



# Regulatory Foundations for Cross-Border Electricity Trading: Nepal

David J. Hurlbut and Sam Koebrich

*National Renewable Energy Laboratory*

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## Preface

This report was developed by the National Renewable Energy Laboratory (NREL) for the U.S. Department of State's Bureau of South and Central Asian Affairs Regional Connectivity Program. The report is part of a project providing technical assistance to support increased cross-border electricity trade and cooperation in the South Asian region (including India, Nepal, Bhutan, Bangladesh, and Sri Lanka). The project aims to identify opportunities for, and the associated value of, increased power trade through peer-to-peer collaborations, power system modeling, regulatory roadmaps, and improved data. The technical assistance involves four critical stakeholder groups: power system engineers, power system planners, regulators, and electricity developers. This technical assistance will contribute to the future development of a more robust regional energy market, bolster the potential for cross-border connectivity in South Asia, and enable growth of renewable energy in the region.

Through the Greening the Grid program, NREL has been developing national and subnational grid integration studies in India that analyze strategies to integrate high levels of renewable energy into the South Asia grid. These renewable energy grid integration studies provide a solid foundation for understanding regional energy resources and needs, and thus inform the creation of a South Asian regional energy coordination strategy.

Other activities in this project build from the data collection, modeling, and analysis supported by the U.S. government under other interagency partnerships in the South Asian region, including the Partnership to Advance Clean Energy, a new Millennium Challenge Corporation program for South Asia renewable market integration, Enhancing Capacity for Low Emission Development Strategies, the Sustainable Growth Working Group under the US-India Energy Dialogue, the Clean Energy Ministerial, and other Indo-Pacific Economic Corridor activities through U.S. Department of Commerce's Commercial Law Development Program. NREL will build from the knowledge, examples, and institutional relationships that have emerged from these initiatives and will provide concrete improvements for U.S. government investment in the South Asian region.

## Acknowledgments

The authors are grateful to the following for their invaluable feedback on this report: Toya Nath Adhikari, Joint Secretary of the Government of Nepal’s Ministry of Energy, Water Resources, and Irrigation; David Tulloch, Deputy Political and Economic Chief of the U.S. Embassy in Kathmandu; Shanker Khagi, Environment and Energy Specialist with the US Agency for International Development; Troy Kofroth, Resident Country Director of the Millennium Challenge Corp. (MCC) in Nepal; and Thomas Haslett, Senior Program Officer of MCC. We are also grateful to our NREL colleagues Dan Bilello, Kristen Ardani, David Palchak, Amy Rose, and Mohit Chandra Joshi for their review and comments. Isabel McCan and Liz Breazeale provided editorial support. Al Hicks provided special assistance with graphics.

## List of Acronyms

AS	ancillary services
CBET	cross-border electricity trading
CERC	Central Electricity Regulatory Commission (India)
ERC	Electricity Regulatory Commission (Nepal)
FERC	Federal Energy Regulatory Commission (United States)
GtG	government-to-government
GW	gigawatts
ISGS	interstate generating station
LDC	load dispatch center
MBED	market-based economic dispatch
MCP	market clearing price
MWh	megawatt-hour
NEA	Nepal Electricity Authority
NPC	National Power Committee
NREL	National Renewable Energy Laboratory
POSO	Power System Operation Corporation
PPA	power purchase agreement
RLDC	regional load dispatch center
RTO	regional transmission organization
SAMAST	scheduling, accounting, metering, and settlement of transactions
SCADA	Supervisory Control and Data Acquisition
SCED	security-constrained economic dispatch

## Executive Summary

Cross-border electricity trading (CBET) can reduce costs, improve reliability, and reduce emissions for all participating countries. Regulatory coordination is essential to making CBET successful. For Nepal, expanding CBET mechanisms could help accelerate development of the country’s large hydroelectric potential, especially if Nepal, India, and Bangladesh were parties to a comprehensive CBET framework. This report maps the regulatory issues Nepal might address if it elects to develop a national strategy for CBET with its neighbors in South Asia.

CBET can take one of three general forms. Each form raises different sets of regulatory issues and involves different levels of cross-border coordination. CBET types include:

- Tenant generation, in which a generator exports power to another country over a dedicated cross-border transmission line with little or no connection to the host country’s system;
- A bilateral contract, where power moves through both national networks and across transmission interfaces linking the two grids; and
- An integrated market exchange where cross-border trades and all other power flows are optimized simultaneously over multiple networks.

These three models vary with respect to new transmission and operational coordination between the two countries. Improvements to dispatch and ancillary service procurement can also differ. Table ES-1 contrasts the three CBET models.

**Table ES-1. Characteristics of CBET Models**

	Tenant Generation	Bilateral Contracts	Integrated Markets
Need for coordinated scheduling between countries	○	◐	●
Need for transmission expansion	●	◐	◐
Fixed pricing*	●	●	◐
Improved dispatch—exporting country	○	◐	●
Improved dispatch—importing country	◐	◐	●
Improved reliability	○	◐	●
Improved ancillary services (less cost, more flexibility)	○	◐	●

○: low      ◐: moderate      ●: high

\*In contrast with market clearing prices, which can vary by hour or more frequently depending on market design and system conditions. See chapter 3 for a discussion of market clearing prices.

India is evaluating major market reforms that could accelerate CBET. Regulators proposed these reforms in 2018 to address inefficiencies in India’s wholesale power markets, but, if ultimately adopted, they could accommodate CBET with India’s neighbors. The development of a South Asian wholesale power market based on security-constrained economic dispatch (SCED) could significantly enhance opportunities for CBET, including power transfers between Nepal and Bangladesh.

Nepal's opportunities for successful CBET depend on strategic coordination across three areas: national policy, regulation, and power system planning. A key question for national policy will be whether to participate in the Indian wholesale market reforms, if and when India permanently enacts them. More generally, national policy provides authoritative guidance on how Nepal balances CBET goals with other national goals. One area that might benefit from policy clarity is guidance on how regulators should balance energy independence with the economic benefits of regional interdependence. This could include identifying critical thresholds for measures such as imported electricity, domestic service disruptions due to insufficient power supplies, and the amount of generation capacity built in Nepal primarily for export.

National policy, in turn, affects the creation of rules and other regulatory decisions. Regulatory issues for all types of CBET might include:

- Accounting for CBET in standards for approving new transmission
- Guidelines for allocating the cost of new transmission intended to enable CBET
- Reporting requirements (sales, purchases, curtailments, cost of energy paid for but not taken).

For bilateral agreements and integrated markets, rules might additionally include:

- Whether to allow customers to switch service from Nepal Electricity Authority (NEA, Nepal's national electric utility) to an alternative provider
- Methods for assessing whether wholesale power prices are reasonable and competitive.

For integrated markets, rules might include:

- Registration of Nepalese entities who will participate in CBET
- Application of standards for scheduling, accounting, metering, and settlement
- Dispute resolution processes.

Increased CBET could create a new role for NEA similar to a power marketer: aggregating hydropower delivered under NEA's numerous power purchase agreements (PPAs) and selling any surplus (over NEA's system demand) to buyers in India. Depending on national policy directives, CBET could also affect NEA's system planning for new generation and transmission.

Wholesale power markets evolve over time, and Nepal's success in achieving beneficial CBET could be aided by tracking indicators of market outcomes. Monitoring prices and trading activity can provide public accountability for CBET policies. It can also provide early signs of the need for mid-course corrections in specific regulations.

Technical analysis can show the theoretical benefits of integrated markets and CBET, but implementation depends on each country's utility laws and regulatory institutions. Building an integrated power market is complex and often requires regulators to enforce transparency, patience, and careful attention to detail. Because institutional evolution does not necessarily proceed at the same pace in all countries, cooperation among regulators is key to managing the process and ensuring that each country enjoys the full benefits of CBET.



