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Study Report on International Best Practices on Business and Financial Models for Developing Cross-Border Electricity Transmission Infrastructure

South Asia Regional Energy Partnership (SAREP) | August 2024

Prepared by:

USAID's South Asia Regional Energy Partnership (SAREP) Program
Ms. Namrata Mukherjee, Chief of Party, SAREP
Mr. Rajiv Ratna Panda, Regional Energy Trade Lead, SAREP
Ms. Maitreyi Karthik, Regional Energy Analyst, SAREP

With additional inputs from Deloitte Touche Tohmatsu India LLP

United States Agency for International Development (USAID)

USAID is the world's premier international development agency and a catalytic actor driving development results. USAID leads international development and humanitarian efforts to save lives, reduce poverty, strengthen democratic governance, and help people progress beyond assistance.

South Asia Regional Energy Partnership (SAREP)

The South Asia Regional Energy Partnership (SAREP) serves as a flagship program of USAID to advance objectives of the U.S. Government's Clean Asia Enhancing Development and Growth through Energy (EDGE) initiative. SAREP is working on developing regional power markets, improving coordination and planning, strengthening national and regional institutions, building consensus on power trade, and institutionalizing a supporting framework and mechanisms. SAREP activities are supporting expansion of cross-border power trade by supporting stakeholders to participate in trilateral, multilateral, and exchange-based markets.

MESSAGE

INTERNATIONAL SOLAR ALLIANCE

As the climate urgency intensifies, immediate action is crucial for a substantial reduction in global emissions by 2030. To this end, the International Solar Alliance (ISA) emphasizes the critical role of the renewable energy transition and offers common solutions for the world, focusing on finance, technology, and policy. The One Sun, One World, One Grid (OSOWOG) initiative is a key component of such solutions being explored by ISA.

Driven by the mantra "The Sun Never Sets", the OSOWOG initiative envisages the interconnection of all forms of renewable energy generators, storage, and loads across continents with a trans-continental power transmission grid - **One Grid for One Sun in One World**. This initiative aims to connect different regional grids through a common grid that would be used to transmit renewable energy power and foster clean energy transition.

Transmission is the Key. There is No Energy Transition without Transmission.

For realizing the vision of One Sun, One World, One Grid, it is necessary for the countries to be able to plan and implement cross border trans-regional interconnections in a seamless and efficient manner. This will require finding solutions to not just technical, but financial, commercial and investment related aspects and challenges. In such a context, the research conducted by USAID's South Asia Regional Energy Partnership (SAREP) program on "***Research Study on international best practices on business and financial models for developing cross-border electricity transmission infrastructure***" is a very timely and welcome initiative. The comprehensive coverage of international examples, and the identified business and financial models and related aspects cover in the above research study will be useful for stakeholder and is expected to form part of a key resource base and starting point for discussions among countries and utilities which seek to plan new cross border transmission grid interconnections. The report has potential for use not just in South Asia but across the developing world where cross border interconnections have not matured yet.

I hope that this research study's findings, information, and insights will assist the region's primary energy players as well as those in other parts of the world and larger stakeholders in the One Sun, One World, One Grid in developing cross-border regional transmission systems and also encourage further deliberation and sharing of knowledge and insight in this area.

Let us continue to work hand in hand, advancing the mission of a just and inclusive energy transition for the benefit of all, aided by initiatives such as One Sun, One World, One Grid.

Dr. Ajay Mathur
Director General, International Solar Alliance

घनश्याम प्रसाद
अध्यक्ष तथा पदेन सचिव भारत सरकार
GHANSHYAM PRASAD
Chairperson & Ex-officio Secretary
To the Government Of India

सत्यमेव जयते

आज़ादी का अमृत महोत्सव

केन्द्रीय विद्युत प्राधिकरण
भारत सरकार
विद्युत मंत्रालय
सेवा भवन, आर.के. पुरम
नई दिल्ली–110066
Central Electricity Authority
Ministry of Power
Sewa Bhawan, R. K. Puram
New Delhi-110066

FOREWORD

Regional energy cooperation and cross border electricity trade in the South Asian region is at a defining juncture, where substantial progressive reforms have been undertaken in the recent past, such as the emergence of clear policy and regulatory framework for cross border electricity trade in India and allowing the use of power exchanges for cross border electricity trade.

In South Asia, India has led the way in the development of cross-border electricity grid connectivity and is well-positioned to expand integration beyond South Asia for interconnection with neighboring regional power grids.

The regional energy trade is further gaining momentum with a greater number of cross-border power projects & transmission interconnections being planned and proposed, in particular in the Bhutan, Bangladesh, India, Nepal, Sri Lanka (BBINS) sub-region, which will enable greater integration of power systems of South Asian countries. With the existing/planned interconnections, hydro power generation of Bhutan and Nepal is being exported to India. Nepal and India have signed an agreement wherein Nepal would export 10,000 MW to India within the coming decade. During lean hydro season, power is being exported from India to Nepal and Bhutan to meet the electricity demand. Power is also being exported by India to Bangladesh. Interconnection between India and Sri Lanka is in advanced stage of discussion.

Further, under the One Sun, One World, One Grid (OSOWOG) initiative, interconnection of Indian Electricity Grid with Maldives, Singapore, UAE, Saudi Arabia etc. is under discussion. The G20 New Delhi Leaders' Declaration recognizes 'the role of grid interconnection, resilient energy infrastructure and regional/cross border power system integration where applicable in enhancing energy security, fostering economic growth and facilitating universal energy access for all'.

Since in many other regions across the globe, cross border transmission projects have been established successfully for quite some time, a need was felt to undertake a study to learn from international experience and use such learnings for development of cross border transmission infrastructure projects in South Asia.

It is commendable that USAID's South Asia Regional Energy Partnership (SAREP) program has undertaken this study, a first of its kind. The report also encapsulates the valuable insights and suggestions from various regional electricity transmission utilities and power pool operators globally.

I hope that the key energy stakeholders in South Asia will benefit from the information and insights of the study. I am confident that the report will enhance further deliberation on the subject and lead to exchange of knowledge and insights on cross border regional transmission system development.

(Ghanshyam Prasad)

दूरभाष / Telephone : 011-26732201, 26732222, ईमेल / Email : chair@nic.in, वेबसाईट / Website : www.cea.nic.in

FROM THE AMERICAN PEOPLE

Foreword

The U.S. Agency for International Development (USAID) has proudly partnered with South Asia since 2000 to support regional cooperation and advance a sustainable energy future. Today, through the South Asia Regional Energy Partnership (SAREP), USAID collaborates with energy leaders across Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka to drive clean energy solutions that address our shared climate goals. SAREP is a central part of the U.S. Government's Clean EDGE Asia initiative, a commitment to support the region's transition to cleaner, more resilient energy systems.

At the heart of SAREP is the vision of a connected, sustainable energy network that can deliver reliable power across borders. By working with South Asian partners to enhance regional energy markets and strengthen grid integration, SAREP supports cross-border power trade and enables a shift toward diverse, clean energy sources that benefit both the economy and the environment.

In line with these goals, USAID has supported a study to explore global best practices in building cross-border electricity transmission infrastructure titled *International Best Practices on Business and Financial Models for Developing Cross-Border Electricity Transmission Infrastructure*. This study provides insights on business models, financing, cost recovery, and management of such projects—timely knowledge for the significant scale-up in transmission infrastructure that South Asia is undertaking.

Releasing this study at COP29 underscores the importance of regional cooperation and integrated energy infrastructure in achieving global climate goals. As countries worldwide look to scale up clean energy systems and build resilience, the insights from this study offer valuable models that can be adapted to foster sustainable energy networks globally. Together, we can unlock South Asia's tremendous potential for clean energy, moving closer to a more sustainable, connected, and resilient future for all.

Steve Olive
Mission Director,
USAID Mission to India and Bhutan

U.S Agency for International Development
American Embassy
Chanakyapuri, New Delhi - 110021

Tel: 91-11-24198000
Fax: 91-11-24198612/8454
www.usaid.gov/in

Acknowledgement

A study on international best practices on business and financial models for developing cross-border electricity transmission infrastructure covering South Asia, Southeast Asia , Central Asia, Middle East, Africa, Europe, South and Central America and North America is not possible without the active support and cooperation of large number of stakeholders across the globe in the area of cross border transmission system interconnections.

The USAID extends special thanks to Mr. Ghanshyam Prasad, Chairperson, Central Electricity Authority (CEA), Government of India, who put forward the suggestion of undertaking this study to us. Further, we also express our gratitude to Mr. A K Rajput, Member (Power Systems), CEA, and Mr. B S Bairwa, Chief Engineer, CEA, for providing valuable inputs and guidance for undertaking this study. We also acknowledge the valuable comments and suggestions provided to us by the members of the One Sun, One World, One Grid taskforce.

As we were undertaking this study, it was imperative to obtain the views of the international power pools/power utilities, so that value-added inputs can be utilized for the study. We are thankful for the following people, who graciously set aside their valuable time to interact with us for this study. Some of the below officials had also supported the stakeholder interaction workshop organized by SAREP on February 28 2024, by participating in person or over online meeting.

- Stephen Dihwa, Executive Director, South African Power Pool (SAPP) Coordination Center
- Alison Chikova, Chief Engineer – Planning and Operations, SAPP Coordination Center
- Dr. (Eng.) John Mativo, Managing Director, Kenya Electricity Transmission Company Limited
- Lorena A Simba, Project Engineer, Kenya Electricity Transmission Company Limited
- José Enrique Martínez Albero, General Manager, Empresa Propietaria de la Red (EPR)
- Karla Hernández, Regulatory & Business Development Manager, EPR
- Martin Montaya, Financial Manager, Empresa Propietaria de la Red EPR
- Ahmed Ali Al-Ebrahim, CEO, Gulf Cooperation Council Interconnection Authority (GCCIA)
- Eng. Ikram Rahim, Sr. Operational Planning Engineer, GCCIA
- Bart Goethels, Chief Commercial Officer, Nemo Link Limited
- Pankaj Khurana, Programme Specialist, International Solar Alliance (ISA)

I express our sincere thanks to all the regional energy stakeholders from public sector, private sector, and development finance institutions, who participated in the stakeholder interaction workshop organized by SAREP on Feburary 28 2024.

I sincerely hope that knowledge created through this research study would be beneficial to all stakeholders concerned in enhancing cross-border electricity transmission capacity and trade in the South Asia regionand beyond through the One Sun, One World, One Grid initiative.

Monali Zeya

Ms. Monali Zeya Hazra
Senior Regional Energy Specialist,
IPO Office, USAID/India

U.S Agency for International Development
American Embassy
Chanakyapuri, New Delhi - 110021

Tel: 91-11-24198000
Fax: 91-11-24198612/8454
www.usaid.gov/in

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Executive Summary

Background and context

Cross-border electricity trade allows to harness complementarities in electricity demand patterns, diversity in resource endowments for power generation, and gains from larger market access. Cross-border transmission infrastructure is the cornerstone that enables the physical cross-border trade of electricity. Cross-border transmission infrastructure can bring significant benefits for participating countries, including increased access to renewable energy resources, improved energy security, economic benefits, provide market access, and improved grid stability. As the world transitions to a more sustainable energy system, cross-border transmission lines are likely to play an increasingly significant role in enabling efficient and reliable exchange of energy between countries. This is equally relevant in the case of South Asia.

The regional energy cooperation and trade in the South Asian region is at a defining juncture, where substantial progressive reforms have been undertaken in the recent past, such as the emergence of clear policy and regulatory framework for cross-border electricity trade in India and allowing the use of power exchanges to undertake cross-border electricity trade. The regional energy trade is further gaining momentum with a greater number of cross-border power projects & transmission interconnections being planned and proposed, in particular in the Bangladesh, Bhutan, India, Nepal, Sri Lanka (BBINS) sub-region, which will enable greater integration of power systems of South Asian countries.

Considering the aims of regional energy integration in mind, and the role of cross-border electricity transmission interconnection infrastructure towards facilitating such regional energy integration, SAREP has undertaken this study on "International best practices on business and financial models for developing cross-border electricity transmission infrastructure". The study seeks to identify global practices that aim to help answer the question of how to develop, structure, manage (along with the associated financials) and implement cross-border transmission infrastructure.

Typical models adopted for the development of cross-border transmission infrastructure.

While there is a very wide variety of ownership models for CBET infrastructure, they may be broadly categorized under any of the following five models as shown in the following figure:

Public/ Government Ownership

Line owned by government owned utility/public sector utility

Independent Power Transmission (IPT)/ Concessions

Line owned by a private under a build-own-operate-transfer(BOOT) or similar concessions agreement or a transmission service agreement

Merchant Power Transmission

Similar to IPT model but with no certainty on transmission revenues rather revenues are depending on market scenarios

Financial Ownership

A very rare model wherein private sector takes financial ownership of line, which developed and operated by government utility. Freeing up government's capital for other purposes

Dedicated Transmission Line

Dedicated line for evacuation of power plant to across the border

Note: *The CBET infrastructure ownership model also has a geographic element to it – Whether there is separate legal entity and ownership for infrastructure in each of the countries through which the line passes, or "whether a single entity owns the entire infrastructure."*

When the CBET infrastructure in key regions across the globe are analyzed considering the previously mentioned models, we can see that for each region, there is a predominant model that is typically adopted, and also there are exceptions / innovative models that are adopted, as can be seen in the following table.

Summary of models adopted for CBET lines across the globe

Region	Predominant Model for CBET lines	Other Models for CBET lines
South Asia	Government/public ownership	IPTC created as a JV including public and private utilities (400 kV Dhalkebar Muzaffarpur line)
Southeast Asia	Government/public ownership	Multiple examples of dedicated transmission lines IPTC model-based transmission line - the 115 kV HVAC Cambodia Thailand interconnection
Central Asia	Government/public ownership	
Middle East	Mix of Government/public ownership and IPTC model through Joint Stock Company (GCCIA)	

Region	Predominant Model for CBET lines	Other Models for CBET lines
Africa	Government/public ownership	IPTC model, such as the 220 kV HVAC Zambia - DRC interconnector line (Copperbelt) and the lines of Mozambique Transmission Company (MOTRACO) Dedicated transmission lines such as the 533 kV HVDC Cahora Bassa Interconnector
Europe	All models are present and available	
North America	Government/public ownership and IPTC models	A few merchant interconnection lines such as the 230 kV HVAC Montana Alberta Tie Line An international captive line – The Twin Rivers Paper Company
South and Central America	Government/public ownership	IPTC - SIEPAC interconnection Dedicated Line – Itaipu Binacional

In order to explore these further, specific cross-border projects were identified from across these regions, for undertaking detailed case studies.

International case studies on cross-border transmission infrastructure projects

The case studies were selected to ensure a balanced selection of cross-border transmission lines from different regions, ownership structures, and types, allowing for a comprehensive understanding of CBET infrastructure projects. The following table provides a summary of the examples covered, and their key characterstics.

Summary of key global examples of CBET infrastructure, selected for detailed case studies

Transmission Line	Type	Underlying arrangement for use of line	Investment entity structuring	Geographical nature in relation to ownership
Cambodia Thailand interconnection	HVAC	Power Purchase Agreement (PPA)	IPTC	Single Entity
Ethiopia- Kenya Power interconnection	HVDC	Wheeling Agreements and PPA	Government	Government ownership within each border
MOTRACO – South Africa to Mozambique via Eswatini	HVAC	Wheeling Agreements and PPA	IPTC and Merchant	Single Entity
Egypt Sudan Interconnector	HVAC	Bilateral	Government	Government ownership within each border
Basslink Interconnector	HVDC	Market-based	Merchant	Single Entity

Transmission Line	Type	Underlying arrangement for use of line	Investment entity structuring	Geographical nature in relation to ownership
NEMO LINK	HVDC	Auctions	IPTC / Government	Single Entity (JV)
GCC interconnection project	HVAC	Multilateral Agreement	Government	Single Entity (JV)
Garabi interconnector (Argentina – Brazil)	HVDC	PPA	IPTC	Single Entity with country specific subsidiaries
Montana Alberta Tie Line (MATL)	HVAC	Market-Based	Merchant	Single Entity
SIEPAC	HVAC	PPA and market	IPTC	Single Entity

In addition to these global examples, the existing CBET infrastructure within South Asia, at 400 kV and above, were also reviewed and selected for case studies. From the review of case studies, the following key findings emerged:

- Availability of a variety of business and financial models.
- Various forms of risk management, such as Bilateral or Multilateral Agreements and tariff mechanisms ensuring
- Payment to line operators, Payment Security Funds, Partial Risk Guarantee Funds, etc.
- Various forms of cost sharing mechanisms, such as equal sharing, geographical sharing, benefit based sharing etc.
- Various types of support trade arrangements, such as lines being designed to support long term PPAs or other long term arrangements viz-a-viz merchant trade lines viz-a-viz dedicated interconnections.
- Various supporting market structures such as Integrated Regional Market, Spot Market, Bilateral Trading Arrangements, Independent Power Exchanges and Merchant Interconnectors.
- Role of regional entities in key operational aspects such as Cross-Border Capacity Allocation Mechanisms.
- Various transmission tariff mechanisms adopted such as Negotiated/Mutually Agreed Tariff, Tariff determined by Regulator, Bundled Tariff under PPA and other mechanisms.
- Mechanisms to coordinate on various policy, regulatory, legal, and institutional framework related matters.

Opportunities for South Asia

Compared to initiatives such as Greater Mekong Sub region (GMS), and Association of Southeast Asian Nations (ASEAN), the institutional frameworks for regional energy cooperation have not fully realized their potential in the case of South Asia. For example, the ASEAN has ASEAN Power Grid Consultative Committee (APGCC), Greater Mekong Subregion has the Regional Power Trade Coordination Center (RPTCC), and the SAPP has SAPP Coordination Center and Regional Electricity Regulators Association (RERA). In contrast, such institutional arrangements are lacking in South Asia. Further, the diverse regulatory frameworks and varying standards across the countries have been one of the major hindrances for cross-border transmission line projects. Harmonizing regulations and establishing effective cross-border energy trade policies are essential for ensuring the smooth operation and integration of transmission lines.

At the same time, in South Asia, there are various opportunities for the development of cross-border transmission lines. The eastern side of South Asia, comprising Bangladesh, Bhutan, India and, Nepal already have high voltage electricity interconnections. The countries in the region have also signed various bilateral power trade agreements /MoU such as those between India and Bangladesh, India and Nepal and Nepal, and Bangladesh. The growing bilateral cross-border power collaboration in South Asia, as demonstrated by recent events, is paving the way for expanded multilateral power cooperation in the region.

Another opportunity is the ready availability/ presence of large power exchanges in India, which can also support expansion of the market area by adding new regions, subject to the approval of governmental and regulatory authorities. These exchanges offer week-ahead, day-ahead, intra-day and real time markets. This should also be seen in the context of the presence of traders acting as market intermediaries who can facilitate trade in the region.

Another key opportunity is the progress in the development of explicit guidelines, regulations and rules relating to regional power trade, as is happening in the case of India. Such clarity in policy and regulatory provisions allows investors to better plan for utilizing the market opportunities in the region. Then there is also the potential for utilizing platforms such as South Asia Forum of Infrastructure Regulation (SAFIR) for regional discussions, until more dedicated regional regulatory cooperation frameworks are put in place.

Such opportunities can be leveraged to build more effective frameworks for cross-border electricity transmission infrastructure development.

Key recommendations for South Asia for developing cross-border transmission infrastructure

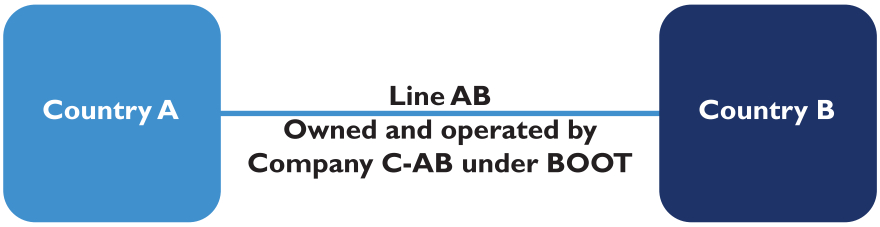
Based on the review of international experiences and review of existing practices for development of cross-border electricity transmission infrastructure in South Asia, a few key recommendations are identified below.

Structuring of line ownership across-borders: There are models that can be adopted beyond the existing border-based approach

In South Asia, irrespective of the business model, all cross-border electricity transmission lines have been developed considering the geographical limitations imposed by national borders. Thus, entities incorporated in each country (government, private, or JV) develop, own, and maintain the line segment and infrastructure within their territory. This model is well suited in the South Asian context, in theabsence of overarching mandatory/ binding regional cooperation frameworks and regional institutions with mandatory powers. However, this should not preclude the decision makers from exploring alternative options.

In the future, consideration may be given to allowing a single entity to construct cross-border transmission line segments, eliminating the need for multiple entities to collaborate across-borders. At the end of the BOOT concession period, the line segments and land could revert back to their respective countries. For the development of lines, option of a single entity is also possible, as has been successfully implemented in the case of Cambodia Thailand Power Transmission Limited (CPTL), Nemo Link (Belgium-UK), and MOTRACO. This model of common ownership across the borders is illustrated in the figure below. The case of restrictions that require national incorporation, the example of Garabi interconnector can be adopted, which allows a single organization to have separate subsidiaries within each of the countries. Another option is to have a single project which is packaged jointly by the countries, get converted into an SPV, and auctioned/ bid out to entities for developing on a Build Own Operate Transfer (BOOT) basis.

Illustration of Common ownership cross-borders



- Company C-AB can be JV of transmission utilities of A and B; or an entirely private third party.
- If legal provisions prevent foreign incorporated entities from operating, Company C-AB can set up fully owned subsidiaries in Country A and Country B, which then look after the respective line segments.

Such single-entity models will provide the following advantages:

1. It is easier to package the single project for awarding a BOOT-based contract which will be attractive for investors as well.

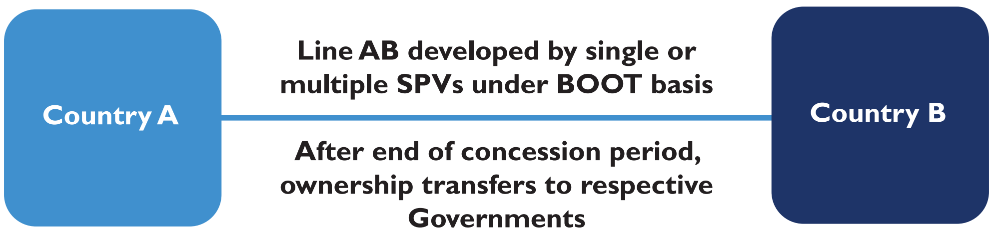
2. There could be separate revenue and tariff mechanisms for the cross-border line, and from each end of the line, interfacing and metering can be done with the respective national grids. It may be noted that the single entity need not necessarily be privately owned. If countries prefer, it could also be a JV of respective national transmission utilities, as has been done in the case of NEMO link, Itaipu Binacional etc.

Business Model: More Public-Private Partnership (PPP) based business models can be introduced in the region

South Asia is in an appropriate time to move towards more PPP in cross-border electricity transmission. India's policy framework already allows PPP in electricity transmission, and the same has been successfully implemented in the case of the Dhalkebar-Muzaffarpur transmission line. If conditions are suitable, this can offer an investment avenue for private investors to achieve reasonable returns on their investment.

For other countries as well, BOOT-based PPP options will provide a means to utilize their capital and resources elsewhere. It is well understood that this may require amendments in the legal and/or the policy framework of countries. However, considering the successful experience of PPP in electricity transmission in even developing economies, such as the case with Cambodia-Thailand Power Transmission, Garabi interconnector, and Basslink interconnector, case for such amendments exists. An illustration of the PPP model for cross-border transmission interconnections is shown in the following figure.

Illustration of PPP model



Alternate Option

If the limitations in legal or policy framework precludes the possibility of 100 percent private ownership, JV models can be explored, which have already been implemented in the case of 400 kV Dhalkebar-Muzaffarpur. A good example of such public-private joint venture in the international context is the Central American interconnection. The example is also very relevant, as it was the involvement of Spain's Endesa company, which provided additional comfort to the financiers such as International Development Association (IDA) to support the project.

Decision on Building Cross-Border Lines: Continued relevance of existing bi-lateral governmental mechanisms and transitioning to a regional planning approach for cross-border transmission

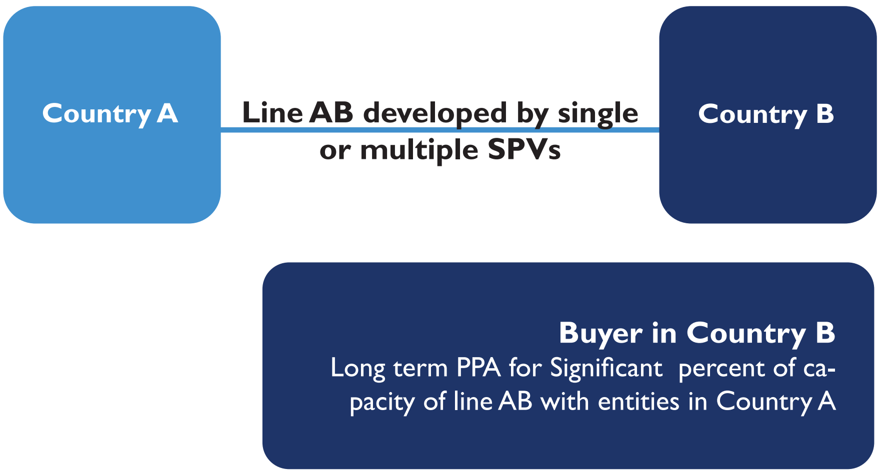
In case of cross-border lines involving India, there is a clearly defined procedure and institutional framework towards identifying and agreeing on the need for lines in the form of Joint Steering Committee (JSC), Joint Working Group (JWG), and the Designated Authority (DA). In the longer term, such arrangements could also be supported by regional coordination mechanisms such as a South Asia Forum of Transmission Utilities (SAFTU) or other regional mechanisms, probably under the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) are set up. In this context, the uniqueness of South Asian context must be acknowledged, as opposed to a direct adoption of regional models in other parts of the globe and develop in a coordinated manner the South Asia Regional Transmission Interconnection Master Plan for facilitating trilateral and multilateral cross-border electricity trade.

Investment Decision: In the absence of firm PPAs for full capacity between Governments, and Intergovernmental or Inter-utility MoUs, anchor customers can be identified who can commit to a major share of line usage

One of the key issues which delay the development of cross-border electricity transmission lines in South Asia is the negotiations relating to which country will ensure the line utilization and associated commercial impacts. This could get complex in some scenarios, as some of the lines will have seasonal import/export trends, or some of the lines will have power flow in one direction for a few years, after which power flows may reverse. Intergovernmental and inter-utility arrangements may take substantial time to negotiate in such cases.

However, when countries or state-owned utilities are unable to arrive at a consensus in such issues, it could be ventured to identify an anchor customer, who can be a large industrial consumer, or a group of such anchor customers who can ensure blocking and utilization of a substantial portion of line capacity, as illustrated in the figure below. This has been successfully tested in the case of MOTRACO interconnection, which facilitates the purchase of energy from Eskom of South Africa, for sale to the Mozal aluminum smelter in Mozambique. The "anchor" customer was the Mozal aluminium smelter plant, 20 km outside Maputo. The aluminium plant had significant electricity demand and was willing to pay MOTRACO a wheeling charge for the reliable energy it received. The aluminum plant also paid the cost of electricity purchased from ESKOM.

Illustration of investment with anchor consumers



This model has a high significance of cross-border lines running to India, as there are large corporate groups which look for options beyond solar and wind power, i.e., large quantum of hydropower from countries such as Nepal and Bhutan, to meet their corporate commitments towards reduction of their Greenhouse Gas (GHG) emissions and achievement of net-zero emissions. It is to be noted that the consumers will have to agree for the recovery of transmission costs irrespective of line utilization, as hydro and other RE projects may have challenges in intra-day and seasonal utilization.

Tariff

CB interconnections ultimately require assurance of an annuity payment, which could be collected in any form. Most international examples follow a Regulated Tariff or bilaterally agreed tariff model. The model is already in practice in the case of the Indian portion of Dhalkebar-Muzaffarpur line, where annual transmission payment calculation methodology is specified in the Implementation and Transmission Service Agreement (ITSA). There is also potential for extending Tariff Based Competitive Bidding (TBCB) regime to cross-border lines also, as shown below. This basically extends India's domestic TBCB regime to the crossborder context. A sample of this model is illustrated in the following figure.

Illustration of tariff mechanisms

The cost and revenue sharing options are linked to the model adopted for development of line. When different entities in each country, develop their own line segments within each territory, associated costs and revenues also gets shared as per respective costs and revenues of those segments. However, in the case of Joint ventures, such as Central American Interconnection, GCC Interconnection etc., there have been different options. In Central American Interconnection, each of the participating countries have equal equity contribution. In GCC, the costs have been shared in the ratio of benefit accruing to those countries, due to reserve sharing. However, as arrangements such as Central American Interconnection and GCC Interconnection wherein a single line traverses across more than two countries are not very relevant in the South Asian context, this aspect of cost and revenue sharing may continue on a territorial approach as is the current practice. Thus, in case of different entities owning different segments of the line, current practice of cost sharing based on infrastructure within each of the boundaries may continue. In case of a single private entity owning the entire cross-border line, this point becomes moot anyway, as capital expenditure of respective state-owned utilities is avoided.

Cost and Revenue Sharing

The cost and revenue sharing options are linked to the model adopted for the development of the line. When different entities in each country, develop their own line segments within each territory, associated costs and revenues also get shared as per respective costs and revenues of those segments. However, in the case of Joint ventures, such as Central American Interconnection, GCC Interconnection etc., there have been different options. In Central American Interconnection, each of the participating countries has equal equity contribution. In the GCC Interconnection, the costs have been shared based on the ratio of benefits accruing to those countries due to reserve sharing. However, as arrangements such as Central American Interconnection and GCC Interconnection wherein a single line traverses across more than two countries are not very relevant in the South Asian context, this aspect of cost and revenue sharing may continue on a territorial approach as is the current practice. Thus, if different entities own different segments of the line, current practice of cost sharing based on infrastructure within each of the boundaries may continue In case of a single private entity owning the entire cross-border line, this point becomes mootanyway, as capital expenditure of respective state-owned utilities is avoided.

Regional Markets

The availability of regional markets for energy trade has been a key enabler in various regional interconnections such as Central American Interconnection, NEMO Link. Adequate access to a regional electricity markets reduces the need for entire line capacity to be tied up under 100 percent long term PPAs. However, it may be noted that South Asia is also moving towards improved regional electricity market, and therefore this aspect is already being addressed by the countries. In the longer term, even transmission line capacity of CB lines can be auctioned out, through market platforms. This is already practiced in some of the lines such as Central American Interconnection (Use of market platform for trading) and NEMO link (Auction of line capacity through market platforms).

