SAARC ENERGY CENTRE
Energy for Peace & Prosperity

On-line Training of SAARC Professionals on Power Purchase Agreements of Renewable Energy Projects

Case studies of regional and international competitive procurements

November 11th 2021

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Learning objectives

- Review global trends on renewable energy
- Learn about various experiences with system-friendly procurement
- Learn about experience transitioning to wholesale markets through feed in premiums
- Learn about procurement for mix-products

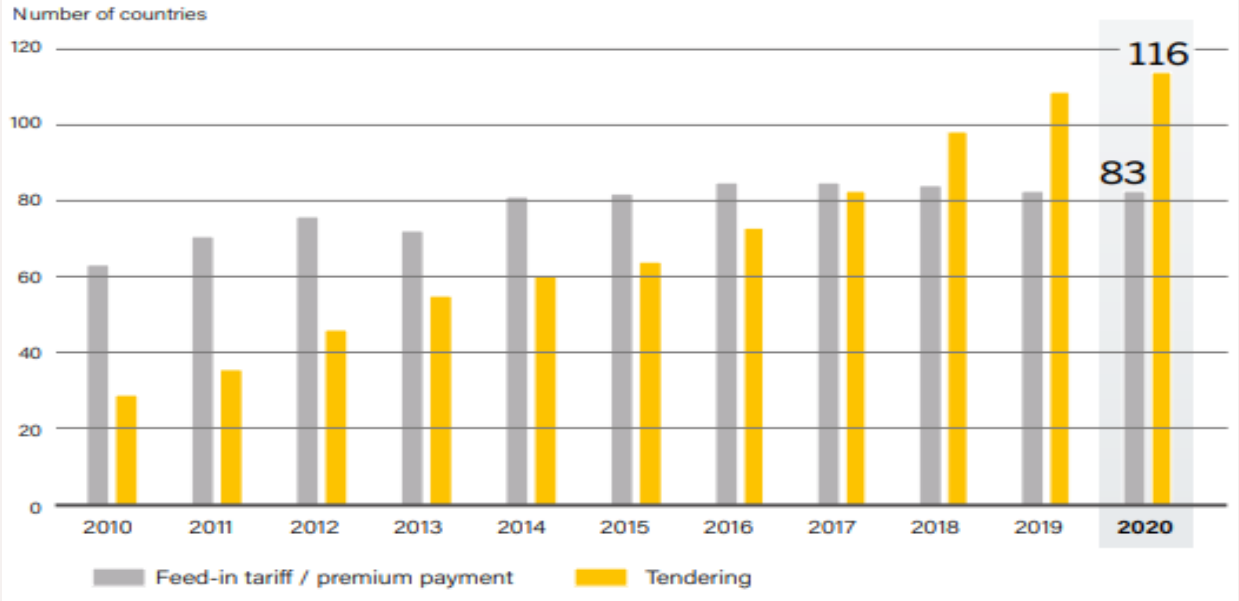
Agenda

- Global RE trends
- System-friendly RE procurement
- Global system friendly case studies of RE procurement
- Case study: India 24x7 RE procurement

Global RE trends

Trend 1: Countries are adopting auctions to meet climate commitments and lower cost of electricity

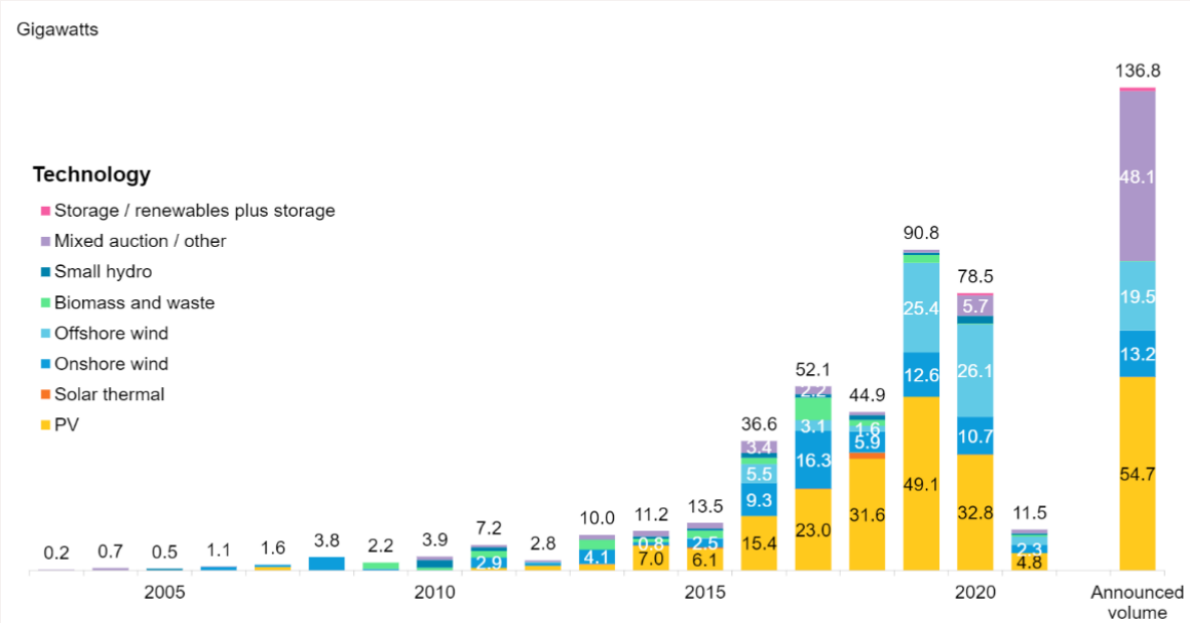
Renewable Energy Feed-in Tariffs and Tenders, 2010-2020