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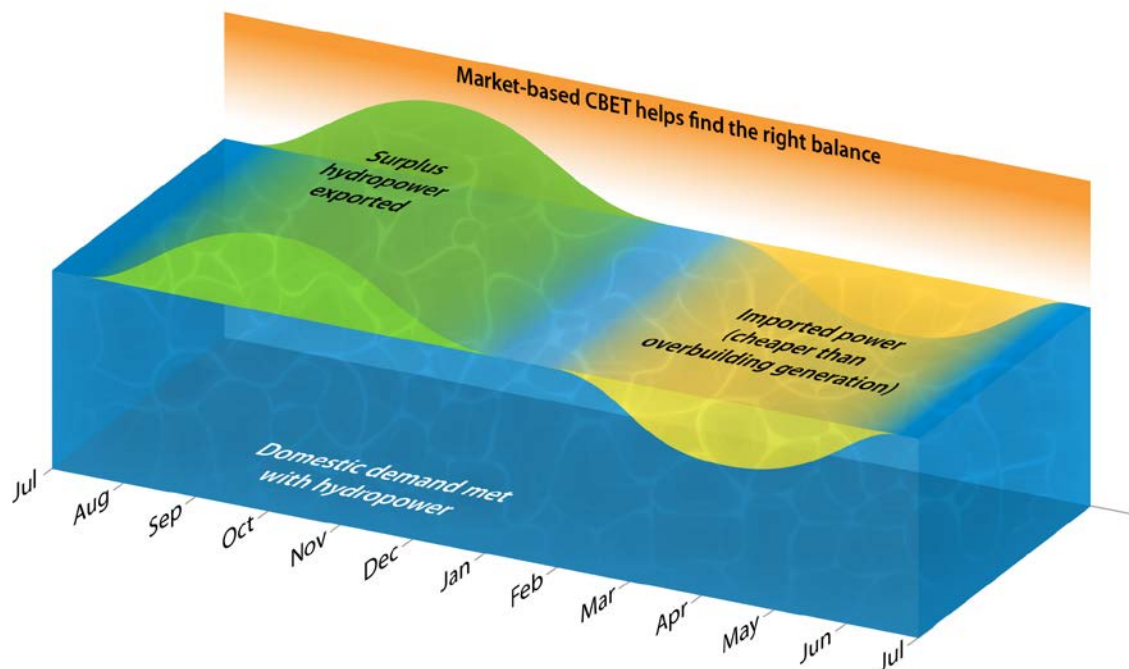
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# 1 Introduction

Greater cross-border electricity trading (CBET) can benefit customers throughout South Asia. Limited trading already takes place, but Nepal, India, and Bangladesh have signaled interest in increasing the commercial flow of electricity among them. Harmonizing policies on both sides of the border is crucial, however, because poor or uncoordinated regulations can suppress CBET and jeopardize the potential public benefits. For Nepal, expanding CBET mechanisms could help accelerate development of the country's large hydroelectric potential, especially if Nepal, India, and Bangladesh were parties to a comprehensive CBET framework. The purpose of this report is to provide an overview of CBET options and the different regulatory decisions they entail, with a focus on Nepal.

Ideally, CBET strikes a balance between two public interest goals: energy independence and cost savings through foreign trade. The early stages of national electrification normally favor energy independence and have little exchange with neighboring countries. As the country's economic development expands to include a larger cross section of the population, however, keeping the price of electricity as low as possible becomes increasingly important to sustainable growth. Low electricity costs might depend on strategies enabled by CBET, such as:

- Greater access to low-cost generation resources
- Development of high-voltage transmission corridors to reduce line losses
- Pooling operating reserves across borders
- Regional resilience plans for speedy recovery from earthquakes, flooding, or other natural disruptions to the grid.



**Figure 1. Using exports and imports to "right-size" domestic generation**

Illustration by Al Hicks, NREL

The use of economic electricity trading can help right-size a country's domestic generation capacity (Figure 1). Domestic generators can export seasonal supply surpluses, while, at other times of the year, utilities can use imports to compensate for seasonal shortages. This can help avoid expensive overbuilding of domestic generating capacity and reduce the risk of load shedding. Stable regulatory policies for CBET can support operational consistency, which in turn can reduce the risk of investing in new generation.

CBET is a feature of the evolving electricity sector around the world, but it does not happen on its own. Economically beneficial trading relies on strategic policies and effective regulation that aim to balance competing public interests. It also involves cooperation among sovereign nations, and agreement on matters such as the allocation of costs, mechanisms for resolving commercial disputes, technical standards, and the governance of institutions charged with operating joint markets on a shared grid.

Major electricity reforms in India could accelerate CBET in South Asia significantly. While these proposed reforms are not certain as of this writing, they would involve considerable preparation if they are implemented and Nepal chooses to participate. India's aim is to eliminate waste and inefficiency by establishing geographically integrated market-based mechanisms for scheduling, energy dispatch, and procurement of ancillary services. In this report, we pay special attention to these reforms and their status as of this writing. While the key driver of these reforms is India's domestic need to increase the efficiency of its own power sector, current and proposed policies appear to contain no inherent barrier to Nepal's participation either as a seller of hydropower or as a buyer of reserves to eliminate load shedding.

CBET can take place through bilateral contracts, an integrated market with joint dispatch, or a combination of both. Under a bilateral contract, a specific supplier in one country delivers electricity to a specific customer in another country. Deals are negotiated directly between two counterparties who agree on prices, quantities, and schedules for energy delivery. In contrast, an integrated market combines many suppliers offering electricity to many customers through a power pooling arrangement. Integrated trading takes place through an automated auction platform that sets prices and determines dispatch quantities for each plant at hourly or subhourly operating intervals. The result is cost-optimized dispatch across the entire grid.

After defining CBET types, this report examines integrated market exchanges with joint dispatch as contemplated in India's proposed wholesale power market reforms. These markets are generally more complicated, but they are also more transparent. If extended to include CBET, these reforms could represent a new framework for South Asian utilities and CBET.

The fundamentals of integrated markets and differences in CBET types suggest foundational questions Nepal might consider answering as it develops its national CBET policies. The aim of this report is not to recommend answers to these questions. Rather, it is to lay out a roadmap of major decision points that can guide the country's policy development. How Nepal answers these questions would guide how it shapes the regulatory issues described in Section 5.

The report finishes with several suggestions for how Nepal could monitor CBET outcomes. Markets often take years to reach a point of consistent efficiency, and this could include mid-course adjustments to regulations. Monitoring would enable the government to track CBET progress and ensure regulatory policies are up to date.

## 2 Types of CBET Arrangements

CBET transaction models can differ significantly in their commercial and political characteristics. This section defines three categories, which, in order of regulatory complexity, include: tenant generation; bilateral commercial agreements; and integrated market exchanges.

Addressing each of these CBET categories on its own merits can make government policy and regulation more effective. Important factors that can differ include ownership of generation, coordination with power system operations on either side of the border, risk management, the ability of the generator to recover costs, and impacts on domestic customer electricity bills.

### 2.1 Tenant Generation

This type of project is built in one country for the primary purpose of serving demand in another country. Dedicated long-distance transmission lines connect the generator to the grid of the importing country with minimal connection to the grid of the host country.

From the viewpoint of the importing country's utility and grid operator, a tenant generator on the other side of the border is operationally the same as a domestic generator. The plant is subject to the importing utility's rules for scheduling, commitment, dispatch, and settlement. Congested transmission flows between the two countries have little or no effect on the delivery of power to the importing country, due to the dedicated transmission line through the host country.

The role of the host government is largely limited to site permitting and terms of tenancy (annual lease payments and other remuneration). Neither the host country nor its grid operator has any role in the plant's scheduling, dispatch, or financial settlement. Financially, energy and capacity revenues for a tenant generator are independent of anything that happens on the host country's grid.

A tenant generator can sign bilateral agreements, participate in an integrated market, or transfer ownership to the purchasing utility. In any case, however, the country hosting the plant generally does not benefit from greater economic or operational efficiency for its grid. The benefits are mostly limited to the terms of tenancy, taxes, and local employment. A tenant project generally does little for the ability of other generators in the host country to access the market of the importing country.

The proposed 900-MW Arun 3 project, for example, would be built and operated in eastern Nepal by SJVN Ltd., a joint enterprise of the Government of India and the state government of Himachal Pradesh (Investment Board of Nepal 2014). The project includes a dedicated 400-kV transmission line from the dam's power house in Nepal's mountainous Sankhuwashabha District to the Muzaffarpur substation in the Indian state of Bihar. Terms of the agreement with Nepal include providing a portion of the output to the Nepal Electric Authority (NEA) grid at a substation near the border, as well as annual royalties and tax revenues.

### 2.2 Bilateral Contracts

Bilateral CBET transactions involve electricity that is scheduled and wheeled across an interconnection between two countries' power systems. The generator is connected to the grid of

the exporting country, while the entity purchasing the power is connected to the grid of the importing country.

Unlike tenant generation, bilateral CBET transactions involve a moderate level of operational coordination between the two countries. Balancing—that is, the continuous task of keeping total generation equal to the sum of load and net transfers to neighboring grids—is one example. Each country’s grid operator has to ensure that actual generation matches actual metered electricity demand at every moment throughout the day. Imports and exports are part of the balancing equation, as Figure 2 illustrates. The importing country and the exporting country need to have the same information about the volume and timing of electricity flows between their two systems for each to maintain balance. After accounting for net imports and exports, each country maintains its system balance with incremental increases or decreases to its active generation and with load management (demand response, interruptible load, and, in extreme cases, load shedding).

Bilateral exchanges are commercially independent of one another. The agreement between one buyer and one seller does not directly affect the price, quantity, or timing of another agreement between two other counterparties. Only when transmission congestion restricts the total flow of power on the system does the grid operator have a role in changing the amount of electricity moving under a bilateral agreement.