Regional Financing of Transmission Lines

Some of the cross-border transmission lines have benefits that extend beyond the countries at the two end-points of such lines. There could be additional benefits for the region as a whole in the form of improved reliability, or improved evacuation of renewable energy etc. In Europe, such projects are covered under a "Projects of Common Interest" (PCI) mechanism, which makes them eligible for substantial amounts of grants from a Connecting Europe Fund (CEF) maintained by the European Union. In the South African Power Pool also, the context of a "Regional Transmission Infrastructure Financing Facility" (RTIFF) is being explored. In the medium to long-term, South Asian countries may also explore such options, which provide some form of viability gap support orconcessional loans or grants to cross-border lines that have regional benefits, spanning beyond the beneficiary countries.

Other Recommendations

In addition to the recommendations derived from review of international case studies and comparison with South Asian context, there are also a few recommendations that have come from stakeholders, as part of the stakeholder consultations held on 28 February 2024. This includes the following:

- Irrespective of models to be adopted, the focus should be on faster decision-making on transmission interconnections.
- Strong institutional / regulatory frameworks at regional level are desired in the longer term, such as seen in the case of Central America.
- Regional entities may work towards facilitating higher levels of commitment among governmental stakeholders for regional energy cooperation.

In the long term, these recommendations can also facilitate the expansion of cross-border interconnections, ultimately contributing to the development of transcontinental infrastructure projects, such as the OSOWOG initiative.

Way Forward

The suggested recommendations based on the international review serve as a reference as the policy-makers and transmission planners in the region continue to deliberate on modalities for development of new cross-border interconnections in the region. It is hoped that these recommendations provide adequate guidance, as the policy makers and key stakeholders try to improve upon the framework for development of cross-border electricity transmission infrastructure and best practices captured in this report, vis-à-vis these recommendations. Further, the countries in South Asia and beyond are embarking upon development of trans-regional cross-border transmission interconnections under the OSOWOG initiative. In such a context, it is hoped that the recommendations of this study provide a common reference point for knowledge on successful development of cross-border electricity transmission which can facilitate appropriate adoption/deliberations on potential models for implementation of such transmission infrastructure being envisaged as a part of OSOWOG initiative.

1. Introduction

1.1 Background

South Asia consists of the eight countries - Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. India and Pakistan are the top two countries in terms of both area and total population. Among the countries, Sri Lanka and Maldives are island nations, in the Indian Ocean. Afghanistan, Bhutan, and Nepal are landlocked countries. India, Bangladesh, and Pakistan have coastal borders with Indian Ocean. The region has abundant natural resources and provides a significant opportunity to benefit from regional energy cooperation for its countries. The bulk of the hydropower potential is in India, Pakistan, Nepal, and Bhutan. India also has the highest coal reserves in the region, and the largest renewable energy (solar and wind) potential. India, Bangladesh, and Pakistan have substantial gas reserves also. There is also the case of Sri Lanka, where exploration activities are underway for oil and gas fields, and plans are in place for offshore wind projects.

The nature of energy cooperation among South Asian countries is characterized by a marked increase in the focus on energy security, energy trade, regional integration, and sustainability. As the region makes significant strides in harnessing its energy potential, transmission infrastructure development for increased energy exchange between the countries is anticipated to emerge as a pivotal determinant for fostering the expansion of regional energy cooperation. Cross-border electricity trade allows to harness complementarities in electricity demand patterns, diversity in resource endowments for power generation, and gains from larger market access. Cross-border transmission infrastructure is the cornerstone that allows the physical cross-border trade of electricity. Cross-border transmission infrastructure can bring significant benefits for participating countries, including increased access to renewable energy resources, improved energy security, economic benefits, providing market access, and improved grid stability. As the world transitions to a more sustainable energy system, cross-border transmission lines are likely to play an increasingly significant role in enabling efficient and reliable exchange of energy between countries.

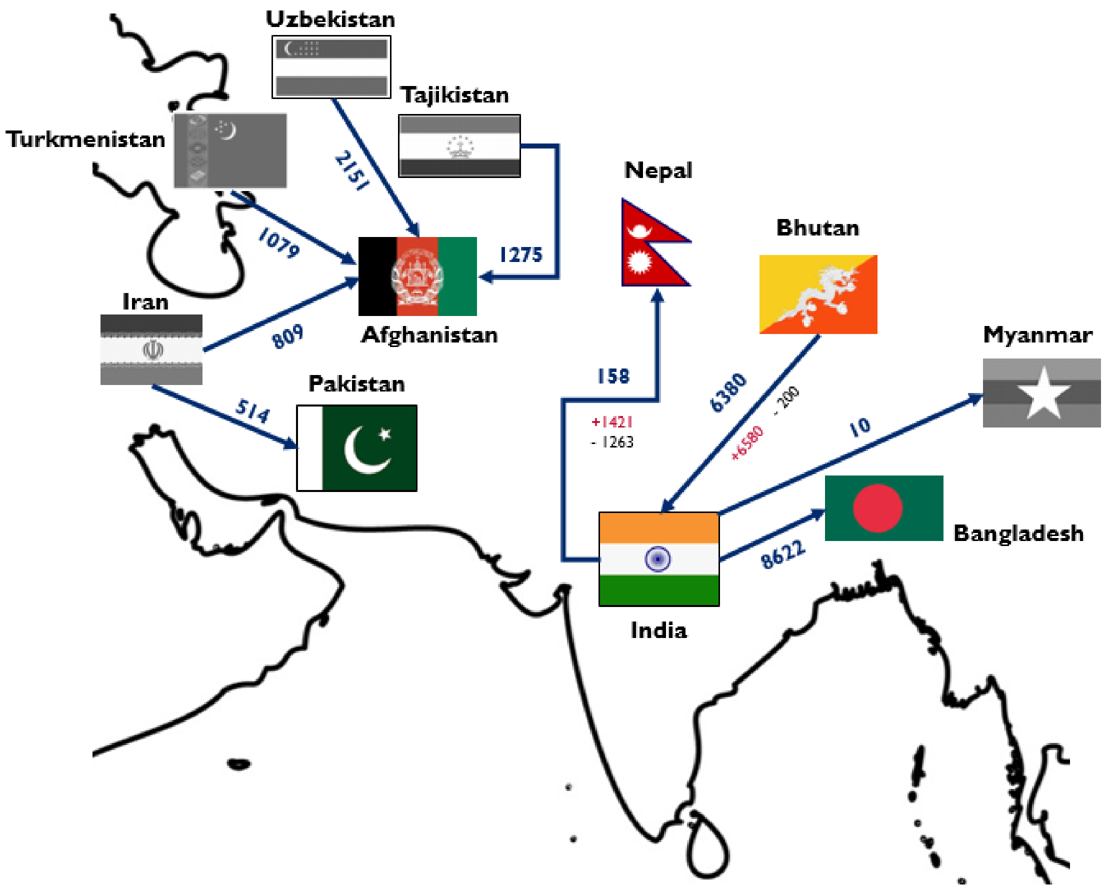


Figure 1: CBET in South Asia (TWh)

* India – FY23, Pakistan – FY22, Afghanistan – CY21 Source: POSOCO, NEPRA, NSIA [1]

The importance and potential benefits of regional energy cooperation and CBET are recognized by South Asian countries. As may be observed in the above illustration, there is a considerable amount of CBET in the region, and by the countries within the region with other regions. The net CBET volumes come to approximately 21 TWh. The trade is supported through a vast network of cross-border transmission lines, especially in the Bangladesh-Bhutan-India-Nepal (BBIN) sub-region.

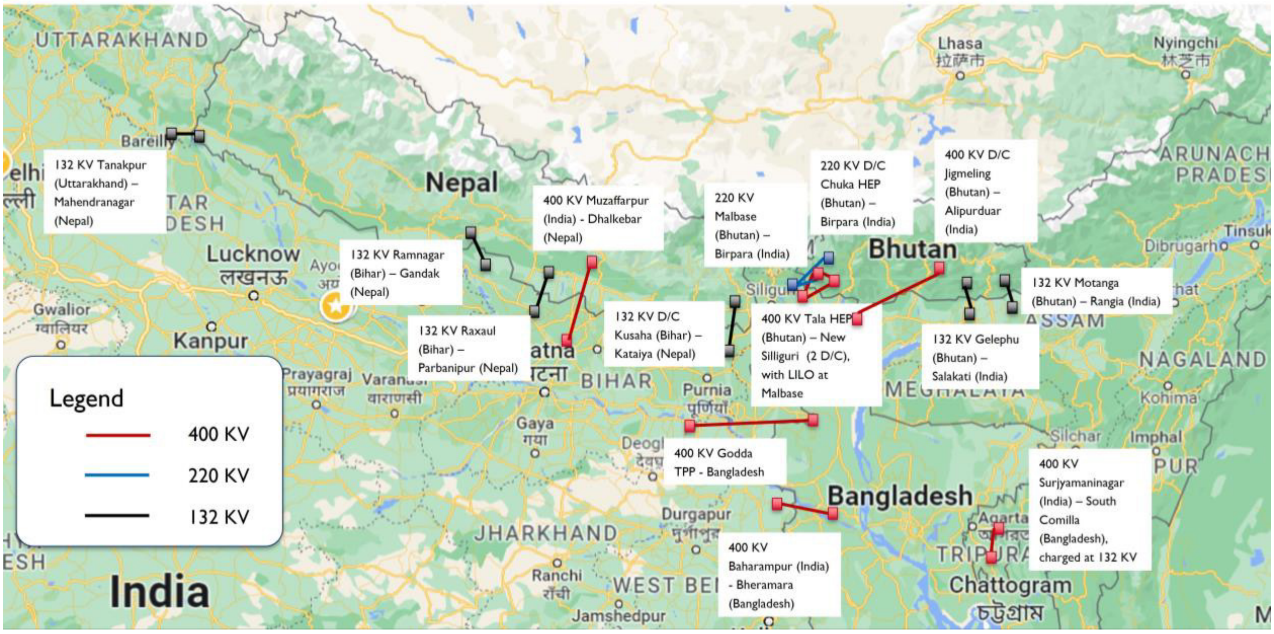


Figure 2: CBET lines at 132 kV and above in BBIN sub-region

* Locations and borders are approximate. Line direction may not follow the exact alignment.

Note: Unlike the above, the lines in western region of South Asia (Pakistan and Afghanistan) run outside the region, to Iran and Central Asia.

CBET is further gaining momentum with a greater number of cross-border power projects & transmission interconnections being planned and proposed, in particular in the Bangladesh, Bhutan, India, Nepal, Sri Lanka (BBINS) sub-region, which will enable greater integration of power systems of South Asian countries. This includes the following:

- India – Sri Lanka transmission interconnection
- 400 kV Butwal – Gorakhpur transmission line
- 400 kV Transmission Line from Arun-III HPP to India-Nepal border near Sitamarhi
- 400 kV Transmission Line of Upper Karnali HPP to India-Nepal border
- 400 kV Inaruwa (Nepal) – Purnea (India) Transmission Line
- 400 kV Dododhara (Nepal) to Bareli (India) two double circuit lines
- 400 kV Attariya (Nepal) to Bareli (India) double circuit
- 400 kV Phulbari (Nepal) to Lucknow (India)
- 765 kV Bornagar (India NER) – Parbotipur (Bangladesh) – Katihar (India ER)
- 400kV, 2xD/C Quad Moose line, Yangbari – Rangia/Rowta
- 400kV, 1xD/C Twin Moose line, Phuntshothang – Rangia/Rowta [2]

Meanwhile, along with these regional efforts, there is also a global effort towards "One Sun One World One Grid" (OSOWOG) currently being led by the International Solar Alliance (ISA). OSOWOG aims at connecting more than 100 countries through a "common grid". The vision behind the plan is that in essence "the sun never sets" as it is always a constant at some or the other geographical location at any given point of time. The aim of the initiative is to generate round the clock electricity from the sun, as it sets in one part of the world, and it rises in the other. OSOWOG is expected to be implemented in a phased manner and is divided into three main phases:

1. The first phase will ensure interconnectivity in the Asian continent; the Indian grid would be connected to the grids of Middle East, South Asia, and South-East Asia as a common grid to share solar energy in addition to other renewable energy sources.

2. The second phase would connect the functional first phase to the pool of renewable resources in Africa.

3. The third and final phase aims to achieve a global interconnection.

Since in many other regions across the globe, cross-border transmission projects have been established and are being carried out successfully for quite some time, the study seeks to learn from international experience in this respect and use such learnings towards the development of cross-border transmission infrastructure projects in South Asia. As the transmission lines are affected by geographical location, regional economic development, population density, and the policies of the relevant national electricity market, the business models adopted for development of cross-border lines are different. This study analyzes typical cross-border infrastructure among various regions throughout the world and summarizes the characteristic of their business model. The study further examines the benefits and challenges associated with cross-border transmission infrastructure successfully deployed in different parts of the world, highlighting the key factors that contributed to their success and the lessons that can be learned for future projects. Such examples are further used to draw insights on strategies and best practices that can enable the development of effective and sustainable cross-border transmission interconnections in South Asia.

1.2 Scope of Work & Objective of the Study

Currently, the decisions relating to the model of cross-border transmission lines in South Asia are taken up on a case-by-case basis the lines are mostly planned in such a way that government-owned utilities on each side build lines up to their respective borders. There has been an exception in the case of 400 kV Dhalkebar Muzaffarpur line, where private sector participation and JV model was adopted. The case-by-case nature of decision-making sometimes causes delays, as discussions to arrive at a mutually acceptable model for each cross-border transmission infrastructure can be protracted, involving countries at both ends. For example, it took multiple levels of discussion at bilateral Joint Working Group (JWG) and Joint Steering Committee (JSC) meetings to decide on mode of implementation of 400 kV Butwal Gorakhpur line between India and Nepal, wherein discussions were spread across a period of over one and a half years. However, there may be learnings from other regions around the globe which can prove beneficial to South Asia. There is potential to study the international best practices on business and financial models for cross-border transmission infrastructure including investment mechanism, ownership, financing mechanisms, project structuring, risk management, allocation principles, and cost recovery methods. This study aims to analyze international practices on different methods adopted for developing cross-border electricity transmission infrastructure projects across the globe. The study focuses on the international best practice for business and financial models including investment entities, ownership, financing mechanism, project structuring, risk management, allocation principles, and cost recovery methods for developing cross-border electricity transmission infrastructure projects. The study seeks to identify global practices that aim to help answer the question of how to develop, structure, manage, and implement cross-border transmission infrastructure. These practices are derived from a comprehensive literature review, input from experts with practical knowledge and experience of cross-border transmission projects, and reviewing case studies across a range of jurisdictions.

1.3 Approach

The approach adopted for this study centered around the following components:

• **Desk research and analysis -** Conducting desk research to understand the key questions that are posed - international best practice on business and financial models including investment entities, ownership, financing mechanism, project structuring, risk management, allocation principles, and cost recovery methods for developing cross-border electricity transmission infrastructure projects. This was undertaken through the review of primary and secondary material, especially the regulatory orders, company financial reports etc. rather than focusing merely on third-party sources, and

• **Expert interviews/interactions –** Engaging with regional transmission line operators and other key experts who can provide insights beyond what is available in public domain documents.

Given the multi-stakeholder nature of the engagement, a collaborative and consultative approach was adopted, as depicted below:

Figure 3: Overall Approach

The first step of the assignment was a comprehensive review and analysis of cross-border transmission infrastructure across the globe. This included detailed analysis of business and financing models, ownership, economic aspects, finance mobilization and market analysis. This was followed by a contextual assessment which involves analysis of various government policies, payment security mechanism, socio-economic analysis, and assessing mechanisms for resolving disputes.

The next phase of the study involved developing detailed case studies/international best practices of various cross-border electricity transmission projects in different regions across the globe. Additionally, a stakeholder consultation workshop was conducted, to solicit key inputs and insights on various facets of cross-border transmission projects.

Based on the findings of the study, this report on best practices covering business models, financial aspects and other key parameters has been prepared. The report also includes the inputs and insights received during stakeholder consultations, incorporating key lessons learned from previously implemented projects and suggested recommendations for South Asia. A concise version of the report (Executive Summary) is also included to inform policymakers and key stakeholders about the study's key findings.

Analysis of International best practices

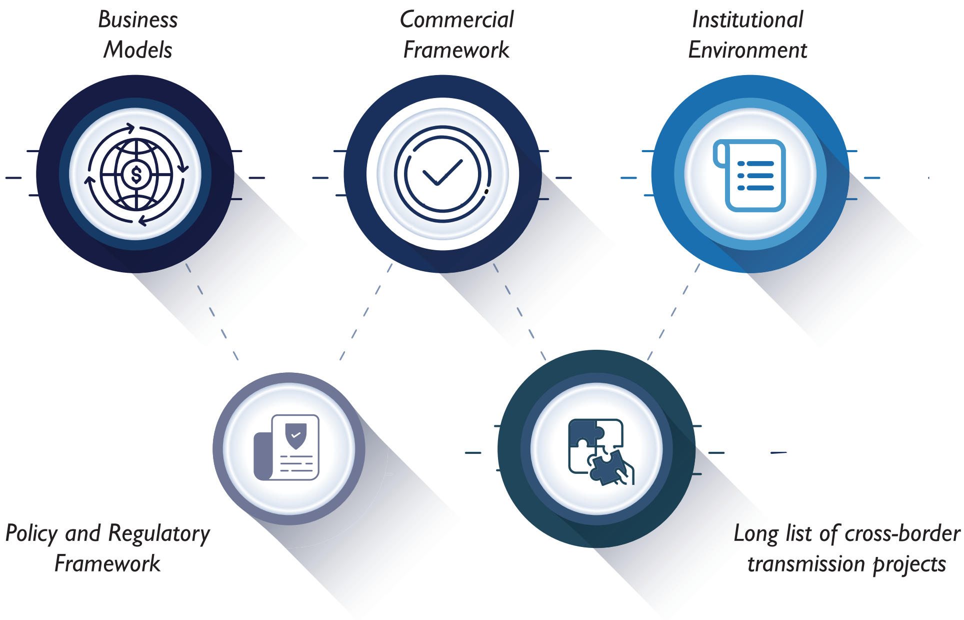


Figure 4: Analysis of International practices

2. Typical Models Adopted

2.1 Overview of Typical Models Adopted For CBET Infrastructure Development

While there is a wide variety of ownership models for CBET infrastructure, they can be broadly categorized under any of the following five models:

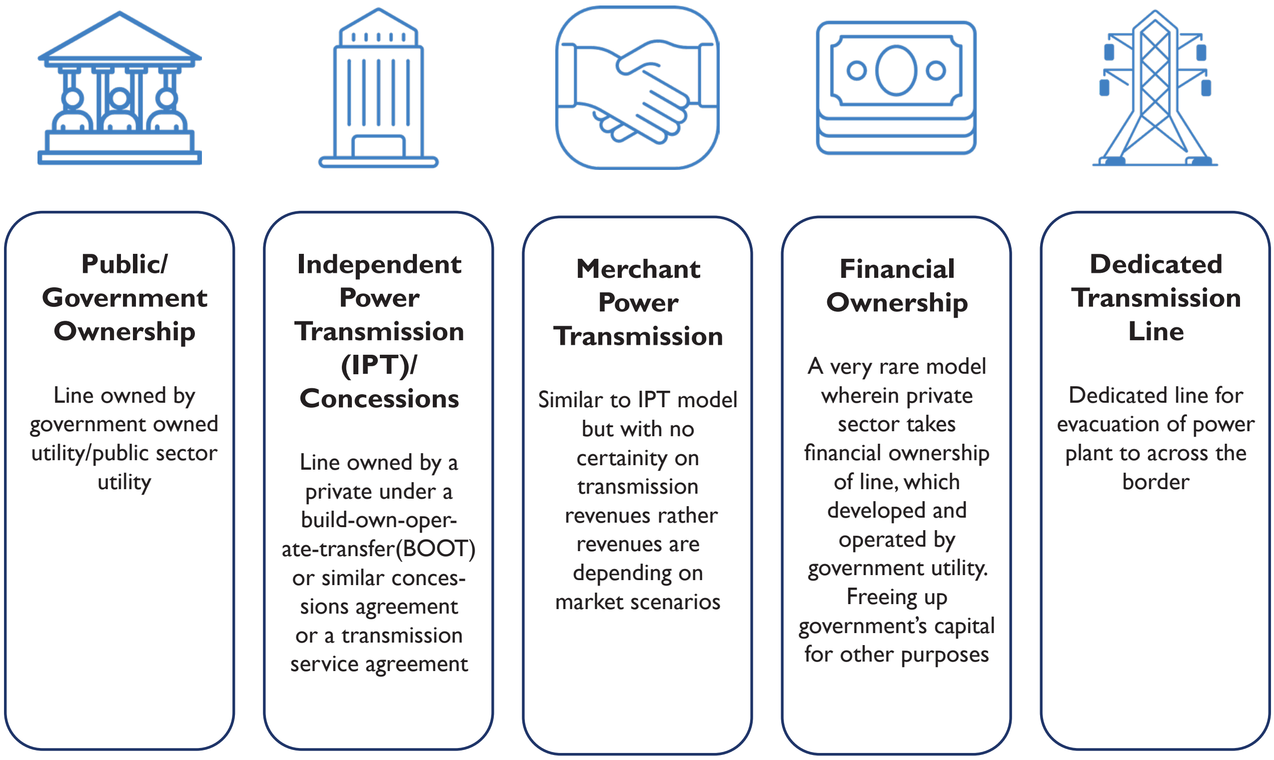


Figure 5: Typical models of CBET infrastructure

While there are also models such as "Whole of Grid" concessions, where an entire grid is handed over to a concessionaire for a concession period, it may be noted that such models are adopted for domestic grids and not for CBET infrastructure. Details about each of the five key models for the development of CBET infrastructure is provided in the following
sub-sections.

Note: The CBET infrastructure ownership model also has a geographic element to it – whether there is a separate legal entity and ownership for infrastructure in each country through which the line passes, or whether a single entity owns the entire infrastructure.

2.1.1 Public/Government Ownership

This is the most widely adopted model, wherein the CBET infrastructure is owned by a government or a government owned/controlled entity. Most of the CBET infrastructure, especially in the developing world, falls under this category.

Table 1: Public/government ownership model

Investment and financing	By Government or Government owned entity
Risk allocation	Most risks are passed on to consumers, except for technical risks related to line availability.
Cost recovery	Usually through aggregated revenue recovery mechanism of the entire Government-owned utility
Other aspects	-

2.1.2 Independent Power Transmission (IPT)/Concession (including JV)

In this model, the CBET infrastructure is developed by a private entity under a Build-Own-Operate-Transfer (BOOT) or similar model of concession arrangement. Sometimes, the entity may also be a Joint Venture (JV) with some degree of government ownership also. While primarily introduced under lines within a country, there are a few examples of this model being practiced for CBET lines also. However, the bulk of CBET lines still follow a JV model with some public ownership.

Table 2: IPT/Concession model

Investment and financing	Usually, private. In some cases, Government owned companies also participate in this model.
Risk allocation	Most risks passed on the consumers, except for construction delay related risks and technical risks relating to line availability
Cost recovery	Usually through dedicated transmission revenue / tariff mechanism linked with line availability
Other aspects	Under the JV model, JV of Government owned, and private owned entities is also possible.

2.1.3 Merchant Power Transmission

The Merchant power transmission model is similar to IPT, but with the distinction that there is revenue assurance by the infrastructure beneficiaries. The infrastructure is developed without any long-term revenue assurance through long term contracts, and instead relies on short term markets and anchor customers for revenue generation. Examples of such models can be found in the USA, Australia etc. For instance, the Basslink interconnector in Australia, which is covered in detail in later part of this study report.

Table 3: Merchant Power Transmission model

Investment and financing	By private sector
Risk allocation	Most risks stay with the line developer and operator
Cost recovery	Usually through dedicated transmission revenue / tariff mechanism
Other aspects	-

2.1.4 Financial Ownership

This is a very rare model, wherein the CBET infrastructure is developed, constructed and operated by a state-owned transmission/system operator. After commissioning, a private entity is provided with a partial ownership stake and resulting dividend/share on profits. This frees up capital that was locked in by the state-owned entity. A few rare examples of this model may be seen in Europe, Africa etc. For example, the Denmark-Germany interconnection.

Table 4: Financial Ownership model

Investment and financing	Initially by Government and later transferred to private sector
Risk allocation	Most risks stay with the line developer and operator (Government utility)
Cost recovery	Dedicated mechanism related to the line or under aggregated revenue recovery models
Other aspects	Rarely adopted model

2.1.5 Dedicated Transmission

This model refers to dedicated CBET infrastructure for evacuation from a power plant, typically operated by the entity owning the plant also. The cost of transmission is typically bundled within the Power Purchase Agreement (PPA) price. Examples of such CBET lines may be found across the globe, such as the transmission evacuation line of Nam Theun II hydropower plant, that runs from Laos to Thailand.

Table 5: Dedicated transmission model

Investment and financing	Usually by entity that owns the related power plant. May be private or Government owned.
Risk allocation	Most risks passed on the generation plant and/or off takers, except for construction delay related risks and technical risks relating to line availability
Cost recovery	Dedicated mechanism related to the line or under aggregated revenue recovery models
Other aspects	-

2.2 Other Models and Variations

It may be noted that these five models are not the only available options for developing CBET infrastructure. For infrastructure developed under a particular model category, there may be variations in terms of financing mechanisms, project structuring, cost and revenue allocation principles, cost recovery etc. Therefore, to analyze such aspects in detail, a case-study based approach has been opted, wherein international examples relating to CBET infrastructure is analyzed, to identify potential learning for South Asia. The following chapter deals with such analysis.

2.3 Regional Examples of Models For Cross-Border Power Transmission Infrastructure

It can be seen that the favored approach for development of cross-border transmission infrastructure varies across the regions. The preferences of South Asia are not necessarily the same as that of Middle East, or Europe. Such geographical variations, as detailed out in the following subsections, provides an understanding of not just the overall regional preferences, but also a few exceptions.

2.3.1 South Asia

In the South Asian region, government /public ownership model remains the most common model adopted for development of cross-border transmission infrastructure, with each line segments in individual country areas developed and owned by respective government owned transmission utilities.

History of cross-border interconnections between India and Nepal starts with the extension of 11 and 33 kV lines from India (Mid 1970s to 1980s), wherein India's Government owned utilities extended their lines to Nepal's border areas. This was followed by transmission lines built based on various irrigation/water sharing agreements, such as the Kattaiya-Rajbiraj 33 kV line, built to import 10 MW of power from the 20 MW power plant built at Koshi barrage site in India, as per Koshi agreement between India and Nepal. Under Gandak agreement, Ramnagar-Gandak 132 kV line (1979) and Sugauli-Raxual 33 kV lines were built to supply power to different parts of Nepal. Thereafter, under Mahakali treaty, Tanakpur-Mahendranagar 132 kV line was built, to import free power from power plant at Tanakpur barrage [3].

Similarly, cross-border lines between India and Bhutan were also developed under government/public ownership model, starting with the arrangement for export of power from India's Jaldhaka hydropower plant to Bhutan in 1968. The two interconnections between India and Bangladesh, the 400 kV Behrampur Behramara interconnection, and 400 kV (charged at 132 kV) Tripura Comilla interconnections also follow the Government/public ownership model. Similar is the case with cross-border interconnections between India-Myanmar, Iran-Pakistan, and multiple interconnections between Afghanistan and Central Asian countries.

However, exceptions exist and business models are evolving. As India's Tariff Policy evolved, development and operation of transmission infrastructure became no longer a government utility monopoly. India shifted to a Tariff Based Competitive Bidding (TBCB) regime, wherein private entities can also own and operate transmission lines which form part of the grid.

The 400 kV Dhalkebar – Muzaffarpur line between India and Nepal was developed under an IPTC model, where the special purpose vehicles which own the line segments in India and Nepal were formed as a joint venture of government owned and private utilities.

2.3.2 South-East Asia

Similar to the example of South Asia, Southeast Asia also follows a prominently government/public ownership model for cross-border transmission infrastructure, while there are also cross-border lines under dedicated transmission model, though such dedicated lines are also owned by government entities.

While the 230 kV Plentong-Woodland interconnection between Malaysia and Singapore was commissioned in 1958, it is not clear whether it started as a 230 kV line, or what model was adopted then[4]. In 1981, the first interconnection of power networks between Thailand and Malaysia was built between Sadao substation of the Electricity Generation Authority of Thailand (EGAT) and Bukit Keteri (Chuping) substation of the Tenaga Nasional Berhad (TNB) in Malaysia, via a 115/132-kV transmission line of 24.5-kilometer length.

In 1990s and 2000s, multiple interconnections were developed to evacuate power from hydropower plants in Laos to Thailand. The first among these was the Theun-Hinboun Hydropower Project, which was commissioned in 1998. The power plant, including 86 KM transmission line till Thailand border was developed by a PPP comprising of Electricité du Laos (EdL), the state-owned power utility (60 percent), and two foreign investors MDX Lao Public Company Limited (20 percent) and Nordic Hydropower AB (20 percent). This model for dedicated lines were followed in future projects also between Laos and Thailand.

While government owned and dedicated transmission line models remain the prominent models in the region, there is at least one exception of an IPTC model-based transmission line, the 115 kV HVAC Cambodia Thailand interconnection. This case is covered in detail in the following chapter.

2.3.3 Central Asia

Similar to the example of South Asia, Central Asia also follows a prominently government/public ownership model for cross-border transmission infrastructure.

2.3.4 Middle East

Cross-border electricity transmission infrastructure in Middle East is primarily covered under the Gulf Cooperation Council (GCC) Interconnection, which is a joint stock company formed by the member countries of GCC. The GCC interconnection consists of a 400 kV transmission backbone, connecting the GCC states of Bahrain, Kuwait, Oman, Saudi Arabia, Qatar and United Arab Emirates (UAE). The interconnection is operated by GCC Interconnection Authority (GCCIA), a joint stock company, subscribed by the six member states. The operations of GCC commenced in 2009-2010. The lines history can be traced to the overall GCC charter and the high-level decision taken by GCC Supreme Council. In 1981, the six gulf states came together to sign the GCC charter. In the charter, one of the objectives was: "To effect co-ordination, integration and inter-connection between member states in all fields in order to achieve unity between them"[6]. The decision to go ahead with an electricity interconnection was communicated in the 18th session of GCC Supreme Council, held in December 1997:

> *"Emphasizing the need to tie and coordinate the economic interests of member states in the area of infrastructure projects, the supreme Council directed to start the implementation of the first stage of the electric network project. The Council agreed that the project will be owned and operated by an independent authority run on a commercial basis."* [5]

This case is covered in detail in the following chapter.

Similar to the example of South Asia, Africa follows a prominently government/public ownership model for cross-border transmission infrastructure, with transmission entities within each country owning and developing line segment within their territory. This is true for most of the cross-border lines such as:

- 500 kV HVDC Ethiopia- Kenya Power interconnection;
- 220 kV HVAC Egypt Sudan Interconnector;
- 330 kV HVAC Nigeria Benin Interconnector;
- 330 kV HVDC Zambia Namibia (Caprivi) Interconnector;
- 220 kV HVAC Egypt Libya Interconnection; and
- 400 kV HVAC Egypt Jordan Interconnection.

At the same time, there are also alternate models that have developed. There are lines developed using the IPTC model, such as the 220 kV HVAC Zambia - DRC interconnector line (Copperbelt) and the lines of Mozambique Transmission Company (MOTRACO). The case of MOTRACO is covered in detail in the following chapter.