REN21 Policy Database

Trend 1: Countries are adopting auctions to meet climate commitments and lower cost of electricity

Annual auctioned and announced capacity by technology



Source: BloombergNEF

Trend 2 Auctions continue to push down prices worldwide

Abu Dhabi's 1.5 GW tender draws world record low solar bid of $0.0135/kWh

APRIL 28, 2020

India hails renewable milestone after first deal for 24/7 green power

The winning price was 2.90 rupees/kWh ($0.038/kWh, $38/MWh) for the first year of the 15-year deals, rising by 3% annually.

11 May 2020

Masdar of Abu Dhabi wins auction for Uzbekistan solar plants

Central Asian country working closely with IFC to establish a robust public-private partnership programme

9 Jun 2021 | Michael Marray

Los Angeles solicits record solar + storage deal at 1.997/1.3-cents kWh

July 2, 2019

Xcel Attracts 'Unprecedented' Low Prices for Solar and Wind Paired With Storage

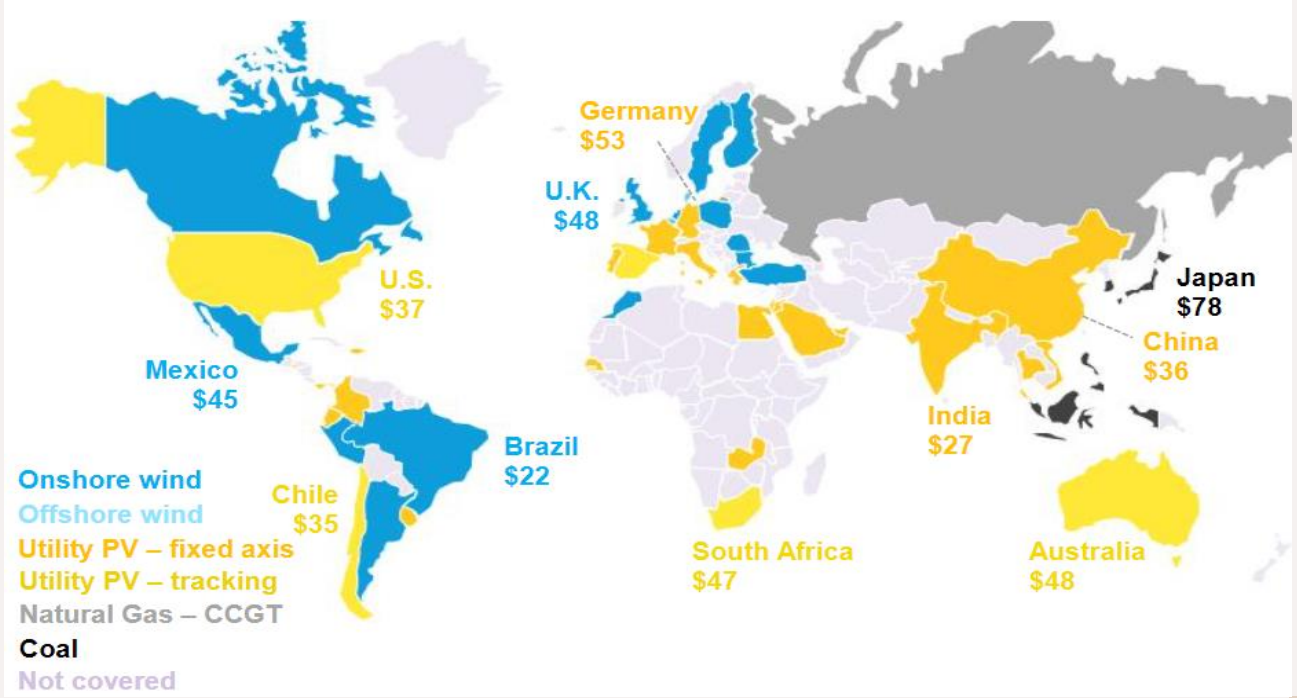
Bid attracts median PV-plus-battery price of $36 per megawatt-hour. Median wind-plus-storage bids came in even lower, at $21 per megawatt-hour.

JANUARY 08, 2018

Trend 3: Renewables are becoming least-cost generation options

At least two-thirds of the global population lives in a country where either onshore wind or utility-scale PV (or both) is the cheapest option for new bulk electricity generation.

