for CTF Project/Program Approval Request[1] | | | |
|---|---|---|---|
| 1. **Country/Region** | India | 2. **CIF Project ID#** | (CIF AU will assign ID.) |
| 3. **Investment Plan (IP) or Dedicated Private Sector Program (DPSP)** | X IP<br>☐ DPSP | 4. **Public or Private** | X Public<br>☐ Private |
| 5. **Project/Program Title** | *Proposed Loan Power Grid Corporation of India Limited Solar Power Transmission Sector Project Guaranteed by India [Originally referred to as "Solar Parks Transmission" in the revised Investment Plan of 2015]* | | |
| 6. **Is this a private sector program composed of sub-projects?** | ☐ Yes ☒ No | | |
| 7. **Financial Products, Terms and Amount** | | | |

| | **USD** (million) | **EUR** (million)[2] |
|---|---|---|
| Grant | | |
| Fee on grant | | |
| MPIS (for private sector only) | | |
| | | |
| Public sector loan | | |
| • Harder terms | | |
| • Softer terms | **50.00** | |
| | | |
| Senior loan | | |
| Senior loans in local currency hedged | | |
| Subordinated debt / mezzanine instruments with income participation | | |
| Second loss Guarantees | | |
| | | |
| Equity | | |
| Subordinated debt/mezzanine instruments with convertible features | | |
| Convertible grants and contingent recovery grants | | |
| Contingent recovery loans | | |
| First loss Guarantees | | |
| | | |
| Other (please specify) | | |
| | | |

[1] This cover page is to be completed and submitted together with the MDB project/program proposal when requesting CTF funding approval by the Trust Fund Committee.
[2] Please also provide USD equivalent in the column to the left

| | | |
|---|---|---|
| **Total** | **50.00** | |
| 8. **Implementing MDB(s)** | Asian Development Bank | |
| 9. **National Implementing Agency** | Power Grid Corporation of India Limited (POWERGRID) | |
| 10. **MDB Focal Point** | *Mr. Jiwan Acharya (jacharya@adb.org)* | |

11. **Brief Description of Project/Program (including objectives and expected outcomes)**

The Clean Technology Fund (CTF) Investment Plan (IP) for India was originally endorsed in November 2011 and revised in August 2015. The revised plan reflects the government's updated target of deploying 100 Gigawatt (GW) solar capacity by 2022, five times increase from the 20 GW initial goal. This scale-up envisions 60 GW of ground-mounted utility scale solar power projects, and 40 GW in rooftop solar installations. Under the IP, CTF resources will catalyze investments in solar park infrastructure and transmission requirements and solar rooftop photovoltaics (PV) which will help achieve 4 GW of new installed capacity. The investment plan has a CTF allocation of $775 million, of which $530 million has already been approved by the Trust Fund Committee (TFC).

**Table 1: India CTF Investment Plan Project Portfolio**

| Project / Program | MDB | CTF financing (US$ M) | CTF TFC Approval |
|---|---|---|---|
| Solar Park: Rajasthan | ADB | 200 | Jul-13 |
| Himachal Pradesh Environmentally Sustainable Development Policy Loan (HP DPL) | World Bank | 100 | Nov-13 |
| Partial Risk Sharing Facility for Energy Efficiency (PRSF) | World Bank | 25 | Jul-14 |
| Solar Rooftop PV | World Bank | 125 | Dec-2015 |
| | ADB | 125 | -- |
| Solar Parks Infrastructure | World Bank | 50 | Jan-16 |
| | ADB | 50 | -- |
| Solar Parks Transmission | World Bank | 30 | Jan-16 |
| | ADB | 50 | -- |
| Solar PV Generation by Solar Energy Corporation of India (SECI) | World Bank | 20 | -- |
| | **Total** | **775** | |

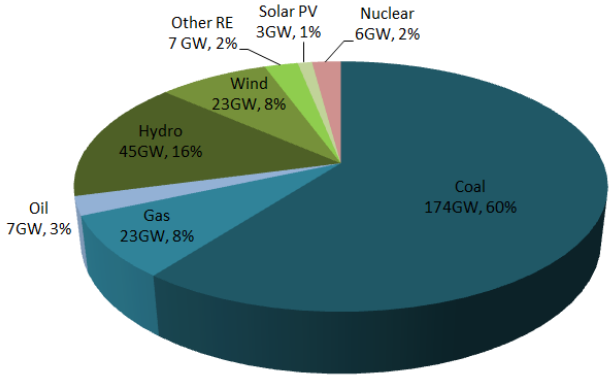
**Country Background**

In 2015, India's economy increased to an average annual rate of 7.6 percent, placing the country among the top 10 fastest growing nations. With a growing economy and large population estimated at 1.25 billion (2013), India's energy demand growth will continue to be driven mainly by the growing manufacturing sector, projected population growth and urbanization, increased grid access and the rising aspirations of the people.

The Indian power system is among the largest in the world with about 288 gigawatt (GW) of installed capacity, which is largely dominated by fossil fuels, particularly coal which represents

60% of the total capacity, followed by hydropower (16%), natural gas (8%) and wind (8%), as shown in Figure 1. Overall, renewable energy sources – hydropower, wind, and solar – covers only about 27% of the total capacity.

**Figure 1: Installed Capacity, 2014**




Source: IEA (2015) India Energy Outlook

In terms of demand, India had the third largest energy demand in the world after China and the United States and just ahead of Russia. According to the Energy Outlook for Asia and Pacific issued by ADB in October 2013, India's energy demand more than doubled from 693 million tonnes of oil equivalent (Mtoe) in 2010 to 1,442 Mtoe in 2035. The country's per capita consumption of electricity in 2013 remains low at about 0.78 megawatt-hour (MWh), versus the world average of 3.03 MWh/capita and OECD countries average of 8.07 MWh/capita. (IEA, 2015)

Lack of high-quality and reliable electricity supply continues to constrain India's economic growth. The country's electrification rate is 81% (96% in urban and 74% in rural), this translates to an estimated 237 million people without access to even basic electricity, but up to 300 million are without access to reliable and national grid (IEA WEO, 2015). In FY2014–2015, India experienced total energy and peak power deficits of 2.1% and 2.6%, respectively.[3] Industrial establishments and manufacturers have been relying on diesel-based back-up power supplies to meet the power requirements, which are significantly more expensive than grid-based electricity. The Central Electricity Regulatory Commission has estimated an aggregate of more than 90 GW of diesel generators across India, used as backup generation capacity.[4] These generators are largely unmonitored and not covered by regulation or included in official statistics. By FY2031–2032, the required power generating capacity is projected to more than double from its present capacity.[5]

