Module Outline

PV APPLICATION CASE STUDIES

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Relevance and Background

Solar PV as a technology has the potential to address various needs and requirements. The major advantage of this technology is its modularity. This enables project formulators to design projects at a very small scale like meeting domestic household electricity demands to very large projects of many MW feeding electricity to the central grid. The falling cost of the technology has only increased its applicability at the ground level. At a project level, the technical architecture of a solar project can be centralized, decentralized or distributed. Depending on the purpose of the project, the technical architecture of the project can be worked out. Through this module, the participants will be exposed to cases on each of these architectures.

Theme - Foundation
Competency – Competency 1 – General

Code of the Module: T01C01M03

Learning Outcomes

The participants shall be conversant with:

- Different applications of solar technologies – PV and thermal
- Technical architecture of solar PV projects
- Different case studies of solar PV projects

An overview of the above topics would equip them with the necessary exposure so that they can contribute to developing solar projects in their respective countries as per their needs.

Method of Delivery

Duration	Resource Code	Resource Delivery
60 min.	M03 L01	Lecture on PV Application Case Studies

M03 L01: Lecture Presentation

The MS PowerPoint presentation first gives an overview of solar energy applications including thermal and electrical applications and will act as a recapitulation of the earlier Module. Thereafter, the presentation discusses different technical architectures of a solar project which will help them conceptualize applications into projects. Based on the three technical architectures, case studies will be shared and discussed.

Key topics to be Covered

1. Case Study 1 - iShack Project, South Africa
2. Case Study 2 – Solar Rooftop Program in Kerala, India
3. Case Study 3 – Electrification of Rural and Arid Areas by Solar Energy Applications, Morocco

4. Case Study 4 – Solar Mini-grids, Bangladesh
5. Case Study 5 – Rewa Ultra Mega Solar Project, India

Table of Contents

1 Case Study 1 - iShack Project, South Africa 6
1.1 Background 6
1.2 Objectives 6
1.3 Methodology 6
1.4 Funding 7
1.5 Sustainable model 7
1.6 Achievements 7
2 Case Study 2 – Solar Rooftop Program in Kerala, India 9
2.1 Background 9
2.2 Challenges Faced 10
2.3 Project Outcomes 11
3 Case Study 3 – Electrification of Rural and Arid Areas by Solar Energy Applications, Morocco 12
3.1 Background 12
3.2 Public-Private Partnership 12
3.3 Financial Arrangement 13
3.4 Achievements of the Project 13
3.5 Key Learnings of the Project 13
4 Case Study 4 – Solar Mini-Grids, Bangladesh 14
4.1 The Need 15
4.2 The Solution 15
4.3 IDCOL's Mini-Grid Initiative 16
4.4 Success Story 16
5 Case Study 5 – Rewa Ultra Mega Solar Project, India 18
5.1 Background 18
5.2 The Project 18
5.3 Financing of the Project 19
5.4 Lessons Learned 19

1 Case Study 1 - iShack Project, South Africa

1.1 Background

A non-profit organization named the iShack Project was founded to roll out solar home systems (SHSs) in the Enkanini informal settlement in Stellenbosch, Western Cape, South Africa. In 2012, the Sustainability Institute Innovation Lab and Stellenbosch University launched the project as a social enterprise in response to years of applied research into the difficulties of upgrading informal settlements. The project is based at the Sustainability Institute Innovation Lab just outside Stellenbosch, South Africa, and runs energy utilities in Stellenbosch and Cape Town.

1.2 Objectives

The project aims to provide off-grid solar electricity to residents of informal settlements while they wait for grid electrification. The objective is to demonstrate, at scale, a viable and financially sustainable public-private business model for the provision of incremental energy services to under-serviced communities.

The project's two main goals have been to:

- Create and demonstrate a sustainable solution for providing informal settlements with cost-effective off-grid solar electricity
- Seize chances for economic multipliers that help the target community by providing the service (e.g., local job creation and skills training).