Cheapest Source of new bulk generation, 1H 2021

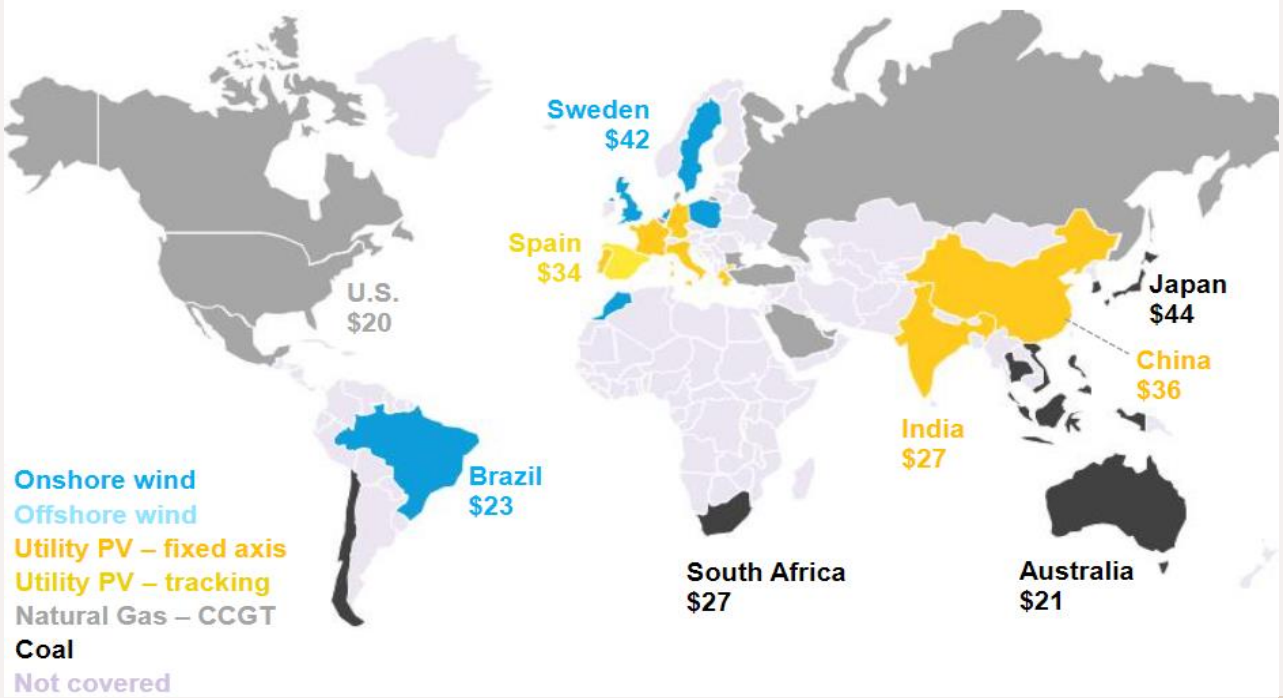


Source: BloombergNEF
Note: The LCOE calculations exclude subsidies or tax-credits. Benchmark LCOE for each country in $ per megawatt-hour

Trend 3: Renewables are becoming least-cost generation options

New solar and onshore wind now competes on cost with existing coal and gas power stations in countries representing almost half of the world's population and 48% of electricity generation.

Cheapest Source of new bulk generation, 1H 2021



Source: BloombergNEF
Note: The LCOE calculations exclude subsidies or tax-credits. Benchmark LCOE for each country in $ per megawatt-hour

Trend 4: Auctions are evolving

Early Auctions → Addressing Grid Integration → Electricity Markets Integration → Commercial and Industrial PPAs

India hits 100 GW renewables milestone

Solar's share in the installed 100 GW renewable energy capacity stands at around 44%, and wind at 40% as per the data available from India's Central Electricity Authority.

AUGUST 13, 2021 UMA GUPTA

Amazon Signs PPA With TotalEnergies for 474 MW of Renewable Energy

Amazon Will help TotalEnergies enhance its digital transformation through cloud computing services

JUL 29, 2021 / HARSH SHUKLA / OTHER, RENEWABLE ENERGY

Serbia to switch from FIT to feed-in premiums and auctions

With its feed-in tariff program set to expire at the end of the year, Serbia will be looking to introduce new mechanisms to support renewables in the form of feed-in premiums and auctions. The country's PV uptake is still in its nascent stage however, with abundant regulatory obstacles still in place