[3] Central Electricity Authority (CEA). 2015. *Load Generation Balance Report 2015–2016. Available:* http://www.cea.nic.in/reports/yearly/lgbr_report.pdf

[4] The 90 GW is an estimated of the Central Electricity Regulatory Commission (CERC) and is only for generators of 100 kVA or greater capacity used by larger commercial and industrial consumers: http://indianexpress.com/article/india/india-others/gensets-add-up-to-under-half-of-installed-power-capacity/ This news article notes that while installed grid-connected capacity was just above 250 GW as of August 2014, only 140 GW of demand was met due to transmission constraints.

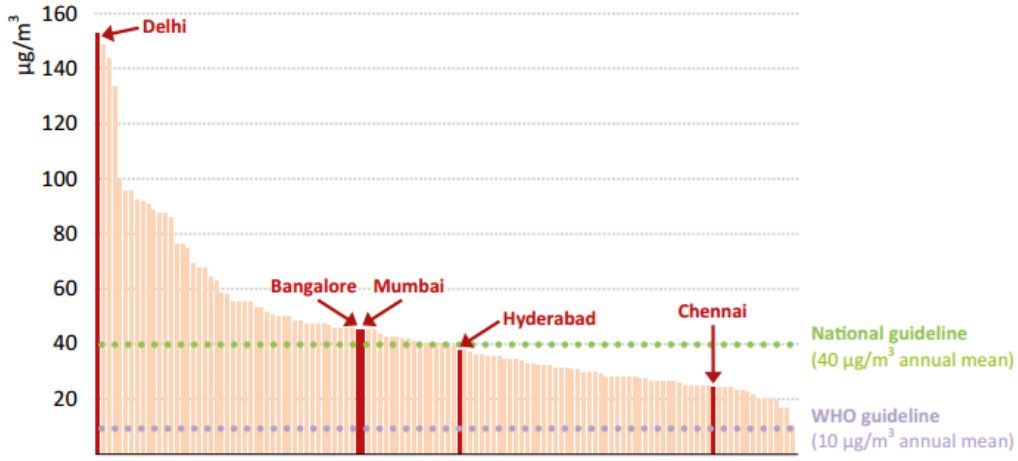
[5] IEA. 2012. *Understanding Energy Challenges in India.* Available: https://www.iea.org/publications/freepublications/publication/India_study_FINAL_WEB.pdf

IEA. 2015. India Energy Outlook, World Energy Outlook Special Report. Available: http://www.worldenergyoutlook.org/media/weowebsite/2015/IndiaEnergyOutlook_WEO2015.pdf

Currently, India is the world's third largest emitter of carbon emissions behind the Peoples Republic of China and the USA, although per capita emissions are far lower. India's total emissions are 3,013.8 million tons of carbon dioxide equivalent (tCO2e) with large share coming from energy sector (2,126.5 million tCO2e); this is about 6.96% of the total global emissions in 2012.[6] The increasing use of inefficient back-up diesel generators by household, commercial, and industrial consumers due to unreliable and unpredictable power supply is also worsening local air pollution.

Based on Figure 2 below, out of the 124 cities in India (for which data exist), only Pathanamthitta City (with a population of 38 000), meets the World Health Organization (WHO) guideline for particulate matter (PM2.5) concentrations. Delhi exceeds this guideline by fifteen-times. In terms of PM2.5 levels, India has 13 of the world's 20 most-polluted cities and an estimated 660 million people in areas in which the government's own national air quality standards are not met (IEA, 2015). GoI recognizes that its coal-centered energy mix and rising pollutant emissions pose a threat to India's sustainable development.

**Figure 2: Average annual particulate matter concentration in selected cities in India**




Source: IEA (2015) India Energy Outlook

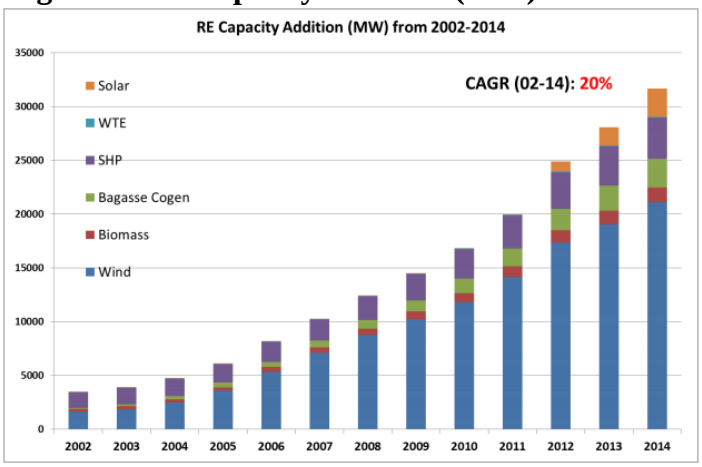
In June 2008, the government issued the National Action Plan for Climate Change (NAPCC) outlining existing and future policies and programs addressing climate mitigation and adaptation. The action plan identifies measures that promote country's development objectives while also yielding co-benefits for addressing climate change effectively. The Jawaharlal Nehru National Solar Mission (JNNSM), launched in 2010, is one of the NAPCC's eight core "national missions" which aims to promote the development and use of solar energy for power generation and other uses with the ultimate objective of making solar competitive with fossil-based energy options through long term policy and large scale deployment. Recently, the GoI announced its ambitious target of 100 GW grid connected solar projects by 2022, from the initial 20 GW. This new solar target is expected to abate or offset more than 170 million tCO2 over its life cycle.