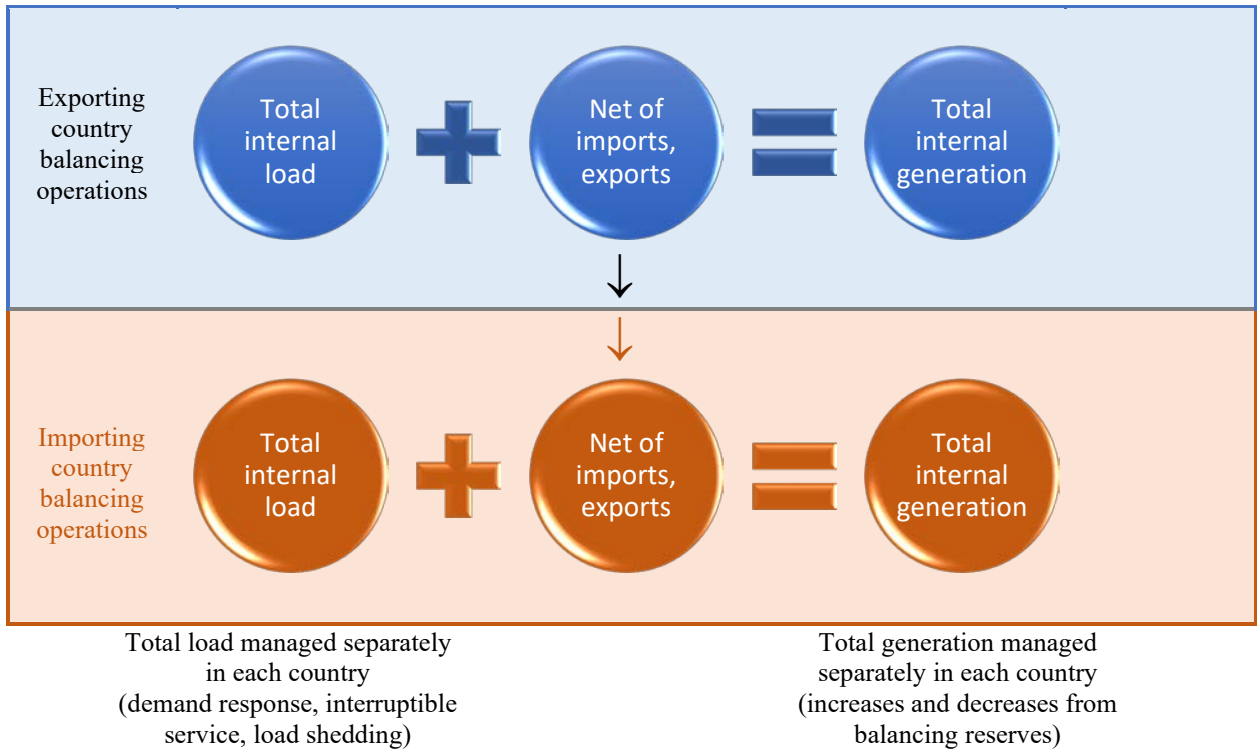
Government policies, such as import tariffs, taxes, and regulations, can create additional costs that counterparties account for when they enter into a bilateral agreement. Such policies tend to be nondiscriminatory, in that they are universally applicable to any deal between two eligible counterparties. Policies might weigh favorably or unfavorably, but it is nevertheless up to the counterparties to decide whether the agreement ultimately benefits both sides.

Barriers to bilateral CBET can include ownership requirements, import tariffs, government requirements for generation to come from domestic resources, or a lack of harmonization in regulations governing grid operations.

## **2.3 Integrated Market Exchanges**

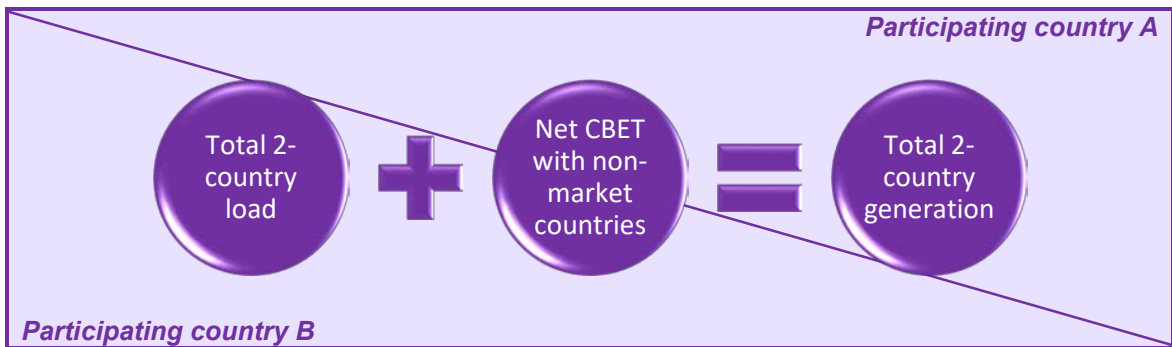
An integrated market optimizes unit dispatch and pricing across the region, so that load is met by the least-cost resources all the time. Energy offers from generators, updated load forecasts, and information on the current state of the grid feed into software that computes market outcomes many times throughout the day.

Bilateral CBET deals are independent of one another and can be as numerous as the market will bear; an integrated market is the opposite. Unit dispatch and pricing are determined simultaneously for all load and all generation within the market footprint. A generator can submit an offer to provide a certain quantity of power at a certain price, but neither the dispatch quantity nor the price will be known to the generator until the market actually clears (i.e., until all offers are processed by the market software to produce a least-cost solution).



**Figure 2. Moderate coordination: Bilateral CBET with separate balancing in each country**

NREL illustration



Combining load, bilateral exchanges, and generation across both countries results in a smaller net imbalance that is easier and cheaper to resolve

**Figure 3. High coordination: Integrated market combining CBET and energy balancing**

NREL illustration

Many integrated markets use security-constrained economic dispatch (SCED) to clear the market every hour or, in some cases, every 5 minutes. SCED is a computerized generator selection process that exactly matches the least-cost portfolio of generators to the amount of load expected for an operating interval without violating the thermal limits of any transmission line in the network. In many markets, SCED run for every hour of the next operating day to determine which generators are started and what their set points (operating levels) will be each hour. SCED can also run in real time to resolve imbalances between actual generation and actual load.

An international border running through an integrated market area has virtually no impact on how the market clears. What distinguishes one generator from another is the marginal cost of generation, the quantity of power available, transmission limits from the generator to the grid, and operational qualities such as ramp rate.

Figure 3 illustrates how balancing is more efficient in an integrated market. First, combining imbalances across several countries (or control areas within a country) often results in a smaller aggregated imbalance: negative and positive imbalances offset one another when combined. Second, this smaller imbalance can be resolved by drawing on a larger number of generators from which the least-cost option can be selected.

Integrated markets and bilateral trading are both driven by the market fundamentals of supply and demand. In bilateral deals, visibility into these fundamentals is a function of knowledge held by the counterparties. In an integrated market, on the other hand, prices form with fuller information about supply, demand, and value across the region.

No government has a hand in determining the quantity or price of electricity traded. A government may, however, approve participation by utilities, generators, and other entities under their jurisdictions. In addition, participating governments may discuss market rules to ensure they are nondiscriminatory, transparent, and promote economically efficient price formation.

Participating in an integrated market involves more regulatory steps by the government and more coordination between governments. Integration significantly changes many of the assumptions behind regulating the power sector. The public interest is less concerned with setting prices that are just and reasonable; it is more concerned with ensuring that pricing, dispatch, and other decisions are based on processes that are fair, transparent, economically efficient, and consistent.

## **2.4 Key Differences Between the Three CBET Types**

With respect to policy and regulation, the major types of CBET involve different levels of coordination among the neighboring countries. Operational issues include generation scheduling, dispatch, and procurement of ancillary services. The types can also differ with respect to the need for new transmission investment and how it is evaluated.

Table 1 summarizes some of the key characteristics of integrated markets in comparison to tenant generation and bilateral contracts.



**Table 1. Characteristics of CBET Models**

	Tenant Generation	Bilateral Contracts	Integrated Markets
Need for coordinated scheduling between countries	○	◐	●
Need for transmission expansion	●	◐	◐
Fixed pricing*	●	●	◐
Improved dispatch—exporting country	○	◐	●
Improved dispatch—importing country	◐	◐	●
Improved reliability	○	◐	●
Improved ancillary services (less cost, more flexibility)	○	◐	●

○: low      ◐: moderate      ●: high

\*In contrast with market clearing prices, which can vary by hour or more frequently depending on market design and system conditions. See chapter 3 for a discussion of market clearing prices.

## 2.5 Government-to-Government Transactions

Government-to-Government (GtG) exchanges are driven by diplomatic goals. They differ from tenant generation, bilateral commercial agreements, and integrated markets, in that the governments themselves are the counterparties.

One significant characteristic of GtG agreements is that they are outside the market. They do not necessarily follow fundamental power sector economics of supply, demand, and price formation (otherwise the transaction would not require government initiation). In the case of hydropower, government objectives that are important but outside power sector economics might include irrigation and flood control.

