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Workshop on Renewable Energy Integration and Procurement

March 18 -19, 2024

South Asia Regional Energy Partnership (SAREP) and Sri Lanka Energy Program

Session 2B: Global Practices and Methodologies in RE Procurement for Large Renewable Energy Parks and Curtailment of Power

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AGENDA

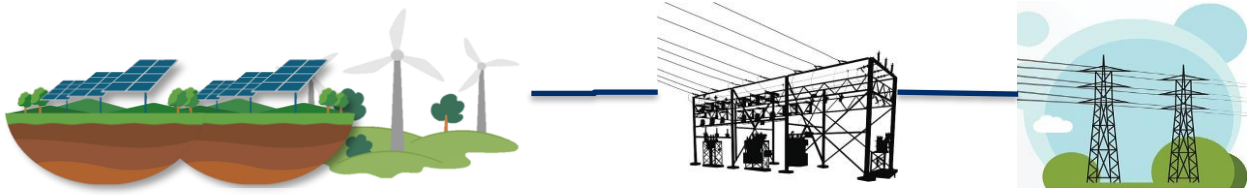
Large RE Procurement

Curtailment of RE Power

Large RE Procurement

#	Type	Entity	Description	Pros	Cons
Model 1	Individual Tender	DISCOM/ Public/ Private	An entity will release a tender for procurement of power for its own use.	• Based on the need of the entity • Customizable	• The participation might be limited. • Individual clearances may delay the project
Model 2	Pooled Tenders	DISCOM/ Public / Private	Demand aggregation	• Chances of getting cheaper power because of high quantum	• Delays due to multiple stakeholders . • Transmission issues
Model 3	RE Parks	State Government/ Nodal Agency	Nodal agency issue the tender for development of park	• Low cost due to easier access to facilities. • Faster.	• Difficulty in identified large land
Model 4	RE Zones/ Green Corridor/T X line/Land	State Utilities/State Government	Developing green corridors. Transmission Line. Acquiring land	• Easier for the developer • Faster	• Cost • Allocation and specific needs

Setting up of RE Park



RE Parks | Evacuation | Transmission

Nodal Agency/ Park Developer	• Appointment of the nodal agency • Development and Management of the park
Policy and Regulations	• Approval of tariff and necessary investment
DISCOM / PPA	• To purchase power and sign and PPA
Transmission Unit	• Provided power evacuation infrastructure
Project Developer /Financing	• Construction of the RE project

RE Park Scheme Implementation

Need Assessment

Identification of Land

Launch of Schemes/ Land Acquisition

Development of Tender

Allocation of Land and Capacity to successful developers

PPA Signing

Development of Land and transmission facility

Project Construction

Interconnection and Commissioning of the Project

Power Evacuation

Tariff Approval

Facilities Provided by Nodal Agency

- Land Approved
- Road Connectivity To Each Plot Of Land
- Water Availability
- Flood Mitigation
- Construction Power
- Tele-communication Facilities
- Transmission Facilities
- Housing Facility For Basic Manpower
- Parking, Warehouse Etc.
- Boundary And Fencing Of The Perimeter
- Centralized Weather Monitoring Center

Considerations for Identification of Land

- Govt. is responsible for identification of land
- Use of waste/ non-agricultural land
- Low land price
- Minimum use of private land
- Good RE potential
- Identify minimum land requirement / MW
- Proximity to CTU
- Proximity to water resource
- Low population density

Important Aspects of Such Parks

Rehabilitation and Resettlement :

- For upliftment of people and community development, there is a need for Rehabilitation and Resettlement (R&R) of Project Affected People (PAP) with the objective that standards of living of the PAP improves or at least regain their previous standards of living.

Environment Impact Assessment:

- By proactively identifying environmental impacts, developers can adopt measures to mitigate them or modify project designs to minimise or completely avoid adverse effects.

