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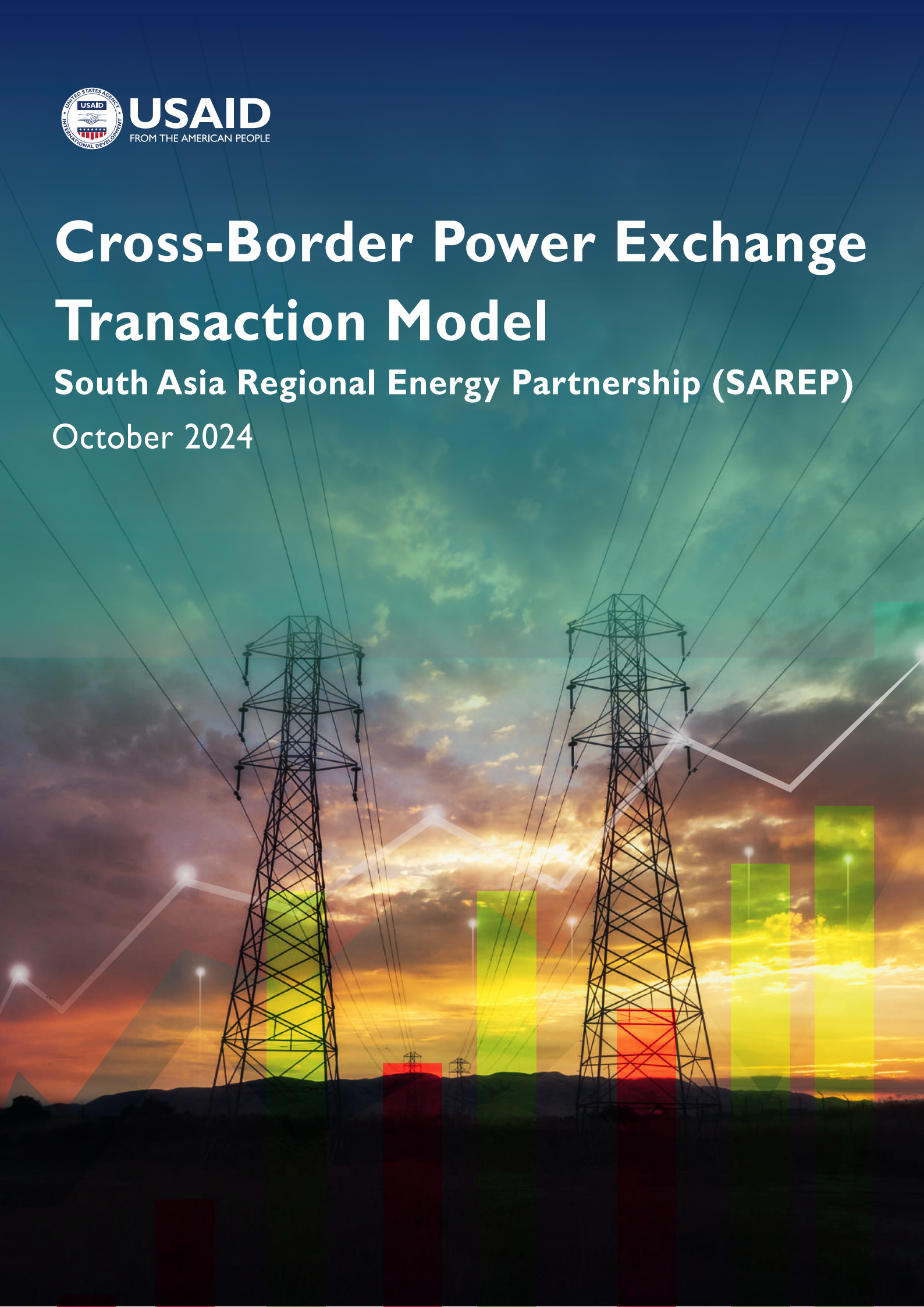
Cross-Border Power Exchange Transaction Model

South Asia Regional Energy Partnership (SAREP)