There is also at least one example of dedicated transmission model, in the form of 533 kV HVDC Cahora Bassa Interconnector, which evacuates power from Cahora Bassa Hydroelectric Generation Station at the Cahora Bassa Dam in Mozambique, supplying to Johannesburg, South Africa. Cahora Bassa was a Joint Venture of Eskom (South Africa) South Africa and Hidroelectrica de Cahora Bassa (HCB), which in turn is a firm owned 15 percent by the government of Portugal and 85 percent by Mozambique.

2.3.6 Europe

In Europe, almost all kinds of business models for cross-border transmission infrastructure exist. There are multiple government owned models, such as the NEMO link between The United Kingdom and Belgium and COBRAcable (Copenhagen-Brussels-Amsterdam), IPTC models such as Eleclink (France-UK), BritNed, NordNed etc. The Kriegers Flak Denmark-Germany interconnection is viewed as an example of 'Financial Ownership' model.

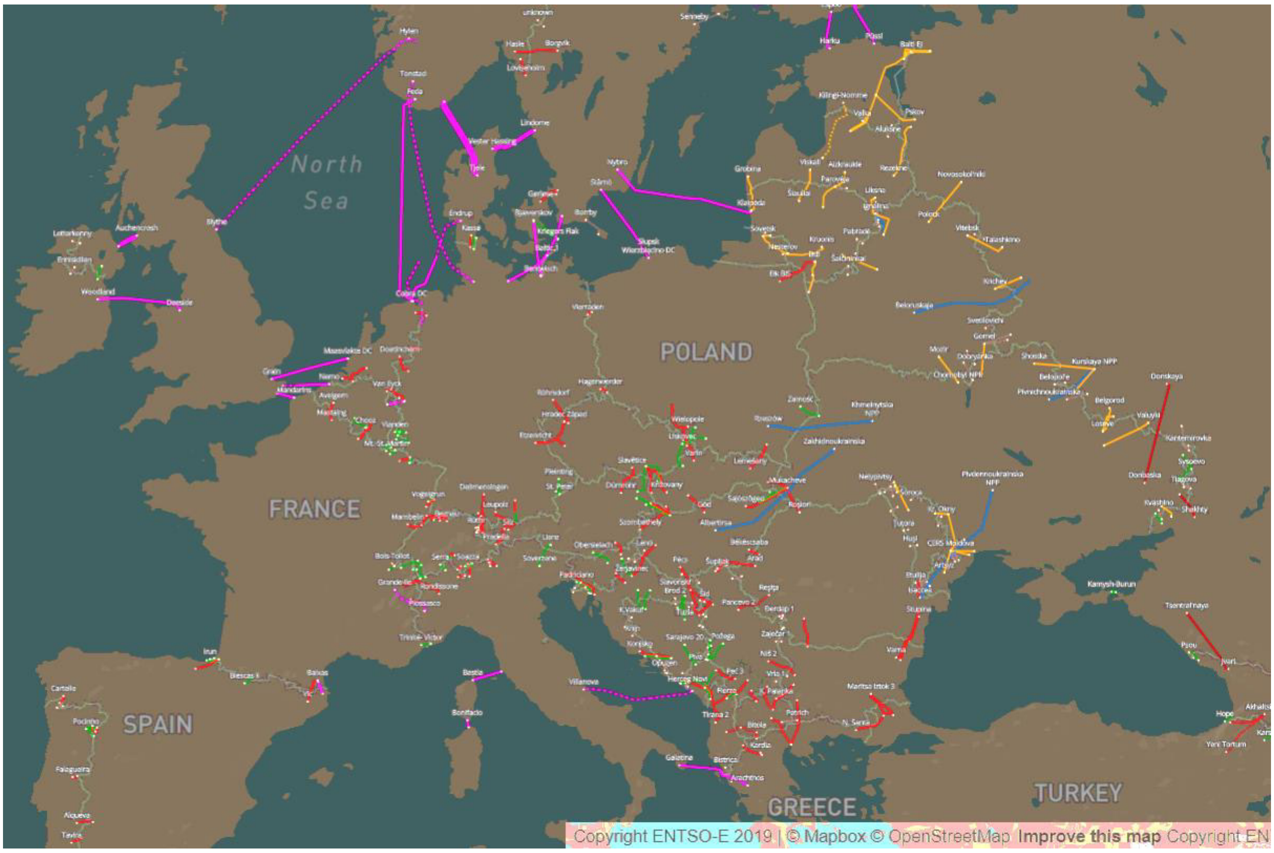


Figure 6: Cross-border electricity transmission lines in Europe

Source: © ENTSO-E [7]

The energy cooperation and CBET in Europe has a long history. This is very well described in a report issued by Secretariat of Union for the Coordination of the Transmission of Electricity (UCTE) in 2011, which is summarized below.

> From 1921 onwards, it was possible to transmit electric power from Nancy, France, via Switzerland to the area around Milan, Italy, representing a distance of roughly 700 km. Although in earlier decades, starting roughly in the 1920s, a few Western European countries had cross-border electricity connections, there was no coordinating body. Some international cooperation did, however, take place between 1910 and World War II, most notably in Scandinavia, Switzerland, and between France and some of its neighbors. After World War II a closely intertwined process of both increased interconnection and institutionalization took place. In 1960s, the regional high-voltage grids were initially connected to one another bilaterally, but soon they were connected multilaterally using rings and close meshes. The uniform 380 kV grid extended across the majority of Western and Central Europe. This created an effective mutual aid in the event of failures.

Source: UCTE [8]

With the liberalization of electricity markets, creation of european common market, and establishment of institutions such as UCTE and eventually ENTSO-E, the development of cross-border lines and CBET further took off in the region.

2.3.7 North America

In North America, the cross-border transmission infrastructure is developed mostly under government model (US-Mexico interconnection, Mexico Guatemala interconnection, Manitoba–Minnesota Transmission Project etc.), or under IPTC model (Cedar Rapids Transmission). Canadian state-owned entities such as HydroQuebec and Ontario Power Generation operates multiple interconnections with USA.

There are also a few merchant interconnection lines such as the 230 kV HVAC Montana Alberta Tie Line.

Another exception is an international captive line – The Twin Rivers Paper Company, which has built a short line to import power from Canada to the US, as its operations are spread across both sides of border in an adjoining area.

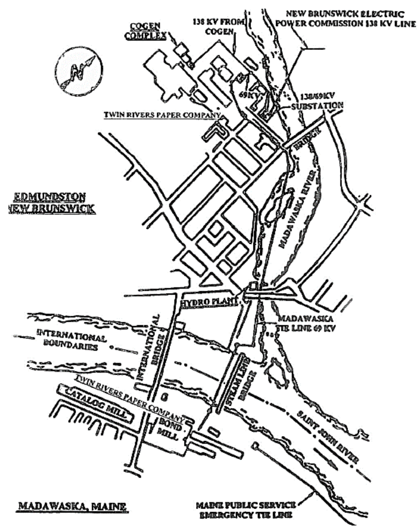


Figure 7: Twin Rivers Paper Company International Transmission Line

Source: Twin Rivers Paper Company [9]

2.3.8 South and Central America

In South and Central America, the prominent models for cross-border transmission are the government owned and IPTC models. One of the best examples of IPTC model is the SIEPAC interconnection, which is detailed in the following chapter. At the same time, there are also government owned models such as the interconnections between Colombia-Ecuador and Mexico-Guatemala. The case of 600 kV HVDC Itaipu is also a key example, which transmit power generated from the Paraguay side of the Itaipu Dam to the Ibiúna converter station near São Paulo, Brazil. It can be considered as a mix of IPTC, government owned and dedicated transmission models, as it is owned by Itaipu Binacional, a joint company equally owned by the Brazilian government (through Eletrobras) and the Paraguayan government (through Ande), created in 1973.

2.3.9 Summary

The predominant models adopted for CBET lines in each of the above-mentioned regions, and some of the other models that are adopted are summarized in below table.

Table 6: Summary of models adopted for CBET lines across the globe

Region	Predominant Model for CBET lines	Other Models for CBET lines
South Asia	Government/public ownership	IPTC created as a JV including public and private utilities (400 kV Dhalkebar Muzaffarpur line)
Southeast Asia	Government/public ownership	Multiple examples of dedicated transmission lines IPTC model-based transmission line - the 115 kV HVAC Cambodia Thailand interconnection
Central Asia	Government/public ownership	
Middle East	Mix of Government/public ownership and IPTC model through Joint Stock Company (GCCIA)	

Region	Predominant Model for CBET lines	Other Models for CBET lines
Africa	Government/public ownership	IPTC model, such as the 220 kV HVAC Zambia - DRC interconnector line (Copperbelt) and the lines of Mozambique Transmission Company (MOTRACO) Dedicated transmission lines such as the 533 kV HVDC Cahora Bassa Interconnector
Europe	All models are present and available	
North America	Government/public ownership and IPTC models	A few merchant interconnection lines such as the 230 kV HVAC Montana Alberta Tie Line An international captive line – The Twin Rivers Paper Company
South and Central America	Government/public ownership	IPTC - SIEPAC interconnection Dedicated Line – Itaipu Binacional

3. International Case Studies

3.1 Introduction

While the broader overview of typical models adopted for cross-border transmission infrastructure projects, and the regional examples/preferences of those models have been explained in the previous chapter, a detailed case study review is preferred to gain deeper insight into key practices. Thus, this chapter focuses on a select list of projects, which have been analyzed in detail as case studies, to understand the key aspects related to their development and operation, so as to derive key learnings for South Asia.

3.2 Methodology Adopted for Selecting Case Studies

The methodology adopted for selecting case studies included starting with an extensive literature review. Relevant research papers, technical reports, case studies, and publications were reviewed to collect data relating to cross-border transmission infrastructure from various sources. This resulted in the development of a large master list of cross-border transmission projects, which are categorized by their model of ownership.

Table 7: Different Ownership Models for Cross Border Transmission Projects

Ownership	Line
Public/ Govt Ownership	• 500 kV HVDC Ethiopia- Kenya Power interconnection • 220 kV HVAC Egypt Sudan Interconnector • 500 kV HVDC NEMO link (UK – Belgium) • 400 kV HVAC GCC Interconnector • 330 kV HVAC Nigeria Benin Interconnector 330 kV HVDC Zambia Namibia (Caprivi) Interconnector • 220 kV HVAC Egypt Libya Interconnection • 400 kV HVAC Egypt Jordan Interconnection • 500 kV HVAC Uzbekistan-Kyrgyzstan Interconnection • 320 kV HVDC COBRAcable (COpenhagen-BRussels-Amsterdam) • 515 kV HVDC Northsea Link (Norway - UK) • 230 kV HVAC Colombia Ecuador line • 400 kV HVAC Mexico Guatemala interconnection • 500 kV HVAC Manitoba–Minnesota Transmission Project (MMTP)
Independent Power Transmission / Concessions	• 115 kV HVAC Cambodia Thailand interconnection • 500 kV HVDC Garabi Interconnector (Argentina – Brazil) • 230 kV HVAC Central American Interconnection (SIEPAC) • 320 kV HVDC Eleclink (France-UK) • 220 kV HVAC Zambia - DRC interconnector line (Copperbelt) • Lines of Mozambique Transmission Company (MOTRACO) • 450 kV HVDC BritNed • 450 kV HVDC NordNed
Merchant Power Transmission	• 500 kV HVDC Basslink Interconnector (Australia) • 230 kV HVAC Montana Alberta Tie Line
Financial Ownership	• 170 kV HVAC Kriegers Flak Denmark-Germany interconnection
Dedicated transmission line	• 533 kV HVDC Cahora Bassa Interconnector • 500 kV HVAC Nam Theun 2 line to Thai border • 600 kV HVDC Itaipu (Paraguay Brazil)

From the above master list, a shortlist of CBET infrastructure projects were prepared for the purpose of development of detailed case studies. The following criteria were considered during the short-listing process:

- **Regional Representation:** To ensure a diverse representation, at least one CBET infrastructure project was selected from each of the regions around the world. This approach facilitated a comprehensive analysis of cross-border transmission lines across different continents and regions.

- **Ownership Structure:** The ownership structure of the transmission lines was taken into account. Preference was given to lines that involved a mix of public and private ownership, joint ventures, privately owned transmission lines, as well as lines where multiple entities collaborated, promoting a balanced assessment of various ownership models.

- **Projects with unique characteristics:** CBET infrastructure projects with unique features such as merchant only transmission lines, transmission lines which were formed with the setting up of a special purpose vehicle, transmission lines jointly owned by multiple countries etc.

- **Data Availability and Secondary Research:** The availability of reliable data and information on the selected transmission projects was a crucial factor. Secondary research was conducted to gather relevant data, including technical specifications, project details, and performance indicators. Lines with readily accessible and comprehensive data were prioritized.

This methodology ensured a balanced selection of cross-border transmission lines from different regions, ownership structures, and types, allowing for a comprehensive understanding of CBET infrastructure projects.

Table 8: Summary of key global examples of CBET infrastructure, selected for detailed case studies

Transmission Line	Type	Underlying arrangement for use of line	Investment entity structuring	Geographical nature in relation to ownership
Cambodia Thailand interconnection	HVAC	Power Purchase Agreement (PPA)	IPTC	Single Entity
Ethiopia- Kenya Power interconnection	HVDC	Wheeling Agree-ments and PPA	Government	Government ownership within each border
MOTRACO – South Africa to Mozambique via Eswatini	HVAC	Wheeling Agreements and PPA	IPTC and Merchant	Single Entity
Egypt Sudan Interconnector	HVAC	Bilateral	Government	Government ownership within each border
Basslink Interconnector	HVDC	Market-based	Merchant	Single Entity
NEMO LINK	HVDC	Auctions	IPTC / Government	Single Entity (JV)
GCC interconnection project	HVAC	Multilateral Agreement	Government	Single Entity (JV)
Garabi interconnector (Argentina – Brazil)	HVDC	PPA	IPTC	Single Entity with country specific subsidiaries
Montana Alberta Tie Line (MATL)	HVAC	Market-Based	Merchant	Single Entity
SIEPAC	HVAC	PPA and market	IPTC	Single Entity

Figure 8: Snapshot of global coverage of CBET infrastructure considered for detailed case studies

Detailed case studies are prepared for each of these identified projects. The data collected for compilation of case studies includes technical specifications, project descriptions, operational data, financial information, funding sources, regulatory frameworks and policies governing cross-border transmission lines in the participating countries. Interconnection agreements, market mechanisms, and tariff structure were also analyzed. Financing models and mechanisms used to fund cross-border transmission projects, cost-recovery mechanisms, risk allocation, and so on were also analyzed in detail.

3.3 Case Studies From South-East Asia

3.3.1 Thailand-Cambodia Interconnection

The Thailand-Cambodia electricity interconnection is a 221 km long 115 kV HVAC transmission line, which is used to provide electricity supply from Thailand to Cambodia. The line is owned and operated by a private entity-Cambodia Power Transmission Lines (CPTL). This project was ADB's first cross-border private sector investment project in Asia.

In 2002, the governments of Cambodia and Thailand signed a power purchase agreement (PPA) that allowed Cambodia's Electricité du Cambodge (EDC) to import power from the Electricity Generating Authority of Thailand (EGAT) via a transmission line to Cambodia's Siem Reap, Battambang, and Banteay Meanchey provinces. The line was created to implement this PPA. On 29 April 2005, a 30-year build–operate–transfer (BOT) concession for the transmission network under a public–private partnership (PPP) was awarded to the entity CPTL.

Criteria	Details
1.Map	

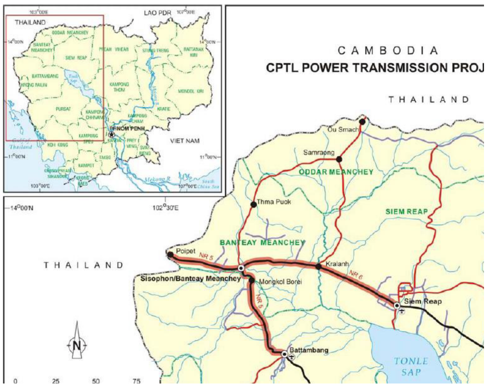


Figure 9 : Map of Thailand-Cambodia electricity interconnection Source: ADB [10]

Criteria	Details
2. Location	This interconnection connects Aranyaprathet, 15 KM from Thailand border to Bantey Meanchay, Siem Reap and Battambang in Cambodia.
3. Type	HVAC Transmission line
4. Physical attributes	This is a 221-kilometer long, 115 kilovolt, high-voltage AC interconnection with a total transmission capacity of 80 MW. 13 The CPTL project contains three elements: (i) 221 kilometers (km) of single-circuit, 115 kilovolt (kV) power transmission line; (ii) one 115 kV switching station; and (iii) three 115 kV/22 kV substations
5. Project cost	USD 33.5million
6. Project schedule	

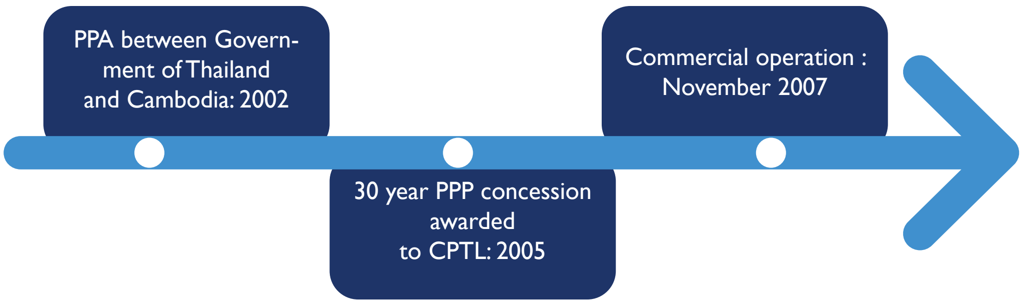
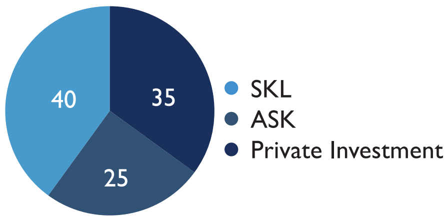


Figure 10 : Project schedule for CPTL line Source: ADB [11]

Criteria	Details
7. Operational date/ year	23 November 2007 [11]
8. Tenure of contract	The project is structured under a build–operate–transfer (BOT) scheme for a concession period of 30 years, after which the assets will be transferred to Electricité Du Cambodge (EDC), the state utility [14].

Criteria	Details
9. Purpose of the project (benefit to the region)	The CPTL project was undertaken in response to a significant shortfall in electricity supply in the northwest region of Cambodia and to provide reliable, cheaper, cleaner energy to end-users in Siem Reap, Battambang, and Banteay Meanchey provinces. Through this project, Cambodia aimed to reduce its reliance on expensive diesel-based power generation and use cheaper power from Thailand. The line and the PPA enabled EDC to import power from EGAT at wholesale rates (B3.083/kWh, equivalent to $0.098/kWh) and significantly cheaper than EDC's average purchase tariff from diesel and heavy fuel oil-based generation ($0.17/kWh), thereby enabling EDC to provide electricity in the three provinces at a lower price to end users, resulting in increased electrification of households and businesses [12].
10. Ownership Structure	Initially, two private companies - SKL and A.S.K created a special-purpose vehicle (SPV) - Cambodia Power Transmission Lines Co., Ltd. (CPTL). SKL took 40 percent direct ownership and A.S.K. took 25 percent to become CPTL's majority shareholders. Two individual investors also joined the company as minority shareholders - Se Thma Pich (20 percent direct ownership) and Tea Tyas (15 percent direct ownership).  Figure 11: Initial ownership structure of CPTL In 2010, Ms. Se Thma Pich purchased 100 percent of the shares held by the majority shareholders. The current ownership structure is as follows: Ms. Se Thma Pich owns 85 percent of CPTL, & Mr. Tea Tyas owns the remaining 15 percent [11].
11. Investment entities structuring	The project was originally to have been developed and built by a joint venture between EGAT and EDC. EGAT later passed on the opportunity to Electricity Generating Company, listed in Thailand and part owned by EGAT, but the company forwent the opportunity, possibly because of border conflicts and related tensions between the two countries. In late 2003, the Government of Cambodia entered into discussion with SKL Group, a local conglomerate, for the construction of the project. A.S.K. Co Ltd, a Cambodian company that is part of the SKL Group, later developed the project by forming CPTL as an SPV, and also entered into a power transmission agreement (PTA) with EDC. The project represents a negotiated transaction. A.S.K. subsequently novated the PTA to CPTL.
12. Auction	The developer of the line was identified by Government of Cambodia through negotiations with private entities within the country.

<table>
<tr><th>Criteria</th><th>Details</th></tr>
<tr><td>13. Investment Decision</td><td>Once the line was awarded to CPTL under a BOT model, CPTIL undertook investment decision even before financing arrangements were not fully in place.
To meet the deadline for the start of electricity transmission, financing transaction development and project construction were undertaken in parallel.
Construction began in January 2006, while ADB, who is the lead financier approved their initial loan only in June 2007. The line was commissioned in November 2007</td></tr>
<tr><td>14. Business and Financing model adopted</td><td>IPTC Model, with CPTL as the IPTC.

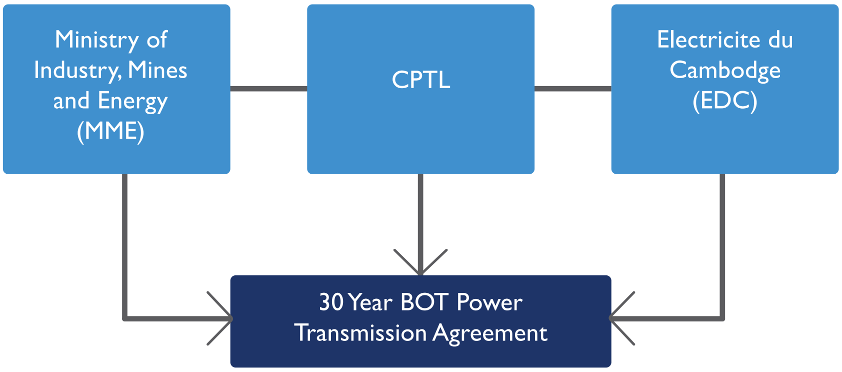


Figure 12: Parties to PTA for CPTL</td></tr>
<tr><td>15. Risk management and Risk allocation principles and mechanism</td><td>The PTA signed between EDC and ASK on 29 April 2005, committed EDC to pay a transmission charge calculated from the amount of energy received at the various delivery points. nder the PTA, it was envisaged that the project would transmit at least 100 gigawatt hours (GWh) of electricity yearly at the outset, and at least 360 GWh each year by the end of the PTA term in 2037. This agreement assured payments to CPTL from EDC.</td></tr>
<tr><td>16. Source of funding</td><td>Entire equity was arranged by private capital. For loans, while ADB contributed $8 million USD, rest of the funds were arranged through loans from the Export–Import Bank of Thailand and local Cambodian banks.

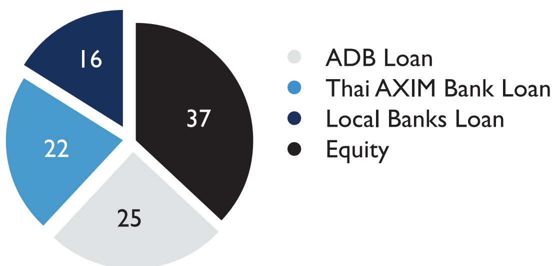


Figure 13: Source of funding for CPTL</td></tr>
<tr><td>17. Cost recovery</td><td>EDC pays a tariff to CPTL for the energy wheeled by it. While exact tariff is not available, ADB in its estimates for evaluation of the project had considered approximately 0.029 USD/kWh as the transmission service fees.</td></tr>
</table>

Criteria	Details
18. Financial information	This was the first private-owned transmission line in the country. It was partially financed by a 15-year term loan from an international consortium of lenders, which include Asian Development Bank (ADB), Export-Import Bank of Thailand, ARCO International and Foreign Trade Bank of Cambodia[15]. In February 2013, CPTL successfully refinanced its debt in the Cambodian local market and fully repaid its 2008 loans.
19. Modality of Development	The project was developed under BOT model[11].
20. Tariff & payment support	EDC pays a tariff to CPTL for the energy wheeled by it. While exact tariff is not available, ADB in its estimates for evaluation of the project had considered approximately 0.029 USD/kWh as the transmission service fees.
21. Payment Security Mechanism	Not known
22. Contractual Arrangements	A power purchase agreement (PPA) was signed in 2002 between the governments of Cambodia and Thailand. The PPA allowed Cambodia to import power from Thailand and to deliver it over a high-voltage transmission line to Cambodia's Siem Reap, Battambang, and Banteay Meanchey provinces.[11] A wheeling agreement was signed between EDC and CPTL, under which EDC provides wheeling service-related payments to CPTL. There was also a BOT Concession Agreement between EDC and CPTL. In addition, there were multiple agreements, as illustrated in following figure.

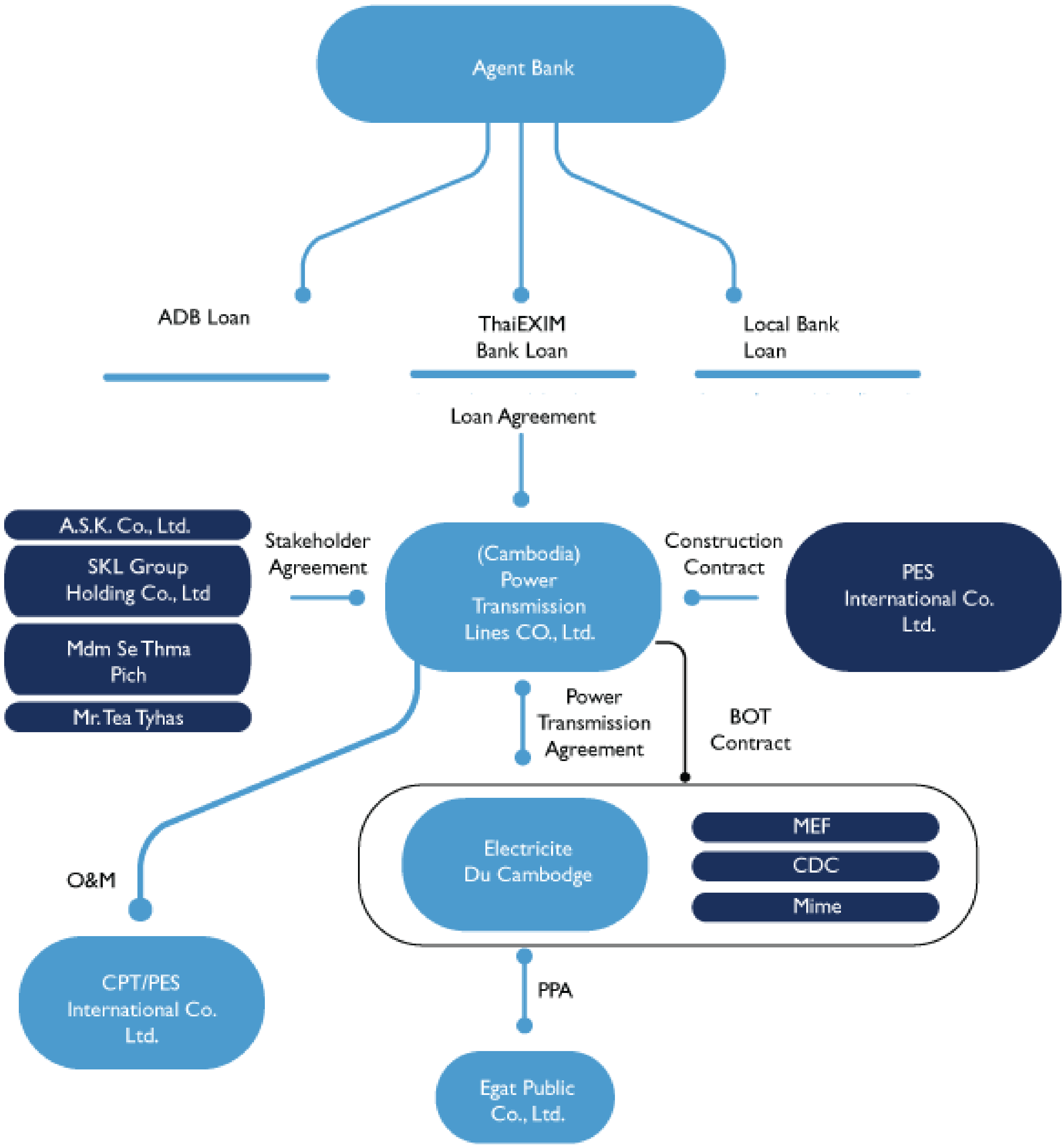


Figure 14: Contractual arrangements of CPTL

ADB = Asian Development Bank; BOT = build-operate-transfer; CDC = Council for the developmenet of Cambodia; CPTL = (Cambodia) Power Transmission Lines Co., Ltd; O&M = operation and maintenance; PPA = power purchase agreement; PTA = power transmission agreement; MEF = Ministry of Economy and Finance; MIME = Ministry ofindustry, mining and energy; ThaiEXIM Bank = Export-Import Bank of Thailand

Criteria	Details
23. Dispute Resolution	Not known
24. CostSharing Model	As the line is built by a private entity, there is no cost sharing between the countries.
25. Role of regional markets in project development	Nil
26. Associated strategic, policy, regulatory, legal, technical, commercial, operational framework	The line was built based on bilateral PPAs between Thailand and Cambodia and complying to laws and regulations of both countries.

27. Trade between the lines over the years

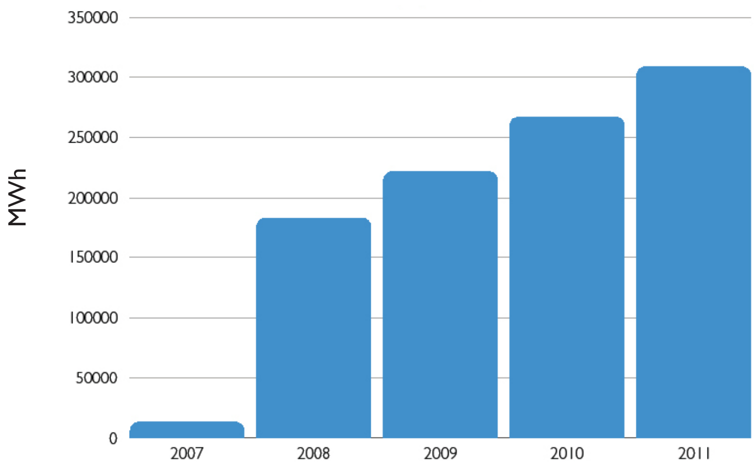


Figure 15: Energy trade between Thailand and Cambodia through CPTL

Source: ADB[11]

28. Challenges	The project was constructed primarily along the government-owned rights of way of national roads. However, small land areas had to be purchased for the substations, resulting in relocation at those areas. These plots were selected through expressions of interest and on a willingness-to-sell basis, compensation was paid, and affected households were relocated within their villages.