1.3 Methodology

Their model is consistent with numerous existing laws and policies in South Africa that prioritize the delivery of subsidized basic services to the poorest members of society.

Clients join the service voluntarily and receive a stand-alone 50-80 Wp SHS to power lighting (three to four lights per household) and energy-efficient media (LED televisions, radios, tablets and smartphones).

The iShack operating model is a long-term commitment to maintaining the utility (for as long as it is needed), rather than a purely technical, drop-and-go intervention. It focuses on building local enterprising capacity, developing skills, creating green jobs and contributing to the resilience of the communities it serves.

The project's operations team includes a group of 'iShack Agents' who all live in the community where they work. Weekly training is provided at the Sustainability Institute, during which the Agents are given the skills necessary to deliver a high quality, durable solar energy service.

1.4 Funding

The Government of South Africa through the Department of Environmental Affairs (DEA) has set up a Green Fund to support the transition to a low carbon, resource efficient and climate resilient development path delivering high-impact economic, environmental and social benefits. On behalf of the German International Climate Initiative (IKI), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH supported the DEA in evaluating and developing the Green Fund. The Development Bank of Southern Africa (DBSA) is the implementing agent of the Green Fund.

Built on initial funding from the Bill and Melinda Gates Foundation, the iShack project was up-scaled with additional finance of R17[1] million from South Africa's Green Fund.

1.5 Sustainable model

The neighborhood municipality provides an operations and maintenance subsidy per family that covers up to 90% of the utility's running costs through a public-private partnership (PPP) agreement with the iShack Project. According to the idea of basic energy as a right, the state extensively subsidizes the initial expenditures and ongoing operational costs of the service to make it more accessible and affordable for low-income households.

Each home must sign a contract with iShack, pay a joining fee, and contribute to the cost of continuous maintenance to use the service. The clear transactional relationship between the project and the end users is facilitated by these co-payments. As end-users must personally opt into the service by making a financial commitment rather than being offered solely as a government handout to homes on a waiting list, this helps to "depoliticize" the service to some level. It also gives a platform for the company to offer more commercially priced goods and services, like appliances and system updates, as well as some accountability for the company's service quality.

1.6 Achievements

Over 1,600 homes are currently served by the iShack Project. Other outcomes include:

- 11 jobs created
- 8 people trained
- R182,000 in external financial contributions
- 1,026 solar systems installed
- 92,556 kWh/year saved
- About 3,000 lives improved
- Municipal grant for free basic electricity provision secured.

[1] 1 South African Rand equals 0.053 United States Dollar(Source: https://g.co/kgs/Rnuzqg; accessed on August 8, 2023)

- Contribution to Sustainable Development Goals – Goal 7: Affordable and clean energy; Goal 9: Industry, innovation and infrastructure; and Goal 12: Responsible consumption and production

The South African Constitution envisages "progressive realization" of services, and the iShack service is a working embodiment of that vision This is a good example of a PPP working together to promote a sustainable model of solar energy systems.

This model can be adopted by municipalities throughout the country in order that they deliver on their statutory obligations to ensure universal access to basic energy.

Video on the case study: https://www.youtube.com/watch?v=Rt6-uuKgBeI

2 Case Study 2 – Solar Rooftop Program in Kerala, India

2.1 Background

The Government of India (GoI) has committed to increasing non-fossil fuel-based energy capacity to 500 GW by the year 2030. As on April 30, 2023, India had achieved a total solar rooftop (SRT) installation of 9,022.71 MW[2]. Of this, with an installed capacity of 471.69 MW, Kerala, in the southern

part of the country, is ranked sixth among the states. Being small, densely populated, and forested, setting up ground-mounted solar projects in the state is a challenge. So, the state is looking at floating, dam-top, and canal-top installations for large projects, or smaller SRT systems. Keeping this in mind, in 2013, Agency for Non-Conventional Energy and Rural Technology (Anert) launched the '10,000 rooftop program'. Though pitched initially as a grid-connected program, restrictions by the Union Ministry of New and Renewable Energy (MNRE) on central subsidy meant the program looked at only 'off-grid systems of 1 kW with battery backup'.