October 2024



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Introduction

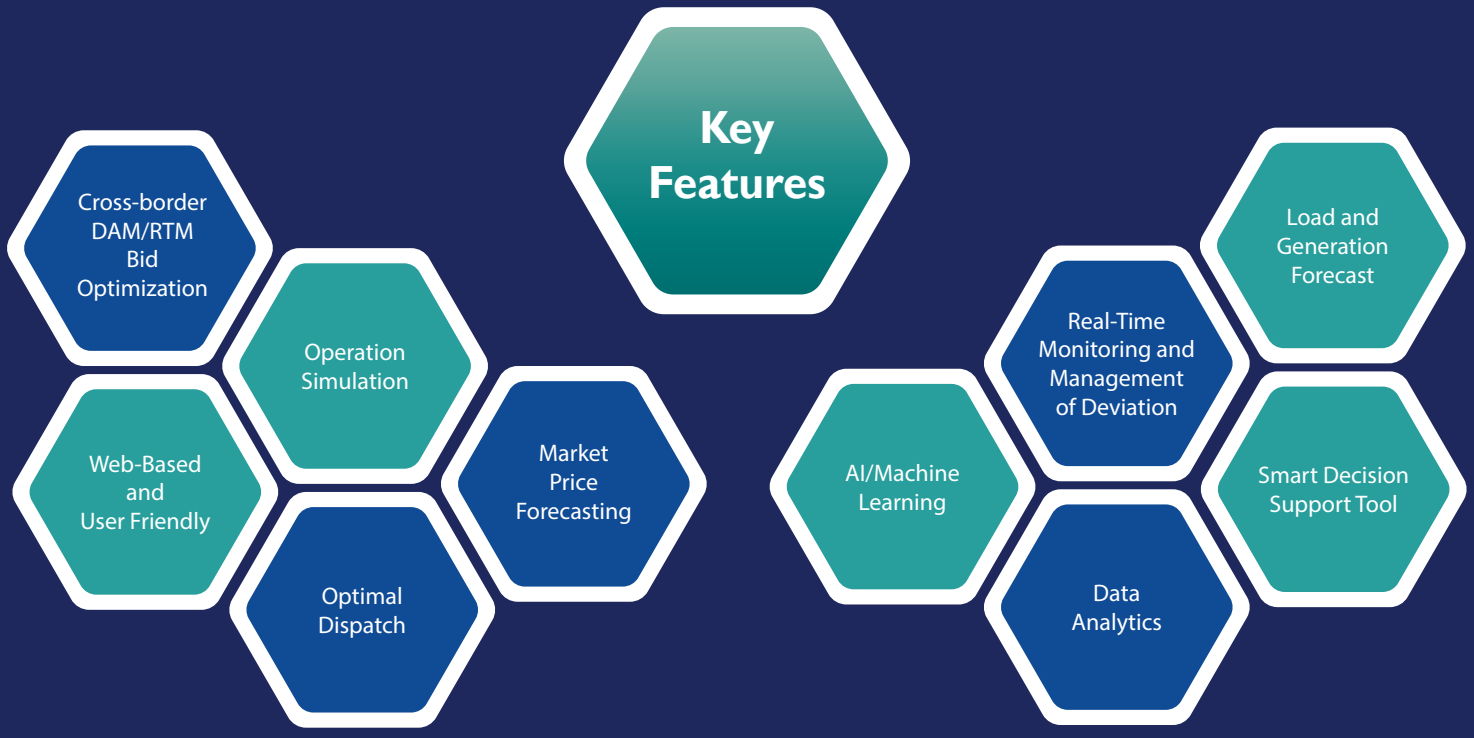
Regional Energy Cooperation through Cross border Electricity Trade (CBET) has been ongoing in South Asia since the 1970s. Over the years, the quantum of power traded has gone up significantly, just in the last decade CBET has doubled from 7.8 TWh in 2014 to 18 TWh in 2024. Until recently, power trading was primarily through bilateral contracts and non-market mechanisms.

CBET through Indian power exchange (PX) platform started with Nepal entering Indian Energy Exchange in April 2021 followed by Bhutan in January 2022. Power Exchange is a competitive market trading platform which ensures fair, neutral, efficient, and transparent price discovery of electricity traded. CBET through the PX platform provides flexibility in trading of surplus and deficits and helps to manage the demand-supply mismatch on a day-ahead and real-time basis, with price discovery based on market dynamics. CBET through PX platform of India has quadrupled with around 1.1 TWh traded during the year 2021-22, which has reached around 4.1 TWh by 2023-24.