3.4 Case Studies From Africa

3.4.1 MOTORACO (Mozambque Transmission Company) Interconnection

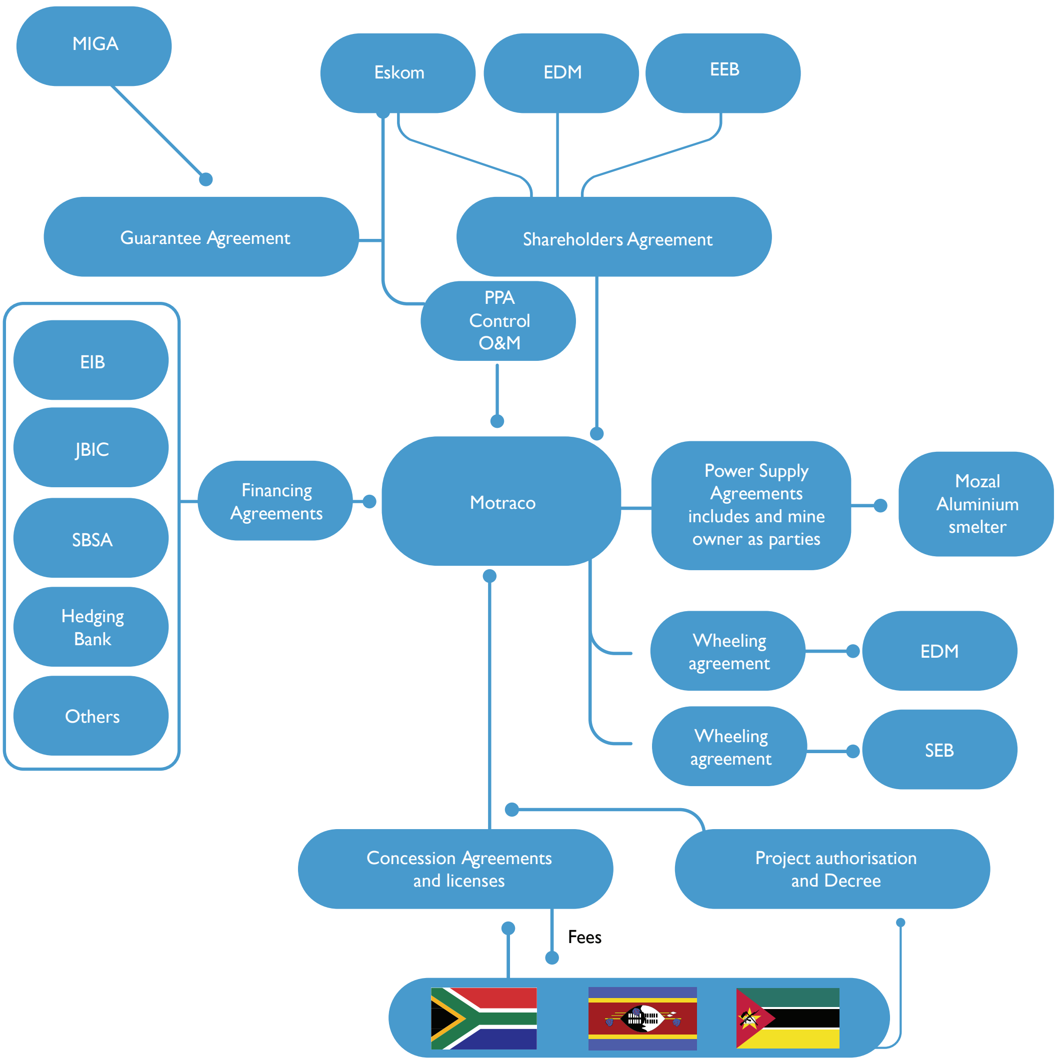
The Mozambique Transmission Company (MOTRACO) was founded in 1998 as a joint venture between the three electricity companies of Mozambique (Electricidade de Moçambique - EDM), South Africa (ESKOM) and Swaziland (Swaziland Electricity Company – SEC, currently Eswatini Electricity Company - EEC). The JV operates a 400 kV interconnection with a length of 565 KM, which connects South Africa (exporter), and Mozambique (importer) via Swaziland (now called Eswatini).

MOTRACO primarily facilitates purchase of energy from Eskom of South Africa, for sale to the Mozal aluminum smelter in Mozambique. MOTRACO also transports electricity from Eskom for EDM and EEC. The total infrastructure also consists of two 400 kV substations and transmission lines at 132 and 400 kV, owned, operated, and maintained by MOTRACO.

Criteria	Details
1. Map	 Figure 16 : MOTRACO Interconnector
2. Location	This interconnector connects South Africa (exporter), and Mozambique (importer) via Swaziland. [16]
3. Type	Overhead AC transmission lines. [17]
4. Physical attributes	This interconnector has 2 lines of 400 kV with a length of 565 km. Each line has a capacity of 1340 MW.[16]
5.Project cost	This information is not available currently.

Criteria	Details
6. Project schedule	1992 August: The SADC Treaty is signed; 1992 October: End of civil war in Mozambique; 1995 August: SADC sign Inter-Governmental MOU (IGMOU) that results in the establishment Southern African Power Pool (SAPP); 1997 January: Governments of Mozambique and South Africa signed an IGMOU for the development of hydro-electric potential and high-voltage transmission lines in Mozambique; 1997 March: Government of Mozambique and Alusaf (one of the largest aluminium producers in the world) sign a Memorandum of Understanding for the establishment of an aluminium plant in Mozambique - Mozambique Aluminium (Mozal); 1997 June: Electricity tariff for the Mozal was agreed. However, the power supply to Mozal could not be carried out by Eskom (legislation problems) or EDM (supply constraints). A company with special purposes had to be created to solve this problem; 1998 March: Government of Mozambique approved the MOTRACO project with some tax benefits; 1998 October: MOTRACO is incorporated with three shareholders EDM, Eskom and SEC, each maintaining an equal share in the Joint Venture. [16]
7. Operational date/ year	The first phase of the project was completed in mid-2000.
8. Tenure of contract	25 years
9. Purpose of the project (benefit to the region)	The main purpose of the project was to supply the Mozal aluminium smelting plant near Maputo in Mozambique, with a reliable electrical power supply. In addition, the project provides electrical power to Mozambique's southern electricity grid serving the Maputo region. The project also provides major re-enforcement of the transmission infrastructure for the supply of electrical power. [17]
10. Ownership Structure	MOTRACO is a regional joint-venture company established in Mozambique to implement, own and operate the project. MOTRACO is owned (one-third each) by the national power utility companies of the three countries concerned: Eskom (South Africa), Swaziland Electricity Company (SEC) and Electricidade de Moçambique (EdM).
11. Investment entities structuring	A joint venture between the three electricity companies of Mozambique (Electricidade de Moçambique - EDM), South Africa (ESKOM) and Swaziland (Swaziland Electricity Company - SEC) with equal ownership share. [17]
12.Capacity allocation and auction mechanisms	Full capacity booked and paid for by MOZAL Aluminium Plant
13. Investment Decision	The investment decision was jointly taken and agreed between two governments. In January 1997, the Governments of Mozambique and South Africa signed an IGMOU for the development of hydro-electric potential and high-voltage transmission lines in Mozambique. [16]
14. Business and Financing model adopted	Along with equity by the JV partners, the project also received funding and grants from the European Investment Bank, the Japan Bank of International Cooperation and the French development agency – AFD. [18]

Criteria	Details
15. Risk management and Risk W allocation principles and mechanism	MIGA issued guarantees to Eskom to cover loan guarantees to the European Investment Bank and the Japan Bank of International Cooperation for their investments in MOTRACO to cover the investment against the risks of expropriation, war and civil disturbance.[18] MOTRACO also signed currency swap agreements with Rand merchant bank and invested in Mauritius to prevent currency volatility.
16. Source of funding	Mix of equity, loan and grant financing. EEC has received equity financing loan from European Investment Bank with a 20-year tenure.
17. Cost recovery	The "anchor" customer was the Mozal aluminium smelter plant, 20 km outside Maputo. The aluminium plant had significant electricity demand and was willing to pay MOTRACO a wheeling charge for the reliable energy it received. The aluminium plant also paid the cost of electricity purchased from ESKOM. The fixed portion of the wheeling charges relating to the energy transmission covered debt service and operational expenditure of MOTRACO. EDM and EEC also have independent wheeling contracts with MOTRACO.[18]
18. Financial information	This information is not available currently.
19. Modality of Development	MOTRACO, a joint venture was established to develop, own and operate the project. [17]
20. Tariff & payment support	Tariff is Determined through process specified in transmission agreements. The prices to be charged by MOTRACO and to be paid by the users for electricity wheeled consists of fixed and variable charge for wheeling, variable charge for emergency wheeling, surcharge and reactive power rates
21. Payment Security Mechanism	In terms of an electricity wheeling agreement between MOTRACO and Swaziland Electricity Company, the Company pledged shares to the value of US$ 2 million to MOTRACO as security that the electricity wheeling service at Edwaleni II substation will not discontinue.

Criteria	Details
	IGMOU between the Governments of Mozambique and South Africa for the development of hydro-electric potential and high-voltage transmission lines in Mozambique. The Government of Mozambique, the Government of South Africa and the Government of Swaziland had concession contracts mutually for: • Construction and ownership of transmission facilities, • Import of energy for direct sales to Mozal, • Transportation of energy on behalf of EDM, Eskom and SEC, and • Establishment of an optic fiber network on its transmission lines to ensure the reliabilit of power supply to Mozal. There are also wheeling agreements between MOTRACO, SEC/EEC and EDM (separate agreements); and power sale agreement between ESKOM and MOZAL.
22. Contractual Arrangements	 Figure 17 :Agreements under MOTRACO transmission project Source: MOTRACO[18]
23. Dispute Resolution	Covered under overall SAPP framework and arbitration provisions of respective contracts.
24. Cost Sharing Model	Equal equity sharing between three countries.

Criteria	Details
25. Role of regional markets in project development	The transmission infrastructure has helped lower the cost of energy and increase its availability, as well as to increase the reliability and security of interconnected systems in the region. By becoming active trading partners in the SAPP, South Africa and Mozambique have benefited from low-cost power purchase in the SAPP market. [18]
26. Associated strategic, policy, regulatory, legal, technical, commercial, operational framework	Utilizes commercially negotiated contracts under the umbrella of IGMOU, and the overall SAPP framework
27. Trade statistics	8220 GWh in FY2019 [19]
28. Challenges	Demand Risks were tackled by having an initial anchor customer - Mozal aluminium smelter plant.[18] Initially, the power supply to Mozal could not be carried out by Eskom due to legislation problems or EDM due to underflow.[16]

3.4.2 Ethiopia-Kenya Power Interconnection

This is a 500 kV HVDC interconnection between Ethiopia and Kenya which originates from Welayta Sodo in Ethiopia and terminate at Suswa in Kenya. The line enables export of power from Ethiopia to Kenya.

Criteria	Details
1. Map	

Figure 18 : Ethiopia- Kenya interconnector   Source: Kenya Electricity Transmission Company[20]

2. Location	This Interconnection between Ethiopia and Kenya originates from Welayta Sodo in Ethiopia and terminates at Suswa in Kenya.[20]
3. Type	500 kV HVDC Overhead transmission line. [21]

Criteria	Details
4. Physical attributes	The network includes a HVDC overhead transmission line which originates at Welayta Sodo in Ethiopia and terminates at Suswa in Kenya. The total length of the interconnector is 1045 km covering 433 km in Ethiopia and 612 km in Kenya. The line voltage is 500kV and it has a transmission capacity of 2000 MW. [21]
5. Project cost	USD 1262.50 Million[22]
6. Project schedule	 Figure 19 : Project timeline[23]
7. Operational date/ year	Nov 17, 2022[24]
8. Tenure of contract	25 years
9. Purpose of the project (benefit to the region)	The project aims at improving the supply of electricity in Kenya and other Eastern Africa Power Pool (EAPP) countries in the long run by exporting power from Ethiopia. Ethiopia will benefit through the sale of energy to Kenya, which faces severe power shortages. [25]
10. Ownership Structure	The Kenya Electricity Transmission company (KETRACO) owns the interconnection assets in Kenya. The company, created in 2008, is owned by the Government of Kenya (GoK). On the Ethiopian side, Ethiopian Electric Power Corporation (EEPCo) will own the interconnection assets. EEPCo is a vertically integrated company that generates and distributes majority of the electricity in Ethiopia and develops and operates the national transmission system.[22]
11. Investment entities structuring	Directly owned by respective transmission utilities in either side of border.
12. Auction	Capacity allocated under bilateral PPAs
13. Investment Decision	Made jointly by the Governments
14. Business and Financing model adopted	The lines are owned by respective government owned transmission utilities in either side of border, and commercial viability is ensured through a 25-year PPA using the line, for trade of firm and non-firm power. A PPA price of US$0.07 per kWh has been fixed. [22]

Criteria	Details
15. Risk management and Risk allocation principles and mechanism	Civil societies and NGOs have voiced their concerns about the impacts of the project. The Joint Project Coordination Unit (JPCU) for the Project has developed a communication strategy to raise awareness on the regional significance and the benefits of the Project and assuage the concerns of these organizations. The line is over 1,000 km long, traversing difficult and conflict-prone terrains, which may delay construction. Hence, KETRACO has allocated 4 million USD for project management, security and supervision purposes. [22]
16. Source of funding	Table 9: Financing details for Ethiopia-Kenya Interconnector (see below); Figure 20 (see below); The borrowing agencies for this project are Federal Democratic Republic of Ethiopia and Republic of Kenya

Table 9: Financing details for Ethiopia-Kenya Interconnector

Sources	Amount (USD)	Instrument
African Development Fund	338 million	Loan
World Bank	684 million	Loan
French Development Agency	118 million	Loan
Government of Kenya	88 million	Equity
Government of Ethiopia	32 million	Equity
Total Financing	1,260 million	

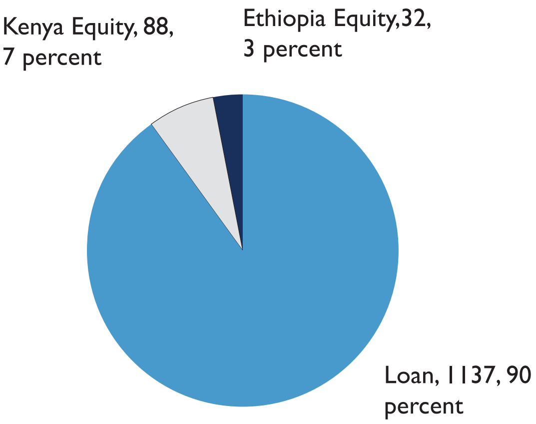


Figure 20: Financing for Ethiopia- Kenya interconnector

Sources: African Energy Portal [23, 26]

The borrowing agencies for this project are Federal Democratic Republic of Ethiopia and Republic of Kenya

Criteria	Details
17. Cost recovery	Transmission revenue stream is currently not known.
18. Financial information	Not known.
19. Modality of Development	Developed by respective countries in their territories through their transmission utilities.

Criteria	Details
20. Tariff & payment support	EEPCo and KETRACO signed a 25-year PPA for the Project at a cost of US$0.07 per kWh for electricity traded up to 400 MW. This price has been fixed for the entire duration of the PPA with no indexation. Kenya Power and Lighting corporation (KPLC) has entered into a transmission ("wheeling") agreement with KETRACO for the use of the interconnector. [22]
21. Payment Security Mechanism	Not known.
22. Contractual Arrangements	PPA and Wheeling Agreements.
23. Dispute Resolution	A Project Implementation Manual includes clear guidelines on dispute resolution in case EEPCo and KETRACO disagree on procurement matters. [22]
24. Cost Sharing Model	Not known.
25. Role of regional markets in project development	The project is developed under the umbrella of East Africa Power Pool (EAPP). EAPP is the regional institution for coordinating and advancing the vision of regional power systems' integration. EAPP was created in February 2005 through the signing of an Inter-Governmental Memorandum of Understanding (MoU) by Ministers of Energy of Burundi, DRC, Egypt, Ethiopia, Kenya, Rwanda, and Sudan. [22]
26. Associated strategic, policy, regulatory, legal, technical, commercial, operational framework	Project is covered under the respective national frameworks and under EAPP.
27. Trade between the lines over the years	Not known.
28. Challenges	The project has been delayed due to environmental and funding issues. HVDC technology, although proven, is new to Ethiopia and Kenya. Hence, KETRACO has entered into an agreement with Power Grid of India which includes capacity building on HVDC technology and operations. Ethiopia is subject to cyclical droughts, which may impact hydro production.

3.5 Case Studies From Middle East And Arab Regions

3.5.1 Gulf Cooperation Council Interconnection Authority (GCCIA)

In 1981, the six gulf states came together to sign the GCC charter. In the charter, one of the objectives was: "To effect co-ordination, integration and inter-connection between member states in all fields in order to achieve unity between them."[27]

The decision to go ahead with an electricity interconnection was communicated in the 18th session of GCC Supreme Council, held in December 1997:

> "*Emphasizing the need to tie and coordinate the economic interests of member states in the area of infrastructure projects, the supreme Council directed to start the implementation of the first stage of the electric network project. The Council agreed that the project will be owned and operated by an independent authority run on a commercial basis.*" [28]

The GCC interconnection consists of a 400 kV transmission backbone, connecting the GCC states of Bahrain, Kuwait, Oman, Saudi Arabia, Qatar and United Arab Emirates. The interconnection is operated by GCC Interconnection Authority (GCCIA), a joint stock company, subscribed by the six member states. The operations of GCC commenced in 2009-2010.

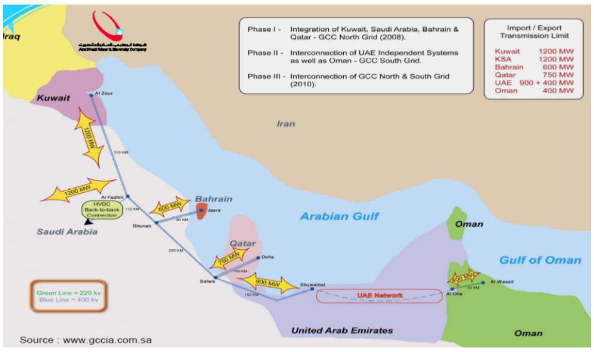
<table>
<tr><th>Criteria</th><th>Details</th></tr>
<tr><td>1. Map</td><td>


Figure 21 : GCC interconnection [29]
</td></tr>
<tr><td>2. Location</td><td>The Interconnection passes through Kuwait, Saudi Arabia, Bahrain, Qatar, United Arab Emirates (UAE) and Oman. [29]</td></tr>
<tr><td>3. Type</td><td>Phase I of the project includes a 400 kV overhead transmission line from Kuwait through Saudi Arabia to Qatar along with a 400 kV submarine cable link to Bahrain. It also includes a 380 kV, 60 Hz back to-back HVDC transmission line to connect this 50 Hz grid with the 60 Hz Saudi Arabian system.

Phase II of the project comprised of the internal integration of isolated networks of the various emirates of the UAE into a national grid and a 220 kV line between Al-Waseet in Oman and Al-Ain in the UAE to form the GCC South Grid. The 220 kV UAE to Oman interconnection was completed in 2006.

Phase III interconnected the northern and southern GCC systems. This includes a double circuit 400 kV line from Salwa (Saudi Arabia) to Ghuwaifat (the UAE) and associated substations. It will also include a double and a single circuit 220 kV line from Al Ouhah (the UAE) to Al Wasset (Oman) and associated substations. [29]</td></tr>
</table>

Criteria	Details
4. Physical attributes	The GCCIA has commissioned a 400 kV grid that connects the electrical power networks of the GCC countries. The 400 kV double circuit transmission line's route length is 900 km. Capacities of the linkages are 1200 MW for Kuwait, Qatar, and Saudi Arabia and 600 MW for Bahrain. The Interconnector backbone does not physically run through the UAE to connect Oman to the system. Instead, the UAE's national grid acts as a bridge to Oman's national grid. [31]
5. Project cost	Phase 1 - US $1.1 billion[32] Phase 2 - US $300 million Phase 3 - US $137 million
6. Project schedule	1981: Gulf Cooperation Council (GCC) electricity interconnection scheme was conceived 1999: GCCIA was established 2001: GCC Countries agreed to establish the GCC Interconnection Authority for the purpose of interlinking the power systems of the GCC Countries 2002: The Authority marked itself in history by initiating its business through employment of staff, and the hiring of a consultant to conduct the tendering of the project. 2003: Project technical, economic and financial feasibility updated 2005: Project execution begins 2009: GCCIA begins operations 2010: First cross-border trade occurs

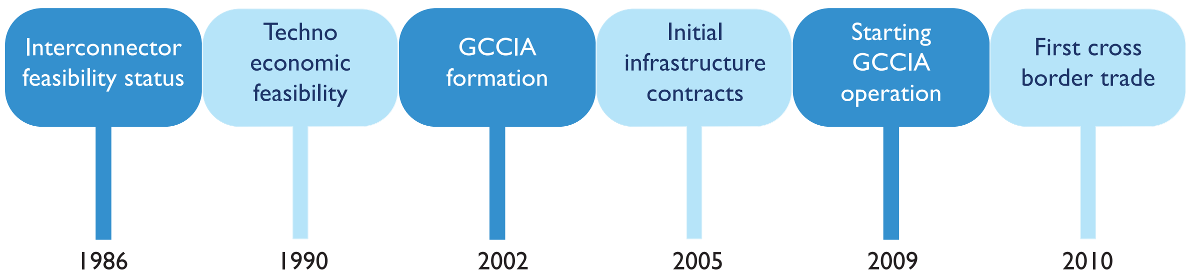


Figure 22 : Project timeline[33]

Criteria	Details
7.Operational date/ year	Commissioned in phases from 2009 to 2010.[29]
8.Tenure of contract	No specific tenure has been defined as there is no concession agreement as such.
9. Purpose of the project (benefit to the region)	The primary objective of the Authority is to provide power, operate, and maintain Grids of the six GCC Countries. The aim is also to become a major player in the Regional Electricity Trading Market[32]. This interconnection enables electrical energy exchange and emergency support among these countries. Physical infrastructure between countries consists of 50 Hz AC interconnection between Kuwait, Bahrain, Qatar, the UAE, and Oman with a back-to-back High Voltage Direct Current (HVDC) interconnection to the 60 Hz Saudi Arabian system.
10. Ownership Structure	The Gulf Cooperation Council Interconnection Authority (GCCIA) is a joint stock company subscribed by the six Gulf States. It has an authorized share capital of USD 1.1 billion. The GCC countries agreed to establish the GCCIA for the purpose of interlinking the power systems of its countries. It is owned by the electricity companies in the six GCC countries of Bahrain, Kingdom of Saudi Arabia (KSA), Kuwait, Qatar, the UAE, and Oman.[32]

Criteria	Details
11. Investment entities structuring	Joint stock company
12. Auction	GCCIA has proposed that net interconnector capacity should be auctioned by the Authority for different timescales. Installed capacity interconnector rights would be auctioned for annual contracts. Interconnector rights for operations would be auctioned for annual, monthly or daily contracts. Secondary trading of rights would also be permitted[29].
13. Investment Decision	The GCC Countries agreed to establish the GCC Interconnection Authority for the purpose of interlinking the power systems of the GCC Countries. As a result, a Royal decree no. M/21 dated July 28, 2001, has been declared to establish the Authority with its official domicile in Dammam, Kingdom of Saudi Arabia[30].
14. Business and Financing model adopted	The member countries decided to self-finance the GCCIA project, by sharing the costs in proportion to the present value of reserve capacity savings, that is, savings.
15. Risk management and Risk allocation principles and mechanism	Not known

16. Source of funding

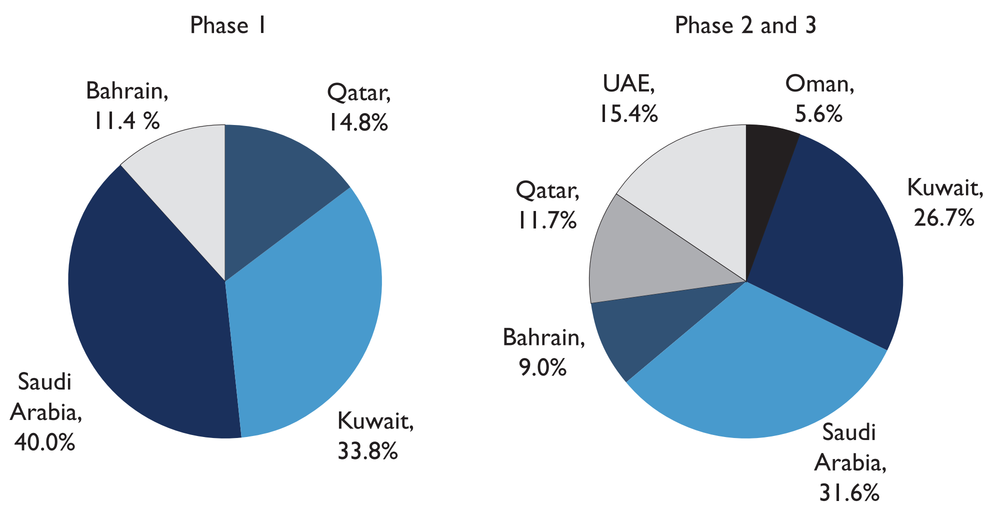


Figure 23: Cost Sharing of the GCC Interconnection[34]

17. Cost recovery	For energy trade transactions, a transmission tariff has been decided by GCCIA.
18. Financial information	The project is financed with funds from the member countries. The capital cost for the three phases were estimated to be – US $1.10 billion, US $300 million, and US $137 million respectively. GCC countries share the cost in proportion to the net present value of estimated reserve savings capacity. Each member country is responsible for arranging their share of the capital required (can be a combination of debt or equity as decided by the member country).

Criteria	Details
19. Modality of Development	IPTC Model, as a Joint Stock Company which is a JV of states
20. Tariff & payment support	The utilization rate of the cross-border transmission interconnection capacity developed by the GCCIA has been less than 5 percent. In order to incentivize power trading, the GCCIA waived carriage charges for using its interconnectors during 2016-2018. It reinstated a nominal charge in 2019 of US $0.5 per mega watthour (MWh), a 90 percent discount off the previous rate of US $5/MWh established in 2010.
21. Payment Security Mechanism	Not known.
22. Contractual Arrangements	Two key legal agreements exist for the interconnection - Power Exchange and Trading Agreement (PETA) and Interconnector Transmission Code (TC). PETA is responsible for energy exchanges, cross-border operative reserve arrangement. The Transmission code (TC) deals with the "Technical Code" for the 400 kV Gulf Interconnector.[33] Power Exchange and Trading Agreement (PETA) - the parties referred to in the PETA are the GCCIA, six Transmission System Operators (TSOs) and the two procurement parties (Abu Dhabi Water and Electric Company) and Oman Power and Water Procurement Company). It governs the terms and conditions, connectivity and usage, technical and commercial rules of the electricity trade. It consists of the following three main components - • Trading Agreement: sets out the terms on which the parties may use the interconnector for scheduling transfers of energy and power; • Interconnection and Use of System Agreement: sets out the terms on which the parties will connect to / have access to the interconnector; • Transmission Code: sets out the detailed technical rules that govern connection to access to the interconnector where the interconnection and use of system agreement requires each party to comply with the Interconnector Transmission Code.
23. Dispute Resolution	The basic reconciliation of regulatory, technical and operational gets handled at the level of basic agreements and documents of GCCIA, such as the General Agreement, PETA, Market Procedures and the Exchange Market Terms and Conditions. In the creation of market rules, the inputs of various committees with representation from member countries play a key role, thereby facilitating a collaborative approach. In key matters such as transmission pricing, the role of 'Advisory and Regulatory Committee' is also crucial. Further, in case of substantial matters of disagreement, or need for a higher level of dispute resolution, the matter can be taken to the GCC Supreme Council, consisting of heads of state of the GCC member countries.
24. Role of regional markets in project development	The line was primarily developed for sharing of reserves and comes under the overall GCC framework.