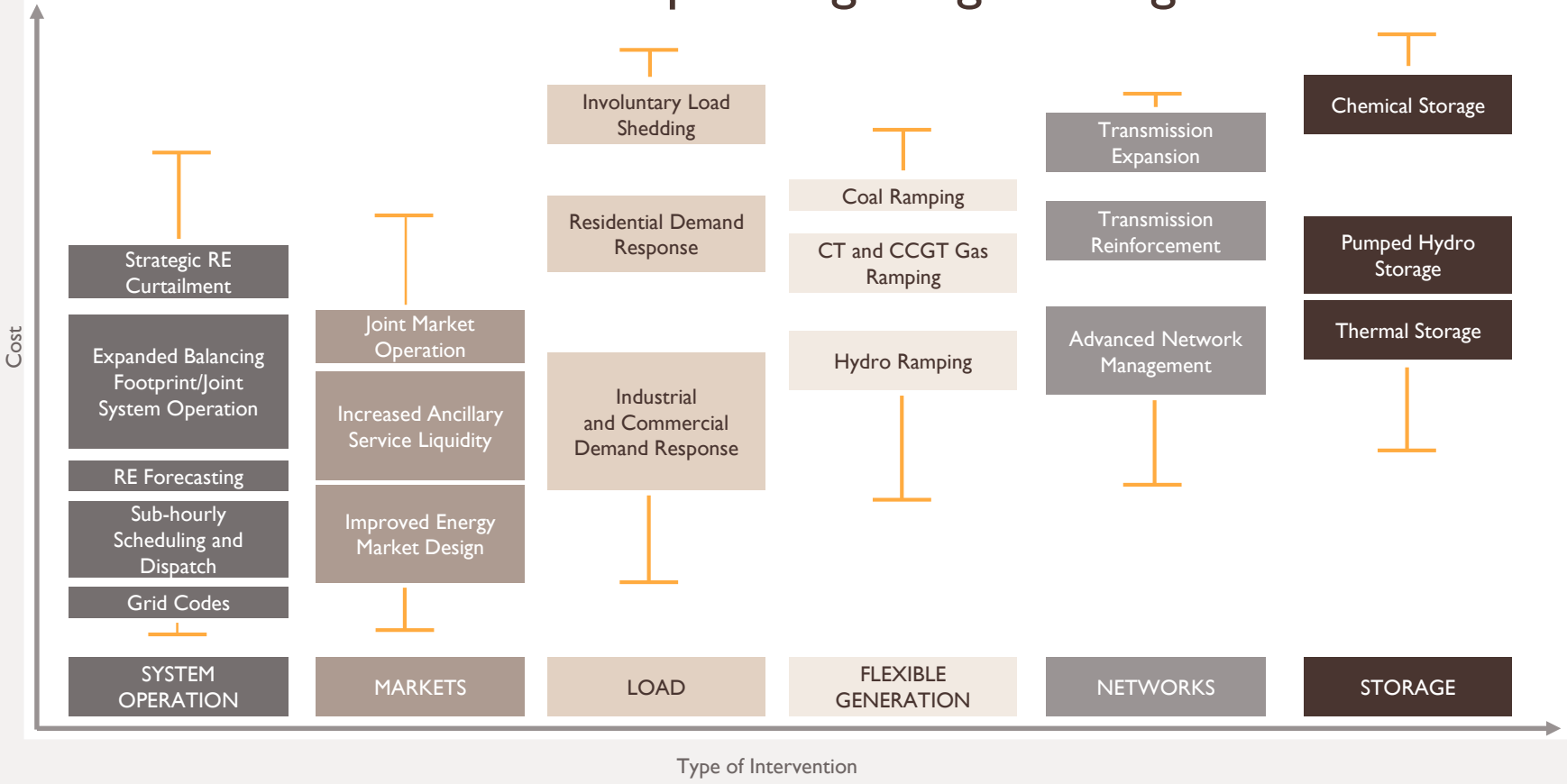
MAY 24, 2018 MARIJA MAISCH

India's NTPC launches tender for 1 GWh of grid scale storage

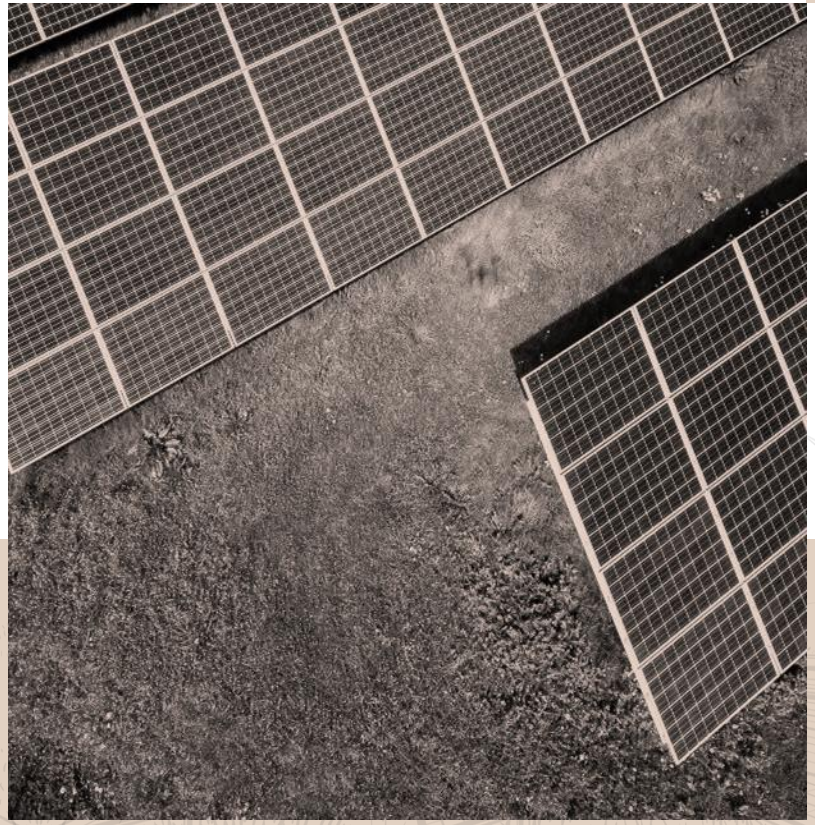
State-run power producer NTPC has more than 65 GW of installed capacity, including gas, coal, hydro, and renewables-based power stations.