With the increasing complexity of renewable energy integration and associated cross border market opportunities, managing demand-supply at the least cost while maximizing market opportunities is a significant computational challenge. Traditionally, expert operations teams responsible for power trading have handled this using Excel-based models. However, recent technological advancements in data and analytical models, combined with growing market complexity, necessitate a more robust and scalable solution.

In this context, USAID through its South Asia Regional Energy Partnership (SAREP) program in partnership with the Royal Government of Bhutan has supported development of a sophisticated and integrated web-based model "the Cross Border Power Exchange Transaction Model (CBPETM)" for integrated supply-demand optimization vis-à-vis cross-border electricity trade by adopting advanced mathematical linear programming-based optimization and Artificial Intelligence/Machine Learning based predictive analytics. CBPETM builds on the earlier developed excel model by the SAREP program). SAREP partnered with EMA Solutions to develop the CBPETM model.

Cross Border Power Exchange Transaction Model helps to forecast generation and demand and determine the optimized bid volumes and prices for buying and selling in the day ahead and real time market. It also enables close monitoring to take timely corrective actions for participating hydro generating plants and demand of Bhutan on a real-time basis. The model provides comprehensive decision support and process automation solutions. To begin with, the CBPETM Model is being prepared for Bhutan, and subsequently the model will be customized for Nepal for bringing efficiencies in power exchange based CBET.



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Cross-Border Power Exchange Transaction Model

To ensure effective participation in the Indian Power Exchange and optimized trading outcomes, the Cross-Border Power Exchange Transaction Model possesses the following capabilities:

1. Domestic Load Forecasting

- Day-Ahead and Real-Time Forecasting: Accurate forecast of country's domestic demand for both day-ahead and real-time scenarios;
- Weather Impact: Integrate prevailing weather conditions to enhance forecast accuracy.

2. Hydro Electric Plants (HEP) Inflow and-Generation Forecasting

- River Inflow Forecasting: Consider weather conditions to predict river inflows to HEPs for day-ahead and real-time scenarios;
- AI/ML Models: Use artificial intelligence and machine learning to forecast generation profiles from hydro generation plants;
- Area Capacity Curve and Storage Volumes: Assess dam levels in fifteen minutes time blocks;
- Technical Parameters: Incorporate gross and net heads, losses, and other plant-specific technical data.

3. Hydro Generation Optimization

- Plant Operations Simulation: Simulate operations of individual HEPs based on inflow and generation;
- The parameters considered for the HEP optimization model include:
  - Area Capacity Curve and Storage Volumes
  - Generation Cost and Off-take terms
  - FRL & MDDL – for pondage-based HEPs
  - Ramp Rates
  - Technical Minimum
  - HEP Operational Requirements.

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4. Load Forecasting and Market Price Forecasting

- AI/ML based Load Forecast for the country's considering demand mix and weather conditions;
- DAM and RTM Clearing Prices: Forecasts Day Ahead Market (DAM) and Real Time Market (RTM) clearing prices on the Power Exchange;
- Bid Pricing and Volumes: Forecast prices are factored into bid pricing and volume decisions for each time block.