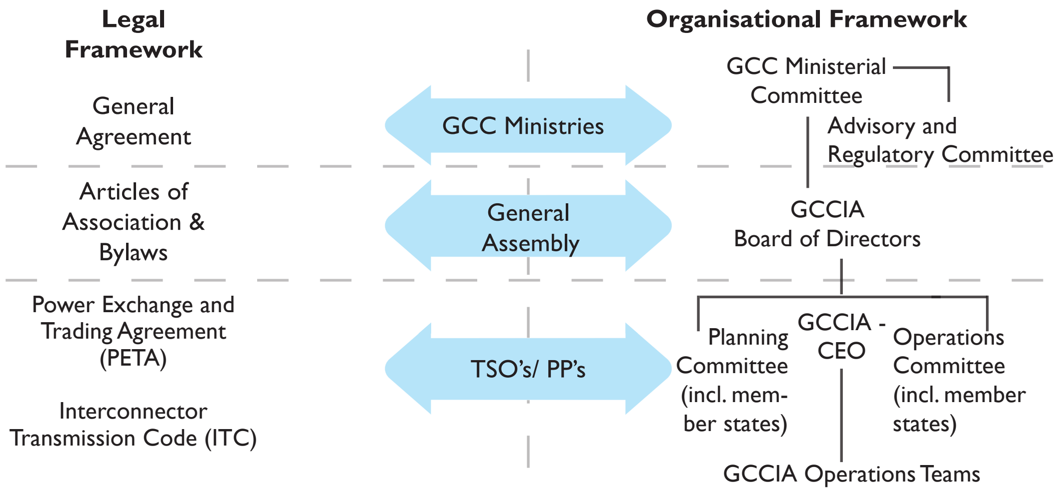
<table>
<tr><th>Criteria</th><th>Details</th></tr>
<tr><td>25. Associated strategic, policy, regulatory, legal, technical, commercial, operational framework</td><td>

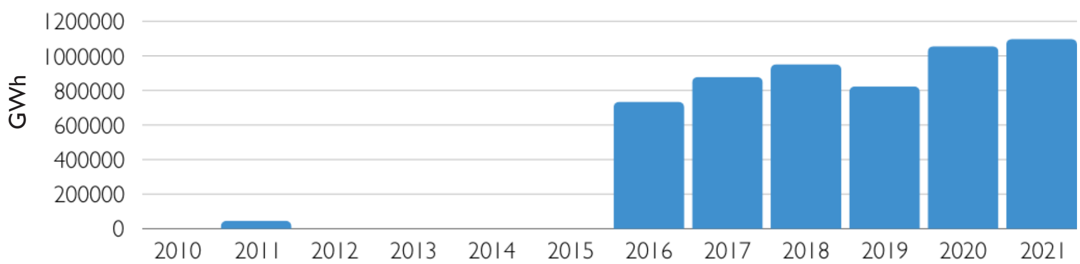
Figure 24 : Policy and regulatory framework for GCCIA [33]</td></tr>
<tr><td>26. Trade between the lines over the years</td><td>

Figure 25: GCCIA trade trends[35]</td></tr>
<tr><td>27. Challenges</td><td>The scheduled power trading was not significant in the initial years of GCCIA, and detailed procedures for market trading were also not available. Therefore, a pilot of trading of power commenced in 2015, to demonstrate the feasibility, and available options. The pilot project in 2015 resulted in one contract between two member states. Based on this experience, the project was further extended and expanded in the future years.</td></tr>
</table>

3.5.2 Egypt Sudan Interconnector

<table>
<tr><th>Criteria</th><th>Details</th></tr>
<tr><td>1. Map</td><td>

Figure 26 : Egypt-Sudan Interconnector [36]</td></tr>
</table>

Criteria	Details
2. Location	The interconnection originates from Toshka in Egypt and terminates at Dongla in Sudan.
3. Type	220 kV HVAC overhead transmission line. [37]
4. Physical attributes	The interconnection has a total length of 170 kms with 100 km in then Egypt region and 70 km in Sudan. The interconnector has a line voltage of 220 kV HVAC, and a transmission capacity of 50 MW (trial operation). Completion of the full synchronous interconnection is planned to transmit a capacity of 240 MW by the end of 2020 after installing the power compensator devices for the Sudanese side power stations[38,39,40].
5. Project cost	Cost (Egypt Section): US $568 million (CAPEX), $61 million (Preparation)[38] Cost (Sudan Section): US $128 million (CAPEX)[41]

6. Project schedule

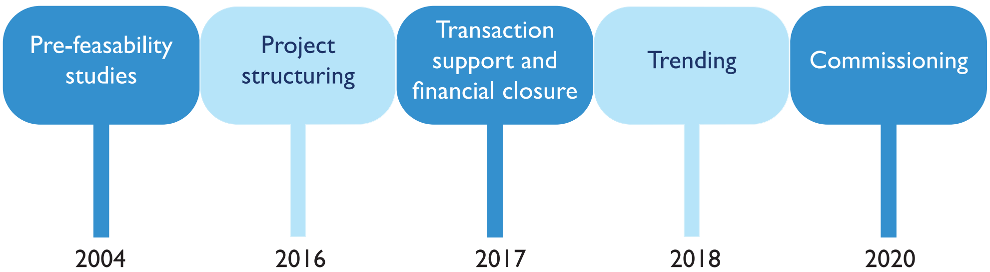


Figure 27 : Project timeline for Egypt-Sudan interconnector [38]

Criteria	Details
7. Operational date/ year	April 2020[42]
8. Tenure of contract	Not known
9. Purpose of the project (benefit to the region)	To promote energy connectivity among the countries by assisting them to integrate their respective networks and thereby develop ability for building larger power projects to meet larger regional markets. To reduce the cost of power in both countries. To create productive employment and economic development across the borders.[38]
10. Ownership Structure	Owned by respective country's transmission utilities within their border.
11. Investment entities structuring	Funding is arranged by African Development Fund (AFDB) and implementing by Eastern Nile Technical Regional Office (ENTRO).[43] ENTRO comes under Nile Basin Initiative, a partnership among the Nile riparian states.
12. Auction	Entire capacity allocated under PPA.
13. Investment Decision	Agreement between two countries
14. Business and Financing model adopted	Public/Government owned model

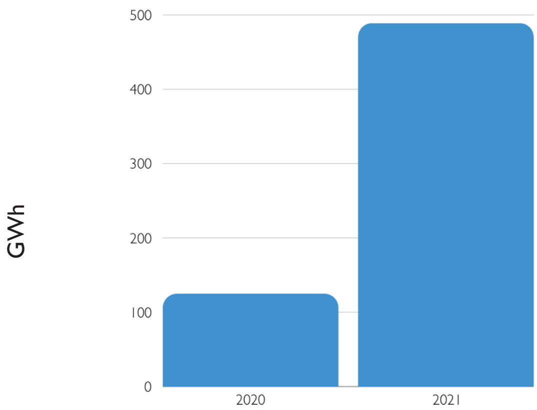
Criteria	Details
15. Modality of Development	Public/Government owned model
16. Role of regional markets in project development	The following entities had a key role in development of the line: • Common Market for Eastern and Southern Africa (COMESA) - Regional Coordinator • Nile Basin Initiative (NBI) - Sectoral Organization • Sudan Ministry of Water Resources, Irrigation and Electricity (MWRIE) and Egyptian Electricity Holding Company (EEHC) - Lead National Agency • Comité Maghrébin de l'Electricité (COMELEC) - Sectoral Organization
17. Trade between the lines over the years	

Figure 28 : Energy trade using Egypt-Sudan Interconnector[42,44]

3.6 Case Studies From American Continent

3.6.1 SIEPAC (Central American Electrical Interconnection System)

Sistema de Interconnexion Eléctrica para los Países de América Central (SIEPAC), popularly known as the Central American Interconnection, is a high voltage regional transmission network, which connects six Central American countries – Guatemala, El Salvador, Honduras, Costa Rica, Nicaragua and Panama. The 230 kV interconnection, with a length of 1790 KM, was commissioned in stages, between November 2010 and October 2014[45]. The interconnection facilitates the operation of Regional Energy Market (MER) among the member countries.

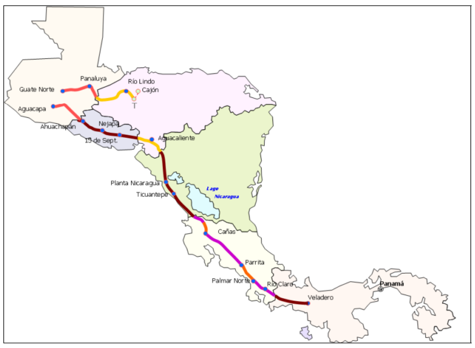
Criteria	Details
1. Map	

Figure 29 : SIEPAC Interconnector[46]

Criteria	Details
2. Location	SIEPAC network is an interconnection of the power grids of 6 Central American nations – Panama, Costa Rica, Honduras, Nicaragua, El Salvador, and Guatemala. [47]
3. Type	Overhead transmission line with fiber optic cable
4. Physical attributes	SIEPAC network includes transmission line length of 1,790 km and transmission Voltage of 230 kV with transmission capacity of 300 MW
5. Project cost	US $505 million[48].

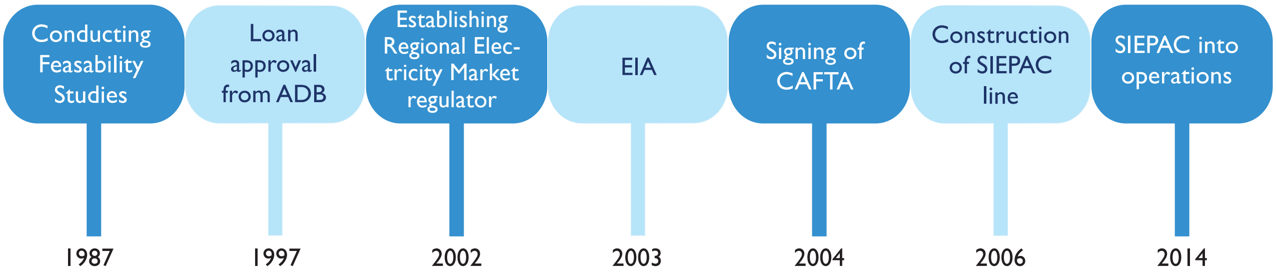


Figure 30: Project timeline of SIEPAC Interconnector

6. Project schedule	1987: Concept of a regional market was first envisaged. A feasibility study was conducted. (IADB funded). 1989: Central American Electrification Council (CEAC) was established as a forum for discussion and coordination among the utilities in the region. 1997: IADB approved a loan for construction and technical assistance to CEAC. 2000: Regional electricity market regulator was established: CRIE - (Comisión Regional de Interconexión Eléctrica 2001: Regional electricity system and market operator was established. (EOR - Ente Operador Regional) Plan Puebla-Panama (PPP) was established as a presidential-level forum for advancing integration in the region. 2002: The regional electricity market (MER) began operating under a transition code in 2002 and moved to an updated code in 2005. The design and concept studies for MER were carried out from 1999 to 2001 2003: Environmental impact assessments for the SIEPAC line completed. 2004: Central American Free Trade Agreement (CAFTA) was signed 2006: Construction of the SIEPAC transmission line begins. 2008: Initially planned completion deadline for SIEPAC network missed. 2014: SIEPAC line completed.
7. Operational date/ year	Commissioned in stages, between November 2010 and October 2014
8. Tenure of contract	SIEPAC was formalized in an intergovernmental framework agreement, known as the Marco Treaty. This agreement is fundamental to the project and provides the legal foundation on which the regional market and the supporting institutional and physical infrastructure are being built. The Marco Treaty requires each government to grant a thirty-year concession across its territory to the transmission line company (EPR).[49]
9. Purpose of the project (benefit to the region)	• Create a competitive & integrated energy market & attract private investment. • Alleviate periodic power shortages in the region. • Reduce operating costs, optimize shared use of hydroelectric power.

Criteria	Details
10. Ownership Structure	SIEPAC transmission project is owned by the Regional Operations Entity La Empresa Propietaria de la Red (EPR), created in 1999 with registration in Panama, and comprising various public utilities and transmission companies as shareholders. It is a public-private joint venture between the governments of the six countries (through their state-owned transmission utilities), one private sector company (Endesa of Spain), and the major transmission owners from Mexico and Colombia[50]. The transmission companies of the six participating countries have 75 percent share and private capital have another 25 percent.
11. Investment entities structuring	SIEPAC transmission line owned by SPV (EPR), which is a public-private partnership. All the countries have equal equity ownership.
12. Capacity allocation and auction mechanisms	As per REMR, the approved market agents will have open access to the regional transmission line. EOR will determine the 'Operational Transmission Capacity' of regional transmission line, based on evaluation of respective national system/market operators, and its own evaluation of various operating scenarios. SIEPAC uses the concept of "Transmission Right" which gives the holder of the same, the right to use the network. The EOR will organize monthly auctions for these transmission rights, for monthly and annual validity periods. The auctions will specify the available capacity for auctions, after considering existing committed transmission rights, and scheduled maintenance. On a monthly basis, EOR publishes the maximum transmission capacity between each of the corridors. If there is a need to modify the awarded transmission rights, due to any changes in network capacity, the entities who hold the rights are offered a reduced transmission right. For those entities who do not agree for such reductions, for the corresponding capacity, a new auction will be conducted. For more near term, and real time congestions, EOR calculates congestion rent for the transactions, through a nodal pricing mechanism.
13. Investment Decision	In December 1996, the presidents of six Central American countries signed an intergovernmental treaty, named the "Marco treaty for Central American Electricity Market". In the treaty, the countries agreed to establish the conditions of growth of a regional electricity market (MER), and to promote the necessary interconnection infrastructure for such market. The treaty specified the creation of following entities: • Comisión Regional de Interconexión Eléctrica (CRIE) as the regulator for regional electricity market; • Ente Operador Regional (EOR) as the transmission system operator for the SIEPAC interconnection; and • Empresa Propietaria de la Red (EPR) to develop, design, finance, construct and maintain the SIEPAC interconnection. The treaty was further detailed through two protocols (1997 and 2007) which were also signed between the external affairs ministers of the Central American countries.
14. Business and Financing model adopted	Total cost of the line amounted US $505 million covered by the six Central American countries and the three external shareholders. Financing for the project was mainly provided by the Inter-American Development Bank (IADB) [Source of funding further explained below].

Criteria	Details
15. Risk management and Risk allocation principles and mechanism	Not known
16. Source of funding	

Table 10: Financing structure of SIEPAC Interconnection

Institution	Equity, development bank loans (USD Mn)	Percent Share
IADB	253.5	50.2 percent
BCIE (BEI)`	109	21.6 percent
CAF	15	3.0 percent
Bancomext	44.5	8.8 percent
Banco Davivienda	11	2.2 percent
Other	13.5	2.7 percent
Equity	58.5	11.6 percent
Total	**505.0**	**100 percent**

Figure 31: Financing structure of SIEPAC Interconnection

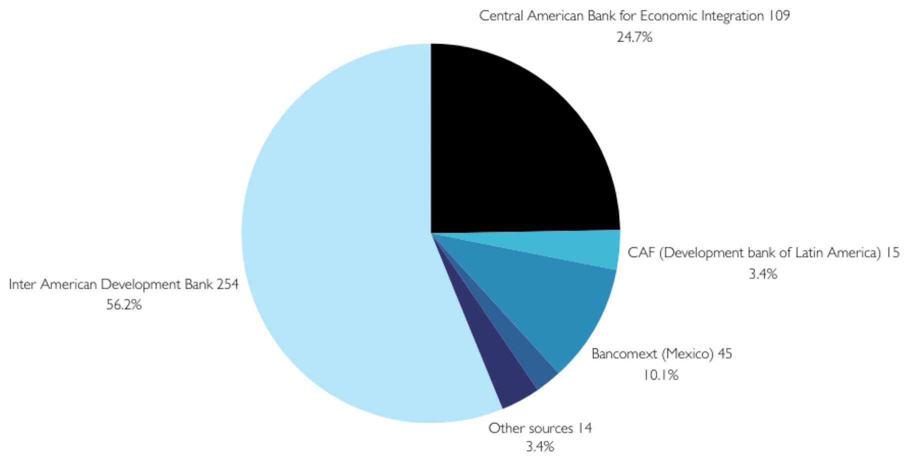


Table 11: Breakup of Equity (as on 2014) for SIEPAC Interconnection[52]

Entity name	Country	Equity share capital
INDE	Guatemala	11.11 percent
CEL	El Salvador	11.06 percent
ETESAL	El Salvador	0.05 percent
ENEE	Honduras	11.11 percent
ENATREL	Nicaragua	11.11 percent
ICE	Costa Rica	10.36 percent
CNFL	Costa Rica	0.75 percent
ETESA	Panamá	11.11 percent
ENDESA	España	11.11 percent
ISA	Colombia	11.11 percent
CFE	México	11.11 percent
Total		**100 percent**

<table>
<tr><th>Criteria</th><th>Details</th></tr>
<tr><td>17.
Cost recovery</td><td>Users of the line pay regional transmission rates, which consist of Variable Transmission Charge (CVT), the Toll and the Supplementary Charge, which are determined by the regulator CRIE [explained further in Tariff].

However, revenue is received by EPR as an annuity determined by CRIE. The regulation ensures an annuity provided to the company, that ensures income for: Administration, Operation and Maintenance – Debt Service – Taxes – Profitability on equity – VEI quality regime. For example, a sample calculation is provided below.

Table 12: Illustration of annual charges for transmission for EPR
<table>
<tr><th>Category</th><th>Amount [in US dollar, million]</th></tr>
<tr><td>Annual O&M</td><td>16.9</td></tr>
<tr><td>Debt Service</td><td>32.1</td></tr>
<tr><td>Return on equity</td><td>8.2</td></tr>
<tr><td>Taxes (paid in respective countries for income generated)</td><td>6.3</td></tr>
<tr><td>VEI quality regime</td><td>0</td></tr>
</table>
Source: EPR, CRIE</td></tr>
<tr><td>18. Financial information</td><td>SIEPAC transmission project was financed by the Interamerican Development Bank (IDB), Central American Bank for Economic Integration (CABEI), Development Bank of Latin America (CAF), and private banks – total investment was around US $505 million.</td></tr>
<tr><td>19. Modality of Development</td><td>Being a regional transmission line spanning multiple countries, development of the line is undertaken through discussions and agreements at a very high level. The existing line was agreed to be developed based on the treaty signed by the respective governments.

Extensions to existing regional transmission line will need to be authorized by the Comisión Regional de Interconexión Eléctrica (CRIE). CRIE will authorize such extensions only if the expansion is part of EOR's long term planning report or medium-term diagnosis report; and if the technical economic studies show that expansion increases the social benefit at regional level.</td></tr>
</table>

Criteria	Details
20. Tariff & payment support	The allowed income/revenue for the SIEPAC line is approved by CRIE considering the following components: • Cost of debt service; • Rate of return on the equity investment, at 11 percent, or as determined by CRIE separately; • O&M cost, calculated as 3 percent of standard costs, or as determined by CRIE separately; • Value towards compensation of planned unavailability of line; and • Taxes. This income is recovered through regional transmission rates, which consist of Variable Transmission Charge (CVT), the Toll and the Supplementary Charge. • The CVT is paid implicitly in the Market of Regional Opportunity or explicitly in the Regional Contract Market (the revenue from Transmission Right auctions). • The Toll is calculated based on actual flows on the lines, and its relationship with overall flows, and national contribution for the regional transactions etc. • Rest of the unrecovered charge is recovered through the Complementary Charge, levied on all the market participants.[54] The CVT/nodal price residual reflects short-run marginal costs but is only sufficient to partially recover the revenue requirement of the transmission owners. The remaining long-run cost of the network is recovered from the Toll and Complementary Charge. The Toll, calculated on the basis of actual power flows (MW), also allows for some locational signaling.[55]
21. Payment Security Mechanism	The approximately 300 users or customers of the SIEPAC Line, to operate in the Regional Electricity Market, must deliver executable bank guarantees to the EOR that cover the cost of one and a half months of their operations in the MER, including the charges of the SIEPAC Line. As per EPR, for over ten years, EPR has not had any type of defaults or late payments.
22. Contractual Arrangements	Shareholders agreement for EPR MER related regulations of CRIE.
23. Dispute Resolution	The regional regulator Comisión Regional de Interconexión Eléctrica (CRIE) provides dispute resolution, and also undertakes coordination with the national regulators
24. Cost Sharing Model	The MARCO Treaty indicated that each country would designate the entity to capitalize the mixed-capital EPR for the implementation of the project. For the execution of the project, an equity contribution of US $6.5 million per shareholder was necessary, with 9 shareholders for US $6.5 MUS, a total of US $58.5 million, and the total cost of the project of US $505 million, which represents that approximately 11.5 percent of the project is capital contribution and the rest are credits mostly from development banks, IDB, CABEI, CAF, BANCOMEXT, etc.
25. Role of regional markets in project development	One of the main motives to create the interconnection line was to create an integrated regional electricity market in Central America. The Mercado Eléctrico Régional (MER) has been designed as a seventh market that connects the six national markets while remaining separate from them. This allows the individual countries to develop their sectors at their own pace while enabling trade within the region.

Criteria	Details
26. Associated strategic, policy, regulatory, legal, technical, commercial, operational framework	

The diverse range of institutional development and capacity in the national electricity sectors is recognized as an important element affecting the design of the regional market. To accommodate these differences, the Mercado Eléctrico Régional (MER) has been designed as a seventh market that connects the six national markets while remaining separate from them. The design deliberately allows the individual countries to develop their sectors at their own pace while enabling trade within the region. The focus on gradualism is explicitly required in the Marco Treaty, which is the intergovernmental founding legal agreement for the regional power scheme.

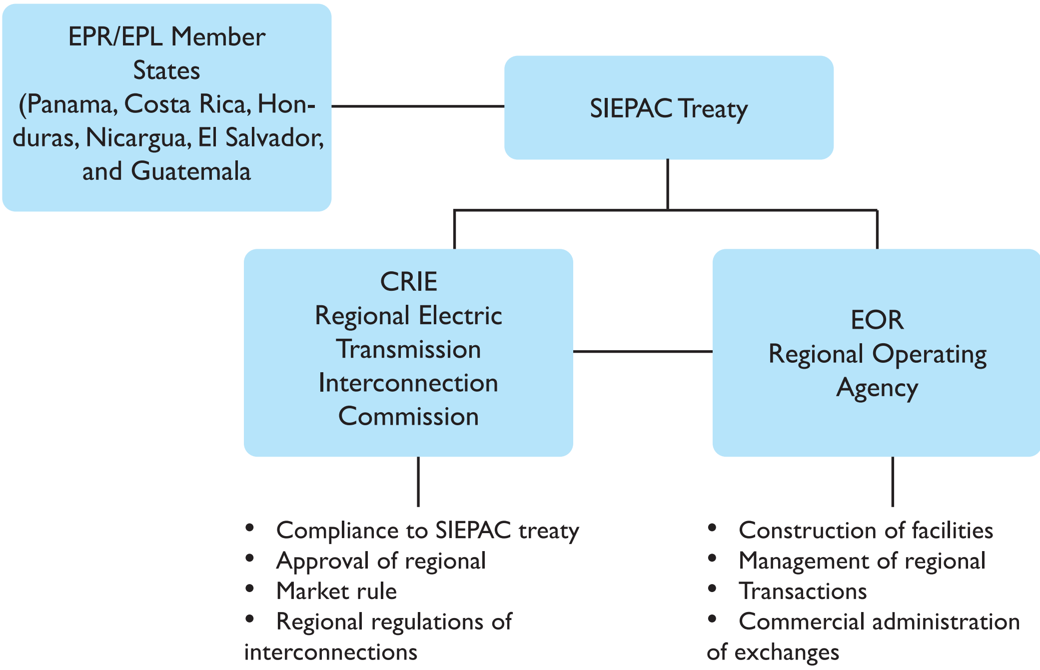


Figure 32: Institutional arrangement for SIEPAC electric interconnection [57]

The regional regulator – CRIE, initially published the transitional regulations for regional electricity market (RT-MER) in 2002, and the final regional electricity market regulations (RMER) in 2005. [58]

The regional electricity market regulations (RMER) deals with aspects such as:

- Eligibility requirements, rights and obligations of market agents;
- Types of market;
- Nodal pricing;
- Ancillary services;
- Reconciliation, billing and settlement procedures;
- Operations planning;
- Transmission rights; and
- Dispute resolution.

CRIE has also developed detailed operational procedures, such as Procedure for processing requests for connection to the Regional Transmission Network (RTR) and Procedure for the Application of Firm Contracts and Firm Rights.

The regional operator EOR has developed its own regulations that govern its organizational structure and functions. These deal with aspects such as planning for five-year periods, annual operational planning, and development of quality, safety and performance standards.

Criteria	Details
27. Trade between the lines over the years	(see Figure 33 below)

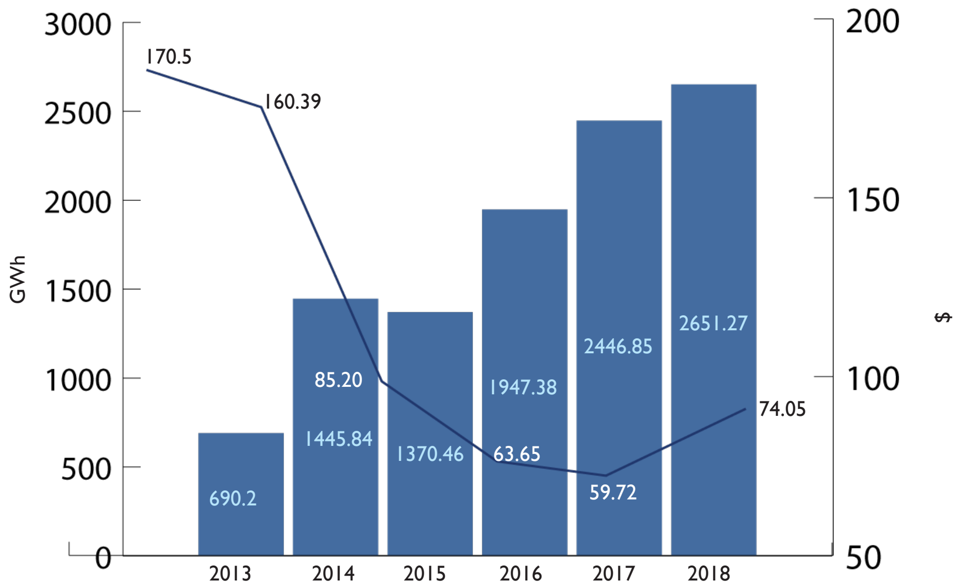


Figure 33: Annual injections in the regional market (GWh), and annual discovered prices in USD/MWh[59]

Source: EOR[59]

● inyecciones Anuales MER (GWh)

● Precio Promedio Anual en el MER (US$/MWh)

28. Challenges	Long process (took about 23 years from feasibility study).

3.6.2 Garabi Interconnector (Argentina – Brazil)

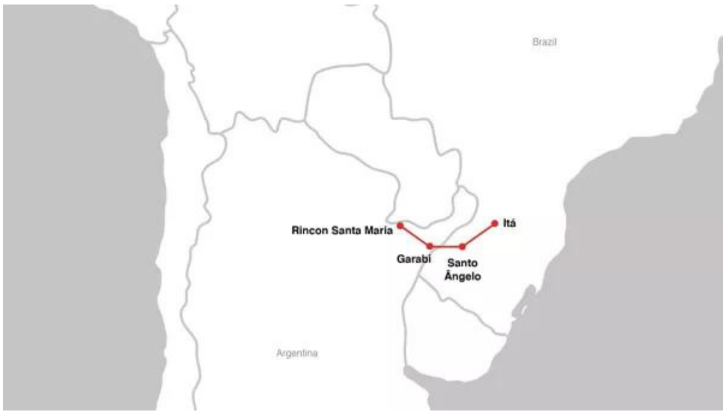
Criteria	Details
1. Map	

Figure 34: Argentina Brazil interconnection[60]

2. Location	The transmission line begins from Rincón de Santa Maria in northern Argentina and terminates at Itá in southern Brazil, with an HVDC converter station at Garabi in Brazil.
3. Type	Overhead Transmission line (HVAC in Brazil) & two HVDC converter stations[61]
4. Physical attributes	Two sets of parallel 500 kV AC transmission lines running a span of 490 km (355 km in Brazil & 135 km in Argentina) comprises with two 1,100 MW high-voltage direct current (HVDC) back-to-back capacitor commutated converter stations located at Garabi in Brazil, close to the Argentine border[61]
5. Project cost	US $700 million[61].

6. Project schedule

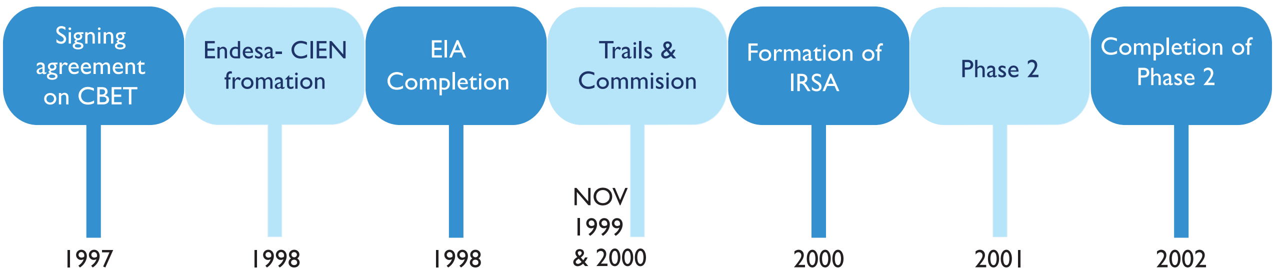
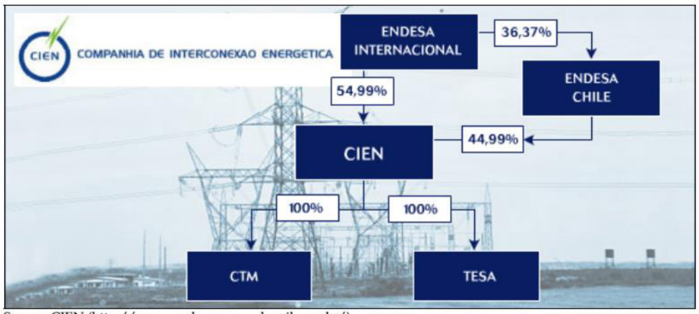


Figure 35: Project schedule for Garabi interconnector

7. Operational date year	The project was commissioned in the year 2000.[61]
8. Tenure of contract	A 20-year contract was signed by the Brazilian Government, the Argentine Government, and a SPV in Brazil - Companhia de Interconexão Energética (CIEN). CIEN was developed by a Spanish-based electricity company (ENDESA) for Brazil to import 1,000 MW of firm capacity from Argentina. Another 1,000 MW was available for private power purchase contracts with Brazilian distribution companies.[61]

Criteria	Details
9. Purpose of the project (benefit to the region)	Garabi project was designed around a contract for firm capacity imports of 1,000 MW by Brazil from Argentina, without committed amounts of related energy. Owing to this project, there also exists an advantageous possibility for Argentina wherein it may substitute imported hydropower for gas-fired electricity during the winter months when demand for gas is high. During the same season the water availability is high in Brazil. The core purpose of the project is for bilateral energy imports and trading.[61]
10. Ownership Structure	The Garabi project is one of very few privately owned regional interconnector schemes in the world[61]. Thus a special purpose company (CIEN) will own the two interconnection systems on the Brazilian side of the border. On the Argentinean side, assets of the Project will be owned by Transportadora de Electricidad, S.A. ("TESA") an Argentinean subsidiary of CIEN[62].  Source: CIEN (http://www.endesageracaobrasil.com.br/) Figure 36 : Ownership structure for CIEN
11. Investment entities structuring	IDB was involved with organizing an equity facility. Along with loans from paid-in capital from IDB member countries, as well as reserves and funds borrowed in international markets. Loans are provided through other banks and institutional investors on a co-financing basis[61].
12. Auction	No auction
13. Investment Decision	A special-purpose company CIEN was set up in Brazil to execute the Garabi project. After handover, the infrastructure has been operated and managed by CIEN.
14. Business and Financing model adopted	The contract prices for energy trade and wheeling via the Garabi system are negotiated by the parties concerned. Historical prices have not been put into the public domain. It is understood that the principle, however, is that the benefits of trade should as far as possible be equally shared between the contracting parties. Where imports occur because of differential generation costs, the price is set at the midpoint between the lower marginal cost of imports plus transmission costs and the higher marginal cost of domestic generation. In cases where the importer has no domestic generation alternative, the price reflects the full cost of supply, including depreciation and fixed costs.