[6] WRI. 2015. Infographic: What Do Your Country's Emissions Look Like?
Available: http://www.wri.org/blog/2015/06/infographic-what-do-your-countrys-emissions-look

Various initiatives are being undertaken by the government to facilitate development and deployment of solar energy, these include (i) mechanisms to lower the cost of solar power off-takers, including reverse auctions, viability gap funding (VGF), and bundling of private sector generated solar power with cheaper public sector coal power[7]; (ii) development of large solar parks in Rajasthan and Gujarat with dedicated land and evacuation infrastructure for private sector developers; (iii) Amendments currently being tabled in Parliament to increase Renewable Purchase Obligation (RPO) targets from 3% to 8% by 2019, introduce Renewable Generation Obligation (RGO) targets, and impose penalties on RPO and RGO non-compliance. In addition, amendments have also been proposed to the National Tariff Policy 2005, to socialize interstate transmission of renewable power, procurement of bundled solar power by distribution companies (DISCOMs) from conventional power generators on a cost plus basis, and easy pass-through of RPO compliance cost.

The overall RE development target is for 175 GW of new capacity installed by 2022, including 100 GW solar, 60 GW wind, 10 GW biomass, and 5 GW small hydro. The RE capacity growth from 2002 through 2014 is illustrated in Figure 3.

**Figure 3: RE Capacity Addition (MW) 2002-2014[8]**




***Solar Park Initiative:*** Approximately 20 GW of the targeted 100 GW of installed solar capacity is expected to be realized from utility-scale projects being developed in 25 solar parks supported by the Government. The solar parks initiative seeks to address the time and expense involved in obtaining suitable land and required clearances for solar projects, which have been identified as key barriers to solar expansion in India. Solar parks provide solar project developers with access to a site and necessary infrastructure for a lease fee. In addition to increasing the speed with which projects can be deployed, lower tariffs are also anticipated from these projects due to economies of scale being realized by developing a plot of land that will host several projects[9]. The Government is also providing capital subsidies for solar park development with an aim to further bring down

[7] The bundling mechanism has been limited to 1000 MW of coal-fired capacity during Phase 1 of the NSM.
[8] http://indiaenergy.gov.in/docs/RE_Documentation.pdf
[9] Solar project auctions for the solar parks at Gani-Sakunala in Andhra Pradesh and Bhadla Phase II in Rajasthan yielded successful low bids of 4.63 Rs/kWh and 4.34 Rs/kWh, respectively.

costs to developers and ultimately the solar power purchase prices. States with sufficient institutional capacity are developing parks through their state utilities, while others are forming joint ventures with SECI or the private sector for park development.

***Solar Park Transmission:*** In 2012, India's central transmission utility, Power Grid Corporation of India Limited (POWERGRID), published a Green Energy Corridors[10] plan to connect renewable resource rich areas to the existing grid. This plan detailed the transmission expansion projects required to achieve the renewable energy targets at that time. The Government's recently revised renewable energy targets will require additional transmission expansion, including to areas where solar parks are being developed. The transmission line expansion associated with solar parks is being built through the state transmission companies or POWERGRID. In cases where at least 50% of the power produced at a park will be consumed within the host state, the state transmission company may choose to build the transmission network. POWERGRID may be requested to undertake the transmission line expansion for the remainder of parks. To date, the Ministry of Power has assigned POWERGRID to connect 9 solar parks in 7 states[11] to the existing grid and declared that the relevant transmission infrastructure to connect these solar parks will be classified as inter-state transmission system assets, thereby socializing the costs across the power network.

**Project Description**

The *Proposed Loan Power Grid Corporation of India Limited Solar Power Transmission Sector Project Guaranteed by India*[12] ('Project') is one of the three engagements under the revised India CTF investment plan, for which the GoI has requested support from ADB. The proposed Project, in parallel with the other two projects on solar parks and rooftop solar (currently under preparation), will help the GoI achieve its new solar targets of 100 GW installed capacity, demonstrate important economies of scale in solar generation, increase efficiency while reducing transaction costs and unit costs of solar power, and minimize environmental pollution and GHG emissions.

The proposed Project will facilitate transmission system expansion and associated substations to help evacuate solar power generated from two or more new solar parks to the national grid that will make available additional clean energy to beneficiaries in India. Subprojects will connect at least 2,000 MW of solar parks to the interstate transmission system.

(i) The first 1,000 MW will be achieved through the core subproject to help Bhadla Phase III solar park connect to the interstate transmission system. This will include establishment of a 765/400/220kV Pooling Station at Bhadla, a 400 kV line to connect this pooling station to an existing substation at Bhadla, and a 765 kV interconnection from the pooling station to the Bikaner substation.

(ii) Additional subprojects will connect solar parks with at least 1,000 MW additional solar

[10] POWERGRID. 2012. *Report on Green Energy Corridors–Transmission Plan for Envisaged Renewable Capacity*. Gurgaon.

[11] States allocated to POWERGRID by the Ministry of Power in January 2015 include Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Meghalaya, Rajasthan, and Uttar Pradesh; additional states may be allocated to POWERGRID in the future.

[12] In the revised CTF Investment Plan of 2015, this project was referred to generically as "Solar Parks Transmission."

capacity to the interstate transmission system, and will include pooling stations, transmission lines, and associated equipment.

The transmission subprojects will include pooling stations, reactors, transmission lines, and associated equipment, as required, to connect solar parks to the existing interstate transmission system. Additional subprojects will be assessed based on readiness and need. Subprojects should satisfy the eligibility criteria: (i) The subproject should be technically feasible; (ii) The subproject will require transmission expansion, including to areas where new solar parks are being developed; (iii) The subproject will be designated as part of the interstate transmission system; and (iv) Any subproject classified as category A in accordance with ADB's Safeguards Policy Statement (2009) will not be eligible.

**Financing**

The proposed project requires total financing of $640 million comprising of a sovereign-guaranteed loan of $320 million including $270 million loan from ADB ordinary capital resources (OCR) and a $50 million loan from the CTF, equity and other sources. Table 2 shows the breakdown of the financing plan.

**Table 2: Financing Plan**

| **Source** | **Amount** ($ million) | **Share of Total** (%) |
|---|---|---|
| Asian Development Bank ordinary capital resources (loan) | 270.0 | 42.2 |
| Clean Technology Fund (loan) | 50.0 | 7.8 |
| POWERGRID (other sources) [a] | 128.0 | 20.0 |
| POWERGRID equity (internal sources) | 192.0 | 30.0 |
| **Total** | **640.0** | **100.0** |

Note: Numbers may not sum precisely due to rounding.
POWERGRID = Power Grid Corporation of India Limited.
[a] Expected to be POWERGRID's domestic bond issuance and other corporate loan financing.
Source: Asian Development Bank estimates.