5. Dispatch Optimisation and DAM/RTM Bid Optimization

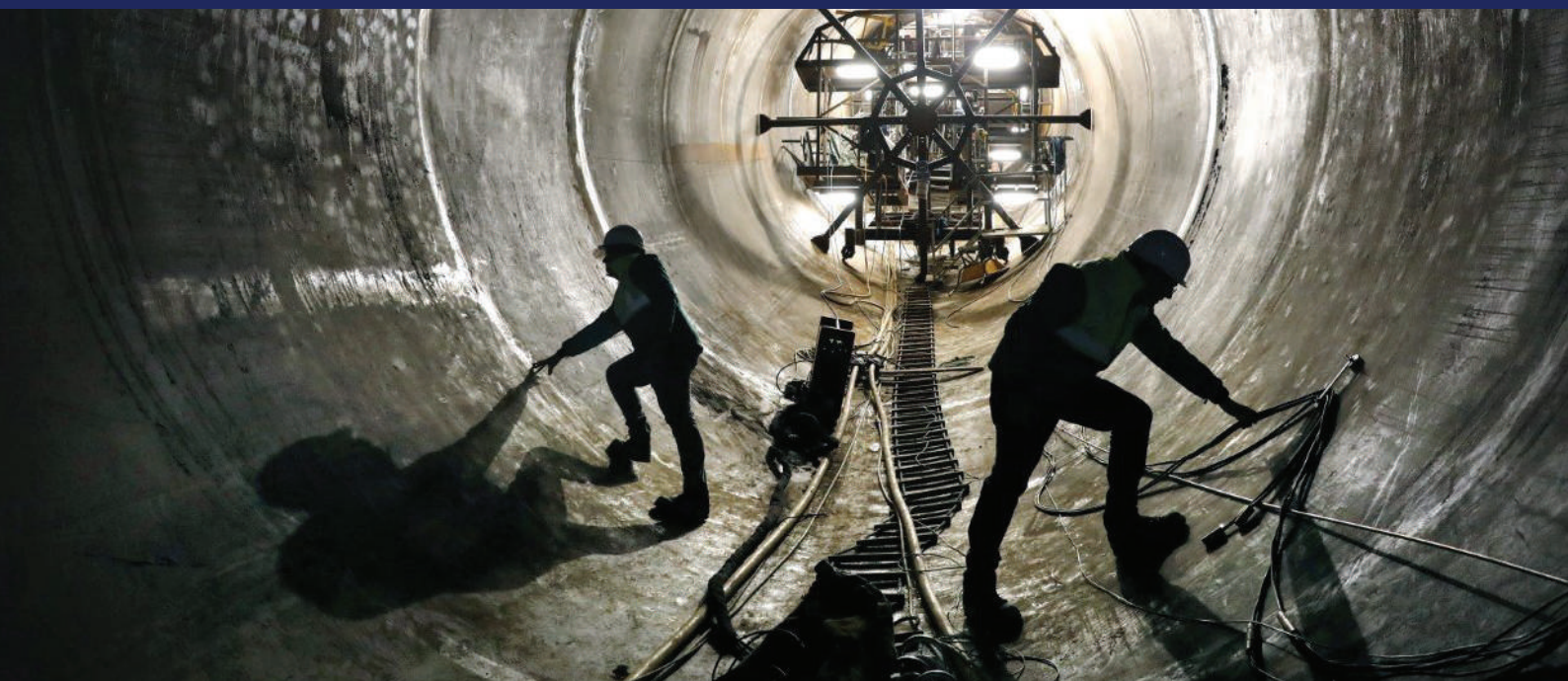
- Optimal Bid Volumes and Prices: This procedure determines optimal bid volumes and prices for both purchase and sale time block-wise;
- Bid Submission: Recommends time slots and formats for bid submissions to maximize gains, considering generation & load conditions and transmission constraints;
- Statistical Tools: Utilizes advanced linear programming-based optimization algorithm- A) Objective Function: Maximize revenue (surplus season) B) Minimize cost (deficit season): Achieve efficient energy balance and trade profiles on fifteen minutes time block basis.

6. Real-Time Monitoring, Demand-Side Management, and Adjustments

- Transaction Monitoring: Monitors actual purchases and sales in real-time post-bid placement;
- Deviation Management: Addresses variations in demand, generation, and cross-border demand-side management (DSM);
- Real-Time Data Interface: Interfaces with RLDC Web-Based Energy Scheduling (WBES) portals and Exchange for real-time schedule/trade updates;
- Intervention Recommendations: To align with agreed-upon schedules and minimize DSM, the report suggests adjustments in generation levels, reservoir operations, and DSM.

7. Rescheduling and Trading Recommendations

- Deviation Handling: Recommends immediate rescheduling of exports/imports to mitigate generation and financial losses;
- Real-Time Market Recommendations: Provides trading recommendations in the RTM segment to optimize outcomes.



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8. Benefits

- Enhanced Efficiency: Streamlines operational processes using automation and analytics, and improve decision-making using optimization tools;
- Cost Savings: Reduces DSM charges and improves financial outcomes through optimized trading;
- Strategic Participation: Accurate forecasting and bidding will help strengthen the country's position in the Indian power market.

About USAID's South Asia Regional Energy Partnership (SAREP)

The South Asia Regional Energy Partnership (SAREP), a flagship program to advance objectives of the U.S. Government's Clean Asia Enhancing Development and Growth through Energy (Clean EDGE), is a five-year initiative (2021-26) that aims to improve access to affordable, secure, reliable, and sustainable energy across six South Asian countries- Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka- in line with these countries' climate and clean energy priorities.

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