[2] https://mnre.gov.in/img/documents/uploads/file_s-1683779844352.pdf (accessed on June 1, 2023)

2.2 Challenges Faced

In 2014-15, Anert organized a series of awareness campaigns in each district of the State. It added to the MNRE standards by introducing criteria like greater inverter efficiency, and the enhanced battery guarantee duration, and slapped on an additional state subsidy of 20% to further improve the application and economics of off-grid systems. When the initiative came to an end in 2017, it had

installed all 10,000 units and was deemed a success. 2015 saw two new programs — 'Solar Connect' (grid-connected systems) and 'Solar Smart' (off-grid systems) — introduced to overcome the capacity limits of the previous scheme. Off-grid systems could now go up to 5 kW while grid-connected systems could go up to 100 kW. By March 2018, Anert had facilitated close to 30 MW of SRT (grid-connected and off-grid).

In 2019, MNRE launched Phase II of the Grid-Connected Rooftop Solar (GCRTS) Program, which made the Kerala State Electricity Board (KSEB) responsible for both installing SRT systems and disbursing subsidies. These were activities previously led by Anert. It was hoped that encouraging KSEB would give the SRT segment the boost it needed. KSEB had set itself a goal of 500 MW by 2022, with 150 MW of SRT coming from home and agricultural clients, 250 MW from commercial and non-governmental buildings, and 100 MW from governmental structures. The result was that Kerala became the sixth most successful state in the country in terms of SRT installations.

The commercial and industrial (C&I) sector now accounts for most installations and chooses SRT due to the clear electricity bill savings. These bill savings, if channeled, might aid in the system's five- to six-year payback. Domestic consumers, who pay a lower tariff rate than C&I consumers, however, may not get the same cost reductions, which may account for their slow adoption rates. In retrospect, the

Centre's Phase II program terminated all financial assistance to the C&I industry (and other larger consumers). Instead, it has increased the capital subsidy percentage accessible to domestic customers and created a means to reward the distribution companies (DISCOMs).

2.3 Project Outcomes

- More than 400 MW of installed capacity
- 1.8 million man-days of employment generated[3]
- 780 superintendents engaged in the program management and execution
- 3 million notices and brochures distributed; 13.5 million official SMS to consumers at different intervals; and 10,000 banners and posters displayed at all field offices and local body offices – as part of solar awareness campaigns.
- Central financial assistance: INR 60 crore[4] till March 2023
- Contribution to Sustainable Development Goals – Goal 7: Affordable and clean energy; Goal 9: Industry, innovation and infrastructure; Goal 12: Responsible consumption and production

Earlier, processing of SRT applications could take up to two years. Anert established an internet portal called "Buy My Sun" (http://www.buymysun.com/) to make buying and installing easier and quicker. The Program Management System, Buy My Sun, and the m-Anert smartphone app were all introduced in 2018 and have made SRT adoption simple to use. It links clients with suppliers, authorized installers, and inspectors, among others.

An SRT system may now be purchased and configured entirely online. Anert released a list of empaneled developers, system integrators, and service providers to reduce the frequency of SRT failures. 'Urja Mithra - Akshaya Urja Service Centers' in 140 constituencies have been launched to better serve local solar prosumers.

Under the Phase-II GCRTS, KSEB was been assigned a grant to develop a single-window portal called KSEB E-Kiran (https://ekiran.kseb.in/), for consumers, DISCOMs and vendors, wherein they can monitor the progress of rooftop solar at each level. The portal is integrated with the customer relation management (CRM) application of KSEB and can even be used to upload relevant documents to the MNRE national portal (https://solarrooftop.gov.in/login).

This is a good example of how government interventions can drive the solar energy sector.