Criteria	Details
15.Risk management and Risk allocation principles and mechanism	Multilateral Investment Guarantee Agency (MIGA) offered partial risk guarantees to cover default risks. MIGA has issued $28 million to Endesa and $37 million to Banco Santander Hispano for their investments and loans in CIEN to expand its power distribution capabilities in Brazil.[61]
16. Source of funding	The IDB was involved with organizing an equity facility of around $150 million, together with A and B loans of $74 million and $169.9 million.[61]
17. Cost recovery	Not known
18.Financial information	The total capital cost of the Garabi project was around US$700 million.[61]
19. Modality of Development	IPTC model, with separate legal entities in each of the countries
20.Tariff & payment support	The original contract had a fixed monthly charge for the 1,000 MW of firm capacity, together with a tariff for energy that was payable only when the electricity was delivered. In general, contract prices for energy trade and wheeling via the Garabi system are negotiated by the parties concerned. Historical prices have not been put into the public domain. It is understood that the principle, however, is that the benefits of trade should as far as possible be equally shared between the contracting parties. Where imports occur because of differential generation costs, the price is set at the midpoint between the lower marginal cost of imports plus transmission costs and the higher marginal cost of domestic generation. In cases where the importer has no domestic generation alternative, the price reflects the full cost of supply, including depreciation and fixed costs. [61]
21. Payment Security Mechanism	Fixed monthly charges along with tariff for energy that was payable only when the electricity was delivered. The tariff cost for energy is discovered through local regulatory entities. [61]
22. Contractual Arrangements	Argentine Government, Brazilian Government (Ministry of Mines and Energy) and CIEN signed an initial 20-year contract to utilize 1,000 MW of Garabi capacity. CIEN had contracts with IPPs in Argentina to supply the electricity and power purchase agreements with two companies in Brazil who were to be the importers. Additional power could be sold into the Brazilian spot market. MIGA issued guarantees for $28 million to Endesa and $37 million to Banco Santander Central Hispano for their investments and loans in CIEN to expand its power distribution capabilities in Brazil. The guarantees covered the investors against the risks of transfer restriction and expropriation [61]
23. Dispute Resolution	Not known

Criteria	Details
24. Cost Sharing Model	All costs are borne by the private sector transmission owner
25. Role of regional markets in project development	Not known
26. Associated strategic, policy, regulatory, legal, technical, commercial, operational framework	In Argentina, CAMMESA's (Wholesale Electricity Market Administration Company, Argentina) functions as the real-time operation of the electricity system, which involves operation and dispatch of generation, price calculation in the spot market, and the administration of the commercial transactions in the electricity market. CAMMESA acts as agent for the various players in the wholesale electricity market and organizes and leads the use of transport facilities for spot transactions. The wholesale market allows exchanges with neighboring countries through power contracts between private companies that meet the requirements of the regulatory framework[61]. Brazil's independent system operator ONS is responsible for coordination of operations and control of electric power generation and transmission facilities in the Brazilian interconnected power system[61]. In Argentina, El Ente Nacional Regulador de la Electricidad (ENRE), established in 1992, is responsible for regulatory functions and tariff matters relating to concessions granted by the national government[61]. In Brazil, the regulatory agency is the Agencia Nacional de Energia Eletrica (ANEEL), which is autonomous but has links with the Ministry of Mines and Energy. ANEEL was created as a result of legislation passed in 1996 as the national electric system regulator, inspector, mediator, and licensing authority[61]. In Argentina, National Electricity Regulatory Entity ENRE establishes tariffs for distribution companies according to an efficiency pricing model differing by zones. Retail tariffs are established by an indexed rate formula for a five-year period. The prices are set in such a way as to recover the Wcost of purchased power, transmission charges, distribution system operating expenses, taxes, and amortization. Tariffs include a rate of return to encourage investment. Penalties have to be paid when quality criteria are not met. In the generation wholesale market, CAMMESA uses the declared costs and availabilities of the companies for load dispatch. In Brazil distribution charges are fixed to reflect the long-run average incremental costs at each voltage level. Transmission charges are based on long run marginal costs, which are calculated as the cost of new investments needed to meet incremental use of the network. Generation is privatized, and a charge for available capacity is computed within an incentive-rate-making framework similar to the RPI-X incentive-based regulatory system developed in the United Kingdom. Energy acquisition costs are allowed as a pass-through to the user[61].
27. Trade between the lines over the years	Not known
28. Challenges	Not known

3.6.3 Montana Alberta Tie Line (MATL)

The Montana Alberta Tie Line Interconnector originates from Alberta Grid through AltaLink near Lethbridge, Alberta Canada and terminates at NorthWestern Energy near Great Falls, Montana, United States.

Criteria	Details
1. Map	

Figure 37 : Map for Alberta Montana interconnection[63] Image courtesy: California Energy Commission

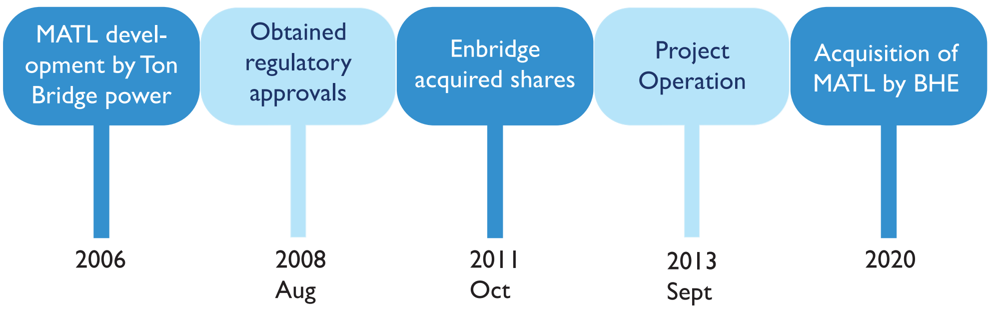
Criteria	Details
2. Location	The interconnector originates from Alberta Grid through AltaLink near Lethbridge, Alberta Canada and terminates at NorthWestern Energy near Great Falls, Montana, United States.
3. Type	Overhead HVAC transmission cable
4. Physical attributes	The transmission line has a total length of 345 kms with a line voltage of 230 kV (HVAC) merchant electricity. The transmission capacity of 300 MW.[64]
5. Project cost	US $300 million[64].
6. Project schedule	

Figure 38 : Project timeline for MATL

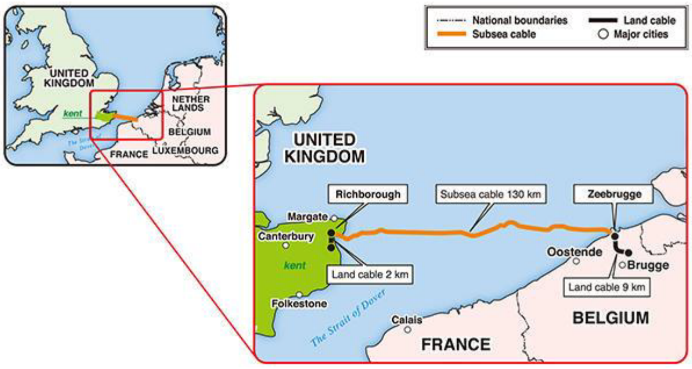
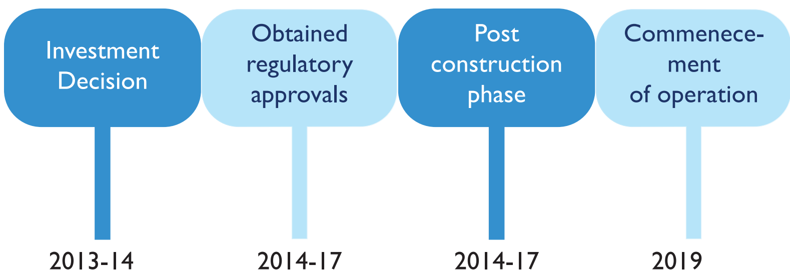
Criteria	Details
7. Operational date/ year	2013[65].

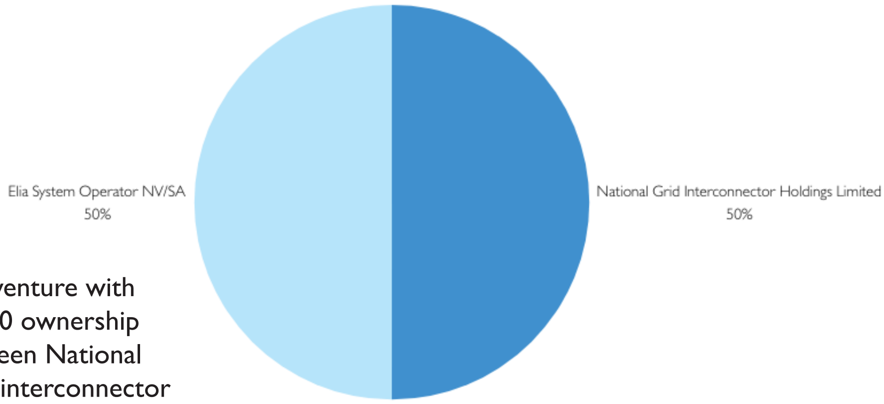
Criteria	Details
8. Tenure of contract	At end of contract, Montana Alberta Tie Line (MATL) will remove the infrastructure including any materials associated with the sub-station. Holes would be filled with clean fill and the Right-of-Way and sub-station site would be allowed to return to their preconstruction condition[66].
9. Purpose of the project (benefit to the region)	Profit taking benefit of the energy price arbitrage between Alberta and the Pacific US Northwest, and also linked with bringing renewable generation to market.
10. Ownership Structure	IPTC Model. Berkshire Hathaway BHE Canada and BHE U.S Transmission own and operate the Montana Alberta Tie Line (MATL)
11. Investment entities structuring	Completely owned by two subsidiaries of BHE- BHE Canada and BHE U.S.
12. Auction	Weekly auctions usually offer three products: Balance of the Year, Prompt Quarter, and Monthly service; whereas Daily auctions usually offer three products: Daily, Light Load Hourly, and Heavy Load Hourly service[67].
13. Investment Decision	Not known.
14. Business and Financing model adopted	The capital required was raised from financing from debt and equity. Apart from that since the project required buying some property rights from private individuals and hence there was a need of compensation. This was done through Right of Way and Easement agreements with landowners.
15. Risk management and Risk allocation principles and mechanism	Not known
16. Source of funding	In October 2009, Western provided a $161 million loan to MATL/Tonbridge Inc. In late 2011, MATL/Tonbridge Inc. was acquired by Enbridge Inc., a major Canadian energy and pipeline company. On Aug. 27, 2012, Enbridge Inc. prepaid the outstanding principal and interest on the loan (about $151 million), ending Western's involvement in the MATL project.[16]

Criteria	Details
17. Cost recovery	Through transmission tariff Long-Term Transmission Service is for a service period of longer than one year for transmission customers, whereas Short-Term Transmission Service is for service periods of one year or less. Resale service agreement is provided to facilitate a robust secondary transmission services market. [68] Contracts are generally signed with wind farms in Northern US like Gaelectric. Any capacity not allocated to contracted companies will be auctioned to other companies in an open season bidding process. [69]
18. Financial information	Owned completely by Berkshire Hathaway Energy, earlier was owned by Enbridge
19. Modality of Development	IPTC Model
20. Tariff & payment support	Based on open access tariff $2.25/MW-hr[70] auction floor pricing (minimum bid) $ 2.85/MW-hr hourly pricing
21. Payment Security Mechanism	Not known
22. Contractual Arrangements	Not known
23. Dispute Resolution	Not known
24. Cost Sharing Model	BHE Canada owns the Canadian portion of the project and manages the day-to-day operation of the facility. BHE U.S. Transmission owns the portion of the line in the United States.
25. Role of regional markets in project development	The transmission line was created to cater to the wind energy sources available in Southern Alberta and since there was no line to the electricity grid to bring this energy to the market.
26. Associated strategic, policy, regulatory, legal, technical, commercial, operational framework	MATL required six major regulatory approvals[71] • US Department of Energy (DOE), Record of Decision • Montana Department of Environmental Quality (DEQ), • Major Facilities Siting Act Certificate of Compliance • Western Electricity Coordinating Council (WECC) Path Rating • Federal Energy Regulatory Commission (FERC) Tariff Approval • National Energy Board (NEB) Approval • Alberta Utilities Commission (AUC) Approval

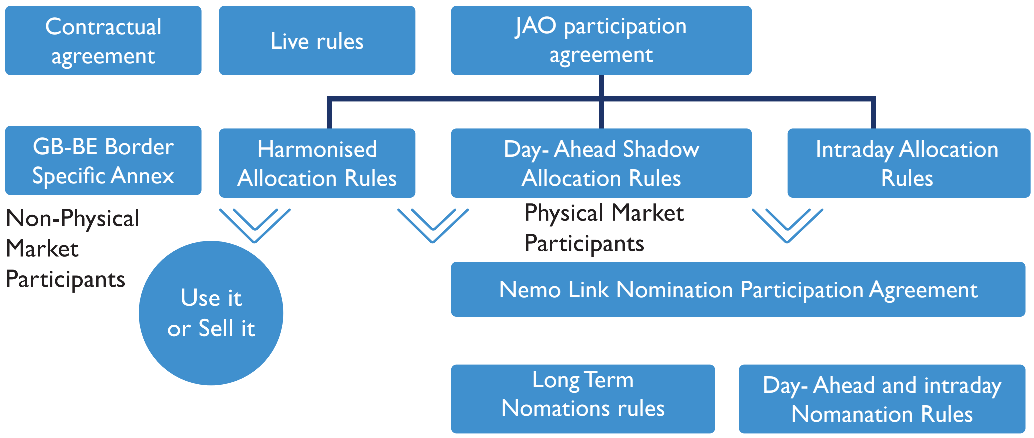
3.7 Case Studies From Europe

3.7.1 Nemo Link (UK - Belgium)

Criteria	Details
1. Map	 Figure 39: NEMO link interconnector[72]
2. Location	NEMO link HVDC Interconnection between nations of Belgium and United Kingdom as European Commission's list of Projects of Common Interest (PCI),[73]
3. Type	NEMO network includes single under sea transmission line originating from Zeebrugge in Belgium and terminates at Richborough in Great Britain (GB). The undersea transmission line has a length of 140 km with line voltage of ± 350kV and ± 400kV and with transmission capacity of 1000 MW.
4. Physical attributes	NEMO network includes single under sea transmission line originating from Zeebrugge in Belgium and terminates at Richborough in Great Britain (GB). The undersea transmission line has a length of 140 km with line voltage of ± 350kV and ± 400kV and with transmission capacity of 1000 MW.
5. Project cost	Euro €598 million.
6. Project schedule	 Figure 40 : Project schedule for NEMO link
7. Operational date/ year	The interconnector started operating commercially on 31 January 2019. and is the first project to be regulated under "cap and floor regime".

Criteria	Details
8. Tenure of contract	Designed operational life of 40 years and the proposed project operational life is 25 years. It is mandatory to set up a provision for cable removal for the permit application for the offshore cable part in Belgium, the removal of the asset at the end of its lifetime may not be mandatory. The competent authorities will determine whether or not Nemo is required to remove its asset.
9. Purpose of the project (benefit to the region)	To facilitate the transfer of power in either direction between the two countries. The capacity will be in the order of 1,000 MW. The interconnection link also serves as a single point connection it is considered prudent to interconnect the UK to different parts of Europe. The Belgium electricity transmission is highly connected to Central Europe.
10. Ownership Structure	Nemo link limited is a joint venture between National Grid Interconnector Holdings Limited and Elia System Operator NV/SA (Elia), the Belgian transmission system operator. Each owns 50 percent of the shares in Nemo Link.  Jointventure with 50 -50 ownership between National Grid interconnector & Elia Group (Belgium) Figure 41 : Ownership structure of NEMO link
11. Investment entities structuring	Joint Venture
12. Auction	NEMO link has set up an auction mechanism for trade through the line. Customers will have the opportunity to buy capacity up to 1000 MW in either direction GB-BE or BE-GB via explicit and/or implicit auctions, as detailed below: 1) With explicit auctions, market parties can buy long term and intra-day physical transmission rights (capacity) from Nemo Link via the Single Allocation Platform (SAP) operated by JAO (Joint Allocation Office). Upon acquiring long-term capacity from SAP, customers can choose to nominate their capacity via the Regional Nomination Platform (RNP) (physical customers) or not nominate their capacity and receive Use-It-or-Sell-It (UIoSI) compensation (non-physical customers) by not physically nominating and placing their capacity into the implicit auction; 2) At the implicit auctions, market participants can buy capacity as well as electricity in one single transaction through the market coupling mechanism at the day-ahead stage via a Nominated Electricity Market Operator (NEMO).

Criteria	Details
13. Investment Decision	Under ENTSO-E planning
14. Business and Financing model adopted	Joint Venture model
15. Risk management and Risk allocation principles and mechanism	Not known
16. Source of funding	Not known
17. Cost recovery	The cap and floor regime are proposed by the Belgian energy regulator, the Commission de Regulation de l'Electricite et du Gaz (CREG)[74]. Revenue floor has been set at £50.4m over the 25 year duration of the regime for Nemo project and the annual revenue cap at £80m (cost in Pound Sterling).
18. Financial information	Nemo Link Interconnector is one of 248 key energy infrastructure projects in the European Commission's list of Projects of Common Interest (PCI), announced in October 2013. These projects will benefit from faster permit granting procedures and easier access to the European Union's Connecting Europe Facility (CEF), which provides financial support.[75]
19. Modality of Development	JV model
20. Tariff & payment support	The cap and floor regime is the regulated route for interconnector development in Great Britain. It sets a minimum and maximum return that interconnector developers can earn from the interconnector. the cap and floor regulatory model for Nemo Link was developed jointly with the Belgian regulator. The assessment has done in three stages Initial project assessment, Final project assessment and Post construction review. The discovered Cap and floor rate for the transmission line to be £76.2m and £42.8m (cost in Pound Sterling).
21. Payment Security Mechanism	Collaterals are provided by registered participants in order to secure payments in form of cash deposits or bank guarantee[76]

Criteria	Details
22. Contractual Arrangements	Project NEMO was granted an electricity interconnector licence in March 2013.[77] Granted Nemo Link Limited (Nemo Link) a cap and floor regime in December 2014.  Figure 42 : Contractual Framework for NEMO link
23. Dispute Resolution	First course of action is amicable settlement through mutual consultation. Dispute resolution provision specified in respective agreement where the parties must meet within 20 working days to resolve the dispute
24. Cost Sharing Model	50-50 cost sharing factor between Great Britain and Belgium[78]
25. Role of regional markets in project development	Under the overall European Common Market in which UK was also then a part
26. Associated strategic, policy, regulatory, legal, technical, com-mercial, operational framework	Not known
27. Trade between the lines over the years	Not known

3.7.2 Transmission Charges for Nemo

Office of Gas and Electricity Markets (OFGEM) has granted Nemo Link Limited (Nemo Link) a "cap and floor" regime in December 2014. It sets a minimum and maximum return that interconnector developers can earn from the interconnector. The cap and floor regulatory model for Nemo Link was developed jointly with the **Belgian regulator, the Commission de Regulation de l'Electricite et du Gaz (CREG)**. The assessment has been done in three stages - Initial project assessment, Final project assessment and Post construction review.

The cap and the floor levels are set based on a building blocks approach of development costs, capital costs, operating and maintenance costs, replacement costs, decommissioning costs, tax and allowed return. The final proposed cap and floor levels for Nemo Link, as specified in its license, are £76.2 m and £42.8m each year (2013/14 prices). Later the cap and floor levels are adjusted to £77m and £43.9m respectively for 2013/14 prices.

The regime sets a yearly maximum (cap) and minimum (floor) level for the revenues that the interconnector can earn over a 25-year period. Revenues generated by the interconnector are compared against the cap and floor levels every five years (default regime) or yearly (approved regime changes). Top-up payments are made to the licensee if generated revenues are lower than the floor; and similarly, the licensee pays back revenues in excess of the cap.

In the default regime, the cap and floor levels are set based on project costs using a typical Regulated Asset Base (RAB) model. With respect to the RAB model applied a different notional financial return parameters to set the cap and the floor independently. The floor is set to allow a developer with a notional financing structure to recover only their costs and a low rate of return equal to a cost of debt index.

Developers may request variations to the default regime design, provided they can demonstrate that these are in the interests of GB consumers. This is to reflect that certain aspects of the default regime may be less suitable for some types of financing solutions, and therefore it might limit the pool of capital developers can access.

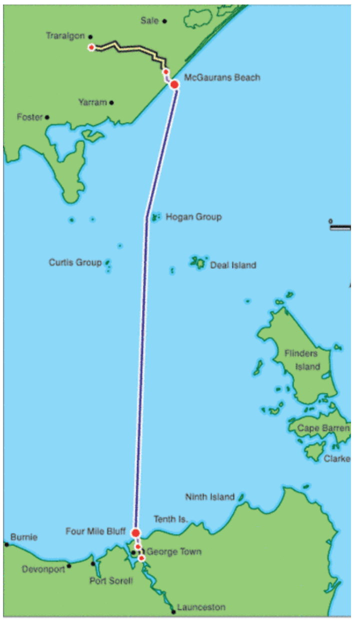
The cap is designed to reflect the equity returns in assets with a similar risk profile. To determine returns at the cap, apply the equity return rate, which is estimated using a Capital Asset Pricing Model (CAPM) approach, to 100 percent of the Regulatory Asset Value (RAV).

High level cap and floor regime design:

Aspect	Design
Regime length	25 years (Rather than 20 years; Developer choice)
Cap and floor levels	Levels set ex-ante and remain fixed in real terms for regime length
Setting costs	Capex: Ex- post capex review. Opex: Ex- ante (i.e., before operation)
Assessment period (Assessing whether revenues are above/ below cap/ floor)	5 years; discrete periodic basis.
Mechanism	Cap and floor returns within boundaries; revenues above cap returned to consumers; revenue below floor require payment from consumers (via network charges)

3.8 Case Studies From Rest of the World

3.8.1 Basslink Interconnector in Australia

Criteria	Details
1. Map	 Figure 43: Interconnector between Australia and Tasmania [79]
2. Location	The Interconnection is between Loy Yang Power Station, Victoria, Australia and George Town substation, Northern Tasmania.[80]
3. Type	Undersea HVDC transmission & Overhead HVDC transmission line.[80]
4. Physical attributes	The network includes an HVDC undersea transmission, Overhead transmission line. The total length of the interconnector is 375 km which includes 295 km submarine cable, 8 km underground cable & 66 km of DC transmission line. The interconnector has a line voltage capacity of 500kV system in Victoria and stepped down to 220kV and rectified to HVAC in Tasmania. The transmission line has a capacity of 500 MW.[81,82]
5. Project cost	US $877million [83]

Criteria	Details
6. Project schedule	1997: Tasmanian Govt commits to participation in the national electricity market via Bass strait Electricity interconnector 1998: BassLink Development Board established 2000-2002: Development and Approval stage 2000: National grid win bid to build and operate BassLink 2002: Basslink issued with a Notice to proceed 2002-2005: Project Implementation 2005: Ready for energisation 2006: commences commercial operation 2007: City Spring acquires BassLink 2009: BassLink telecom commences commercial operation

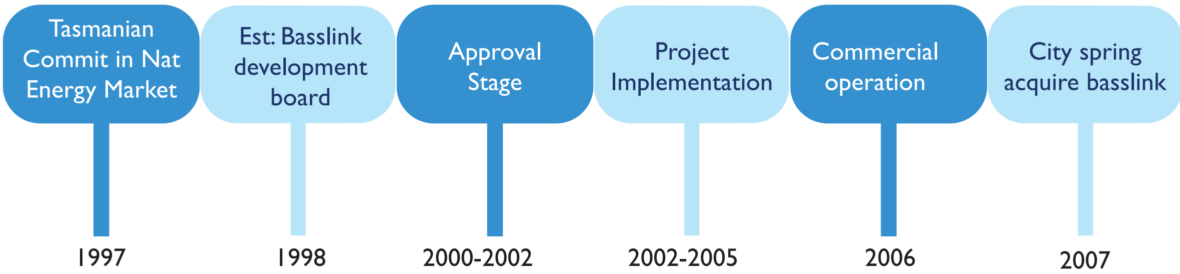


Figure 44: Project timeline for Basslink [84]

Criteria	Details
7. Operational date/ year	The project met various milestones and it was successfully commissioned in early 2006. BassLink became commercially active in the Australian electricity market on 28 April 2006.[80]
8. Tenure of contract	The BOA is the contractual mechanism between the State of Tasmania and the operators of BassLink, the primary focus of which is ensuring that an interconnector is available to the State for a period of 40 years.[85]
9. Purpose of the project (benefit to the region)	BassLink connects the electricity transmission systems of Tasmania and Victoria. The introduction of BassLink made Tasmania could participate in the National Electricity Market (NEM). This allows Tasmania to buy or sell power into the NEM.
10. Ownership Structure	In February 2000, the Government of Australia announced the formation of a new entity - Basslink Pvt Ltd. It is a fully owned subsidiary of National Grid International Limited.[86] In 2007 Keppel Infrastructure Trust (formally known as CitySpring) acquired Basslink from National Grid and on the 3rd July 2009 Basslink Telecoms commences commercial operation.[87] On 18th October APA Group based on Australia (APA) acquired the Basslink.[83]

Figure 45: Ownership structure for Basslink interconnector

Criteria	Details
11. Investment entities structuring	Merchant transmission
12. Auction	Not known
13. Investment Decision	Not known
14. Business and Financing model adopted	Merchant transmission
15. Risk management and Risk allocation principles and mechanism	The Basslink Facility Fee (BFF) paid by Hydro Tasmania is subject to risk sharing arrangements that reward Basslink Pty Limited (BPL) with an increased fee (via Commercial risk sharing payments) when the arbitrage value provided by the link is high, provided the interconnector is fully available during periods of high Victorian prices. Conversely, those same arrangements substantially reduce the BFF if the link is not fully available during these high-priced periods, or if the arbitrage value is low. The commercial risk sharing arrangements have resulted in Hydro Tasmania paying an increased BFF in only one of the link's first six years of operation (calendar year 2007). In that year, the price volatility in the Victorian spot market was such that Hydro Tasmania made additional payments equivalent to 25 per cent of the BFF for that year, the maximum amount payable under the terms of the BSA. This reflects that the arbitrage value available to Hydro Tasmania was high, providing it with the financial capacity to fund the additional payments. Cumulatively, however, to the end of September 2011 Hydro Tasmania has been a net beneficiary from the risk sharing arrangements in the BSA since it commenced delivering energy in 2006.
16. Source of funding	Private sector involvement and mobilised funds.
17. Cost recovery	Through Basslink Facilitation Fee and market participation
18. Financial information	The total construction cost of approximately US $877 million. [83]
19. Modality of Development	Merchant transmission
20. Tariff & payment support	Basslink earns revenue for its owners in a similar way to generators in the NEM, by bidding into the spot market its capacity to deliver energy, with the returns determined by price differences and the energy flows between Victoria and Tasmania. The BSA provides for the owners of Basslink to swap that market-based revenue for an agreed fixed facility fee plus performance-related payments, which consolidated annually via monthly payments. The agreement also gives Hydro Tasmania the rights to control the way in which Basslink Pty Ltd bids its interconnector capacity, although these provisions have been partly curtailed by Tasmanian legislation. The initial term of the BSA was set at 25 years, with an option to extend the term for a further 15 years.

Criteria	Details
21. Payment Security Mechanism	Not known
22. Contractual Arrangements	The operation of Basslink is governed by two main contracts, the Basslink Operations Agreement (BOA) and the Basslink Service Agreement (BSA). The two agreements are, however, independent of each other and the performance obligations in both are different. The BOA is the contractual mechanism between the State of Tasmania and the operators of Basslink, the primary focus of which is ensuring that an interconnector is available to the State for a period of 40 years. The BSA, on the other hand, which is the agreement between Hydro Tasmania and BPL establishing the rights and obligations of both parties with respect to the operation of Basslink, includes a number of financial incentives relating to the link's performance, in terms of its availability.
23. Dispute Resolution	Not known
24. Cost Sharing Model	Privately owned line
25. Role of regional markets in project development	Not known
26. Associated strategic, policy, regulatory, legal, technical, commercial, operational framework	Not known
27. Trade between the lines over the years	During the period 1 January 2007 and 31 December 2009, the benefits of Basslink were clearly evidenced during the drought period witnessed by Tasmania. Tasmania imported 5,239.14 GWh during the period compared with total exports to Victoria of 1,260.01 GWh.
28. Challenges	Not known

3.9 Planned Cross Continental Transmission Lines

3.9.1 Greece-Cyprus-Israel Euro Asia Interconnector

The proposed project consists of two new interconnections: one between Greece (Crete) and Cyprus and one between Cyprus and Israel. Both will be HVDC submarine cables with a total length of around 1200 km (approx. 314 km between Cyprus and Israel, 894 km between Cyprus and Crete). Total capacity is expected to be 1000 MW in phase 1, and 2000 MW in phase 2. VSC technology is proposed which will allow for transmission of electricity in both directions. It is expected to be completed in 2028-2029.

Figure 46: Greece Cyprus Israel interconnection Source: Med-TSO[88]

The first stage (Greece – Cyprus) has already secured a US $736 million European Union grant (European project of common interest PCI 3.10). In July 2023, Euro Asia Interconnector announced that they had signed a €1.43-billion contract with a French firm Nexans to build the line. To develop the project, an entity "Euro Asia Interconnector Limited" was incorporated in Cyprus. However, later the project activities were transferred to Greece's Independent Power Transmission Operator (IPTO).

3.9.2. Australia-Asia Power Link

Australia-Asia Power Link is an ambitious project concept to set up solar power plants in Australia and evacuate the power to Singapore, which is over 4500 KM away, through Indonesia. Though the project was private sector driven, by a company named "SunCable", the company faced financial difficulties and went to voluntary administration in 2023. The company was taken over by new promoters in 2024.

Figure 47: Australia-Asia power link Source: SunCable[89]

3.10 Case Studies From South Asia

3.10.1 Baharampur (India) – Bheramara (Bangladesh) Interconnection

On October 5, 2013, Bangladesh and India connected their grids with the commencement of Bheramara (Bangladesh)–Baharampur (India) 400 kV back-to-back HVDC transmission link with a capacity of 500 MW, which was later enhanced to 1,000 MW.

The total cost of the transmission line both on the India and Bangladesh sides for 1,000 MW is nearly US $313 million. Of the 1,000 MW transmission line including back-to-back HVDC link, the first phase (500 MW) in the Bangladesh side was commissioned in 2003 at a cost of US $183 million USD. This first phase consisted of:-

1. 27.3 kilometers (km) of 400 kV, double circuit overhead transmission line;

2. One 500 MW high-voltage direct current back-to-back station at Bheramara; and

3. 4.5 km of 230-kilovolt Double Circuit line in line out overhead transmission line at Ishurdi Khulna.