Transmission and Evacuation of Power from RE Park

- Interconnection of each plot with Pooling Stations
- The Nodal Agency will set up the pooling stations in the park
- Nodal Agency will draw transmission to transmit power to Substation
- CTU/STU to set up Substation
- Intimation by appropriate authorities at least 6 months before evacuation
- Applicable charges to be identified by the Regulators
- Standards and network should be designed with high quality

India Experience-Solar Parks

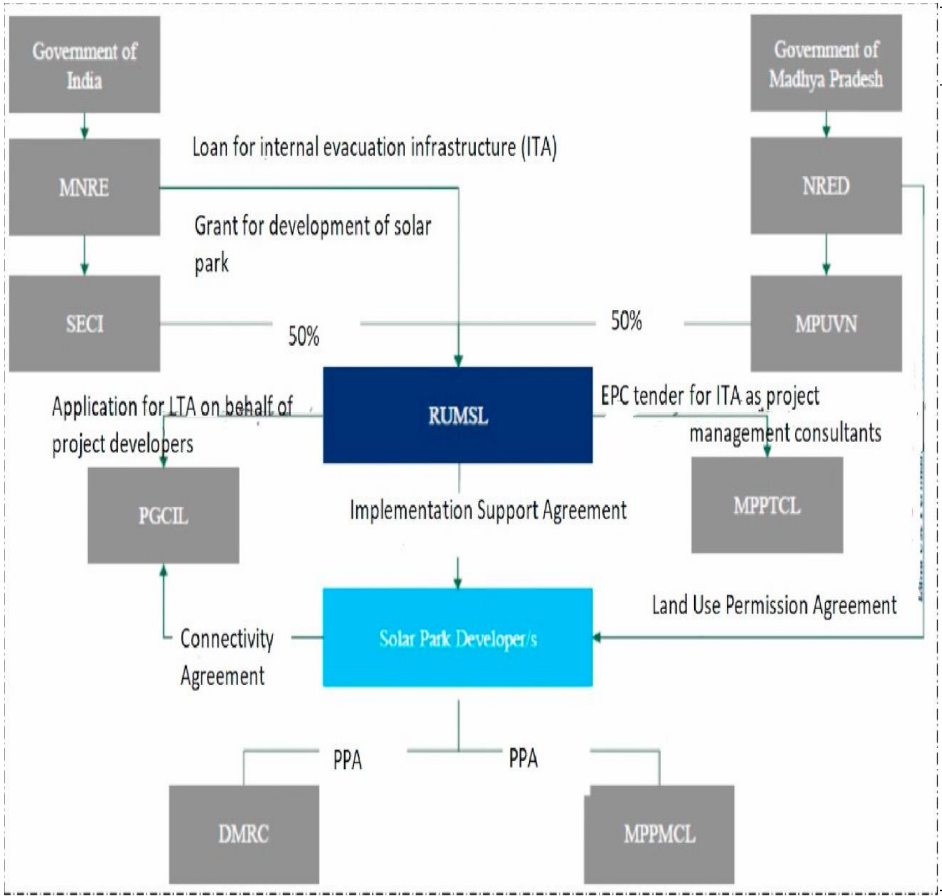
- Solar park scheme was launched in2015
- More than 500 MW Ultra Mega Solar Project
- The scheme prefers non-agricultural barren contiguous land between
- Solar Power Project Developers (SPPD) who would facilitate in "bidding, erection, commissioning & Operationalization of Ultra-Mega Solar and Solar Parks Power Projects" and feed all generated power to the grid.
- Four modes-Total control, majority by central Govt, state Govt or private player
- Till June 2023 50 parks with 37.99 GW in more than 20 Indian states have been approved. Eleven Commissioned with a capacity 8.51 GW. Seven in pipe line with a capacity of 3.985

Case Study –REWA, India Solar Park

- First solar park in India
- Three units of 250 MW each with separate s/s of 33/220 kV connecting to single 220/400 kV s/s for evacuation of power
- The initial land availability of 1589 ha, comprising of 1255 ha of contiguous barren government land surrounded by 334 ha of private land, was available across five villages.
- State government owned entity handling everything from project conceptualization, land identification, institutional arrangements, technical, market consultations, financial and legal structures and bid process management from the beginning.
- The levelized tariff is INR3,34 per unit for 25 years after reverse bidding for continuous 30 hours.
- PGCIL was assigned to develop substation 220/400 kV and connecting to 33/220 kV s/s.