GtG agreements may involve government-financed infrastructure. In the Mahakali Treaty of 1996, for example, the governments of Nepal and India agreed in principle to build a multipurpose water project on the portion of the Mahakali/Sharda River forming part of the border between the two countries (Ministry of Water Resources 1996). Power generation would be divided equally between Nepal and India, similar to how the United States and Mexico share the production of two hydropower projects the countries built on the Rio Grande/Rio Bravo. Nepal and India resumed talks in 2018 and started work on a new detailed project report that envisions a generating capacity of 6,480 MW (*Hindustan Times*. 2018).

Diplomatically driven GtG arrangements differ from transactions that involve government-owned enterprises. These are often cost-based transactions that resemble bilateral contracts (defined in Section 2.2) and are different from GtG agreements.

This report sets aside GtG transactions as a model for CBET. Each agreement is guided by a unique set of government objectives and does not necessarily form a precedent for future CBET policy. Public interest goals outside the bounds of other types of CBET transactions would make comparisons inapplicable.

Building an integrated power market is complex and often requires transparency, patience, and careful attention to detail. Coordination can be even more challenging when different countries

are involved, because institutional evolution does not necessarily proceed at the same pace in all participating countries. Cooperation among regulators is key to managing the differences, thus ensuring that each country enjoys the full benefits of CBET.

## 3 Indian Market Reforms and Opportunities for Nepal

Market reforms in India could open new opportunities for CBET across South Asia. The reforms, proposed in 2018 in a series of discussion papers issued by India's Central Electricity Regulatory Commission (CERC), aim to address major inefficiencies that India has with its own system. While they are not aimed specifically at creating a CBET platform, the reforms represent a movement toward integrated markets that could, as a byproduct, enhance CBET.

### 3.1 Drivers for Reform in India

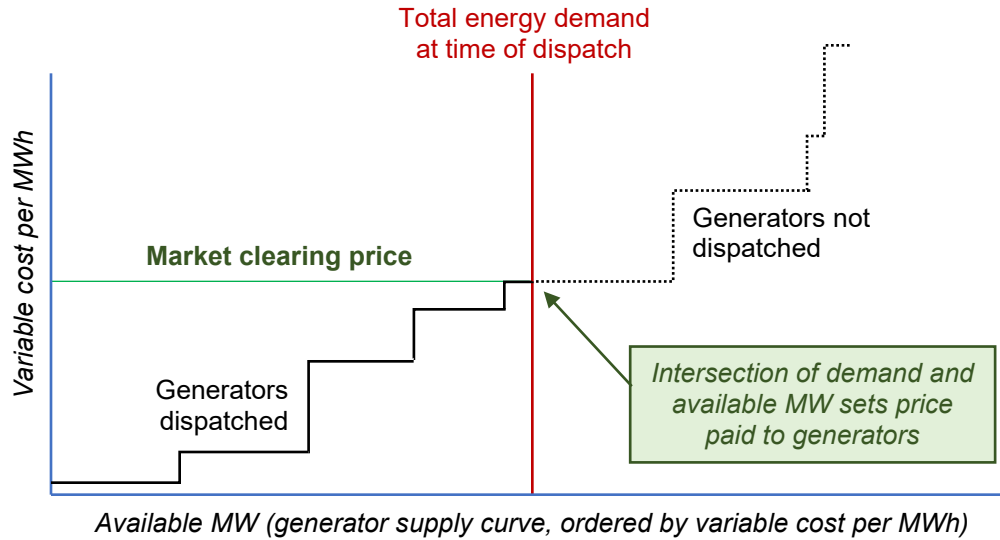
India's power grid began as a collection of separate state systems with limited connections among them. Consequently, India's electricity procurement and planning practices were largely uncoordinated across states and regions. Individual state-owned distribution companies were responsible for their own power scheduling, and many of these practices continue today. States may schedule their generation between an assortment of long-term electricity contracts with generators within the state, bilateral short-term contracts with generators in other states, and purchases from regional bulk power markets on a day-ahead basis.

The creation of central and state electricity regulatory commissions from the 1990s onward and the formation of the Power Grid Corporation of India (a national transmission company) in the late 1980s were major milestones in the development of India's interstate transmission system. Over the next decade, the all-India network continued to evolve with open access and other tariff reforms, power exchanges, point-of-connection transmission pricing, and (in 2013) operation of the state and regional grids as a synchronous system (Forum of Regulators 2016). Today, most state distribution companies can negotiate power purchases from anywhere in India. The national transmission network can deliver power into regional markets or to individual states.

Interstate generating stations (ISGSs) are generators with ownership shares from two or more states. An ISGS declares its available generation for the next day to its regional load dispatch center (RLDC), which then allocates the available capacity to states within the region based on shares and contracts. State distribution companies may purchase their allocation from the ISGS, sell it to someone else through bilateral contracts or on power market, or release the allocation and allow the ISGS to sell it on a power market (CERC 2018c). Some ISGS have as many as 15 beneficiaries in various Indian states, while some states receive power from more than 40 ISGSs (CERC 2019a). In addition to this, each state schedule its own resources along with these ISGSs to meet its demand. While this system allows for some level of state and regional optimization, lack of coordination between the states, the large number of long-term bilateral contracts, and the uncertainty of when capacity is released all prevent economically optimal dispatch.

### 3.2 Market-Based Economic Dispatch

The new Indian electricity market would operate on the principles of market-based economic dispatch (MBED). The proposed reforms envision a new regime in which energy dispatch and ancillary service procurement would both be done across all of India simultaneously on a least-cost basis. A day-ahead market and a real-time market would determine which generators are dispatched and what they are paid. In each time interval of the market, all dispatched generators would receive a uniform market clearing price (MCP).



**Figure 4. Simple illustration of uniform MCP for energy**

NREL illustration

The MCP is the lowest price that will provide exactly enough energy to meet demand for a specific market period, based on the energy offers submitted for the period; this is called clearing the market. It represents the intersection of available supply and demand as illustrated in Figure 4.<sup>1</sup> All generators offering energy at or below the MCP would be selected for dispatch and would receive the MCP as compensation. Offers priced higher than the MCP would not be dispatched and would not be paid.

Under MBED, generators with capacity not already obliged through long-term contracts would offer their power into a single, national day-ahead market. Similar to power markets in the United States and Europe, generators would be able to select the price of their bid for various time blocks at different quantities.<sup>2</sup> Generation is scheduled and dispatched in merit order of bid prices and subject to technical restrictions, such as the unit’s ramp rate and thermal limits on transmission lines.

The market operator would also simultaneously run energy and ancillary service markets and would utilize co-optimization to ensure the most economic suite of resources for each market is selected. Additionally, the market operator is proposing a national real-time market to coordinate and optimize energy purchases at the time of delivery before falling back upon ancillary services for procurement shortfalls.

### 3.3 SCED Pilot Project

In early 2019, CERC authorized India’s Power System Operation Corporation (POSOCO) to launch a pilot project on SCED (CERC 2019a). The pilot project includes government-owned thermal power ISGSs that have been participating in the national Reserve Regulation Ancillary

<sup>1</sup> The figure illustrates how MCPs form if there is no transmission congestion. The market would separate into different MCPs if transmission congestion limited the flow of power between high-volume points on the grid.

<sup>2</sup> CERC might establish price mitigation rules if any generation entity has market power.

Services mechanism since 2016. The pilot project will include 57 thermal plants with a cumulative capacity of 55 GW (POSOCO 2018).

While SCED governs the physical dispatch of the participating federally owned ISGSs, the plants' long-term bilateral contracts or power purchase agreements (PPAs) are still in force. The contracted prices on these PPAs are often different from the MCPs that clear through SCED. To grandfather these plants into the new framework, government regulators suggest that distribution companies and generators negotiate new bilateral arrangements to hedge against the variability in MCPs and to share the potential cost savings. Scheduling and dispatching of power would still be decided through SCED, but differences between MCPs and the contracted price should be shared among state utilities and ISGSs (CERC 2019c).

International experience shows that healthy markets often have several forms of hedging mechanisms to balance the potential volatility and savings of day-ahead markets. As such, additional hedging instruments might appear in the Indian context.

### 3.4 CBET Implications

India's primary objective for reform is to move away from its current patchwork of contracts, markets, and operational norms, to a model that is economically and electrically efficient. An efficient all-India wholesale power market could create significant savings across the entire Indian economy, so the stakes are high.

For Nepal, the implications of India's market reforms could include the ability to sell surplus hydropower to India, which would improve the economics of having more hydropower capacity on hand during the dry season when capacity factors are lower. Generators in Nepal might also participate in India's market for ancillary services. Access to the ancillary service market could even provide potential new value for fast-response reserves from some hydropower resources. Integration would also facilitate the transfer of hydropower from Nepal to Bangladesh.