The loans will be made directly to POWERGRID (implementing agency) with a separate guarantee agreement with the government. Financing from ADB's OCR will have a 20-year term, including a 5-year grace period, straight line amortization, an annual interest rate determined following ADB's London interbank offered rate-based lending facility, a commitment charge of 0.15% per year, and other terms and conditions set forth in the draft loan and guarantee agreements. The ADB CTF loan financing comes with a 40-year term, including a grace period of 10 years, an annual interest rate of 0.25%, a management fee of 0.18% per year, and such other terms and conditions set forth in the draft loan and project agreements. The remaining financing will be mobilized by POWERGRID, including debt from other lenders and equity contributions.

The Project supports the Ministry of New and Renewable Energy's (MNRE) solar park scheme by setting up transmission infrastructure to evacuate power from selected solar parks. It is aligned with GOI's NAPCC and JNNSM in promoting solar energy and is consistent with the ADB Strategy 2020 and Energy Policy 2009 that advocate the promotion of renewable energy, improved energy security, and facilitation of the country's transition to a low-carbon economy. It is also

consistent with India Country Partnership Strategy 2013–2017, that supports (i) clean and renewable energy expansion, particularly solar; (ii) transmission expansion at the state and central levels; and (iii) grid integration of renewable energy.

The proposed Project aims to increase supply of renewable energy to the Indian power system and reduce greenhouse gas emissions intensity of the Indian economy through increased contribution of solar energy to India's power mix.

## 12. **Consistency with CTF investment criteria**

**(1) Potential GHG emissions savings**

The Project will facilitate generation of power in solar parks in selected states and transmission of power from these parks to the national grid for use by residential, commercial and industrial consumers across the country. The transmission expansion project will be able to evacuate 2 GW installed solar capacity with 18% plant load factor (output) and additional electricity output of at least 3,154 GWh per year.

Assuming a conservative grid emissions factor of 0.7 tCO2e/MWh (700 t/GWh), the total emission reduction potential from the implementation of the project is estimated at 2.2 million tCO2e annually, or about 55 million tCO2e over a 25 year project lifetime.

*3,154 GWh/year x 700 t/GWh = 2.2 million tons CO2e / year*

The emissions factor of 700 t/GWh is more conservative than the 830 t/GWh for typical baseline scenario[13] as well as the grid emission factor for India[14]; the factor of 700 t/GWh accounts for decreasing emissions intensity associated with higher RE penetration rates. If black carbon emissions are included, assuming that the solar output is mainly displacing diesel-fired backup generators during afternoon and early evening peak demand periods, the effective GHG reductions would be almost two times greater.[15]

*Solar Potential.* The main rate limiting factors for India's solar development are availability of land, financing, and transmission capacity to deliver power to the grid. The proposed project will directly address financing and transmission constraints. Assuming that 1% of theoretically available land area can be developed, solar radiation is sufficient for 991,200 GWh/y of output, which equates to 566 GW of capacity operating at 20% load factor.[16] The 100 GW solar capacity

[13] 830 kg/MWh for coal generation from supercritical plants
[14] 980 kg/MWh, from CO2 Baseline Database for the Indian Power Sector, Central Electricity Authority
[15] For example, Appendix 4 of the Revised CTF Investment Plan for Indonesia 2013, notes an emissions factor for low efficiency diesel generators including black carbon of 1.39 tCO2e/MWh which is 98% higher than 0.7 tCO2e/MWh.
[16] The estimate is based on discussion in: Lu Yeung *et al*, *Can money be made from the Indian sun?*, UBS Investment Research, India Solar Industry, 16 April 2012. The assumptions for the 566 GW estimate are:
solar radiation of 1,600 kWh/m2/y x 1 km2 = 1,600 GWh/y
x 413,000 km2 theoretically available land area
x 1% discount for actual land availability

target is quite ambitious, yet realistic considering the ultimate potential. The economically and financially viable capacity will depend on future declines in installed system costs, costs of financing, and prevailing tariffs; the potential impact on global learning rates is discussed below.

**(2) Cost-effectiveness**

The project's cost-effectiveness is summarized in Table 3, assuming 25 year operational lifetime.

**Table 3: Avoided GHG Emissions and CTF Cost-Effectiveness**

| Case | Annual Avoided Emissions (million $tCO_2e$) | Lifetime Avoided Emissions (million $tCO_2e$) | CTF$ / $tCO_2e$ | Total project $ / $tCO_2e$ |
|---|---|---|---|---|
| **Before Replication & Scale-up: 2 GW** | 2.2 | 55 | 0.91 | 11.64 |
| **5x Replication & Scale-up: 10 GW** | 11.0 | 275 | 0.18 | 2.33 |

CTF = Clean Technology Fund; GHG = greenhouse gas; tCO2e = tons of $CO_2$ equivalent.

*Reduced cost of low carbon technologies and practices.* According to IRENA (2012), PV costs will continue to decline with increased deployment due to the high PV learning rate. Using a conservative learning rate[17] of 18%, PV system costs for utility scale systems is projected to decline from between $3,600 to $4,000/kW in 2010 to $1,800/kW in 2020 and as low as $1,060 to $1,380/kW by 2030. Residential systems can expect to achieve similar reductions from $4,200 to $6,000/kW in 2010 to between $1,800 to $2,700/kW by 2020 and to $1,500 to $1,800/kW by 2030.

In India, due to falling capital costs, project development at scale and reverse auctions carried out by the Government of India under the JNNSM, private sector PV projects cost has dropped from 17.91 rupees/kWh in 2010 to about 7 rupees/kWh in 2013. In the last two to three years, the energy sector has witnessed rapid development with installed solar capacity increasing rapidly from 18 MW to about 3800 MW during 2010-2015. Given the success of capturing the global cost reduction in solar PV and easing of PV tariffs, these allowed the GOI to significantly increase the national target for installed solar capacity from 20 GW to 100 GW.[18] Although it is difficult to predict the impact of the proposed solar parks and transmission line projects at present, it is however expected to provide learning and economy of scale benefits which can help facilitate further reductions in cost of PV in the future.