[3] Solar Power Jobs: Exploring the Employment Potential in India's Grid-Connected Solar Market (https://www.nrdc.org/sites/default/files/renewable-energy-solar-jobs-report.pdf)
[4] 1 Indian Rupee equals 0.012 United States Dollar (Source: https://g.co/kgs/QtPjz7; accessed on August 8, 2023)

3 Case Study 3 – Electrification of Rural and Arid Areas by Solar Energy Applications, Morocco

3.1 Background

The rate of electrification is very varied within the African continent; 17% in Mali, 59% in Ivory Coast and 82% in Gabon[5]. The situation is more dire for the rural sub-Saharan population, where in 2022, 50% of people were without electricity in isolated, sparsely populated areas[6].

Morocco is a solar-rich country with more than 3,000 hours of sunshine per year or about 5 kWh/m2/day of irradiation. According to the 2004 census, when this project was conceptualized, Morocco had a population of 29.7 million people, of which 45% resided in rural areas. 16.4% of rural residents in 2004 lived on less than $2 per day, and many lacked access to the contemporary services that are available in urban regions. This is due, in part, to the Moroccan power system's centralization to satisfy the demands of industrial and urban areas. Although the government has been aware that having access to dependable energy can promote both human and economic growth, connecting rural houses to the grid has always been expensive. So off-grid systems, which include mini-grids and stand-alone systems, can offer electricity at a lower cost in such areas.

3.2 Public-Private Partnership

The government organization in charge of electrifying rural areas in Morocco is called the Office National de l'Electricité (ONE). To power rural households using solar energy, ONE and a private enterprise (a renewable energy service company or RESCO) formed a public-private partnership in June 2002. The main goal of the solar project was to supply photovoltaic (PV) kits to more than 58,000 rural Moroccan families to meet their basic energy demands, boost local development in terms of health, education, and economic growth, and generate jobs in sales, installation, and after-sales services.

The RESCO was chosen through a competitive tender and managed the design, production, installation, operation, and maintenance of PV solar power systems. It was made up of a French oil provider, a French electricity company, and one of their joint companies. The RESCO also collected user fees across 24 Moroccan provinces.

ONE monitored the solar power operator's adherence to its project agreements and gauged consumer satisfaction. Additionally, it offered cash for subsidies, allowing the operator to offer the service at a cost that was more reasonable for people living in rural Morocco. The subsidy was funded by loans and grants from bilateral aid organizations.

[5] M. Alaoui and M. Bahri, "Defis et opportunites de developpement rural en afrique subsaharienne," pp. 46-78, 2018

[6] https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ZG

3.3 Financial Arrangement

The solar electricity project had a $35.5 million investment budget. 66% of the costs were covered by an equipment grant from ONE through the German Bank KfW ($6.5 million), a soft loan ($6.5 million) from the French Development Agency (AFD), and around $1.5 million from the French Fund for the World Environment (FFEM), which was used in the project's start-up phase to provide technical assistance.

A quarter of the project's budget was provided by the RESCO. It was able to amortize its initial investment, upgrade equipment, and pay operating expenses thanks to the monthly payments it received.

Customers provided 10% of the first funding in the form of connection fees. The government grant, however, significantly lowered this cost to the consumer. Rural solar clients received a 40% subsidy, which brought the price of their electricity close to what city inhabitants paid for electricity from the grid. A rural household that typically spent 15-20% of its income on electricity could pay these fees.

3.4 Achievements of the Project

For the first phase of the project, 16,000 customers in four provinces had a choice between three types of service. Each client received a solar panel, one battery of 150 Ah, one charge controller and one 12 V outlet with two sockets, but those who were willing/able to pay for higher capacity systems were able to install more lamps. The battery backup was for five days, allowing the equipment to run year-round, even when the weather was not favorable. During the second phase of the project, 37,000 customers in 20 provinces chose between two types of service. Once again, the solar panel, battery, regulator and 12 V outlet were standard equipment, but the higher capacity system could now handle the voltage demands of a refrigerator. Overall, by 2007, the project targets were met.