JUNE 29, 2021 UMA GUPTA

Trend 5: Countries are planning for grid integration of VRE



System-friendly procurement



Higher shares of renewable energy require new approaches to our energy system

DEMAND-SIDE INTEGRATION

GRID INTEGRATION

STRATEGIC ENERGY PLANNING

MARKET INTEGRATION

PROCUREMENT: ROUND-THE-CLOCK RE

Benefits of Round-the-Clock power	More dispatchable RE for supply-demand match	More firm RE power (on-site or different locations)	Demand-based supply managed by seller

System Friendly Procurement- A Cost-effective Solution

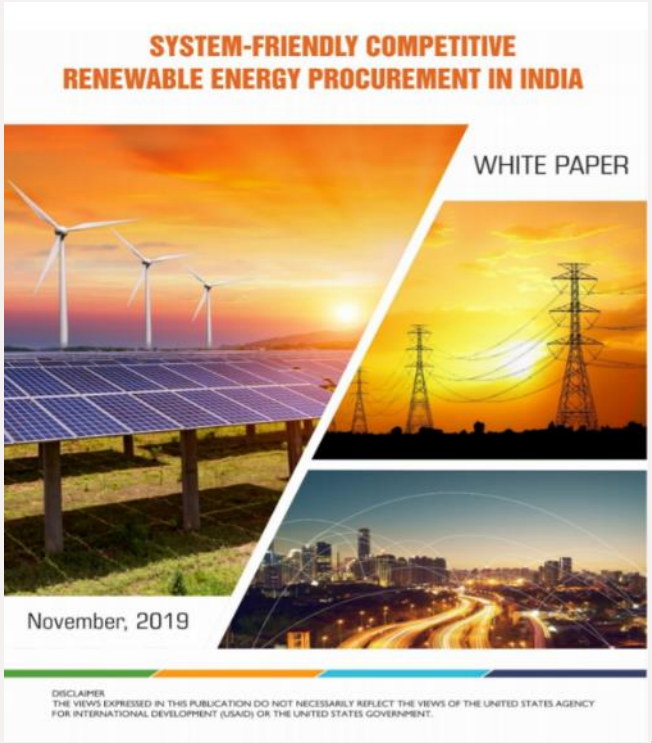
System Friendly Procurement - supply of power from a portfolio of energy sources to meet the requirements of DISCOMs/Consumers while maintaining a maximum share of RE

Benefits

Manages variation in RE generation at supply side – unburdening consumer/ utility	Manages supply with demand profile across various time slots and seasons
Determines optimal capacity requirement of RE sources- cost	Shifts responsibility of managing portfolio of assets to suppliers

Types of System Friendly Procurement

- Time-slot based procurement
- **Round the Clock Power**
- Time based Incentives and penalties
- Hybrid Systems
- Virtual Power Plants
- Location Signal



Comparison of RTC Design Options

Model	Benefits	Challenges
Fixed (Continuous) Demand procurement	• Simple procurement model for the supplier and buyer • Expected to receive high responses from suppliers	• Meeting peak demand – surplus power disposal • Not meeting peak demand - buyer needs to find other avenues for procuring power – difficulty in management

Slot wise Fixed Demand procurement	• Higher potential to meet peak demands	• Same as above, but in lesser degree
		• Comparatively complex
		  • Optimizing slots VS expected tariffs
		  • Structuring procurement
		• Potentially higher cost of power

Real time Demand procurement	• No surplus power, no shortfalls	• Granular load curve forecasting needed - modelling • Additional flexible generation capacity reserves needed • Difficult to monitor the contracts • Comparatively much higher expected cost of power