Efficient markets operate on the principle of nondiscriminatory access; therefore, market participants located in neighboring countries might well expect the same treatment as market participants located in any Indian state. Indeed, India's Ministry of Power generally affirmed the principle of nondiscriminatory access in its 2018 guidelines on foreign participation (Government of India 2018).

The market reforms would not preclude tenant generation or bilateral CBET contracts, but they would provide more supply alternatives that would potentially be more cost-effective. Moving Nepal hydropower to Bangladesh illustrates some of the choices.

- Under the tenant generator model, a dedicated transmission line running 500 kilometers from eastern Nepal to central Bangladesh might add billions of dollars to the cost of a hydropower project, assuming no major siting problems in Nepal, India, or Bangladesh.<sup>3</sup> The Bangladesh grid would continue to schedule and balance using its existing resources.

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<sup>3</sup> Using indicative cost estimates from the United States, a 500-kV high voltage DC line capable of providing 3 GW of transfer capacity for 500 kilometers might cost around \$3 billion. (Estimates obtained using the Western Electricity Coordinating Council's transmission capital cost calculator updated in 2019, which is available at [https://www.wecc.org/Administrative/TEPPC\\_TransCapCostCalculator\\_E3\\_2019\\_Update.xlsx](https://www.wecc.org/Administrative/TEPPC_TransCapCostCalculator_E3_2019_Update.xlsx)). The transmission

- Under a traditional bilateral contract using Indian state grid systems, power delivery would incur four sets of transmission charges: Nepal, Bangladesh, and the Indian states of Bihar and West Bengal. Delivery would also be subject to the system transmission losses on each network.
- Connecting to India's interstate grid and participating in an integrated market would result in a single transmission charge. It would also allow more supply options, as the hydropower generator supplying Bangladesh would not necessarily have to be in eastern Nepal if it is connected to the Indian interstate grid. The transmission loss factor applicable to India's interstate grid would apply, but this loss would be less than the aggregate losses on lower-voltage state grids. Nepal and Bangladesh would also be able to use India's MBED markets to reduce the cost of balancing and ancillary services.

An analysis of South Asia CBET scenarios conducted by NREL found that increasing market integration among Nepal, India, and Bangladesh would tend to reduce the overall cost of generation and potentially provide savings benefits to ratepayers (McBennett et al. 2019). One scenario tested a fully integrated market comprising Nepal, Bangladesh, and the Indian states of Bihar, West Bengal, Jharkand, and Odisha; cost per MWh fell by more than 6% inside the integrated market, and costs for the rest of India fell slightly as net transfers from Bangladesh, Bhutan, India, and Nepal to the rest of India increased more than 4%.

As India's reforms evolve on its interstate system, CBET with other countries connecting to that system will likely become more liquid and more cost-effective. Additionally, economically efficient transactions from Nepal to Bangladesh, for example, would be pooled on the interstate transmission system using India's integrated market.<sup>4</sup>

But participating in an integrated market would involve other transaction costs that would not be present with a simple tenant generator or a bilateral contract approach. Market readiness would require time and money, as explained in Section 3.5. Market participants in Nepal (either NEA or through another representative entity) would need to dedicate personnel to take part in stakeholder committees involved in market development.

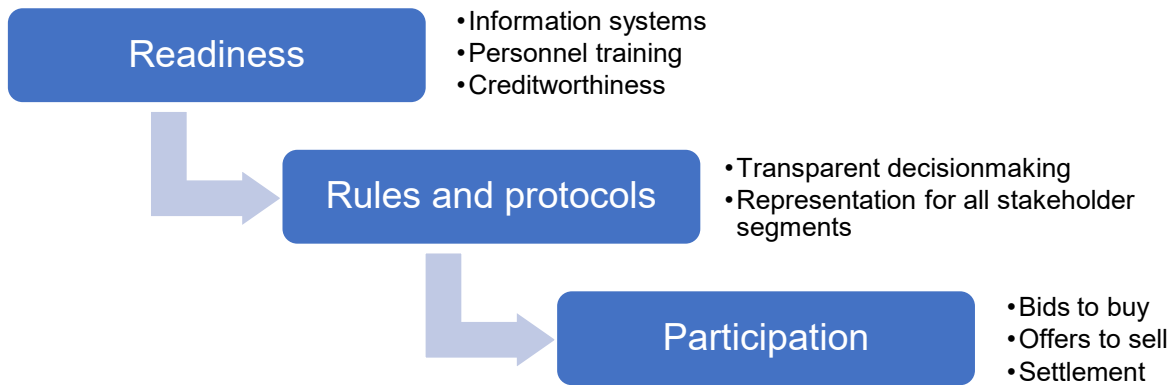
### 3.5 Stages of Market Integration

Participating in an integrated market requires advance preparation by regulatory authorities, grid operator, and the market entities themselves. An integrated electricity market is the most complicated, but many of the steps also apply to bilateral trading. The first stage is readiness, or the technical capacity to buy or sell power via the market platform. Second is the development and acceptance of common rules applicable to all participants. Third is actual participation in the market with offers to provide and bids to take electricity.

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cost could add \$10 to \$20 per MWh to the delivered cost of energy, depending on the line's financing costs and utilization rate.

<sup>4</sup> This would be consistent with India's Neighborhood-First regional policy (Kaura 2018).



**Figure 5. The main steps toward market integration**

### 3.5.1 Readiness

Market readiness is the advance preparation that each participant needs to complete to ensure the accurate and timely flow of information. Each market participant—generator, load-serving entity, or power trader—is responsible for accurately translating its intent into the language of the market.

Among the items included in market readiness are:

- Validation of metering, accounting, and settlement standards (hardware, software, and procedures)
- The ability to comply with daily schedules, including gate closures (deadlines for submitting final bids to buy and offers to sell)
- Application of the interconnection standards used by the system operator
- Telemetry protocols for communications with generators
- Minimum technical qualifications for various ancillary services, such as response times, ramp rate, and sustained delivery
- For bid-based integrated markets, adoption of data formats used for submitting generation offers, commitment schedules, and next-day load forecasts.

India’s Forum of Regulators published a report in 2016 listing best practices for scheduling, accounting, metering, and settlement of transactions (SAMAST) that aimed to standardize procedures across all Indian states. The group developed these guidelines in anticipation of market reforms within India. Among the 25 points in the Forum’s readiness checklist are assessments of metering, load forecasting, interchange scheduling, power pool accounting, adequacy of human resources, computation of transmission losses, and procedures for clearing debits and credits within the pool (Forum of Regulators 2016). The Forum’s recommended timeline for market readiness is about one year.

Major market-wide changes can take longer, however. In the United States, the market in Texas took about 7 years to transition from a zonal market to a full nodal market. This included a “test

flight” period, during which both the old and the new systems operated in parallel, with actual market settlement shifting to the new system once all validations were complete.<sup>5</sup>

### 3.5.2 Common Rules and Protocols

An important aspect of market readiness is compliance with rules that all other market participants follow. These rules evolve over time, however. This means that even after completing the readiness stage, a market participant needs to remain informed about how the market is performing overall and about new rules and protocols to improve that performance.

Common rules can include procedures for reporting unit outages, formulas for determining ancillary service obligations, assignment of transmission costs, timelines for providing unit operating schedules to the grid operator, penalties for uninstructed deviations from schedules, payment formulas for operator-instructed changes from scheduled generation, and financial settlement schedules. While the price of energy is a matter of negotiation (in the case of bilateral deals) or SCED optimization (in the case of integrated markets), items like a unit’s capacity value involve a formula applied across the market. In many cases, the rules are not controversial and can be set without the need for regulatory approval.

For a market to operate efficiently, rules need to have the following characteristics.

- **Nondiscriminatory:** Any market participant can expect to be treated as any other market participant in the application of any rule governing market operation.
- **Nonarbitrary:** Often, specific procedures and responses are expressed as equations that use market data or other performance measures as inputs. The aim is to reduce to a minimum the need for discretionary decisions by the grid operator.
- **Transparent:** The means by which any rule takes effect, regardless of how detailed it may be, are known to all market participants. This includes open access to stakeholder decision processes and accountability for outcomes.

Most integrated markets have two levels of governance. At the top is the governmental entity with legal jurisdiction over the market, its system operator, and its participants. The jurisdictional authority authorizes the initial formation of the market and its guiding principles of operation; however, regulatory decision-making processes are often too cumbersome for operational details. These fine-tuning protocols are often delegated to a structured stakeholder process. Market participants engage directly in the review of existing rules and the formulation of new ones. If stakeholders cannot reach agreement on an operational rule, the jurisdictional entity makes the ultimate determination.

In the United States, for example, most regional transmission organizations (RTOs) are under the jurisdiction of the Federal Energy Regulatory Commission (FERC), which reviews and approves the RTO’s master tariff governing market operations. The FERC-approved tariff includes provisions for creating an RTO governing board and stakeholder processes, which constitute a second level of governance.

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<sup>5</sup> Texas began its restructured wholesale market in 2001 with a zonal design similar to India’s market reforms described in Section 3.