3.5 Key Learnings of the Project

One of the main barriers to large-scale solar adoption in rural areas was the economic factor. An average solar kit costs twice as much to connect a home to a mini-grid powered by a diesel generator system (including equipment, installation, and maintenance). The solar project survived only due to the subsidies from ONE. Moroccan grid-connected consumers paid a fee of 2% of their monthly bill to support the subsidies and encourage the use of solar energy in rural areas.

The project's viability and sustainability were made possible by the fee-for-service business model. Since the majority were illiterate, promotional campaigns were launched on the radio.

The RESCO decided to train and hire local technicians to offer prompt and dependable services to its clients at competitive prices. Additionally, it established a reputation for accessibility and dependability through its local offices and participation at the weekly souks (markets). The low payment default rate is a result of this focus on customer service.

The RESCO was required to pay for the equipment upfront before being reimbursed by the ONE subsidy. Since the equipment installation was paid for with notable delays, this created serious cash flow issues, which were only solved with support from the French oil and electrical firms.

4 Case Study 4 – Solar Mini-Grids, Bangladesh

4.1 The Need

Although most villages in Bangladesh are connected to the national grid, reliability is a major issue. Remote settlements are susceptible to regular power outages, and villages might go for days without electricity. Responding to these reliability demands, distributed renewable energy producers are providing stable electricity to both grid-connected and off-grid areas.

4.2 The Solution

Community mini-grid deployment initiatives have shown that they can significantly contribute to socio-economic development in the surrounding communities, which are primarily rural. Besides providing jobs, they can also improve the quality and effectiveness of rural electricity supply to nearby businesses.

However, distributed renewable energy (RE) suppliers do not receive any operating subsidies. So mini-grid providers charge higher rates than the average national grid tariff, making it expensive for rural customers. Distribution companies (DISCOMs), on the other hand, are heavily subsidized. Additionally, there is significant doubt about the scalability of mini-grids due to the political viability of coordinating development projects with national grid extension efforts.

Solar mini-grids (SMGs) are a key strategy for the Government of Bangladesh (GoB) to electrify rural areas, offer related social benefits, and lower carbon emissions. When compared to grid-connected power and diesel mini-grid alternatives, a typical SMG that can supply 400 MWh of annual demand emits about 90% less CO2.

4.3 IDCOL's Mini-Grid Initiative

As of 2019, there were 22 SMGs operational in Bangladesh; however, the technical potential for growth was much greater. Infrastructure Development Company Limited (IDCOL) had financed the majority (20) with a 50% grant, 30% concessional loan and 20% equity investment, and intends to finance a further 200 SMGs by 2025. Commercial finance is becoming a viable alternative to the IDCOL financing program, and Uttara Bank has financed one small microgrid.

A key feature of the initiative is the approach followed by IDCOL – the Anchor-Business-Customer (ABC) approach. This involves collecting customers in two stages: before the project begins, securing commitments from important industrial and/or medium-sized company clients; after the SMG is running, acquiring residential and smaller individual commercial users. In contrast to the alternative of starting customer acquisition immediately when the SMG is operational, the anchor customer's function is to maintain a continuous base load demand, delivering more income certainty and stability. Therefore, suitable anchor customers must have a sizable and consistent load, ideally during the daytime when the SMG can provide power without the need for batteries. To facilitate connectivity, the anchor consumers should ideally be situated close to the SMG. Base transceiver stations (BTS) for telecommunications, village markets, cold storage facilities, and sawmills are some such loads. Adopting an ABC approach offers a potentially higher rate of return, and lowers project risks. Analysis undertaken by Vivid Economics[7] with and without the adoption of the ABC model shows that:

- The 'fast' scenario would see all target customers connected to reach the generating capacity of the SMG within two years. Under this scenario, the equity IRR is as high as 22% with the ABC model compared to 18% without.
- The 'slow' scenario where customer acquisition takes six years instead of two. If the ABC model is adopted (i.e., industrial and business customers are connected immediately), the equity IRR is 16% but falls to 10% otherwise.
- The 'partial customer acquisition' scenario where the SMG is only able to acquire 70% of projected customer demand. With this reduced customer base, IRR on equity would fall to -4% without an anchor, and -3% even with an anchor.