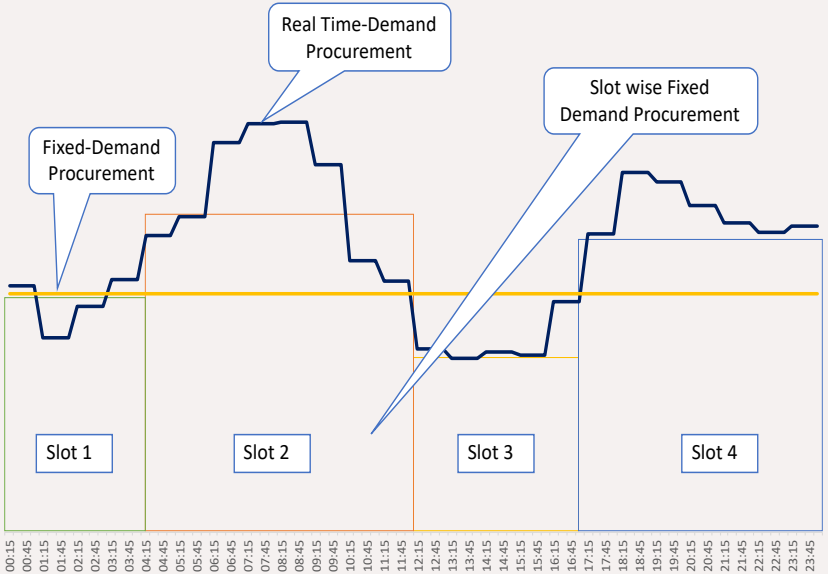
How RTC helps address RE Challenges?

Allow buyers to leverage the strengths of developers and solution providers to achieve their desired outcome

- Developers have better understanding of generation profiles of various technologies and geographies
- Developers can leverage new technologies and IT to design better integration methods

RTC procurement can be designed as per the need of the buyers

- Fixed (Continuous) Demand procurement
- Slot wise Fixed Demand procurement
- Real time Demand procurement

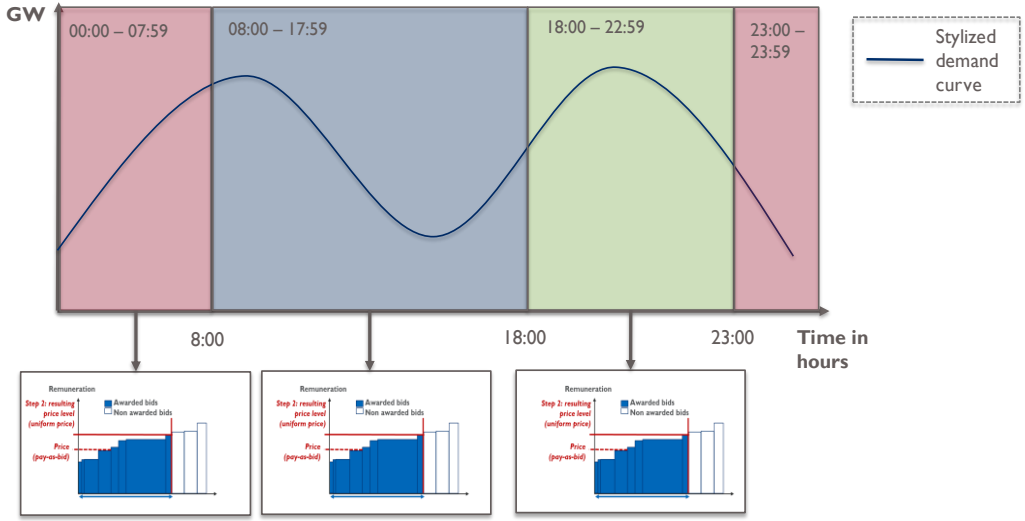


Other system-friendly case studies

Chile's supply blocks enable continuous supply while mitigating resource risk for sellers (I/II)

Intraday and seasonal supply blocks in Chile's 2017 auction

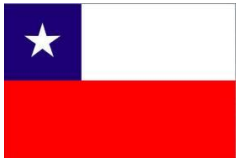
Objective	Allowing intermittent technologies to optimize their feed-in potential and guarantee supply to distribution companies.



- Distribution companies provide demand projection
- Regulator aggregates projected supply requirements, conducts auction
- Bidders bid for one or several blocks representing projected (not real-time) demand
- Blocks have a base and a variable component to absorb unexpected demand increase
- Production deviations settled at spot-market prices

Sources: ACERA 2017

Chile's supply blocks enable continuous supply while mitigating resource risk for sellers (II/II)



Intraday and seasonal supply blocks in Chile's 2017 auction

Benefit	Considerations
▪ Continuous power supply successfully contracted – all from new RE ▪ Contracted price of $3.25ct (₹2.5)/kWh lower than spot market prices of $5.5ct (₹4.1)/kWh	➢ Compliance of bidders with delivery obligations cannot yet be evaluated as projects still under construction ➢ Precondition: sufficient information of distribution company on hourly/seasonal demand and generation patterns

Sources: ACERA 2017

1 USD = 75.3 Indian Rupees on Jun 10, 2020. Source: Oanda

Sources: ACERA 2017, Comisión Nacional de Energía (CNE) 2017, MERCOM India 2020

Nevada's peak tariff rewards supply at peak demand periods (I/II)

Nevada's 2019 auction

Objective	Incentivize supply during summer evening hours (4 – 9 pm)

- Procurement of PV + storage capacity to help state meet 2030 target of 50% RE generation
- NV Energy (utility) defined on-peak tariff for summer evening hours (4 – 9 pm)
- On-peak tariff paid is 6x higher than off-peak tariff paid to producers