Therefore, an ongoing aspect of market participation is the ability to participate in stakeholder processes. Generally, each segment of participants—generation owners, load-serving entities, transmission utilities, power marketers, consumer representatives, and, in some cases, even environmental interests—will have its own caucus for discussion of the group’s common interests. Each stakeholder group will then have one representative to working groups, committees, and the organization’s governing board.

### **3.5.3 Participation**

Only after they are market-ready and rule-compliant can a buyer or seller engage in energy transactions.

Settlement is the process of paying generators and billing load based on valid market prices. A market uses one of two approaches for pricing: pay-as-bid or MCP. Both approaches select the lowest-cost portfolio of generation resources. Under pay-as-bid, each selected resource receives its offer price for the energy it provides. Procurements through a request for proposals and periodic auctions are typically paid as bid.

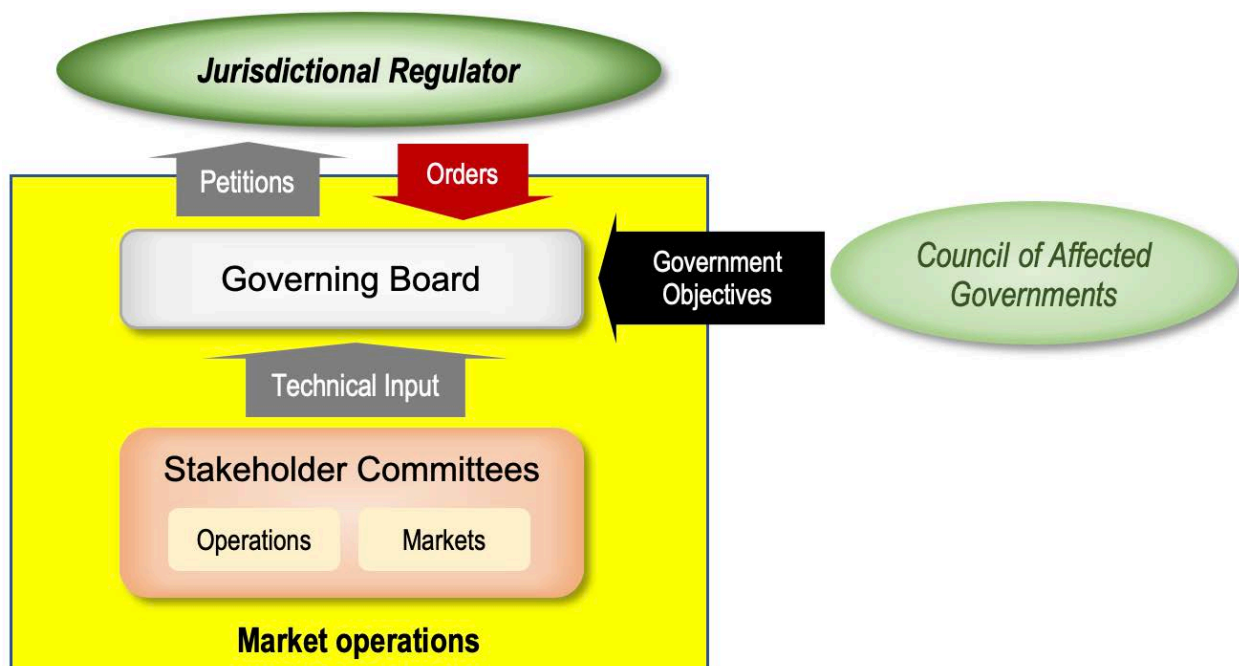
The selection of pay-as-bid or MCP is a market design decision that applies to everyone. Most integrated markets use MCPs as the basis for setting hourly energy prices. Pay-as-bid is the de facto pricing approach when CBET is a collection of independently negotiated bilateral agreements.

Both pricing approaches incentivize generators to offer energy into the market based on their marginal cost of generation. Doing otherwise—that is, submitting a higher offer price—reduces the likelihood that the offer would be accepted and paid. The MCP approach, however, enables most generators (other than the “marginal generator” whose offer has set the MCP) to earn a profit. The likely profit margin of MCPs above marginal cost informs a generation developer’s decision to build new capacity.

## **3.6 Governance**

Using India’s market reforms as a vehicle for enhanced regional CBET could require special attention to market governance. A South Asian market might have issues similar to those faced by some RTOs in the United States, where market operations affect the energy policies of many state governments, but regulatory jurisdiction over the RTO is assigned by law to the federal government. In the case of South Asia, the question would be how the sovereign governments of participating nations might have a role in common market structures that affect their electricity sectors.

One possible model, used in several U.S. RTOs, is a governmental council that provides special executive-level input into decisions by the RTO’s governing board. The council is one part of a permanent stakeholder process through which procedures and protocols for market operations evolve with experience.



**Figure 6. General flow of market governance**

NREL illustration

Figure 6 illustrates governance generally. At the apex of the stakeholder process is a governing board, which is responsible to the regulatory entity with legal jurisdiction over the integrated market's tariff. (In India's case, the CERC would likely be the regulatory authority.) Below the governing board are permanent committees and subcommittees comprising representatives of all stakeholder groups. If stakeholders reach a consensus on how to improve markets or operations, the proposed revision moves through peer review to consideration and possible adoption by the governing board. The board may enact the revision if it is within the tariff authority already granted by the regulator, otherwise it can petition the regulator to change the tariff.

The council of affected governments may advise the board of their support for or opposition to a change in market operations or policy. Once the board takes action and sends a petition to the regulator, the regulator can give weight to whether the board sufficiently considered issues raised by affected governments, as might be required by the laws that define the regulator's jurisdiction.

## 4 Foundational Issues of National Policy

The CBET models outlined in this report have implications for public policies at many levels of government. Here, we frame the key issues as threshold questions: bedrock policy decisions to guide later decisions about details. Among the most important decisions of national policy is the assignment of regulatory authority and clarifying which agencies are empowered to address which specific areas. Nepal’s Federal Parliament may elect to address pertinent questions as part of legislation addressing CBET. Preamble language to international CBET agreements could also provide basic guidance.

### 4.1 General Clarifications

General clarifications might include the following:

- Should CBET be isolated from other bilateral trade issues?
- What tests should Nepal use to balance energy independence with mutually beneficial interdependence?<sup>6</sup>
- What aspects of CBET should be under the sole jurisdiction of Nepal’s Electricity Regulatory Commission (ERC)? Are there CBET matters that should be regulated by an entity besides ERC?<sup>7</sup>
- What market-making functions should NEA and its subsidiaries provide?<sup>8</sup>

### 4.2 Clarifications Regarding MBED

Questions to clarify Nepal’s participation in India’s MBED markets include the following:

- Should it be the policy of Nepal to enable entities under its jurisdiction to participate in India’s MBED markets as these markets evolve, subject to appropriate oversight?
- If Nepal participates in MBED, who should negotiate with India (and other participating countries) on Nepal’s behalf in the formation of market rules?
- If a market participant in another country causes harm to Nepal by market manipulation or other rule violations, which authority in Nepal should prosecute such violations?

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<sup>6</sup> For example, the government could monitor the percentage of available energy provided by imported power. Policymakers may set a threshold value that would trigger additional investigation as to whether a disruption to imports might affect the reliability and resilience of Nepal’s grid.

<sup>7</sup> The use of foreign currency is one example of possible regulatory coordination. Rules governing the settlement of CBET transactions in currencies besides the Nepalese rupee (as well as foreign currency deposits required by banks) could involve coordinated regulations between the ERC, the Ministry of Finance, and Nepal Rastra Bank.

<sup>8</sup> “Market-making functions” are those that enable other companies in Nepal to engage in CBET as buyers or sellers. Normally, an operational entity, such as NEA, would provide these functions on a nondiscriminatory basis, meaning that the same rules would apply to any company buying or selling wholesale power. Examples of market-making functions include metering, scheduling, dispatch, and other services related to operating the grid and maintaining reliability. These are different from power marketing functions, which include the buying and selling of wholesale electricity and could put NEA in competition with other buyers and sellers. Legislation recently introduced by the Ministry of Energy, Water Resources, and Irrigation would split NEA’s power marketing operations from grid management functions (Online Khabar 2019).

## 5 Regulatory Issues

Strategic expansion of CBET would involve coordination between many policy areas. Most of these policies would probably require legislation, and many would involve implementation and oversight by Nepal's ERC.

Nepal's ability to participate in CBET of any type is bounded by its national policies on foreign trade. Therefore, a review of national statutes and executive orders on foreign trade could be an important step in ensuring CBET outcomes are in Nepal's public interest. Such a review could identify potential conflicts in legislative intent, complementary policies, and clarifications of statutory authority. Key areas include rules governing foreign ownership of assets, trade tariffs, and financial requirements governing the use of foreign currencies.