4.4 Success Story

A 141 kW mini-grid called the Shoura Bangla (SBL) SMG, located on Paratoli Island in the Narsingdi district, started operating in 2014. Because most of the electricity was used in the evenings and at night, the SMG generated energy during the day using solar PV panels and stored extra energy for use

[7] https://www.mckinsey.com/about-us/overview/alliances-and-acquisitions/vivid-economics

at night in 288 lead-acid batteries. A 66 kVA diesel generator served as a backup in case demand outpaces solar panel output. The project is expected to last for 20 years.

Suntech (China) produced the solar panel, Rahimafrooz (Bangladesh) the battery, SMA (Germany) the inverter, and EM Power the generator (Bangladesh). The investment cost BDT66 million[8] in total. With a 10-year term, a two-year grace period, and a 6% interest rate, IDCOL offered a concessional loan. According to the IDCOL financing model, grants covered 50% of the entire cost, loans covered 30%, and SBL equity covered 20%. The financial model given to IDCOL, which predicted a project IRR of 12%, has been consistent with customer acquisition and revenue thus far.

DHAKA | SATURDAY | 31 OCTOBER 2015

daily sun TRUE AND IMPARTIAL

Mini grid solar power plant brings light to remote lives

Ambassador of Federal Republic of Germany to Bangladesh Dr. Thomas Prinz seen among others after inaugurating Souro Bangla Mini Grid Solar Power Plant, at Paratoli Islands, Raipura in Narsingdi on Thursday.

STAFF CORRESPONDENT

In a remote area - Paratoli Islands at Raipura in Narsingdi, some 613 families remained cut from the national power grid and so were deprived from all modern facilities. But now they have started getting electricity.

They are now electricity subscribers to a plant. Mosques as well as the school-going children are being benefited from this power-source. Electricity has reached the shops in the bazar, the ice-cream factory, the auto-rickshaw drivers and agro-irrigation.

A 9 kilometer transmission line is in effect that includes seven villages. A new life has emerged in the mundane life of these inaccessible people.

This is the blessings of the Souro Bangla Mini Grid So-

set of electricity generators and energy storage systems interconnected to a distribution network that supplies the entire electricity demand of a localized group of customers.

IDCOL (Infrastructure Development Company Limited), a government owned non-bank financial institution and the country's pioneer in off-grid renewable energy financing has already approved 16 Mini grid projects and has a plan to finance 50 Mini grids by 2018.

IDCOL plans to finance 50 projects by 2018

After the inauguration, IDCOL made a presentation detailing on the project and its future implications. Later, all were guided to a visit to and take a closer look into the project which was followed by a session of opinion sharing with the customers.

Ambassador of Federal Republic of Germany to

of Souro Bangla Ltd at its project site at Paratoli Islands, Raipura, Narsingdi on Thursday.

In his speech, German envoy applauded this as an extra-ordinary venture and said, Souro Bangla has taken the task of carrying light to the lives of these people living in such remote corners. German government would always stand by the government of Bangladesh in any kind of similar initiative, he assured.

Headmaster of Paratali Kalimuddin High School Mr Alimuddin Chowdhury thanked the initiators for their good initiative.