The private sector is responding aggressively to opportunities to develop solar projects in India in light of the Government's ambitious targets under the JNNSM and the conducive policy environment created by complementary legislation and initiatives that recognize the environmental benefits of solar energy, including India's Electricity Act, 2003 and the NAPCC. However, the transmission infrastructure required to enable increased penetration of solar energy remains a

x 15% energy conversion efficiency = 991,200 GWh/y => 566 GW @ 20% plant load factor.
The total incident radiation falling on the country (the "raw" resource) is 5,000,000 terawatt-hours per year; assuming 15% energy conversion factor, the theoretical solar output would be 750,000 TWh/y, which is more than 90,000 GW of equivalent baseload generation output.

[17] This is a conservative estimate, as historical learning rate is 22%.

[18] Government of India, 2015 (http://pib.nic.in/newsite/PrintRelease.aspx?relid=122566)

public sector responsibility. Solar power is still more expensive than conventional power in India and imposes an additional cost burden for integrating the associated variable power generation to the grid. The Government has approved transmission expansion to connect solar parks be declared as part of the inter-state transmission system, with costs socialized across the entire network, ensuring these connection costs do not further increase solar tariffs. Use of CTF and ADB OCR resources to finance this transmission expansion reduces the cost of connecting the solar parks to the existing network, ultimately reducing the transmission charges paid by consumers.

**(3) Demonstration potential at scale**

*Scope for avoided annual GHG emissions.* The proposed Project will directly contribute towards achieving GOI's ambitious target of 60 GW of ground-mounted utility-scale solar power plants by 2022. CTF financing will help mobilize future commercial investments for replication and scale up, which will stimulate economic growth and facilitate the long-term transition to low-carbon development. Five-fold replication and scale up would result in 10 GW of new capacity, which is about 16.6% of the 60 GW target; this 10 GW would have lifecycle emissions reduction of 275 million tCO2e as shown above in Table 3.

*Transformation Potential.* CTF guidance defines transformation potential based on 3 scenarios:

*(a) Scenario 1* -- a baseline trajectory of GHG emissions for the targeted sector.

(b) *Scenario 2* -- the trajectory of reduced emissions that would result directly from the CTF co-financed project alone.

(c) *Scenario 3* -- the trajectory of reduced emissions that would result if the CTF co-financed project were to be replicated throughout the targeted area, region, and/or sector. [19]

A project's relative transformational potential can be measured by the ratio of emissions reduction potential between Scenario 3 and Scenario 2.

Given the rapid evolution of utility scale solar power in India, defining Scenario 1 is somewhat problematic. For purposes of discussion, forecasts circa 2011 (when the original IP was endorsed) can be taken as a baseline: 260 GW of new thermal capacity dominated by coal, plus 20 GW of new solar capacity. In 2011, domestic coal output had been flat for several years at around 500 million tons per year (Mt/y), and the rate-limiting factor for new coal-fired capacity was the import terminal and intermodal trans-shipment capacity. As of early 2016, domestic coal production is projected to increase to 1,500 Mt/y by 2019-20, and import terminal capacity has been expanded.[20] This increase in domestic coal output, as well as imports, will allow rapid development of new coal fired capacity which in turn may crowd out investment in solar capacity.

In Scenario 2, the project will result in avoided GHG emissions of 2.2 MtCO2e/y. Backup generator capacity estimated at 90 GW can be expected to remain operational until the grid can

[19] Transformation potential is defined in paragraphs 15 - 17 of the *CTF Investment Criteria for Public Sector Operations* dated 9 February 2009.

[20] STRATFOR, *Why Energy Will Determine India's Future*; 7 January 2016. STRATFOR Global Intelligence. Austin TX, USA. https://www.stratfor.com/analysis/why-energy-will-determine-indias-future This article also notes that India is expected to become the world's largest coal importer by 2020.

supply reliable power on an around-the-clock basis. Therefore, in Scenario 2, solar output will effectively be displacing a mix of petroleum-fueled backup generation and grid supplied power which is dominated by coal.

In Scenario 3, a five-fold replication and scale up would deliver about 16.6% of the targeted 60 GW capacity. The aggregate capacity supported by ADB, World Bank, and others can be expected to drive down the levelized cost of solar energy (LCOE) to reach grid parity in the foreseeable future, and eventually reach parity with coal (RE < C) which is a tipping point for energy sector transformation. Given the potential capacity of 566 GW noted above, the transformation potential is at least 5.

**(4) Development impact**

The direct impact accrues from additional clean energy supplies, more reliable electricity services, and offset and displacement of fossil-fuel emissions including avoided fuel costs. The macro-economic impact accrues from solar industry and market development within India as outlined in the JNNSM and broader policy framework for low-carbon development.

Power sector development is a key driver for the country's economic growth and development. Access to reliable, stable, and adequate electricity supply increases agricultural, industrial, and commercial productivity and enhances economic growth. Economic growth helps reduce poverty and improve quality of life, particularly for the most vulnerable segments of society. As such, GoI is promoting the solar power capacity addition to help address the high demand of a rapidly growing economy, growing energy imports, high proportion of unserved population, and high emissions of particulate matter, nitrogen oxides, sulfur oxides, and CO2 from the extensive use of coal. The proposed transmission expansion project will support the delivery of additional solar energy capacity to the country's energy mix which is expected to help the country achieve (i) energy security, (ii) increase access to quality and reliable energy, (iii) employment generation; (iv) environmental benefits.

*Energy security and macro-economic benefits.* New investment in transmission infrastructure to facilitate GW-scale RE development will improve energy security. It will promote diversification of energy supply. Furthermore, as an indigenous and non-tradable energy source, new RE capacity serves as a natural hedge against the volatility of fossil fuel prices. Assuming 400 tons coal per GWh, the project will result in avoided coal consumption of 1.13 million tons per year. To date, India is the third-largest importer of crude oil in the world. By value, crude oil accounts for one-third of total imports, averaging around $135 billion a year since 2011 (although offset in small part by net exports of refined oil products).

The additional electricity output will also improve reliability of supply to households, industries and businesses. As reported, power shortages in FY2015 were equivalent to about 3.6% of total energy and 4.7% of peak capacity requirements. The macro-economic impact accrues from the development of solar manufacturing industries and market within India as outlined in the JNNSM and broader policy framework for low-carbon development.