### 5.1 ERC Actions

Clarifying ERC authority would be an important outcome of the government's review of national policies affecting CBET. ERC will need specific authority over generators and load entities in Nepal who might participate in any type of CBET. This would include NEA's cost-of-service-regulated operations and its subsidiary enterprises. It would also include merchant generators and large electricity customers participating in the market independent of NEA.

#### 5.1.1 *Actions Applicable to Integrated Market Participation (MBED)*

- **Registration of MBED market participants in Nepal:** This would be a basic step the ERC could take to monitor MBED benefits. Assuming that (a) national policy endorses Nepal's participation in MBED and that (b) the law gives the ERC clear jurisdiction over the Nepal-domiciled entities participating in MBED, registration would help the ERC ensure MBED participation remains consistent with Nepal's national interest. Registration requirements could include proof of creditworthiness, disclosure of ownership (including foreign ownership shares), qualifications of executive management, geographic areas of operation, and recent financial statements. The ERC could also set bonding requirements. By being the legal registration agent for market participants in Nepal, the ERC would be Nepal's lead oversight agency dealing with counterparts in India and other participating countries.
- **Application of standards for SAMAST to entities in Nepal participating in MBED:** India's state electricity regulators have agreed on common SAMAST standards for their own interstate electricity exchanges. MBED market participants in Nepal might need to follow these same standards or risk higher transaction costs. Because Nepal entities would be under ERC jurisdiction, however, any mandatory application of standards developed by and for Indian states would require an exercise of ERC authority. The ERC could conduct a review of India's SAMAST standards to determine their applicability to entities operating in Nepal.
- **Participation in MBED stakeholder processes:** This would authorize the ERC to take measures to ensure Nepal's effective participation in MBED governance. Such participation would be necessary to ensure Nepal has a role in refining market rules. ERC could elect to take on this role itself, or it could delegate to another national entity subject to ERC oversight.

- **Demand response:** Demand response (DR) is the ability and willingness of end-use customers to reduce their load at a specific time in response to a price signal. This is one of the hallmarks of a modern power sector and is becoming valuable in markets similar to MBED worldwide. For example, integrated markets often include procedures for allowing DR to provide ancillary services, which can greatly increase DR’s opportunities for value. Large end-use customers in Nepal under ERC jurisdiction could be DR providers. The ERC could establish DR rules that would both provide domestic value to Nepal and lay the foundation for additional value if CBET were to expand under MBED.

### 5.1.2 *Actions Applicable to Integrated Markets and Bilateral Agreements*

- **Switching service from a utility to another provider:** CBET might enable large customers to replace service from NEA with service arranged by competitive third-party providers. If Nepal elects to enact policies to enable switching, the ERC might need to establish rules to ensure other remaining customers are not harmed economically when a large customer leaves the utility.
- **Reasonably competitive pricing:** The ERC might also need authority to investigate whether the prices under a new CBET arrangement are unreasonably high. If a foreign supplier has some ability to control wholesale prices (due to its size in the market or due to some other unfair advantage), customers under ERC jurisdiction might need protection against predatory pricing. Besides authority, the ERC would require sufficient resources to evaluate and mitigate potential market power by a foreign supplier.

### 5.1.3 *Actions Applicable to Integrated Markets, Bilateral Agreements, and Tenant Generation*

- **Transmission siting approval:** Generally, a regulator’s siting authority over new transmission addresses whether a proposed line would be sufficiently used and whether the use would benefit the public. When a line enables CBET, regulators also need to protect customers under their jurisdiction from paying an unfair share of the new costs. To make such a determination, the commission would need authority to compel the release of data and other information that it would need to quantify the distribution of benefits between countries.
- **Reporting requirements:** Because ERC would be responsible for implementing government policy in Nepal’s electric sector, it would need to establish standards for all market participants to report CBET outcomes to ERC on a regular basis. ERC would use this information and other market data to monitor national outcomes and trends that affect Nepal (discussed further in Section 6).

## 5.2 System Planning and Operator Actions

CBET—especially if it eventually involves Nepal’s participation in India’s MBED reforms—would create three areas of resource planning for NEA: (1) generation and transmission investments needed to ensure Nepal’s beneficial participation in CBET; (2) new generation that would not participate in CBET but instead would solely support domestic demand; and (3) distribution system planning. Planning might include joint modeling with NEA’s regional counterparts, along with participating in regional coordination meetings and trainings.

ERC would likely have regulatory oversight over NEA planning. The public interest objective would be to avoid the cost of building new resources if the same service could be acquired from the market at a lower cost. This aim would relate to the commission's basic goals of ensuring reliability and keeping rates at just and reasonable levels.

A well-designed regulatory framework could enable NEA to aggregate independent hydropower generators that would otherwise be too small to participate in the MBED market on their own. Many small independent power producers have take-or-pay contracts with NEA, which could result in NEA paying for surplus generation during the wet season. Access to an integrated market could provide NEA with an avenue for evacuating its surplus power, reducing the financial risk of having to pay for power it might not be able to use. The ability to dispose of wet season surplus power would reduce the risk of having more domestic resources available during the dry season.<sup>9</sup>

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<sup>9</sup> With access to an integrated market to dispose of surplus hydropower during the wet season, NEA's use of take-or-pay contracts with independent power producers would provide capacity value, which is different from the value of energy. One could infer that the take-or-pay PPA price includes an implicit capacity value based on the likelihood of reducing load shedding during the dry season. NEA's effective cost of capacity would be the difference between what it paid independent producers for the surplus hydropower and the energy revenues it would receive when it offered the surplus energy into the integrated MBED market.

## 6 Oversight and Monitoring

Tracking key metrics can help regulators assess whether CBET outcomes are consistent with legislative intent and the public interest. Government oversight is also important to policing the behaviors of market participants. This section describes some of the metrics that the Government of Nepal could monitor to assess the effect of CBET policies.

Exchange volumes and wholesale prices are the starting points for regulatory oversight. Other measures, however, are useful in formulating long-term strategy and in anticipating problems before they happen.

### 6.1 Volume of Power Trading

**Energy (in total MWh) exported from Nepal:** The pace of export growth during the early years of a CBET initiative largely depends on two factors. First is the time it takes domestic generators to learn the new rules and strike deals with cross-border partners. Second is the confidence potential importers have in Nepal hydropower as a reliable component of their resource portfolios. Both factors might vary according to the type of CBET involved (tenant generation, bilateral contracts, integrated markets). Therefore, the ERC might consider reporting requirements that break out exports by type of CBET arrangements. This extra visibility into export trends could help the ERC identify specific issues that might require new regulations or revisions to government CBET policies.

**Energy (in total MWh) imported to Nepal:** Power imports have historically been driven by the need to reduce load shedding. As load shedding becomes less frequent, imports will be more dependent on economic fundamentals of supply and demand (Hurlbut 2019). Trends in the economically driven volume of imports could help inform decisions about the need for new domestic generation, especially if dry-season imports offset the need for new hydropower.

**Balance of exchange (net of exports and imports):** The use of Nepal's electricity banking agreements with India will be reflected in the net trading balance between imports and exports. Over time, the balance of exchange could be examined further in the context of pricing, transmission congestion, and reliability metrics.

### 6.2 Prices

**NEA PPAs:** Negotiated bilateral contract prices between NEA and independent power producers can provide a benchmark for all other price analyses included in regulatory oversight. Reliable, consistent PPA price data could be assured by promulgating rules for reporting that would be applicable to all generators. Regulators in many countries exercise such authority (FERC 2002). In most cases, public release of aggregated data can protect contract-specific data that might be competitively sensitive.

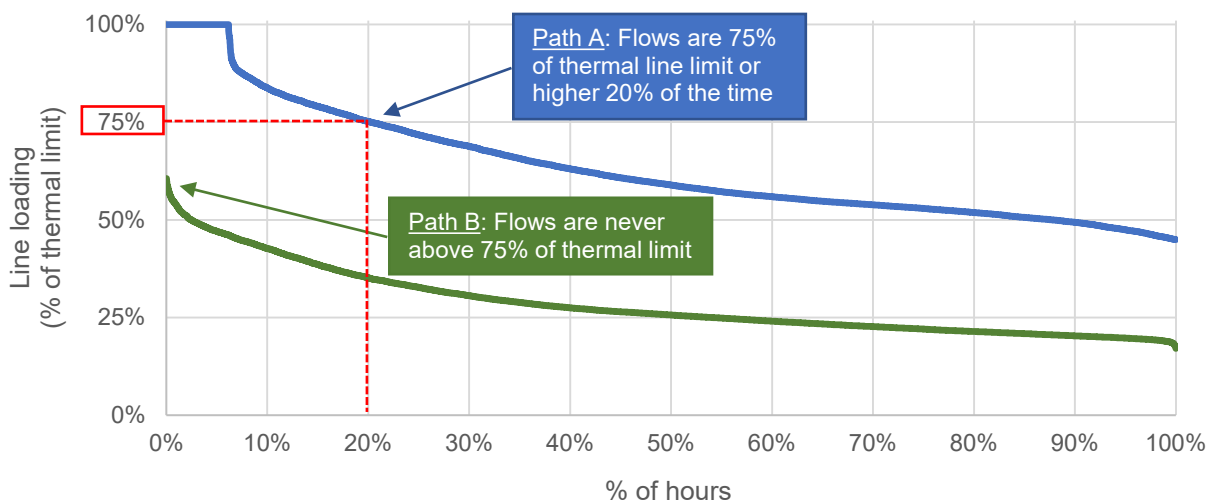
**Market exchange prices:** Energy market platforms, such as the Indian Energy Exchange, report on wholesale power exchange prices regularly by region. Besides monitoring prices at state hubs such as Bihar and Uttar Pradesh, Nepal authorities might consider a study with Indian power exchanges about tracking transactions in Nepal.