Mahmood Malik, Executive Director and CEO, IDCOL, David Kunze, Country Director, KFW, Tazmilur Rahman, Senior Sector Specialist Energy, KFW, S.M Monirul Islam, CFO and Head of Operations, IDCOL, Md. Enamul Karim Pavel, Head of Renewable Energy, IDCOL, Nazmul Haque Faisal, Unit Head Corporate Affairs, Farzana Rahman, Unit Head Investment (Renewable Energy), Sabbir

SBL relied on big industrial customers like mobile base stations, sawmills, and ice mills to support demand, and being close to a sizable village market aided in attracting commercial clients like neighborhood business owners. SBL further emphasized the great willingness of local homes to pay off their debt because of the advantages of electricity (to operate cooling fans or pumps for water tanks) and (ii) the likelihood that the national grid would not reach them soon. SBL's marketing initiatives made sure that customer acquisition was swift. The first year saw the acquisition of 70% of the clients, with the following year seeing the balance acquired. Before notable occasions like Ramadan, SBL provided discounts or a few units of energy free of charge. They also organized customer focus groups and distributed charts comparing oil lamps to SMG electricity. The mini-grid provides electricity at BDT30 per kWh to 724 households and 124 businesses. For home consumers, the monthly fee ranges from BDT485 to 780, with some higher-load users paying around BDT1,630. Commercial customers typically paid between BDT330 and 845 each month. Residents now have greater opportunities to start new enterprises or grow current ones because of increased access to power.

[8] 1 Bangladesh Taka equals 0.0091 United States Dollar (Source: https://g.co/kgs/nWZr3r); accessed on August 8, 2023)

5 Case Study 5 – Rewa Ultra Mega Solar Project, India

5.1 Background

The launch of the National Solar Mission, as part of the National Action Plan on Climate Change (NAPCC) in 2008, saw solar coming to the forefront of RE deployment. As of 31 March 2023, India's installed RE capacity stood at 178.79 GW, which contributed to 16% of the country's power generation.

The Government of India (GoI) aims to deploy 500 GW of RE by 2032, which is expected to constitute 50% of the total power generation capacity in the country.

5.2 The Project

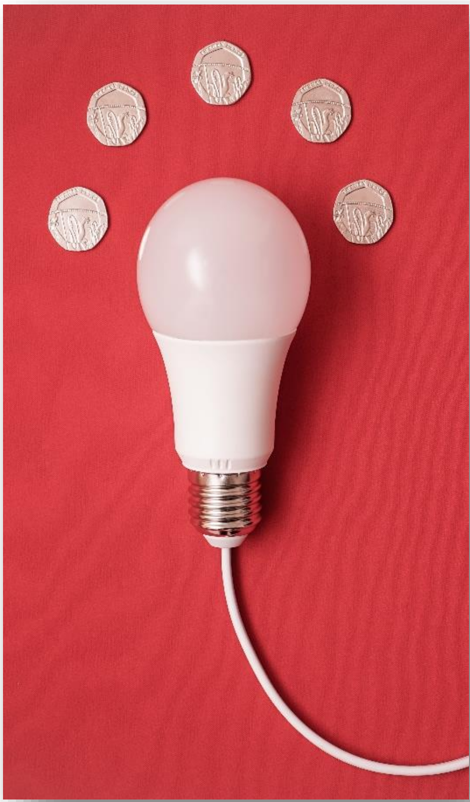
Set up in 2017-18, Rewa Ultra Mega Solar Power Project is located in the Rewa district of Madhya Pradesh state, India. It occupies 1,590 acres of woodland and private land that were obtained from a collection of nearby settlements/villages. With an installed capacity of 750 MW, it is one of the largest solar PV power generation projects in the world. The project has a 25-year Power Purchase Agreement (PPA) with Delhi Metro Rail Corporation (DMRC) and Madhya Pradesh Power Management Company Limited (MPPMCL) to sell its power. The state energy distribution companies (DISCOMs), who are served by MPPMCL, get 76% of the project's power production, with the remaining 24% going to DMRC. The project is satisfying up to 90% of DMRC's daily electricity needs.