*Increase access to reliable and quality energy:* The development of solar energy will have

significant benefits in terms of the reliability and security of electricity supply to consumers. The Project will facilitate additional electricity output of at-least 3,154 GWh annually. This will increase supply and availability of electricity which will enable utilities to expand connection and serve new customers. As noted above, about 237 million people in India do not have access to electricity. Assuming the GOI target of providing 1,000 kWh per person per year, the additional output will be sufficient to supply more than 3.15 million people, or about 630,000 households. It will likewise improve social service provisions of hospitals, schools, and other social infrastructure.

The energy output from the project will be fed into the grid, and it is not possible to determine the specific end-users. However, using the World Bank methodology[21] for calculating inferred access to electricity for residential use from power generation projects, the proposed project will be able to benefit an estimated of 1.3 million new customers or about 260,000 household beneficiaries[22].

*The methodology and assumptions used for the inferred access:* 3,154 GWh expected annual energy output. Transmission and distribution losses assumed at 10 percent. The net generation of 2,839GWh was allocated for residential and non-residential use. Based on the pattern from International Energy Agency's (IEA) Energy Balance Database for 2013 report[23], India's residential consumption was 35% and non-residential use was 65%. Using these patterns, the disaggregated amount of electricity generated for non-residential use (i.e. industries, businesses, transport and agriculture) is 1,845 GWh/year; while residential consumption is 994 GWh/year. India's 755 kWh per capita consumption of electricity is higher than the 2010 average global consumption per capita of 685 KWh; given these, it was assumed that new electricity generated is directed to new connections. As a result, the 994 GWh/year would benefit approximately 1.3 million new consumers.

*Employment opportunities.* The Project is expected to generate substantial employment opportunities during construction as well as implementation. Value-added employment will be created in solar industries, including manufacturing and energy services.

*Environmental benefits.* As one of the top carbon emitters, the project will help displace fossil fuel emissions including GHG and conventional pollutant emissions. At local level, air pollutant emissions under the thermal counterfactual are estimated at 74,800 tons of NOx, 51,500 tons of SOx and 8,100 tons of PM10 per annum, which will be reduced by displacing coal-fired power generation with increased solar electricity (World Bank, 2015).

**(5) Implementation potential**

As discussed above, the project has been developed in a strong policy context at the national and state level. It is fully aligned and consistent with the government's action plan and solar mission

[21] World Bank (2014). Available at: https://www.openknowledge.worldbank.org/bitstream/handle/10986/17370/853760BRI0ADD00for0collection0title.pdf?sequence=1

[22] Average number of household members in India is 4.8.

[23] IEA. 2015. Energy Balances of Non-OECD Countries.

strategies. ADB is actively engaged with key agencies MNRE and participating states and there is a strong commitment to develop solar parks and inter-state transmission lines. Policy and regulatory reforms, implementation mechanisms and incentives are being pushed by the government to ensure solar power cost are kept low and there is sufficient demand for the offtake of solar power generated under the project. Financial sustainability is seen positive for solar parks based on strong response from the private sector to participate in solar bids from the recently developed Rajasthan and Andhra Pradesh. The proposed transmission projects have been the subject of detailed feasibility assessments and due diligence.

POWERGRID has a sound implementation record in upgrading and strengthening the national high-voltage transmission network, with consistent good operational performance evidenced by transmission network availability of above 99% for the past 5 years. It has in-house planning capabilities, including computer-aided facilities for transmission system planning, design, operation, and maintenance. Since 1995, ADB has provided POWERGRID eight sovereign-guaranteed loans and two nonsovereign loans to strengthen its transmission system nationally. The projects have a good implementation history and high ratings. POWERGRID's financial management capacity has been thoroughly evaluated by ADB and determined to be strong. Based on the cost-plus nature of the tariff-setting process coupled with its operating efficiency, POWERGRID has increased revenues and net profits consistently, maintaining a robust financial position with stable cash flows to cover its costs, capital investment, and debt payments. It has maintain an international long-term issue credit rating of BBB– (Outlook: Stable) from both Standard & Poor's and Fitch, and enjoys the highest domestic credit rating of AAA.[24] Although POWERGRID has an aggressive investment plan and a large need for additional borrowings, financial projections show it has a sound financial position even under stress scenarios. POWERGRID observes strong governance measures as imposed by India's Securities and Exchange Board, which enhance accountability, transparency, and predictability of its financial governance through information disclosure to shareholders, investment professionals, and the general public. It has an advanced accounting system using computerization with confidentiality and integrity at various levels.

*Leverage:* The project will be funded by ADB ($270 million) through its ordinary capital resources, CTF ($50 million), the other financing will be mobilized by POWERGRID including equity contributions, and domestic bond issuance and other corporate loan financing ($320 million). The CTF leverage ratio is calculated at $640 million / CTF$50 million = 12.8:1 before replication and scale up. As noted above, replication and scale up potential is at least 5, therefore the leverage ratio is expected to increase to 64:1.

Project will effectively mobilize large amounts of investment in generation capacity by utilizing public sector financing for the development of the required transmission infrastructure which is a relatively small portion of total investment, but which is necessary to reduce the risk of investment

[24] Since 2001, POWERGRID's domestic bonds have been rated AAA by the Credit Rating Information Services of India Limited and AAA by the Investment Information and Credit Rating Agency of India Limited. Since 2008, the Credit Analysis and Research has also given these bonds an AAA rating.

in generation capacity. The use of CTF cofinancing for this project can be thought of as precision-guided subsidies enabling brute force investment.[25]

**(6) Additional costs and risk premium**

Solar power is still more expensive than conventional power in India and imposes an additional cost burden for integrating the associated variable power generation to the grid. [The "fuel" may be free, but the kit to convert that fuel to useable energy is not.] The economic benefits of solar energy versus fossil fuels cannot be readily monetized as upfront financing. Hence, concessional finance has a catalytic role to plan in India's solar program.