**Market clearing prices for energy (MCPEs):** As India’s market reforms evolve, MCPEs will grow in importance as indicators of market performance. The SCED software used by POSOCO (see Section 3.3) determines these prices for each hour in the day-ahead market, and on a sub-hourly basis in real time. Prices for zones where CBET occurs will provide highly detailed information about the value of imports and exports. Among the important insights revealed by MCPE analysis:

- Seasonal pricing patterns
- Hourly pricing patterns
- Same-time differences between injection zones and withdrawal zones, such as the injection of hydropower from Nepal and withdrawal of power into Bangladesh.

### 6.3 Transmission Congestion

**Loading on CBET transmission paths:** One possible effect of increased CBET is more congestion on cross-border transmission paths. This, in turn, could suggest a future need for transmission improvements. One indicator of future congestion is how frequently line flows approach a path’s thermal limit. This can be expressed visually as a duration curve—power flow for each hour of the year as a percentage of the path’s thermal loading limit, with the values arranged in descending order. Figure 7 illustrates two sample CBET transmission paths, using 75% of the path’s thermal limit as an example benchmark.<sup>10</sup> In this example, Path A is used more than Path B and is more likely to be congested with increased CBET.



**Figure 7. Loading duration curves of two sample transmission paths, with 75% utilization metric**

NREL illustration

### 6.4 Reliability: Reductions in Load Shedding

Reductions in load shedding and other supply-related service disruptions are particularly important areas for Nepal. The government can monitor the reliability impact of CBET in two

<sup>10</sup> The path utilization metric can be based on any threshold deemed useful. In the United States, for example, the Western Electricity Coordinating Council often compares metrics for three thresholds—75%, 95%, and 99%—to provide a more complete picture of path utilization. (WECC 2018)



ways: (1) by changes in actual incidents of load shedding; and (2) by modeling reliability metrics, such as loss of load expectation.

**Number of load shedding hours:** Reductions in the number of load-shedding hours could indicate whether CBET is contributing to greater domestic reliability.

**Curtailed load:** This refers to the actual level of demand at the time the curtailment occurs. It is measured based on energy and not capacity. For example, a substation might have a maximum loading capacity of 10 MW but might be serving only 2 MW of load at the time it is interrupted. The load actually dropped—2 MW—would be a more accurate measure of actual lost load.

**Simulated loss of load:** The effect of CBET on reliability can also be simulated by NEA and included in its annual report. A loss of load expectation is the number of days that available generation capacity plus imports would not be enough to meet demand. A similar measure, loss of load probability, is the probability that a load loss event might occur. A relationship between CBET and these loss of load indicators could provide regulators with an estimate of how imports can affect future reliability.

## 6.5 Utilization of Domestic Generation

**Capacity factor (plant load factor):** Capacity factors for generator groups aggregated by geography, age of plant, storage capability, and other factors can provide a more detailed picture of CBET benefits from the perspective of generators. This includes analysis of capacity factors by the generator's primary CBET type (integrated market participation, bilateral trading, or tenant generation). Greater generator use resulting from more CBET could increase investor confidence. This, in turn, could reduce obstacles to financing new projects in Nepal.

## 7 Summary

CBET can take many forms. Each requires different preparation and places different demands on policy and regulation. Bilateral trading and participating in an integrated wholesale power market are not mutually exclusive, but policies supporting one are not necessarily applicable to the other. Nor would effective regulation of one model be useful in regulating the other.

A major policy decision facing Nepal is whether to participate in India's MBED reforms. While India's market reforms could be a platform to facilitate Nepal's national goals (export of hydropower to Bangladesh and the elimination of load shedding, for example), participation would be far more demanding than a bilateral trading regime would be. Entities in Nepal would have to take at least a year to get ready, and the government would need to decide how to address a number of sovereignty questions. Both India and Nepal would have an interest in ensuring efficiency and fairness, but it would require common rules.

An integrated market, such as the one contemplated in MBED, fundamentally changes the relationship between the public and private sectors. The government controls fewer outcomes but takes on a larger oversight role. It may prosecute more cases of market abuse, fraud, and anticompetitive behavior—actions that seldom arise with cost-of-service regulation of a monopoly utility. For the regulatory agency, participation in an integrated regional market would create special staff needs: besides normal expertise in engineering and utility accounting, the ERC would need expertise in applied economics and antitrust law.

Monitoring CBET outcomes could help improve benefits over time and would provide public accountability. This report lists metrics that can be tracked regularly and over time. The ability to quantify benefits could help political acceptance of CBET activity, and wider public scrutiny of the data could discourage fraud.

The technical issues involved in making CBET efficient are unique and may lead to treating it as an area separate from other trade and diplomatic issues. Benefits are at stake for all sides, and as with other traded commodities, the market is likely to produce better results for the public if there are few out-of-market disruptions.

Technical analysis can show the theoretical benefits of integrated markets and CBET, but implementation depends on each country's utility laws and regulatory institutions. Building an integrated power market is complex and often requires regulators to enforce transparency, patience, and careful attention to detail. Because institutional evolution does not necessarily proceed at the same pace in all countries, cooperation among regulators is key to managing the process and ensuring that each country enjoys the full benefits of CBET.

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## Appendix A. SAMAST Checklist (Adapted for Nepal)

Table A-1. SAMAST Checklist

	Activity	Days From Start
1	Identification of intra-country entities	7
2	Demarcation of interface boundary for each intra-country entity	14
3	Assessment of meters—main, check, and standby	21
4	Assessment of Automatic Meter Reading logistics requirement	30
5	Assessment of IT infrastructure (hardware and software) requirement	45
6	Preparation of Bill of Quantities (considering logistics already in place)	60
7	Preparation of detailed project report and completion of first stakeholder workshop	90
8	Approval of the Nepal-specific SAMAST scheme by ERC*	120
9	Commencement of load forecasting by load dispatch center (LDC)**	120
10	Commencement of interchange scheduling by LDC** for all intra-country entities	120
11	Formation of a National Power Committee (NPC) for preparation of account	120
12	Establishment of National Regulatory Pool Account	120
13	Application for funding	150
14	Inviting tenders	150
15	Placement of award	210
16	Adequacy of human resources in LDC** as approved by ERC*	210
17	Implementation of the recommended IT infrastructure-hardware	225
18	Completion of boundary metering and automatic meter reading system	240
19	Implementation of the recommended IT applications—Software	300
	A. User registration	
	B. Short term open access processing	
	C. Scheduling	
	D. Meter data processing and validation	
	E. Accounting	
	F. Settlement	
	G. Billing and clearing	
	H. Data archival and retrieval	
	I. Management information system	
	J. LDC** website	
20	Computation of transmission losses for each 15-min interval by LDC**	330
21	Preparation of energy accounts by NPC/LDC** and publication of the following on NPC/LDC** website	345
	a. Process document (SAMAST handbook)	
	b. At least four weekly deviation accounts for all intra-country entities	

	<b>Activity</b>	<b>Days From Start</b>
	<ul style="list-style-type: none"> <li>c. At least one monthly National Energy Account</li> <li>d. List of tie lines for each intra-country entity with Intra STS</li> <li>e. List of Interface energy meters to be used in accounting</li> <li>f. CT/PT ratios to be used in accounting</li> <li>g. Formula to be used for computation of injection / withdrawal</li> <li>h. Implemented schedule--DC, entitlement, injection schedule, withdrawal schedule, short-term open access schedule, scheduled losses, interchange with regional grid</li> <li>i. Deviation rates as notified by ERC*</li> <li>j. Comparative plot of actual interchange computed from Supervisory Control and Data Acquisition (SCADA) and from energy meter data of each intra-country entity for at least four weeks</li> <li>k. Plot of measured transmission losses for at least four weeks</li> </ul>	
<b>22</b>	Clearing of Pool A/c Credit/Debit for at least 4 weeks and its Reconciliation	345
<b>23</b>	Two stakeholder workshops by LDC** on SAMAST system	345
<b>24</b>	Quarterly Reconciliation Certificate from all National Pool members	365
<b>25</b>	Annual peer review of SAMAST by LDC**	365

\*Regulatory task for Nepal ERC  
\*\*Load dispatch center functions performed by NEA  
Source: Forum of Regulators 2016