Out of this, US $111 million was provided by ADB as a loan, and the remaining amount was arranged by the Government of Bangladesh/PGCB through sources including additional borrowing. As per ADB's estimate, the project has an equity IRR of 26.9 percent, and financial IRR of 4.7 percent.[90]

The second phase consisted of 28 kilometers (km) of 400 kV, double circuit transmission line, adding a capacity of 500 MW was commissioned in 2018.[91] The doubling of capacity of the cross-border power transmission link to 1,000 MW, at Bangladesh side was funded by ADB (60 percent), the Government of Bangladesh and PGCB (40 percent), at a cost of US $202.1 million. As per ADB's estimate, the combined project (1,000 MW) has an equity IRR of 30.7 percent, and financial IRR of 4.3 percent.[92] Indian portion of this line (1,000 MW, 17 KM) was financed by Power Grid Corporation of India Limited (PGCIL) at a total cost of ₹1,984.8 million.[93]

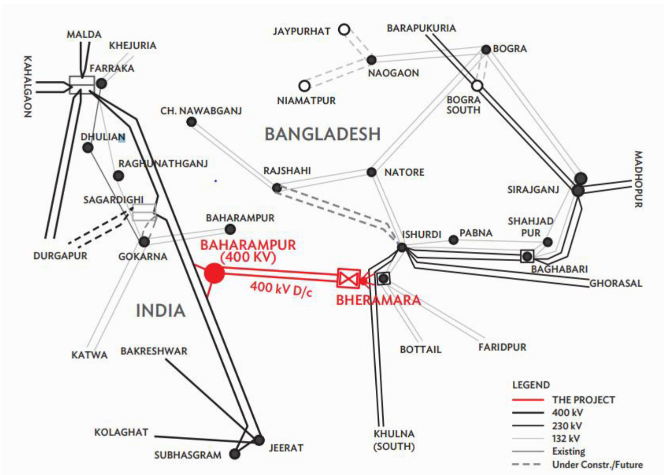
<table>
<tr><th>Criteria</th><th>Details</th></tr>
<tr><td>1. Schematic Diagram</td><td>

Figure 48: Bangladesh India Electric Interconnection Single Line Diagram Source: CEA</td></tr>
<tr><td>2. Location</td><td>Bheramara, Bangladesh to Baharampur, India</td></tr>
<tr><td>3. Type</td><td>400 kV double circuit AC transmission line with HVDC back-to-back converter at Bangladesh end. Originally a 500 MW, interconnection, but it was expanded to 1GW in 2018.</td></tr>
</table>

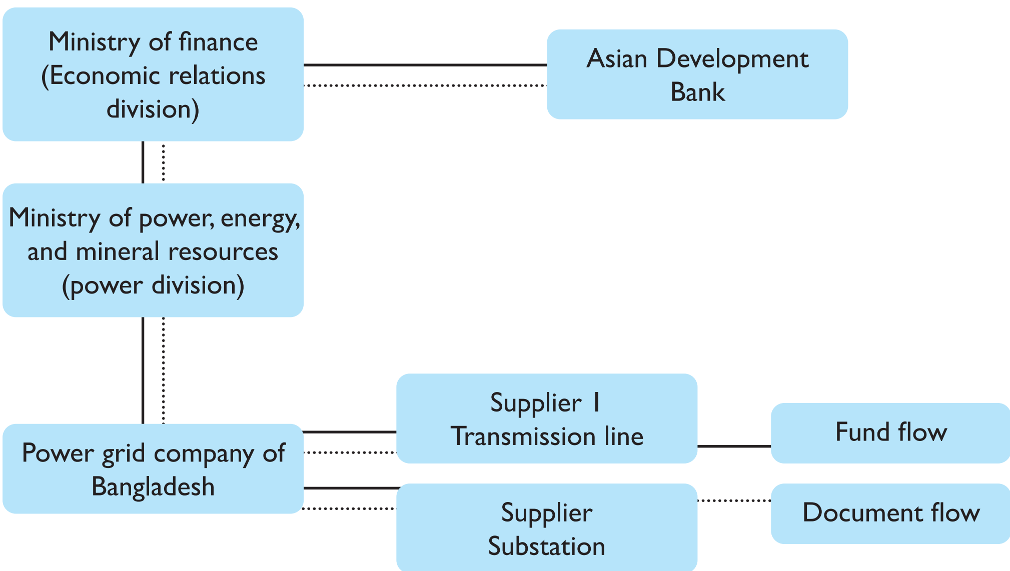
Criteria	Details
4. Physical attributes	Line Indian portion: 85 KM 400kV Double Circuit line and switching station Line Bangladesh portion: 27 KM 400kV Double Circuit line and HVDC back-to-back station
5. Project cost	Phase 1: Total Project Cost: US $183 million Phase 2: Total Project Cost: US $202.1million
6. Project schedule	First line commissioned in 2013 Second line in 2018
7. Operational date/ year	October 2013
8. Tenure of contract	35 years[95]
9. Purpose of the project (benefit to the region)	To establish a Grid Interconnection with India and to minimize the power crisis in Bangladesh to some extent[96]
10. Ownership Structure	Bangladesh portion owned by: Government of Bangladesh, through PGCB Indian portion of the line owned by: PGCIL
11. Investment entities structuring	Owned by respective transmission utilities
12. Auction	Indian side – Open access as per Indian regulations Bangladesh side – Fully made available for BPDB
13. Investment Decision	Nomination by Govt: The governments of India and Bangladesh signed a MoU in January 2010, to enhance bilateral cooperation in areas of power generation and transmission.
14. Business and Financing model adopted	

Figure 49: Business model adapted in Bangladesh side

Criteria	Details
15. Risk management and Risk allocation principles and mechanism	In Bangladesh, PGCB's cost recovery is ensured by the regulator, through the determination of transmission charges covering the entire network. Similarly, in Indian side, PGCIL's cost recovery is assured in a cost-plus model by the CERC.
16. Source of funding	• Phase 1: Total Project Cost: US $183 million 60 percent Grant by ADB and 40 percent equity of Government of BD • Phase 2: Total Project Cost: US $202.1 million 60 percent Grant by ADB and 40 percent equity Indian portion of this line (1,000 MW, 17 KM) was financed by Power Grid Corporation of India Limited (PGCIL) at a total cost of ₹1,984.8 million
17. Cost recovery	Transmission Charges for both lines (Indian Portion): BPDB to pay POWERGRID tariff determined as per prevailing CERC regulations. Costs in Bangladesh side covered under overall recovery of PGCB.
18. Financial information	Not known
19. Modality of Development	Developed by PGCB in Bangladesh and by PGCIL in India
20. Tariff & payment support	In Bangladesh, it is covered under overall revenue requirement of PGCB. In Indian side, it is under a cost-plus regime for PGCIL
21. Cost Sharing Model	Bangladesh till now has been net importer of electricity and it pays transmission tariff to PGCIL (India)
22. Role of regional markets in project development	The line has allowed Bangladesh to enter into competitive long term and medium-term contracts with suppliers in India.
23. Associated strategic, policy, regulatory, legal, technical, commercial, operational framework	The line was developed primarily under government. to government. agreement as larger policy guidelines were not in place yet in the countries.[97]
24. Trade between the lines over the years	Approximately 20-22 GWh per day, as of March 2023.

3.10.2 Tripura (India) – Comilla (Bangladesh) Intereconnection

The 400 kV line (operated at 132 kV) from Tripura in Suryamaninagar, India to South Comilla in Bangladesh was commissioned in 2016, through which nearly 160 MW of power is imported by Bangladesh. The Indian portion of the 400kV Double Circuit line (Twin ACSR Moose Conductor) line length is 18 km and the Bangladesh portion 400kV Double Circuit line length is 47 km. The total project cost at Bangladesh side was BDT 1,717.474 million or US $20.08 million, of which BDT 1,573 million was financed by the Government of Bangladesh and BDT 143.81 million by PGCB[98]. Indian portion of this line was financed by PGCIL India at a total cost of ₹1billion or US $13.36 million. The total project cost is around US $33.45 million.[99]

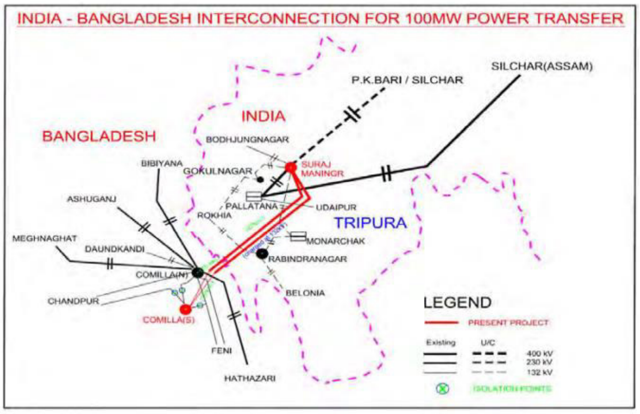
<table>
<tr><th>Criteria</th><th>Details</th></tr>
<tr><td>1. Map</td><td>

Figure 50: Map and SLD of Tripura Comilla interconnection[100] Source: CEA</td></tr>
<tr><td>2. Location</td><td>Surajmaninagar (India) - South Comilla (Bangladesh)</td></tr>
<tr><td>3. Type</td><td>Radial interconnection</td></tr>
<tr><td>4. Physical attributes</td><td>Surajmaninagar - South Comilla (400kV D/c line up to North Comilla, remaining portion 132kV D/c line) has been implemented to provide 100MW power to Bangladesh in radial mode from Palatana Generation Project in Tripura in Northeastern Region.[101] Capacity got increased later to 160 MW and then 200 MW. Line Indian portion: 18 KM 400kV Double Circuit line (Twin ACSR Moose Conductor).

Line Bangladesh portion: 47 KM 400kV Double Circuit line</td></tr>
<tr><td>5. Project cost</td><td>The project cost was estimated to be USD 33.5 million</td></tr>
<tr><td>6. Project schedule</td><td>Commissioned in 2016</td></tr>
<tr><td>7. Operational date/ year</td><td>23rd March, 2016[102]</td></tr>
<tr><td>8. Tenure of contract</td><td>Not known</td></tr>
</table>

Criteria	Details
9. Purpose of the project (benefit to the region)	To improve transmission capacity and ensure efficient evacuation of power for reliable electricity supply in the eastern region in Bangladesh
10. Ownership Structure	Owned by respective power transmission utilities in either side
11. Investment entities structuring	The Government of Bangladesh (GoB), PGCB, and Asian Development Bank (ADB) jointly provided financial assistance for this Project.
12. Auction	Not known
13. Investment Decision	Government decision through signing of MoU between the two countries to improve power trade
14. Business and Financing model adopted	Bangladesh buys power from India under medium and long term PPAs.
15. Risk management and Risk allocation principles and mechanism	Not known
16. Source of funding	The total project cost at Bangladesh side was BDT 1,717.474 million or US $20.08 million, of which BDT 1,573 million was financed by the Government of Bangladesh and BDT 143.81 million by PGCB. Indian portion of this line was financed by PGCIL India at a total cost of ₹1 billion or US $13.36 million. The total project cost is around US $33.45 million.[104]
17. Cost recovery	Transmission Charges (Indian Portion): BPDB to pay POWERGRID tariff determined as per prevailing CERC regulations
18. Financial information	Not known
19. Modality of Development	Developed under government. to government model.

Criteria	Details

20. Tariff & payment support

Transmission tariff is determined by CERC. The charges are paid by BPDB. The BPTA signed between BPDB and POWERGRID provides as under: -
"3.2 BPDB shall pay the transmission tariff and other charges on account of the said transmission system mentioned at para 2.1 to POWERGRID INDIA with effect from the date of commercial operation in accordance with the norms/order/notification issued by CERC from time to time. POWERGRID INDIA shall ensure intimation to BPDB about Tariff hearing process of CERC and facilitate BPDBs participation for the same. However, any other taxes and duties imposed by Government of Bangladesh shall be paid by BPDB."
The charges determined during 2016 by CERC for the India side assets were as below:

Table 13: Transmission tariff for India side assets

Revenue approved for the Line Component by CERC

in ₹ lakh

Particulars	Asset-I			
	2015-16 (pro-rata)	**2016-17**	**2017-18**	**2018-19**
Depreciation	13.03	374.51	406.16	406.16
Interest on loan	14.70	406.39	408.91	374.03
Return on equity	14.41	414.49	449.77	449.77
Interest on Working Capital	1.00	28.23	29.86	29.08
O&M Expenses	0.48	12.99	13.42	13.86
Total	**43.62**	**1236.61**	**1308.12**	**1272.89**

Revenue approved for the Substation Bay Component by CERC

Particulars	Asset-1(A)			
	2015-16	**2016-17 (pro-rata)**	**2017-18**	**2018-19**
Depreciation	-	39.20	65.38	65.38
Interest on loan	-	40.27	63.47	57.85
Return on equity	-	40.94	68.07	68.07
Interest on Working Capital	-	5.87	7.77	7.77
O&M Expenses	-	62.07	66.50	68.72
Total	**-**	**188.34**	**271.19**	**267.78**

Source: CERC[105]

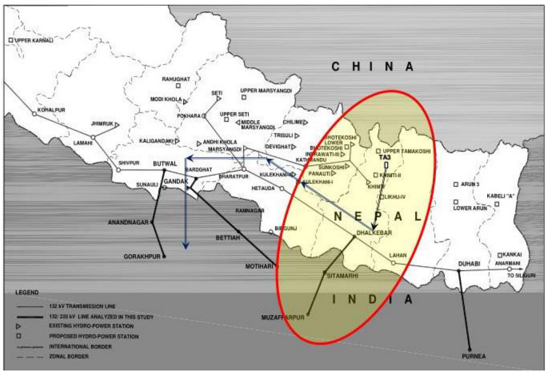
Criteria	Details
21. Dispute Resolution	There exists a Grievance Redress Committee (GRC) to deal with disputes and grievances. The committee has a defined jurisdiction and provides a clear redressal process.
22. Cost Sharing Model	Shared by each country within its territory
23. Role of regional markets in project development	Line developed to make use of power from India

Criteria	Details
24. Associated strategic, policy, regulatory, legal, technical, commercial, operational framework	A Joint Steering Committee (JSC) and Joint Working Group (JWG) were constituted for reviewing and enhancing bilateral cooperation in the power sector between the two countries. JSC is led by the secretary power of the countries. The India-Bangladesh power system operation is coordinated from NLDC, India at New Delhi, and NLDC, Bangladesh at Dhaka
25. Trade between the lines over the years	Approximately 2-3 GWh per day, as of March 2023.

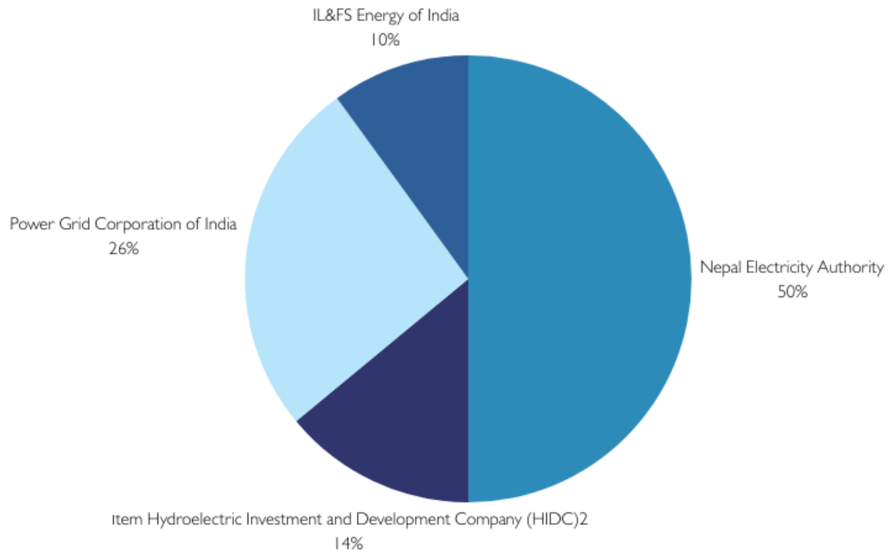
3.10.3 Dhalkebar (Nepal) – Muzaffarpur (India) Line

In February 2016, the 400 kV Dhalkebar (Nepal) - Muzaffarpur (India) was commissioned. Out of 140 km of line length, 40 km of the line is in Nepal while 100 km is in India. Power Transmission Company Nepal Limited (PTCNL) was established for the operation of line on the Nepal side. The Nepal Electricity Authority (NEA) owns 50 percent of the PTCNL, while Nepal's Hydroelectric Investment and Development Company (HIDC) owns 14 percent. Two Indian companies Power Grid Corporation and IL&FS Energy of India have 26 and 10 percent stake in the company respectively.

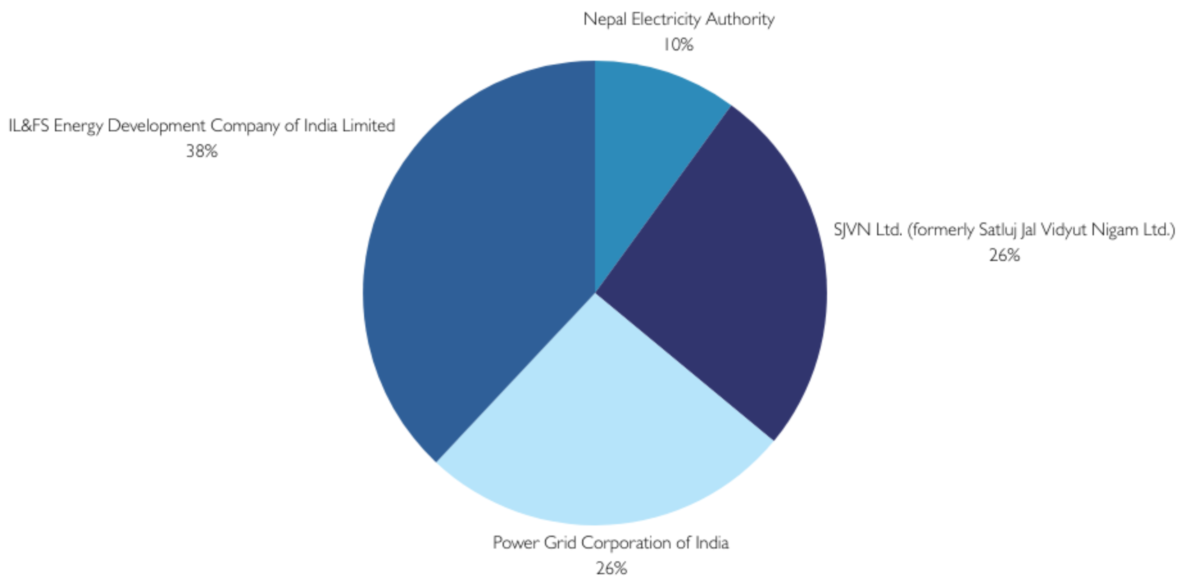
The audited final executed project cost of the Nepal portion is NPR 1.54 billion and the project has been implemented on a 70:30 debt: equity ratio. A parallel company, Cross-Border Power Transmission Company Limited. (CPTCL) was set up in India to develop the transmission line in the Indian portion[106, 107].

Criteria	Details
1. Map	 Figure 51 : Map between Dhalkebar and Muzaffarpur
2. Location	Dhalkebar in Nepal & Muzaffarpur in Bihar, India
3. Type	140 km HVAC Transmission Line[108]
4. Physical attributes	The transmission line is designed to operate at 400 kV[109]. The length is 140 km Currently the line is able to transfer up to 800 MW.
5. Project schedule	Commissioned in 2016

<table>
<tr><th>Criteria</th><th>Details</th></tr>
<tr><td>6. Operational date/ year</td><td>Initially February 2016[108]</td></tr>
<tr><td>7. Tenure of contract</td><td>On long-term (25 year) basis,[108]</td></tr>
<tr><td>8. Purpose of the project (benefit to the region)</td><td>The line was envisaged to initially support import of power by Nepal from India, and after a period of 7 years, the line was envisaged to support export of power from Nepal to India.</td></tr>
<tr><td>9. Ownership Structure</td><td>
Ownership Structure of
Power Transmission Company Nepal Limited (PTCN)



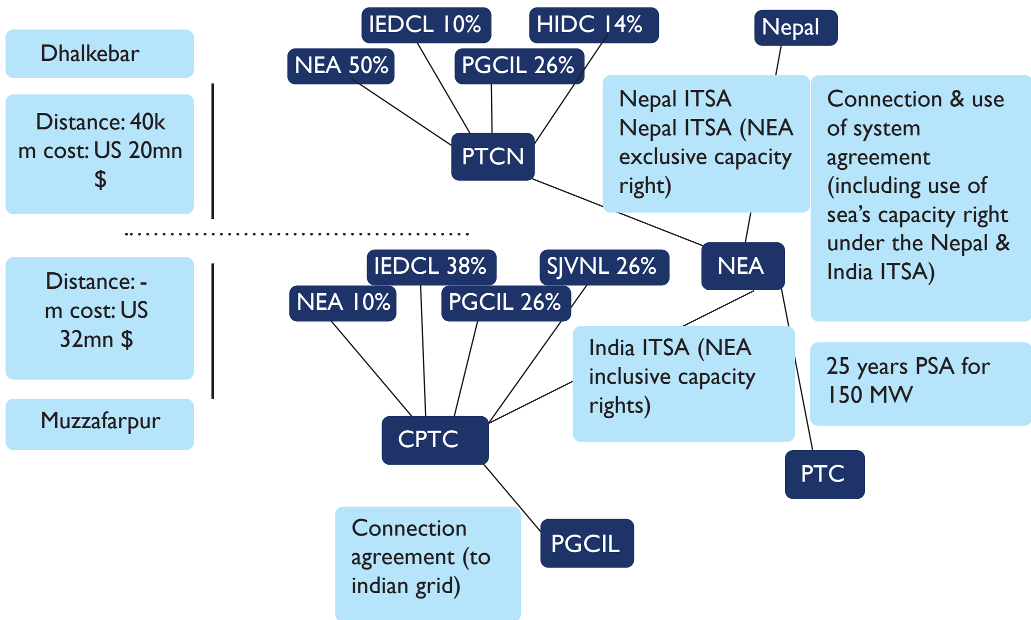
Ownership Structure of
Cross-border Power Transmission Company Limited (CPTC)

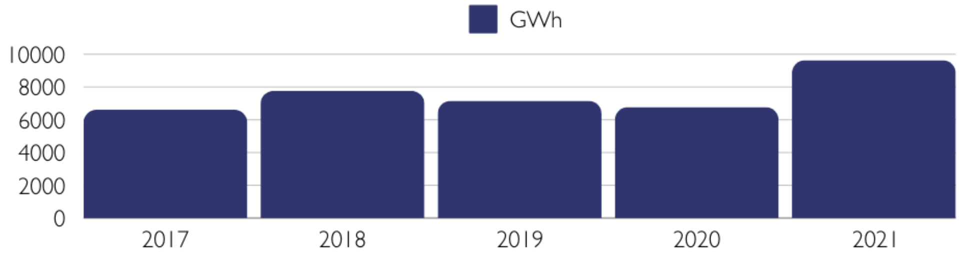
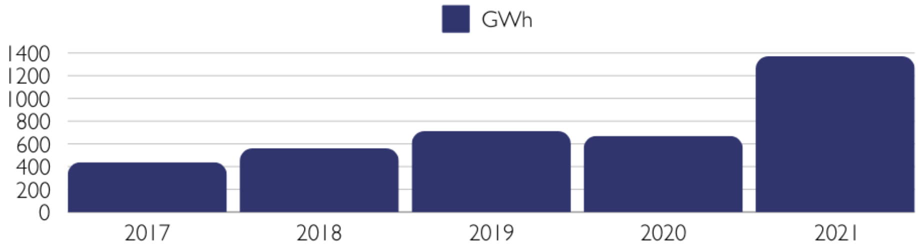


</td></tr>
</table>

Figure 52: Ownership structure of transmission line JVs for Dhalkebar Muzaffarpur line

Criteria	Details
10. Investment entities structuring	POWERGRID entered into Shareholders' Agreement on 9th July 2012 with IL&FS Energy Development Company Limited (IEDCL), SJVN Limited (SJVN) & Nepal Electricity Authority (NEA) of Nepal and formed a JV Company under the name "Cross-border Power Transmission Company Ltd" (CPTC). POWERGRID entered into a "Joint Venture cum Share Purchase Agreement" on 5th April, 2014 with NEA, Hydroelectricity Investment & Development Company Ltd (HIDCL) of Nepal and IEDCL and formed a JV Company under the Name "Power Transmission Company Nepal Ltd" (PTCN) incorporated in Nepal for implementation of Nepal portion i.e. Dhalkebar - Bhittamod section (Nepal Portion) of 400 kV D/C Muzaffarpur - Dhalkebar Indo-Nepal Cross-border transmission line.[109]
11. Auction	Capacity booked fully by Nepal
12. Investment Decision	Intergovernmental decision
13. Business and Financing model adopted	Combination of IPTC and JV models
14. Risk management and Risk allocation principles and mechanism	Not known
15. Source of funding	Power Transmission Company Nepal Limited (PTCNL) was established for the operation of line on the Nepal side. The Nepal Electricity Authority (NEA) owns 50 percent of the PTCNL, while Nepal's Hydroelectric Investment and Development Company (HIDC) owns 14 percent. Two Indian companies Power Grid Corporation and IL&FS Energy of India have 26 and 10 percent stake in the company respectively. The audited final executed project cost of the Nepal portion is NPR 1.54 billion and the project has been implemented on a 70:30 debt equity ratio.
16. Cost recovery	Indian side – Through transmission payments specified in Implementation and Transmission Service Agreement (ITSA)
17. Financial information	The Shareholding of POWERGRID, SJVN, IEDCL and NEA in CPTCL is 26 percent, 26 percent, 38 percent and 10 percent respectively. The Audited cost of the India Portion is ₹241.27 crore, and the Project was implemented with debt: equity as 80:20[110] The Shareholding of NEA, POWERGRID, HIDCL and IEDCL in PTCNL is 50 percent, 26 percent, 14 percent and 10 percent respectively. The Audited final executed Project cost of the Nepal Portion is NPR 154.57 crore and the project has been implemented on 70:30 debt equity ratio. The Audited cost of the Nepal Portion is ₹101 crore, and the project has been envisaged to be implemented on 70:30 debt: equity ratio. Total: ₹342.27 Crore (US $41.646 million)
18. Modality of Development	Combination of IPTC and JV models

Criteria	Details
19. Tariff & payment support	The tariff mechanism for use of Indian segment is provided in the Implementation and Transmission Service Agreement (ITSA), which has proposed a cost plus return mechanism, in the lines of CERC norms. For Nepal side, all the costs are borne by Nepal Electricity Authority.
20. Payment Security Mechanism	NEA to establish the irrevocable revolving letter of credit in favour of PTCN in a schedule Bank in Nepal with a value equal to 105 percent of the estimated value of one month's monthly TSC payment The term of LC shall not be less than 12 months and shall be renewed time to time As a credit enhancement NEA to furnish the bank Guarantee valid for 12 months for an equivalent value of twelve months monthly TSC payment.[111]
21. Contractual Arrangements	Implementation and Transmission Service Agreement (ITSA) between NEA and CPTC. Other documents as shown below.  Figure 53 : D-M line structure and agreements
22. Cost Sharing Model	While entities bear costs within their borders, NEA has agreed to ensure full capacity payments for the transmission capacity in Indian portion, irrespective of usage.
23. Role of regional markets in project development	Allowed Nepal to access Indian power market, including power exchanges.
24. Associated strategic, policy, regulatory, legal, technical, commercial, operational framework	Within the overall frameworks in India and Nepal

Criteria	Details
25. Trade between the lines over the years	 Figure 54 : India's electricity exports to Nepal  Figure 55 : Nepal's electricity exports to India

3.10.4 400 KV Tala Hep (Bhutan) – Siliguru (India) - Two Lines

Criteria	Details
1. Location	Tala HEP (Bhutan) - Siliguri (India)
2. Type	Tala HEP (Bhutan) - Siliguri 400kV 2xD/c
3. Physical attributes	Tala HEP - Siliguri 400 kV three D/C transmission lines of 72 km line length from Chukha HEP in Bhutan to Birpara in West Bengal, India. [113]  Figure 56: Indicative map of Tala - Siliguri lines
4. Project schedule	Commissioned in 2005
5. Operational date/ year	01 October 2005[114]

Criteria	Details
6. Tenure of contract	35 years
7. Purpose of the project (benefit to the region)	For power export to main grid of Indian power system for transfer to power deficit regions[115] . Net export from hydro power plants in Bhutan to India on an annual basis. However, during dry season when river flows reduce due to low temperature, there is import of power from India.
8. Ownership Structure	See below.
9. Investment entities structuring	Tala transmission project executed by Tala Delhi Transmission Company, a 49:51 joint venture between Power Grid and Tata Power.[116]
10. Auction	Capacity booked as per Open Access framework.
11. Investment Decision	Conceived as a joint venture with Government of India funding (60 percent grant and 40 percent loan).
12. Business and Financing model adopted	Line within Bhutan financed along with the generation component. Line in India developed by a PPP arrangement between Power Grid Corporation of India Limited (PGCIL) and Tata Power[117]
13. Source of funding	Part of the Tala Project Total project cost: ₹41.26 billion or US $551.5 million 60 percent grant and 40 percent loan
14. Cost recovery	Through PPA: The Power Trading Corporation (PTC) of India signed a 35-year power purchase agreement (PPA) with the Government of Bhutan in 2006
15. Financial information	Line within Bhutan financed along with the generation component. Line in India developed by a PPP arrangement between Power Grid Corporation of India Limited (PGCIL) and Tata Power.[117]
16. Modality of Development	Intergovernmental
17. Trade between the lines over the years	Net export from Bhutan to India in April 2019 to March 2020 was 6311 MU.

3.10.5 Jigmeling (Bhutan) – Alipurduar (India) 400KV D/C

Criteria	Details
1. Map	 Figure 57 : Indicative map of Alipurduar - Jigmeling interconnector
2. Location	Jigmeling is a location on the India-Bhutan border while Alipurduar is located in West Bengal.[118]
3. Type	Overhead HVAC Quad line
4. Physical attributes	Bhutan portion of the link comprises two double-circuit 400kV lines from Mangdechhu (the location of the hydropower plant) to Jigmeling, via the Goling polling station. Jigmeling - Alipurduar 400kV HVAC(Quad) line (Indian side) NER -portion – 126 km. [119]
5. Project schedule	June 2012 - Construction work on the project began August 2019 - Power purchase agreement June 2021 - Become operational[120]
6. Operational date/ year	June 2021 [120]
7. Tenure of contract	35 years
8. Purpose of the project (benefit to the region)	Mutual energy transfer.
9. Ownership Structure	Under BPC in Bhutan side, and under PGCIL in India side.
10. Investment entities structuring	As above

Criteria	Details
11. Auction	As per open access procedures
12. Investment Decision	Linked to generation project evacuation.
13. Business and Financing model adopted	Government/Public owned
14. Cost recovery	Through transmission revenues (India) and wheeling tariffs (Bhutan).
15. Financial information	Estimated outlay of $607 M (Rs.4,500 crore), is funded by the Indian government by of grant (30 percent) and loan (70 percent).[118]

4. Review of International Experience

4.1 Introduction

There are multiple examples of cross-border transmission lines across the globe. The learnings from these select transmission lines trying to facilitate cross-border electricity trade while ensuring reliability, could be used for developing a compendium of case studies for best practices for development of cross-border transmission lines in South Asia.

Some of the key examples are discussed below, which highlight the nature of the ownership, business model adopted, risk management, cost sharing mechanisms, contractual design, regional market structure.

4.2 Models of Ownership

From the above case studies, various models of ownership of cross-border transmission lines have been identified depending on the arrangements between the participating countries and entities.

Table 14: Models of ownership for case study examples outside South Asia

Public/Government ownership	**Ethiopia Kenya Interconnection** **Egypt Sudan Interconnector**
Independent Power Transmission (IPT) / Concessions [Including JVs, Regionally Owned Lines etc.]	Thailand Cambodia Interconnection Garabi Interconnector GCC Interconnection (also under government) SIEPAC (Also regional JV of government utilities along with private entity) NEMO Link (Also owned by government utilities)
Merchant Power Transmission	Montana Alberta Tie Line Basslink Interconnector
Dedicated transmission line	MOTRACO

These are explained further:

- **Government Ownership:** The transmission line is owned and operated by the governments of the countries involved or their state-owned entities. For example, the Ethiopia- Kenya Power interconnection is jointly owned by the government entities of Ethiopia and Kenya. The Kenya Electricity Transmission company (KETRACO (owned by the Government of Kenya) owns the interconnection assets in Kenya. On the Ethiopian side, Ethiopian Electric Power Corporation (EEPCo) owns the interconnection assets.

- **Joint Venture:** The transmission line is jointly owned by multiple entities, which can include government entities, private companies, or a combination of both. The Nemo link is a joint venture between National Grid Interconnector Holdings Limited and Elia System Operator NV/SA (Elia), the Belgian transmission system operator. Each owns 50 percent of the shares in Nemo Link.