Rewa Ultra Mega Solar Limited Company (RUMSL), a joint venture between Solar Energy Corporation of India (SECI) and Madhya Pradesh Urja Vikas Nigam (MPUVN), was established in July 2015 as the project implementation company. With assistance from the International Finance Corporation (IFC), RUMSL conducted the project auction based on the lowest tariff in 2016. The three units of the project, each with a capacity of 250 MW, were awarded to Mahindra Renewables, ACME Solar Holdings, and Solengeri Power, with first-year prices of Rs 2.979, Rs 2.970, and Rs 2.974, respectively. The auction produced the first sizable project of its kind in India when the RE tariff of 5.5 US cents per kWh breached grid parity. The levelized tariff, which has an annual increase of 5 paise built in for the first 15 years, is around INR3.3/kWh[9].

To facilitate the evacuation of power from the project site to a range of consumers, Power Grid Corporation of India Limited (PGCIL) has developed the necessary infrastructure.

[9] 1 Indian Rupee equals 0.012 United States Dollar (Source: https://g.co/kgs/QtPjz7; accessed on August 8, 2023)

5.3 Financing of the Project



The project was funded by an investment of US$437 million from the Infrastructure Investment Department of the International Finance Corporation (IFC), split into three separate transactions, one for each of the 250 MW units, and processed simultaneously, demonstrating the viability of the scaling concept and opening the door for replication throughout the industry. The cost of the project was financed by IFC to the tune of about 75%, with the remaining 25% coming from shareholder loans and equity.

The project also benefited from financing from the World Bank and the Clean Technology Fund (CTF). These loans, which were approved in March 2017, paid for the construction of three 220/33 kV substations, connected 220 kV transmission lines, and common evacuation infrastructure at the Rewa solar power project. PGCIL is building the 400/330 kV substation at no cost to RUMSL or the state of Madhya Pradesh. With assistance from MP Transco, the infrastructure for internal evacuation has been constructed. The World Bank and CTF loan terms directly reduced the tariff by 4 to 5 paisa (US cents 0.07/kWh). The project is India's only solar project to get funding from CTF, available at a rate of 0.25% for 40 years and the only solar park in the country to get a concessional loan from the World Bank.

5.4 Lessons Learned

This innovative project provides the following key lessons for future such initiatives:

- **Risk mitigation:** Systematic risk mitigation was prioritized over directly subsidizing expenses to lower ultimate pricing. Even though a portion of the offtake was by a State utility with poor creditworthiness, the project was able to secure a tariff that was 24% lower than the lowest tariff for national companies and avoided the need for subsidies. In addition, efficient utilization of scarce public resources can help leverage private capital. A World Bank loan was used to build shared infrastructure in several solar parks, including Rewa, which aided in the success of the project. This worked to further de-risk projects and proved to be an effective use of the few public resources.
- **Careful conflict of interest management:** it is possible to engage in multiple levels of transaction design and implementation: At various times during the Rewa transaction, many teams within the World Bank Group were involved, and it was crucial to manage real and perceived conflicts of interest. Without any assistance from the IFC investment team, the World Bank and IFC Transaction Advisory Department operated as independent units before the bid. In the same way, after the bid, IFC Transaction Advisory declined to represent the

government or IFC in any PPA or lender negotiations with bidders and clarified cross-function duties with the customer.

- **Extensive consultation is key for increasing investor interest:** The post-bid project agreements were streamlined through a rigorous iterative process that involved bidders, investors, procurers, transmission utilities, regulators, and system operators. These publications are used as references in the national rules for all Indian solar bids, which is evidence of the implementation's success.
- **Project preparation is critical:** According to feedback from bidders, the "pre-baked" nature of the land, grid evacuation, and project paperwork led to lower projected returns on equity and cost of capital overall, which is likely what caused the offer price to drop by 20 paise (or around 5%). Another 20 paisa was attributable to clauses that strengthened the predictability of financial flows, such as termination payments and presumed creation.

For Further Reading

16 Case Studies on the Deployment of Photovoltaic Technologies in Developing Countries (https://www.rpc.com.au/pdf/rep9_07.pdf)

Renewables and Energy Transitions in Small Island States

(https://sdg.iisd.org/commentary/guest-articles/renewables-and-energy-transitions-in-small-island-states/)