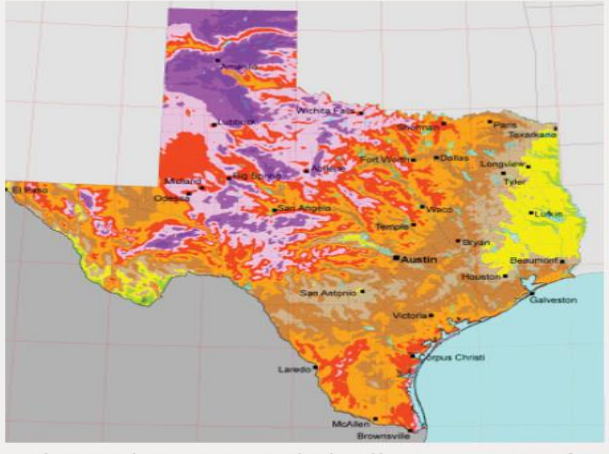
Source Planning and developing large solar power plants: A case study of 750 MW Rewa Solar Park in India by Brijesh Kumar Vyas a, Ambuj Adhwaryu a, Kalyan Bhaskar b,*

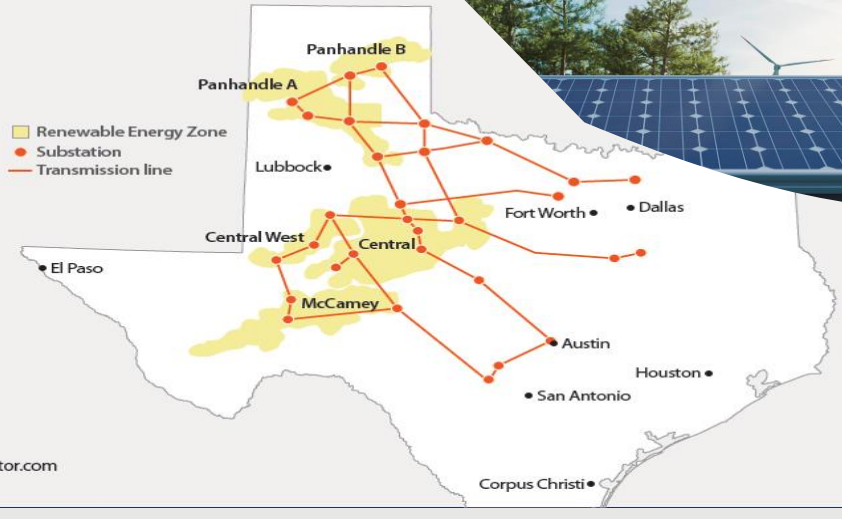
Case Study –REWA, India Solar Park



Serial No.	Year	Milestone
1	June 2014	275 ha allotted in Badwar village for Rewa Project
2	April 2015	MP government approved setting up RUMS
3	June 2015	RUMSL formed as 50:50 joint venture between MPUVNL and SECI
4	July 2015	981 ha allotted *(Badwar, Barseta Desh, Barseta Pahar, Itar pahar, Ramnagar Pahar villages)*
5	March 2016	Request for Proposal (RFP) released
6	February 2017	Financial bid opened and reverse auction held
7	April 2017	PPA and other commercial agreements signed
8	April 2017	5 ha allotted *(Badwar, Barseta Desh villages)*
9	July 2018	Part Capacity commissioning starts for Unit 1
10	July 2018	10 ha allotted *(Badwar village)*
11	August 2018	Part Capacity commissioning starts for Unit 2
12	January 2019	Part Capacity commissioning complete for Unit 2
13	January 2019	67 ha allotted *(Barseta Pahar village)*
14	February 2019	Part Capacity commissioning - 50 MW by Unit-3
15	March 2019	Part Capacity commissioning - 100 MW by Unit-1
16	April 2019	Flow of Power commences to DMRC
17	January 2020	Commencement of full commercial operation
18	July 2020	Inauguration by the Prime Minister of India

Case Study of RE Zone: Texas, USA





Wind map: Wind resource estimates developed by AWS Truepower, LLC for windNavigator Web: windnavigator.com awstruepower.com. Spatial resolution of wind resource data: 2.5 km. Projection: UTM Zone 14 WGS84.