Sources: ACERA 2017

Source: NV Energy, BloombergNEF

Nevada's peak tariff rewards supply at peak demand periods (I/II)

Nevada's 2019 auction

Benefit	Considerations
▪ Smooth and extended PV output contracted at competitive prices: • Off-peak price: $2.1ct (₹1.6)- $2.5ct (₹1.9)/kWh • On-peak price: $13.8ct (₹10.4)-$16.1ct (₹12.1)/kWh • Levelized tariff: $3.68ctts (₹2.8) - $4.28ct (₹3.2) cents/kWh	➢ Effectiveness in covering peak periods cannot yet be evaluated as projects still under construction

1 USD = ~75.3 Indian Rupees on Jun 10, 2020. Source: Oanda

Sources: BNEF 2019, MERCOM India 2020

Germany's virtual power plants bundle diverse VRE and dispatchable generation to provide flexible power (I/II)

Objective	Optimize operation of generation, demand and storage assets to provide flexible power

Simplified representation of virtual power plant (Next Kraftwerke)

- A control center operates the connected generation, demand, and storage assets
- Assets are forecasted, optimized, and traded in energy markets like one single power plant
- Example: Provision of reserves:
  - Pre-qualified assets participate in reserve market (operated by grid operators)

Sources: Next Kraftwerke

Germany's virtual power plants bundle diverse VRE and dispatchable generation to provide flexible power (II/II)

Benefit	Considerations
▪ Reduced provision of reserve energy by thermal generation: ▪ 2016: Provision of 67 MW as primary reserve, 67 MW as secondary reserve, and 1160 MW as tertiary reserve	➢ Preconditions: ➢ Liquid wholesale power market and/or reserve market or alternatively PPAs with large consumers

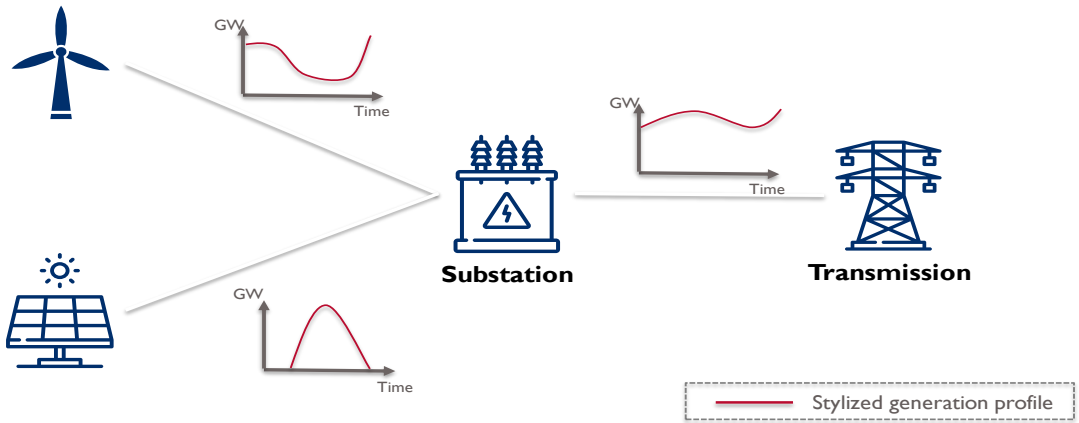
Sources: Next Kraftwerke

Case Study: India 24x7 procurement

India's physical hybrids provide a more firm RE power and optimize grid infrastructure use (I/II)

Objective	Efficient utilization of land (i.e., kWh/m2) and transmission capacity (i.e., MWh/MW), as well as a reduction in the intermittency of VRE generation to increase grid stability

Simplified representation of a physical hybrid



- SECI auctions RE capacity to be procured as solar-wind-storage hybrid
- Capacity Utilization Factor (CUF) set at 30% for solar-wind
- Solar and wind installation are co-located and feed power into a pool substation.
- Power from the pool substation is evacuated into the transmission grid

Sources: Next Kraftwerke

India's physical hybrids provide a more firm RE power and optimize grid infrastructure use (II/II)

Benefit	Considerations

▪ Solar-wind hybrid capacity contracted at competitive tariff:
  ▪ 2018: 840 MW at $3.6ct (₹2.67 - ₹2.69)/kWh
  ▪ 2019: 720 MW at $3.6ct (₹2.69 - ₹2.70)/kWh
▪ Comparison: Discom average purchase cost ~$5.3ct (₹4)/kWh
	➢ Sites with good, often complimentary solar and wind resources available in India
	➢ Uniform and ambitious CUF and ceiling prices across states
	  ➢ Only achievable in regions with higher RE resource potential
	  ➢ Can restrict number of bidders or risk the non-completion of awarded projects.