The CTF concessional financing will reduce the overall financial risk of the project by reducing the cost of capital, particularly mitigate risks of additional costs of solar energy systems, transmission utilization, and cost of high levels of renewable energy penetration. The renewable purchase obligation (RPO) and renewable energy certificates (REC) policy framework supports the generation and off-take ends of the system but not the transmission "middle man." Alternatively stated, the policy and regulatory framework has reduced the development risk in the generation subsector, as demonstrated by significant commercial investments that have been mobilized already. RPO enforcement and REC market risks are moderate to high and cannot be readily mitigated.

Government intervention via India's Electricity Act, 2003, the National Action Plan on Climate Change (2008), and the JNNSM (updated 2015) has created the necessary legal and regulatory framework to capture the environmental benefits of solar and wind power, thereby attracting private sector investment. However, the enabling transmission infrastructure for increased penetration of renewable energy remains a public sector responsibility. This provides the rationale for ADB support. Project will provide means to export excess solar energy from states that will either have a surplus of generation beyond RPO requirements or will not be able to absorb capacity outside of peak demand periods. This will not only support renewable energy capacity expansion but will also form part of the integrated interstate and interregional grid, and thus provide for the flow of real and reactive power derived from conventional generation as well as renewable energy, optimizing generation dispatch at a regional level, enhancing transient and dynamic stability, and improving overall grid security. Exported electricity would displace coal-fired generation from existing plants (a resource cost saving) in states with renewable energy shortfalls. In light of these benefits, and consistent with other ADB economic analysis of renewable energy transmission, the subprojects' economic internal rates of return are expected to be greater than 16%. The projects are thus preliminarily assessed as financially viable and economically sustainable.

The project's financial viability was examined by comparing the incremental costs and benefits. The financial internal rate of return (FIRR) is calculated at 4.49% in real terms (8.87% on a nominal basis), which compares favorably with the estimated weighted average of cost of capital (WACC) value of 3.94% in real terms (7.66% on a nominal basis), thus substantiating the project's financial viability. While the project is considered financially viable according to ADB guidance (FIRR > WACC), the single digit FIRR is not attractive for purely commercial investors. This sub-

[25] In military terms, CTF co-financing is a "force multiplier."

commercial rate of return justifies the use of CTF in accordance with paragraph 25 (b) of the *CTF Investment Criteria for Public Sector Operations* (2009), and paragraph 20 (b) ii and paragraph 25 (a)[26] and (b) of the *Clean Technology Fund Financing Products, Terms, and Review Procedures for Public Sector Operations* dated 15 December 2011.

| **Additional CTF investment criteria for private sector projects/ programs** | |
|---|---|
| (1) Financial sustainability | n/a |
| (2) Effective utilization of concessional finance | n/a |
| (3) Mitigation of market distortions | n/a |
| (4) Risks | n/a |

13. **For DPSP projects/programs in non-CTF countries, explain consistency with FIP, PPCR, or SREP Investment Criteria and/or national energy policy and strategy.**

**n/a**

14. **Stakeholder Engagement**

The key stakeholders include executing agencies, implementing agencies, central government, local government authorities, non-government organizations (NGOs), community based organizations (CBOs), co-financers, private sector entrepreneurs, and affected people including the poor, women, children, and indigenous people. The stakeholders will be consulted through meetings, interviews, workshops and surveys throughout project design and subprojects selection. Consultation with the affected indigenous people, poor and CBOs will include discussions on environmental, involuntary resettlement, compensation for loss of crops and trees, and other social issues that may affect them. The Project envisions gender equitable and participatory public consultations and focus group discussions along transmission corridors and the areas of the proposed solar parks. These aim to engender the informed consent of stakeholders and facilitate implementation.

15. **Gender Considerations**

The Project is expected to be gender neutral as all benefits are indirect (alternatively stated, transmission projects are not amenable for Effective Gender Mainstreaming). A Gender Action Plan will be developed for the project to ensure gender design features and women's participation and benefits. Integral to the action plan is the designing of a framework for community development and livelihood activities with a gender-sensitive approach. Specific interventions include skills training, needs-based livelihood intervention, equal opportunities to access employment, and equal pay for men and women under civil works contracts, etc.

16. **Indicators and Targets**

| **Project/Program Timeline** | |
|---|---|
| Expected start date of implementation | January 2017 |
| Expected end date of implementation | 30 June 2022 |
| Expected investment lifetime in years (for estimating lifetime targets) | 25 |

[26] Paragraph 25 (a) specifically refers to the risk of "the intermittence of solar and wind resources."

| **Core Indicators**[27] | | **Targets** |
|---|---|---|
| GHG emissions reduced or avoided over lifetime (tonnes of $CO_2$-eq) | | 55 million tCO2e |
| Annual GHG emissions reduced or avoided (tonnes of $CO_2$-eq/year) | | 2.2 million tCO2e |
| Installed capacity of renewable energy (MW) | | 2 GW |
| Number of additional passengers using low-carbon transport per day | | n/a |
| Energy savings cumulative over lifetime of investment (MWh) | | n/a |
| Annual energy savings (MWh/year) | | n/a |
| **Identify relevant development impact indicator(s)** | | **Targets** |
| Job creation | | *To be determined* |
| 17. **Co-financing** | | |
| | Please specify as appropriate | Amount (in million USD) |
| • MDB 1 | ADB | 270 |
| • MDB 2 (if any) | | |
| • Government | POWERGRID equity contributions and corporate loan financing | 320 |
| • Private Sector | | |
| • Bilateral | | |
| • Others (please specify) | | |
| **Total** | | 590.0 |
| 18. **Expected Date of MDB Approval** | | |
| Q3 2016 | | |

Version December 9, 2014

[27] In the revised Investment Plan of 2015, the results indicators for this Project were combined with the "Solar Park Infrastructure" project to avoid double-counting of GHG emissions, RE capacity, etc. The Government of India has requested that the CTF allocation for the proposed ADB Solar Park Infrastructure project be shifted to the ADB Solar Rooftop Investment Program. With this proposed change, ADB will have 2 CTF-supported operations: this Project for solar transmission, and the Solar Rooftop Investment Program. Therefore, avoided GHG emissions and renewable energy capacity which would have been counted under the solar parks infrastructure project are now included as results indicators for this transmission Project. For the purpose comparing IP and project level targets, the targets specified in Table 14, page 34 of the revised IP should be used.