WIND SUPPLIED **17.5%** OF ALL IN-STATE ELECTRICITY *GENERATION* POWERING **7,745,800** HOMES IN TX

41 ACTIVE MANUFACTURING FACILITIES IN THE STATE

$285M PER YEAR IN STATE & LOCAL TAXES

CAPITAL INVESTMENT **$53.1B** SUPPORTING MORE THAN **25,000** FULL-TIME JOBS

CASE study of RE Zone: Texas, USA

Competitive Renewable Energy Zone (CREZ),

Project duration: 2005–2014
Length of new 345 kV T-Lines: 3,862 Km
Power evacuation capacity added: 18.5 GW leading to capital investment of $25 billion
Project cost: $6.9 billion
Annual Income Generation $2billion
Tariff below $2cents/kWh

Source: David Hurlbut, Ilya Chernyakhovskiy, and Jaquelin Cochran, Renewable Energy Zones: Delivering Clean Power to Meet Demand, NREL, 2016

Examples of Multi-tenant Zones and Parks-Dubai

- The largest single-site solar park in the world:
- The Mohammed bin Rashid Al Maktoum Solar Park is the largest single-site solar park in the world based on the Independent Power Producer (IPP) model. It has a planned production capacity of 5,000 MW, with investments totaling AED 50 billion.

- Phase 1+2= 213 MW (2017)
- Phase 3: 800 MW (Nov 2020)
- Phase 4: 250 MW (2.4 US cents/kWh) (2023)
- Phase 5: 900 MW (1.69 US cents/kWh) (June 2023)
- Phase 6: 1800 MW (1.625 cents/kWh) 2024-2026

Source: https://mbrsic.ae/en/about/mohammed-bin-rashid-al-maktoum-solar-park/

Phase III of the Park

Case Study-RE Zones Tajikistan

Phase 1: Preliminary RE Zone Identification

- GIS-based analysis of RE resources
- GIS-base analysis of other criteria: Terrain, Transmission, logistics, environment

Phase 2: Pruning and LCOE-Based Ranking

- Pruning of Zones based on country-specific criteria and official data
- LCOE based
- ranking of Zones
- Identification
- of highest ranked Zones

Phase 3: Site visit and Final Selection

- Site visit to assess suitability of RE Zones
- Land-use assessment
- Preliminary technical and financial
- viability
- Final selection of RE Zones

Phase 4: RE Zone Development

- Develop country-specific roadmap
- Reserve land
- Conduct measurement compaign
- Conduct studies: Grid integration, EIA, logistics
- Conduct competitive procurement

Case Study-RE Zones Tajikistan

GIS processing of renewable resource intensity maps to identify high resource areas

Phase 1

Exclusion analysis

Exclude areas with:

- RE resource quality (CF/PV/OUT) < Threshold value
- MW potential < Threshold value
- Slope < Threshold value
- Overlap with protected areas
- Overlap with land use like agriculture, water bodies, glaciers, built-up areas and others

Pre-liminary RE zones

Prune preliminary RE zones

Phase 2

Zonal parameters

Calculate the fol-lowing zonal parameters:

- Average CF/PVOUT
- Average slope
- Distance to Transmis-sion
- Diatance to nearest Logistics Hub
- Distance nearest load center and line loss

Calculate LCOE

Examples of Wind Farms

S. No.	Name of the Project	Capacity	Key Highlight	COD
1	Jiuquan Wind Power Base, China	20,000	World's largest wind park	2010
2	Jaisalmer Wind Park, India	1, 600	The biggest onshore wind farm in India	2008
3	Alta Wind Energy Centre, US	1,548	The onshore wind farm was originally developed by Terra-Gen Power, but later redistributed to different companies.	
4	Muppandal Wind Farm, India	1,500	Receives strong winds for nine months in a year	
5	Shepherds US	845	The fifth biggest wind farm in the world.	2012
6	Roscoe Wind Farm, US	781.5	Covering 400km² of farmland	2009
7	Horse Hollow Wind Energy Centre, Texas, US	735.5	The wind farm covers an area of 47,000 acres	2006
8	Capricorn Ridge Wind Farm,	662.5	Each turbine is more than 260ft-tall from the	2008

Key Take Aways

- **Techno-economic and financial barriers** including cost of generation vs generation cost from other sources
- **Policy, regulatory, and political barriers** , and
- **Public perception** including social, cultural, and behavioural

- Identification of right land parcel
- Early involvement of key agencies.
- Identification of power procurer
- Payment Security
- Risk identification and mitigation strategy

Curtailment of Power

What is Curtailment?