Sources: Next Kraftwerke

The Indian success story of RE 24x7 procurement – 3 types of tenders by SECI

RE + storage for peak supply 1200 MW ISTS-Connected RE Projects with assured Peak Power Supply in India	• Two-part tariff- "Off-Peak Tariff" fixed at INR 2.88/kWh and Peak Tariff • Minimum annual CUF of 35%. Penalty- 25% of cost of shortfall, calculated as PPA tariff. • Peak blocks (6am–9am; 6pm–12am) • Off-peak blocks (9am – 6pm; 12am – 6am)	Winners: • Greenko- 900MW with pumped storage; INR 4.04/kWh avg tariff & INR 6.12/kWh peak tariff • ReNew Power - 300 MW with battery energy storage; INR 4.30/kWh avg tariff & INR 6.85/kWh peak tariff
100% RE + storage round the clock Round-the-Clock Supply of 400 MW RE Power to under Tariff-based Competitive Bidding (RTC-I)	• Supply obligation of min. 80% capacity utilization factor (CUF) • 400 MW of capacity awarded	Winners: • ReNew Power • Continuous supply contracted at INR 2.9/kWh), levelized cost of INR 3.55/kWh – INR 3.60/kWh
Round the clock supply from RE and thermal Supply of 5000 MW RTC Power from ISTS-connected RE Power Projects, complemented with Coal based Thermal Power in India (RTC-II	• Minimum of 51% of annual energy from RE sources • Meet demand at least 80% of time in a year. (70% monthly) • Penalties 25% of PPA tariff on shortfall • Composite tariff with fixed tariff + variable tariff	

Highlights In PPA of SECI 2500 MW and 150 MW Indian Railway

Capacities and Technologies Allowed		
Statement	SECI Tender	For IR
Tender Capacity	2500 MW	150 MW
Maximum Bid Capacity	2500 MW	150 MW
Minimum Bid Capacity	250 MW	50 MW bucket filling till 150 MW. Reverse auction.
RE Component	51% of total energy from RE sources on annual basis	Minimum 80% from RE on an annual basis
RE Technologies allowed	Wind, Solar and others	All RE Technologies recognized by MNRE and their combination along with ESS
Non RE	Allowed	• Both coal, gas and hydro to be allowed • Short term purchases for supplier to be allowed • Long tie up need not be mentioned
Bid Process	• Tariff Based Competitive Bid Process • Reverse Auction	• Tariff Based Competitive Bid Process • Reverse Auction
Tenure of PPA	• 25 years	25 years

Highlights In PPA of SECI 2500 MW and 150 MW Indian Railway

Project Component Capacities		
Statement	SECI Tender	For IR
Project Component Capacities	Developers free to choose	Developers free to choose
Supply from existing projects	• Not Allowed for RE sources • Allowed for thermal sources	• Allowed for non-RE component only • New capacity development is compulsory for RE component
Changing the projects during PPA tenure	Not Allowed	Follow MoP Guidelines
Commissioning		
Projects upto 1000 MW	24 months	18 months (not later than June 2023)
Projects larger than 1000 MW	30 months	

Highlights In PPA of SECI 2500 MW and 150 MW Indian Railway

Project Location and Open Access		
Statement	SECI Tender	For IR
Location of Project components	• Can be co-located or located at different locations • Project components can be located anywhere	• Can be co-located or located at different locations • Project components can be located anywhere
Delivery Points	• Multiple Delivery Points allowed • ISTS Sub-station to which project components are connected	• Multiple Delivery Points allowed • ISTS Sub-station to which project components are connected
Connectivity	• All project components to be connected to ISTS • Project components can be connected to different ISTS sub-stations	• All project components to be connected to ISTS • Project components can be connected to different ISTS sub-stations
Location of ESS	To be co-located with RE Components	Need not be co-located. As per existing RTC guidelines
ISTS Connectivity	• Developers' responsibility	• Developers' responsibility
ISTS Losses and Charges	• Buyers' responsibility	• Buyers' responsibility

Highlights In PPA of SECI 2500 MW and 150 MW Indian Railway

Statement	SECI Tender	For IR
Tariff structure	Four part tariff • Fixed RE Component • Fixed Non RE Component • Variable Non RE Component (Fuel) • Variable Non RE Component (Transportation)	Two part tariff • RE component • Non RE component
General Eligibility Criteria	• Should be registered as a Company • Consortium Allowed • Foreign companies allowed	• Should be registered as a Company • Consortium Allowed • Foreign companies allowed
Project Availability	• 24 hours - 85% of allotted capacity on annual basis • Peak Hours - 85% of allotted capacity on annual basis	• 24 hours - 85% of allotted capacity on annual basis • No peak hour requirement • At least 50% availability for each time block
Peak hours	• 4 hours a day • RLDC declares the peak hours periodically	To be removed

Round-the-clock procurement is driven by buyer requirements and demand characteristics

RTC concept is unique to India but touches upon system-friendly approaches piloted in other countries

Benefits of Round-the-Clock power	More dispatchable RE for supply-demand match	More firm RE power (on-site or different locations)	Demand-based supply managed by seller
Chile – Supply blocks	✓		✓
Colombia - Supply blocks	✓	✓	✓
Nevada – Peak tariffs	✓	✓	
Germany – Virtual Power Plant	✓	✓	✓
India – Physical hybrids	✓		✓

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Thank you