# Review of India's Proposed Solar Power Transmission Sector Project with CTF Financing

**February 2016**

**Review of Solar Power Transmission Sector Project with CTF Financing**

The draft Report and Recommendation of the President (RRP, the primary document for Asian Development Bank [ADB] Board consideration) and CTF funding application (the CTF "cover sheet") for the proposed sector loan (the Project) were reviewed for consistency and eligibility for CTF co-financing. The comments based on documents made available for the review are summarized in the table below. This review was conducted by Mr. Pil Bae Song, independent consultant and Visiting Professor at Korea Development Institute School of Public Policy and Management. The Project has been subject to the ADB's internal peer review process as well. Based on the documents reviewed, the Project is consistent with both CTF and ADB eligibility requirements.

| Criteria | Comments | Responses |
|---|---|---|
| Eligibility for Clean Technology Fund (CTF) financing | The Project concept is included in the Revised CTF Investment Plan for India (IP) which was endorsed by the Trust Fund Committee in 2015. The Revised IP elucidates a programmatic approach with funding allocations to ADB and World Bank to support solar energy development with cofinancing for transmission, solar parks infrastructure and rooftop solar. The original IP endorsed in 2011 also emphasized solar energy development with similar project concepts for solar parks and related transmission system expansion. The Project scope and outputs reflect the concept note appended to the Revised IP.<br><br>The Project is similar to the solar transmission investment program in the Indian state of Rajasthan, for which CTF cofinancing was approved in 2013; that investment program was subsequently approved by ADB's Board in 2013. The Project is more expansive than the earlier Rajasthan program in that it will support new solar parks, which have not been supported by CTF, and the investments include inter-state transmission expansion vs. only intra-state transmission for the Rajasthan program. The interstate transmission investments represent a design advance with respect to CTF support for India's national-level solar ambitions. This is ADB's first use of the sector loan | Noted. |

| Criteria | Comments | Responses |
|---|---|---|
| | modality for CTF (a sector loan supports programmatic investments, similar to that for the multi-tranche financing facility (MFF) approved for Rajasthan).<br>The Project fulfills the 6 CTF eligibility criteria for public sector operations, consistent with the recently approved World Bank projects and the earlier Rajasthan MFF. A detailed examination of each criterion is not presented herein but some specific points are raised below. | |
| Potential GHG Emissions Savings, Cost-effectiveness, Demonstration Potential at Scale, and Potential for Replication and Scale-up | The potential GHG emissions savings are dependent on availability of land, transmission capacity, and financing. Availability of land has been a critical constraint in developing large-scale infrastructure and industrial projects in India. Paragraph 30 and footnote 25 of the draft RRP discuss land acquisition, noting the procedures in place. It would be useful to note the situation for land acquisition in the solar parks to be supported by the transmission investments, i.e., is land acquisition a barrier to the solar parks development which could negatively affect the viability of the Project?<br><br>The discussion of Transformation Potential raises a somewhat philosophical question about CTF guidance on how to define baselines or BAU scenarios. The baseline Scenario 1 might logically be presented as the current 60 GW target instead of the 20 GW target of 2011, that is to say that 60 GW is the "new BAU;" however, until the first 20 GW of utility scale solar is up and running, the scenarios as outlined appear reasonable. It may be worth noting that if the proposed 100 GW total solar capacity (parks plus rooftop program) is successfully developed by 2022, the solar output would provide only about 10% of total project electricity consumption. What is the prospect for solar development beyond the 100 GW program? | Land acquisition is a critical element and Government of India has made allocating of lands for the solar parks a high priority.<br><br>The Transformation Potential could be presented differently, for example the baseline could assume 60 GW of solar power and a larger number could be used for Scenario 3 but this is problematic since there is no future target beyond the 100 GW total solar program objective. As noted in the CTF cover sheet, the ultimate solar potential based on using just 1% of theoretically available land is more than 500 GW, so the Transformation Potential is arguably higher than presented. Assuming that the |

| Criteria | Comments | Responses |
|---|---|---|
| | The discussion of Black Carbon is appropriate, considering the rather dismal air quality situation noted in Figure 2. The co-benefits of reducing black carbon, which occurs in the form of PM2.5, might be further explored in parallel with Project implementation, so as to provide the Government of India with a better understanding of the negative impacts – including non-climate impacts – of expanded reliance on fossil fuels.<br>The use of CTF is justified, since other potential carbon or concessional financing is not readily available for large-scale transmission capacity. | 100 GW program is successful, further expansion would require consideration of utility-scale storage and other technological improvements to ensure grid stability and load balancing |
| Private Sector Participation and Leveraging | POWERGRID's status as a "navratna" is duly noted in paragraph 25 of the draft RRP. The company is a commercially operated enterprise even if the Government still owns the majority of the shares and as such is not a pure private sector entity.<br>Table 4 of the draft RRP indicates overall risk of the Project is low.<br><br>It would be useful if the project team could comment on potential risks in developing the 2000 MW of solar capacity, which will be done by parties other than POWERGRID. Assuming an installed system cost of $2 / Watt, the generation capacity will require more than $4 billion investment. | The CTF cofinancing will help attract private investment for generation capacity by financing transmission infrastructure, which lowers risks for investment in generation capacity.<br><br>The history of solar development in India during the last 5 years suggests that investor expectations are realistic, and that sufficient financing will be forthcoming for the generation assets.<br>Of course there are unquantifiable risks in a national program of this scale; the sector loan modality provides flexibility to adjust subproject implementation and funds flow so that transmission investments are not put at undue risk due to premature construction and commissioning. |
| Technology and Price Risks | There are no details presented on technical specifications, so it is assumed that the proposed investments will use readily | Correct, the Project will use readily available technologies and there are no undue risks in |

| Criteria | Comments | Responses |
|---|---|---|
| | available technology from commercial vendors, and that there are no major technical risks to be mitigated.<br><br>Prices for aluminum and steel have been trending downward during recent years and are currently depressed. Has the risk of future price increases been taken into account? | this regard. POWERGRID does track technology developments, and will introduce new software and hardware to support grid efficiency and operational security in accordance with its operational plans.<br><br>Financial and economic evaluation included sensitivity analyses and the Project remains viable even if there is some prince increases. Contingencies have been incorporated as per ADB guidelines. The project team does not expect to see an upsurge in aluminum and steel prices in the foreseeable future. |