A reduction in the output of a generator from what it could otherwise produce given available resources, typically on an involuntary basis. The term curtailment is broadly used to refer to the use of less wind or solar power than is potentially available at that time;

- Automatic Generation Control Systems
- Thermal Backing
- RE Curtailment
- Storage

Need for Curtailment:

- Planned/forced outages on the evacuation infrastructure
- Over-voltages on transmission line/evacuation infrastructure
- Over-loading of transmission line and/or associated evacuation infrastructure (incl. ICT)
- Demand crash in the State with heavy under-drawal from ISTS
- Ensuring thermal generators are running at technical minimum
- Under-drawal is far below the volume limits specified by Regulations

How to Avoid Energy Curtailment

1. **Onsite Energy Storage**: Implementation of onsite energy storage
2. **Better Demand Response:** Enhanced DR initiatives to enable adjustments in consumer demand, both up and down, when warranted by grid conditions.
3. **Time of Use rates/Real time tariff**: Implementation of Time-of-Use rates that match consumption with efficient use of clean energy supplies
4. **Minimum Generation**: Policies to reduce minimum operating levels for existing generators, to provide room for RE generators.
5. **Energy Imbalance Market**: development of advanced market system automatically finds low-cost energy to serve real-time consumer demand
6. **Regional Coordination**: offers more diversified set of clean energy resources through a cost effective and reliable regional market
7. **Electrical Vehicles**: incorporate EV charging stations that are responsive to changing grid conditions
8. **Investment in Flexible Resources**: Invest in modern, fast-responding resources that could follow sudden increase and decrease in the demand.

Curtailment In India as Per Model Guidelines from Forum of Regulators

Grid Frequency	Curtailment for maintaining Volume Limit (Under-drawal) at State Periphery	
	For Deviation <= 250 MW (or threshold limit as specified)	For Deviation > 250 MW (or threshold limit as specified)
F < 49.90 Hz	No	No
F >49.90 and < 50.05 Hz	No	Yes
F > 50.05 Hz	Yes	Yes

Case Studies

	Description	Constrained Operation Procedures	Amount Curtailed	Compensation
ERCOT	Congestion is currently managed by ERCOT on a zonal basis. ERCOT used special rules for this zone as transmission constraints limited transfers from the zone into the load centers in eastern Texas.	may call upon wind plants in to make reductions in output during periods of transmission congestion.	From December 2008 to July 2009, curtailed between 500 MW and 1000 MW daily, and at times up to 3000 MW daily.	paid out-of-merit energy payments, but only up to the daily operating limit.
Southern California Edison	Wind curtailment system in place for the Tehachapi region due to transmission constraints.	Agreement with Terra-Gen Power to reduce output on an as-needed basis.	6-8% of the time	Make whole payment for energy.
Xcel Energy	Northern States Power MN (NSP) is in Midwest ISO and follows the Midwest ISO's direction on whether curtailment is required.	Agreements with wind plants in Southwest Minnesota to curtail on a rotational basis when required by Midwest ISO.	About 23,000 MWh in 2008.	payments for both fixed and variable costs.

Case Studies

	Description	Constrained Operation Procedures	Amount Curtailed	Compensation
New York ISO	Wind integrated into real-time and day-ahead market dispatch.	Generation will be curtailed according to economic bids.	Not Available	LMP-based market, no additional compensation.
Midwest ISO	No specific wind curtailment program.	During Minimum Generation Events, will order curtailments in certain order: For ex. 1. Generation identified through the Reliability Assessment Commitment process. 2. Generation above the day-ahead schedule from non- Designated Network Resources.	No ISO-wide data available.	Locational marginal price (LMP) -based market, no additional compensation.

https://www.nrel.gov/docs/fy10osti/46716.pdf

Thank You

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