- **Private Ownership:** The transmission line is owned and operated by private companies or consortiums, without direct government ownership. The Garabi project is a privately owned transmission system. A special purpose company (CIEN) is the owner of the two interconnection systems on the Brazilian side of the border On the Argentinean side, assets of the project are owned by Transportadora de Electricidad, S.A. ("TESA") an Argentinean subsidiary of CIEN. Another example is the Cambodia Thailand Transmission Line (CPTL).

Case Study: Wholly Owned Privately Owned Transmission Interconnector

The Zambia-DRC transmission interconnector, also known as the CEC (Copperbelt Energy Corporation) interconnector, is a cross-border transmission line that links the electricity networks of Zambia and the Democratic Republic of Congo (DRC). It is owned and operated by the Copperbelt Energy Corporation, a private company based in Zambia. The CEC interconnector project is wholly owned by Copperbelt Energy Corporation. Functioning as a licensed private entity responsible for the entire grid within the Copperbelt region, CEC successfully constructed and executed this transmission line that facilitates power exchange between SAPP members, including SNEL in the Democratic Republic of Congo (DRC) and other participating entities. This project enables CEC to derive advantages from both wheeling charges and energy trading across the interconnector.

Public-Private Partnerships (PPPs): The transmission line is jointly owned and operated by a government entity and a private company, combining public and private resources and expertise. The Basslink interconnector, linking the Australian states of Victoria and Tasmania, is owned by the Tasmanian government and a private consortium consisting of Macquarie Group and Infrastructure Capital Group.

Regional Cooperation: Ownership is shared among multiple countries or regional entities, often facilitated by agreements or organizations promoting regional energy cooperation. The Central American Electrical Interconnection System (SIEPAC) is a regional transmission network connecting several Central American countries, and its ownership is shared among the participating countries.

Use of Special Purpose Vehicles: Special purpose vehicles (SPVs) are legal entities used in investment to separate an asset and pool money from several sources of finance. SPVs can be combined with several of the models above. In Cambodia- Thailand Interconnection, SKL and A.S.K created the special-purpose company (Cambodia) Power Transmission Lines Co., Ltd. (CPTL). SKL took 40 percent direct ownership and A.S.K. took 25 percent to become CPTL's majority shareholders. Two individual investors joined the company as minority shareholders: Se Thma Pich (20 percent direct ownership) and Tea Tyas (15 percent direct ownership). A.S.K. novated all project-related documents to CPTL on 28 July 2005.

Bilateral Ownership Model PPA/Bilateral Contract: In this model, both the countries own and manage the transmission line. The model is governed by bilateral purchase contracts and PPA Example: The Great Northern Transmission Line between the United States and Canada is jointly owned by Minnesota Power (the United States) and Manitoba Hydro (Canada).

4.3 Risk Management

Table 15: Models of risk management adopted for case study examples outside South Asia

Model	Example
Payment Security Funds	Basslink Interconnector
Partial Risk Guarantee Funds (PRGF)	Garabi Interconnector
Bilateral or Multilateral Agreements	MOTRACO and other lines

Cross-border transmission lines involve payment risks due to various factors such as currency fluctuations, non-payment by counterparties, or financial instability. To mitigate these payment risks, different payment risk mechanism models are implemented. Some commonly followed payment risk mechanism models in cross-border transmission lines:

Payment Security Funds: A separate fund is established to provide security for payments related to the cross-border transmission line. Payments are made from this fund to mitigate the risk of non-payment or delay in payments by counterparties. For example, in Basslink Interconnector, there's a provision of commercial risk sharing arrangement which has resulted in Hydro Tasmania paying an increased BFF in only one of the link's first six years of operation.

Partial Risk Guarantee Funds: A PRG fund helps mitigate the risks associated with changes in regulations, policy shifts, or political instability. It improves the creditworthiness of the project by providing a guarantee against certain risks. For example, in the Garabi interconnector, the Multilateral Investment Guarantee Agency (MIGA) offered partial risk guarantees. MIGA has issued $28 million to Endesa and $37 million to Banco Santander Central Hispano for their investments and loans in CIEN to expand its power distribution capabilities in Brazil.

Bilateral or Multilateral Agreements: Bilateral or multilateral agreements between countries can incorporate provisions related to payment guarantees and dispute resolution mechanisms. These agreements outline the responsibilities and obligations of the parties involved, minimizing payment risks.

Case Study: MOTRACO Transmission Project

MOTRACO transmission project, also known as the Mozambique Transmission Company (MOTRACO) project, is a collaborative effort between Mozambique, South Africa, and Eswatini (formerly known as Swaziland). It is a joint venture between the government utilities of Mozambique (Electricidade de Moçambique — EDM), South Africa (Eskom) and Eswatini (Swaziland Electricity Board, now Eswatini Electricity Company — EEC).

EDM and EEC have separate wheeling contracts with MOTRACO, enabling them to engage in power trading and participate in the Southern African Power Pool (SAPP). These contracts allow for bi-directional power exchange. The initial investment phase, valued at approximately USD 93 million, was successfully concluded in the mid-2000s. To safeguard the investments made by the European Investment Bank and the Japan Bank of International Cooperation in MOTRACO, MIGA issued guarantees to Eskom to cover loan guarantees. These guarantees provided protection against risks such as expropriation, war, and civil disturbances. Additionally, the French development agency AFD contributed further financing for subsequent project stages.

4.4 Cost sharing Mechanisms

Table 16: Models of cost sharing adopted for case study examples outside South Asia

Cost Sharing Model	Example
Proportional Cost Sharing	GCC Interconnector (though based on ratio of savings from reserve capacity) NEMO Link
Equal Cost Sharing	SIEPAC
Geographical	Ethiopia-Kenya Egypt-Sudan
Bilateral or Multilateral Agreements	Basslink

Cost sharing mechanisms in cross-border transmission lines are established to distribute the investment and operational costs among the participating countries or entities. These mechanisms ensure fair sharing of expenses and promote cooperation in cross-border energy projects.

USD Proportional Cost Sharing: Under this mechanism, the costs of developing, constructing, and operating the cross-border transmission line are divided among the participating countries or entities based on a predetermined proportion/ equal basis.

- **Equal Cost Sharing:** SIEPAC is an example where costs are equally shared between entities.
- **Geographical:** Entity in each country shares the cost of infrastructure within the borders.
- **Capacity Allocation:** Under this model, capacity is allocated to participants. The costs of the cross-border transmission line are allocated based on the capacity or transmission rights assigned to each participating country or entity. The costs are divided proportionally to the allocated capacity, reflecting the transmission volumes each participant is entitled to utilize. In Montana Alberta Ter-Line, capacity is allocated to wind farms.
- **Based on bilateral/multilateral agreements:** The cost sharing mechanisms of various cross-border transmission lines were found to be governed by the bilateral agreements in place. For example, the cost sharing mechanism for the Basslink interconnector project was established through a commercial agreement between Basslink Pty Ltd, the owner and operator of the interconnector, and the respective utility companies in Tasmania and Victoria.

4.5 Contractual Design & Arrangements

Table 17: Models of underlying contractual design for case study examples outside South Asia

Contractual Arrangements	Example
Long Term PPA	Thailand-Cambodia Interconnection Ethiopia-Kenya Interconnection Egypt Sudan Interconnector Garabi Interconnector MOTRACO
Spot Market Contracts	Montana Alberta Tie line Basslink
Bilateral or Multilateral Agreements	GCC Interconnection SIEPAC NEMO Link

- **Long-Term Power Purchase Agreements (PPAs):** Long-term PPAs are contracts between electricity producers and buyers that establish the terms and conditions for the sale and purchase of electricity over an extended period, typically ranging from 10 to 20 years. These agreements provide stability and security for both parties involved.

- **Spot Market Contracts:** Spot market contracts, also known as day-ahead contracts, involve the purchase or sale of electricity for immediate or near-immediate delivery. These contracts enable participants to buy or sell electricity at prevailing market prices, promoting efficient allocation of electricity resources. Spot markets are often facilitated through regional electricity exchanges or marketplaces.

- **Bilateral or Multilateral Agreements:** These govern the technical and commercial aspects of electricity transmission between interconnected power systems. These agreements define the terms for capacity allocation, operational procedures, and grid access.

4.6 Regional Market Structure

Table 18: Regional market structure for case study examples outside South Asia

Regional Market Structure	Example
Integrated Regional Market	GCC Interconnection SIEPAC
Spot Market	Basslink
Bilateral Trading Arrangements	Thailand-Cambodia Interconnection Ethiopia-Kenya Interconnection Egypt Sudan Interconnector Garabi Interconnector MOTRACO
Independent Power Exchanges	NEMO Link
Merchant Interconnectors	Montana Alberta Tie line

- **Integrated Regional Market:** In this model, multiple countries or regions form a common market for electricity trade. They establish harmonized regulations, grid codes, and market rules to facilitate cross-border transactions. The transmission lines act as interconnectors, enabling the seamless exchange of electricity. The Gulf Cooperation Council is an excellent example of where the interconnection enables electrical energy exchange and emergency support among six constituent countries of the GCC.

- **Spot Market:** In the Basslink interconnector between Victoria and Tasmania, Basslink earns revenue for its owners to generators in the National Electricity Market (NEM), by bidding into the spot market its capacity to deliver energy, with the returns determined by price differences and the energy flows between Victoria and Tasmania.

- **Bilateral Trading Arrangements:** In this structure, neighboring countries or regions negotiate bilateral agreements for cross-border electricity trade. Transmission lines are established to facilitate these transactions between specific pairs of countries.

- **Independent Power Exchanges:** Some cross-border transmission lines may have independent power exchanges where electricity is traded. These power exchanges act as intermediaries, providing a platform for market participants to buy and sell electricity across-borders. Nemo Link is an example of an independent power exchange, it includes a dedicated market coupling process, known as the Nemo Link Integrated Auction, which allows market participants to trade electricity between the two countries. Through the Nemo Link transmission line, market participants can engage in cross-border electricity trading, taking advantage of price differentials, supply-demand dynamics, and market opportunities in the United Kingdom and Belgium.

- **Merchant Interconnectors:** In certain cases, transmission lines operate as merchant interconnectors.

They are owned and operated by private entities that profit from the cross-border electricity trading activities. These interconnectors operate based on market principles and aim to maximize their revenue through efficient utilization of the transmission capacity. The Montana-Alberta Tie Line is one of the few merchant cross-border interconnectors in the world. It offers transmission services to market participants through bilateral negotiated agreements. The negotiated transmission service model allows market participants to contract for transmission capacity on the MATL line through individual negotiations with the transmission provider. This model provides flexibility in terms of contract duration, pricing, and terms and conditions, allowing market participants to tailor the transmission service to their specific needs.

Cross-Border Capacity Allocation Mechanisms

In some regions, transmission capacity on cross-border lines is allocated through auctions or market-based mechanisms. Market participants bid for access to the available transmission capacity, and the allocation is determined based on market principles. This approach promotes efficient use of cross-border transmission infrastructure. For example, in Montana - Alberta Tie Line, contracts are generally signed with wind farms in the Northern US like Gaelectric. Any capacity not allocated to contracted companies will be auctioned to other companies in an open season bidding process.

4.7 Tariff Mechanism

Table 19: Tariff mechanism for case study examples outside South Asia

Tariff Mechanism	Example
Negotiated/Mutually Agreed Tariff	MOTRACO
Tariff determined by Regulator	SIEPAC NEMO Link
Bundled Tariff under PPA	Cambodia Thailand Interconnection
Other Mechanisms	GCC Interconnector

- **Negotiated/Mutually Tariff:** Here, the tariff is mutually negotiated either as a fixed number with escalations, or under a mutually agreed methodology. Wheeling charges for MOTRACO is an example under this category.

- **Tariff determined by Regulator**: Under this model, a national or regional regulator determines tariff, as can be seen in the case of NEMO link (determined by OFGEM, UK), SIEPAC (determinedby CRIE) etc.

- **Bundled Tariff under PPA:** Under this mechanism, transmission related charges are bundled in a PPA tariff, as transmission related costs are paid back to the entity from the same. Example is Cambodia Thailand interconnector wherein EDC wheels the power and pays back transmission charges to CPTL.

- **Other Mechanisms:** GCC's transmission tariff is determined by GCC's Advisory and Regulatory Committee (ARC) as a matter of policy measure.

4.8 Policy, Regulatory, Legal, and Institutional Framework

Regulatory Coordination

Countries with interconnected transmission systems often establish coordination mechanisms between their respective regulatory bodies. These mechanisms facilitate the harmonization of technical standards, market rules, and cross-border electricity trading procedures. Regulatory coordination may involve regular meetings, information exchange, and joint decision-making on cross-border transmission issues. Regulatory bodies play a crucial role in overseeing the operation and market activities of cross-border transmission lines. They ensure fair competition, grid reliability, and compliance with technical and safety standards.

The interconnection between France and Spain, operated by the French TSO (RTE) and the Spanish TSO (Red Eléctrica de España), follows the regulatory framework set by ENTSO-E. Another example is the Nord Link cross-border transmission line project which adheres to the regulatory framework set by the Norwegian Water Resources and Energy Directorate (NVE) and the German Federal Network Agency (BNetzA). These frameworks include parameters like Licensing and Permitting, Grid Access and Connection, Market Monitoring and Competition, and System Operations and Security. The NVE and BNetzA's respective regulatory frameworks offer a clear and unified set of rules and regulations for the energy sector in Norway and Germany. While taking environmental and safety considerations into account, they seek to ensure fair competition, dependable operation, and effective growth of the gearbox infrastructure.

Grid Planning

Countries with interconnected transmission systems often engage in joint grid planning exercises to ensure the efficient and reliable operation of cross-border transmission infrastructure. These planning processes involve assessing electricity demand, identifying transmission capacity needs, and coordinating investment in transmission infrastructure across-borders.

Legal Framework

Cross-border transmission lines require legal agreements between the participating countries to define their rights, responsibilities, and obligations. These agreements typically cover aspects such as project ownership, cost-sharing, operation and maintenance, and dispute resolution. One notable example is the Nordic Imbalance Settlement Agreement (NBSA) between the Nordic countries, which facilitates balancing and settlement of electricity imbalances across their interconnected systems.

The IFA (Interconnexion France-Angleterre (England) cross-border interconnector is governed by the IFA Interconnector Agreement, a legally binding agreement between the French and British transmission system operators. A legal basis for cooperation, operation, and governance of the IFA interconnector is provided by the IFA Interconnector Agreement. It makes sure that the rights, obligations, and operating processes of the TSOs and market participants involved in the energy exchange between France and England through the interconnector are clear, consistent, and understood by both parties.

5. Review of Key Framework In South-Asian Countries

5.1 Introduction

Worldwide, various policies and regulations directly or indirectly influence the framework for investment and development of cross-border transmission lines. Some of the key policies discussed about South Asian countries include key details of existing cross-border transmission lines, the investment decisions, contractual arrangements, implementation arrangements followed by framework of South Asian countries private investment, foreign investments, dispute resolution etc. The following subsections also cover regulations, incentives and institutions in the respective country that would determine the environment for building cross-border transmission lines.

5.2 Key Details of Existing Cross-Border Transmission Line

Investment Decision:

The investment decision for development of cross-border lines in Asia has been largely due to government decisions. For example, the initiative to build Dhalkebar (Nepal)-Muzaffarpur (India) Cross-border Transmission Line took shape when India and Nepal started exploring possibility of four transmission lines:

1) Anarmani-Siliguri, 2) Duhabi-Purnea, 3) Dhalkebar-Muzaffarpur, and 4) Butwal-Gorakhpur

The first 400 kV cross-border transmission line between Nepal and India, from Dhalkebar to Muzaffarpur, was charged at 220 kV voltage level in August 2018. The installation of 400/220 kV, 3 x 315 MVA transformers was completed later.

NEA signed an MoU with the Infrastructure Leasing & Financial Services Limited (IL&FS). The MOU was signed by the Power Exchange Committee (PEC) and the Joint Committee on Water Resources (JCWR). India's PEC team was led by a Member (Power System) of the Central Electricity Authority (CEA) and an ex-officio Additional Secretary from the Government of India (GOI), The Nepalese team was led by NEA's Managing Director.

The financing of the project was a major issue of negotiation between Nepal and India. As part of the deal, in December 2011, NEA entered into a Power Sale Agreement with the Power Trading Corporation of India for the purchase of 150 MW of power for a 25-year period, which was a key element in bringing the project to its financial closure. Also, NEA needed to apply to CTU of India (i.e., PowerGrid), as per the regulations and procedures of the CERC for injecting power into the Indian grid. The Nepalese side agreed to work out the details of possible export potential, its time frame, and export points, and accordingly apply to CTU seeking connectivity and Long-Term Access (LTA) for injecting power into the Indian grid.

For the Tripura-Camilla interconnection, the investment decision was due to the government decision through signing of MoU between the two countries to improve power trade. This agreement stemmed from the decision made by the Joint Steering Committee (JSC) in September 2017, consisting of the Power Secretaries of Bangladesh and India, to enhance interconnections in eastern and northern Bangladesh. Similarly, for the Mangdechhu (Bhutan)- Jigmeling (India) Cross-border Transmission Line, an agreement was signed between the Indian Government and the Bhutanese government.

Implementation

Usually, the implementation of the projects is usually taken care of by the respective entities of the participating countries. For example, the India-Nepal 'Dhalkebar (Nepal)-Muzaffarpur (India)' project was built through two parallel institutions, one incorporated in Nepal and the other in India, each responsible for building, maintaining, and operating the transmission line on its side of the border. On the Nepal side, the Power Transmission Company Nepal Limited (PTCN) was formed in 2012, with two Nepali entities, the NEA and HIDCL holding 50 percent and 14 percent share, respectively;and two Indian companies, PowerGrid India and IEDCL holding 26 percent and 10 percent share of the company, respectively. On the Indian side, the Cross-Border Power Transmission Company Limited (CPTC) was established in 2006, with three Indian companies, IL&FS Energy Development Company Limited (IEDCL), POWERGRID, and SJVN holding 38, 26, and 26 percent share respectively; and one Nepali company, NEA, holding 10 percent of the company. Whereas for the India-Bangladesh transmission line PowerGrid Corp. of India and Bangladesh Power Development Board had signed a contract for the development and operation of the project. For the project, Mangdechhu (Bhutan)- Jigmeling (India) Cross-border Transmission Line, Bhutan Power Corporation(BPC) built transmission lines from Mangdechhu plant to Jigmeling to Salakati.

For the Tala HEP- Siliguri transmission line, the entire infrastructure transmission capacity was assigned to PGCIL under a TSA for a regulated transmission fee. The transmission charges are paid by the Indian consumers/ beneficiary.

Contractual Arrangements

Power Trade Agreement: The power trade through the cross-border transmission line is regulated by the bilateral Power Trade Agreement (PTA) between the two countries. For the DM line, NEA entered into a Power Sale Agreement with the Power Trading Corporation of India for the purchase of 150 MW. NEA has also signed an

"Implementation and Transmission Service Agreement" with both PTCN and CPTC. Finally, NEA has booked the full transmission capacity of the lines and shall pay the Transmission Service Charge. CPTC will provide the entire transmission capacity of TLP-India to NEA on a commercial basis, allowing NEA to utilize the line for its own needs or extend access to other users in Nepal and/or India through separate transmission service= agreements. NEA will compensate CPTC with Transmission Service Charges as outlined in the agreement. CPTC will obtain the necessary Consents from relevant Governmental Authorities for the setup of TLP-India and for the sale of its transmission capacity to NEA, with the terms and conditions of such Consents aligning with the agreement. While India- Bangladesh have established a cross-border electricity trading arrangement through the South Asia Subregional Economic Cooperation (SASEC) framework. An MoU signed between India and Bangladesh led to the formation of a Joint Steering Committee (JSC) and Joint Working Group (JWG) dedicated to enhancing bilateral cooperation in the power sector. The JSC, led by the power secretaries of both countries initiated their collaboration by establishing a cross-border link. The JSC and JWG meet regularly to determine the strategic direction for electricity cooperation. Furthermore, a Joint Technical Team (JTT) consisting of experts from both sides was established to assess proposals from a technical perspective and provide recommendations to the JSC/JWG.

To tap into Bhutan's hydro-electric power resources, power purchase agreements (PPAs) are signed between Bhutanese hydropower projects and Indian utilities, ensuring a long-term electricity supply arrangement. For example, in the Mangdechhu- Jigmeling-Salakati Cross-border Transmission line, in August 2019, PTC India Ltd signed a power purchase agreement with Druk Green Power Corp. Ltd (a Bhutan government company) for purchase of surplus power from 720-MW Mangdechhu hydropower project in Bhutan for 35 years. The Government of India designated PTC as the nodal agency from the Indian side to purchase this power from Bhutan.

Business Model

JV Model: The Nepal-India Power Transmission Project, where both countries collaborated to establish cross-border transmission lines for the exchange of electricity. On the Nepal side, the Power Transmission Company Nepal Limited (PTCN) was formed in 2012, with two Nepali entities, the NEA and HIDCL holding 50 percent and 14 percent share, respectively; and two Indian companies, PowerGrid India and IEDCL holding 26 percent and 10 percent share of the company, respectively. Similarly for Tala HEP- Siliguri transmission line, there is a joint venture ownership structure. Powerlinks Transmission Ltd. is a joint venture between Power Grid Corporation of India Limited (PGCIL) and Tata Power Limited. Most of the other lines are under the Government / Public sector model.

5.3 Current Framework

The current framework for investment in cross-border transmission lines in South Asia is described below. It seeks to analyze the following aspects:

- Strategic and political framework
- Legal policy and regulatory framework
- Technical and operational framework
- Commercial framework
- Institutional framework and stage of power sector reform

Parameters related to Investment of cross-border Transmission Lines	Key Insights
Strategic and political framework	**Afghanistan** • Afghanistan is one of the participating countries of Central Asia South Asia Electricity Transmission and Trade Project (CASA-1000), wherein available summer electricity surpluses from Tajikistan and Kyrgyz Republic will be transmitted to Pakistan and Afghanistan through HVDC lines • The country is also one of the signatories of SAARC Framework Agreemen for Energy Cooperation (Electricity), signed between the South Asian countries in November 2014 • Afghanistan currently has arrangements to import power from Iran, Tajikistan, Uzbekistan, and Turkmenistan **Bangladesh** • Bangladesh has signed bilateral agreements with India and Nepal, for regional cooperation in electricity • The Power Sector Master Plan 2016 of Bangladesh envisages up to 15 percent of generation capacity from imports **Bhutan** • Bhutan has signed various agreements with India for cooperation in power sector such as: Treaty of Friendship and Cooperation (signed in 1949 and revised in 2007); Agreement on Cooperation in Hydropower and the Protocol to the 2006 agreement signed in March 2009 (10,000 MW hydropower to be developed, with surpluses exported to India); • Intergovernmental Agreements for development of four HPPs of 2120 MW, signed in April 2014 **India** • India is also one of the signatories of SAARC Framework Agreement for Energy Cooperation (Electricity), signed between the South Asian countries in November 2014; and the MoU for establishment of the BIMSTEC Grid Interconnection, signed in August 2018 • India has been undertaking CBET with Bangladesh, Bhutan, Myanmar and Nepal under Intergovernmental Agreements / MoUs, Nepal • Country is one of the signatories to the SAARC Framework Agreement for Energy Cooperation (Electricity), signed in 2014; and the MoU for establishment of the BIMSTEC Grid Interconnection, signed between BIMSTEC countries in August 2018 • The Government of Nepal's white paper issued in 2018 has set a target of developing 5000 MW of export-oriented capacity in ten years **Pakistan** • Pakistan is one of the participating countries of Central Asia South Asia Electricity Transmission and Trade Project (CASA-1000), wherein available summer electricity surpluses from Tajikistan and Kyrgyz Republic will be transmitted to Pakistan and Afghanistan through HVDC lines • Country is one of the signatories to SAARC Framework Agreement for Energy Cooperation (Electricity), signed in 2014

Parameters related to Investment of cross-border Transmission Lines	Key Insights
	Sri Lanka • In June 2010, an agreement on conducting a feasibility study for the interconnection of the Indian and Sri Lankan electricity grids was signed between the respective Governments. The proposed India-Sri Lanka grid interconnection involves the construction of a submarine or overhead connection between Madurai in South India, and Anuradhapura in central Sri Lanka, through the Palk Strait. In 2017, a Memorandum of Understanding (MoU) was signed with India on economic co-operation. Sri Lanka and India also undertake Secretary level Joint Working Group meetings on cooperation in the power sector. • Country is one of the signatories to the SAARC Framework Agreement for Energy Cooperation (Electricity), signed in 2014; and the MoU for establishment of the BIMSTEC Grid Interconnection, signed between BIMSTEC countries in August 2018
Legal policy and regulatory framework	**Afghanistan** • The Power Services Regulation Act, 2016 allows awarding of import licenses and export licenses, for a maximum period of 15 years • No specific instances of regulatory framework to support CBET could be found **Bangladesh** • The Quick Enhancement of Electricity and Energy Supply (Special Provisions) Act, 2010 agrees on the need for quick implementation of the plan to import electricity and energy from abroad • The Electricity Act, 1910 also has provisions for enabling cross-border trade provision to obtain sanction from the government • As per 'Policy Guidelines for Enhancement of Private Participation in the Power Sector, 2008', PGCB and all Distribution Licensees shall provide non-discriminatory open access, to their transmission and/or distribution system for use by any Generation Licensee subject to payment of transmission/distribution wheeling charges determined by BERC • Regulations on cross-border trade have not yet evolved **Bhutan** • The Electricity Act, 2001 covers aspects relating to licensing, system operations, non-discriminatory access to transmission and distribution • The Act recognizes export and import of electricity as licensed activities. The Act also allows the Bhutan Electricity Authority (BEA) to designate a bulk supplier who will be responsible • A corporation can apply to the Authority for the issue of a licence authorizing trade, and for import and export of electricity, according to the Electricity Act of Bhutan, 2001 **India** • The policy framework for CBET is defined in Government of India's Guidelines for Import/Export (cross-border) of Electricity, 2018. These guidelines have lai down the broad principles for eligibility, approval process, institutional framework, tariff, and transmission aspects for CBET. The guidelines have enabling provisions for trilateral power trade, and trade through power exchanges. • Based on the Government of India's Guidelines for Import/Export (cross-border of Electricity, 2018, the CERC has issued its regulations on cross-border Trade of Electricity in 2019

Parameters related to Investment of cross-border Transmission Lines	Key Insights
	• The Procedure for Approval and Facilitating Import/Export (cross-border) of Electricity by the Designated Authority, issued on 26th February 2021 and its amendment describe the detailed procedures related to CBET. **Nepal** • Nepal's Electricity Act has a dedicated section covering import and export of electricity • Licensees can import electricity after obtaining the approval of the Government of Nepal • The licensee desiring to export electricity generated on its own to the foreign country may do so by entering into an agreement with the Government of Nepal Nepal's Hydropower Development Policy of 2001 has stated support for export-oriented projects • An independent electricity regulatory commission started functioning in Nepal only from May 2019. The regulatory framework is in its initial stages, and therefore the regulatory framework for CBET remains to be developed **Pakistan** • National Electric Power Regulatory Authority's (NEPRA) Import of power regulations of December 2017 lays down principles of power import and covers aspects such as approval of rate of import, and execution of PPA • Pakistan has recently transitioned from a single buyer plus model to the whol sale/competitive electricity market model • In 2020, NEPRA had approved the detailed design and implementation plan of the Competitive Trading Bilateral Contract Market (CBTCM), which enables a competitive environment in the power sector. The CTBCM implementatio started in June 2022, on a test-run basis for the initial six months. Post the test run period, financial transactions will commence under the CTBCM to achieve the benefits of affordable, reliable, and sustainable electric power for the consumers of the power sector of Pakistan. • NEPRA's Electric Power Trader Regulations of 2022 provides the regulator framework for licensing and operation of electric power traders. These Regulations also allow a Power Trader to be provided a license for "import and export of power". NEPRA's Market Operation Regulations of 2022 defines the regulatory framework for the licensing and operation of Market Operators. **Sri Lanka** • The regulatory framework specific to cross-border electricity trade is not available. Framework for open access is also not available as CEB continues to be the single buyer for electricity.
Technical and operational framework	**Afghanistan** • Afghanistan has three distinct geographically separate transmission networks: Northeast Power system (NEPS), Southeast Power System (SEPS) and Herat (presently covered by imports from Iran and Turkmenistan) • Northeast Power System of Afghanistan (NEPS) is supplied by existing hydr power and diesel projects of Afghanistan and imported power from Uzbekistan and Tajikistan • Under the CASA-1000 project,

Parameters related to Investment of cross-border Transmission Lines	Key Insights
	Afghanistan is entitled to obtain a wheeling charge, for use of its transmission network, for transmission of power from Tajikistan and Kyrgyz Republic to Pakistan. **Bangladesh:** • Bangladesh Energy Regulatory Commission (BERC) has approved the 'Grid Code', which mentions the transmission system planning, security standards, scheduling, frequency management, metering and protection aspects. • As per the Grid Code, a Power System Master Plan is to be prepared, updated periodically (preferably once in every five years) which covers both generation and transmission system expansion plan. **Bhutan** • Bhutan's Grid code has provisions which specify the principles, procedures and criteria for the planning and development of the transmission system and promote coordination among all licensees • The Grid Code covers all important aspects of transmission system operation, including operation planning. The system is considered to be in a normal state when the transmission system frequency is within the limit of 49.5 Hz to 50.5 Hz. **India** • As per the provisions of the guidelines, the Designated Authority [Member (Power Systems) of Central Electricity Authority] has issued its 'Procedure for approval and facilitating import/export (cross-border) of electricity' in 2021. • The detailed procedure documents of the National Load Despatch Center deal with procedure for determination of total transmission capacity (TTC). available transmission capacity (ATC), and congestion management. **Nepal** • Transmission System Development Plan of Nepal, 2018 includes the six Nepal-India cross-border connection points in the Terai Region and two Nepal-China cross-border connection points in the Himalayan Region • The hydropower plants are required to provide monthly forecasts of energy to be delivered. For shortfall in actual energy delivery, there are penalties imposed upon them. **Pakistan** • The Grid Code specifies the detailed planning code, connection code and scheduling code. For wind and solar power plants, there is a day ahead, four hourly and hourly scheduling requirements. Deviation in actual generation from hourly schedule will necessitate a rebate to be offered by the generator to the buyer. **Sri Lanka** • The grid code published in 2014 lays down rules for transmission planning, system modeling and operation, generation planning, grid connection etc. • Ceylon Electricity Board (CEB) publishes its Long-Term Transmission Development Plan (LTTDP) at regular intervals. LTTDP and Long-Term Genera-

Parameters related to Investment of cross-border Transmission Lines	Key Insights
Commercial framework	**Afghanistan** • No specific commercial framework for transmission tariffs, open access etc. except for commercial provisions under the CASA-1000 project. **Bangladesh** • Regulatory framework already has other enabling provisions such as transmission pricing and grid code. **Bhutan** • There are tariff regulations, though transmission tariff is embedded within th overall tariff. **India** • Open Access – Open access to lines is allowed under Electricity Act, 2003 with its implementation as per detailed regulations issued by CERC in inter-state level. • Deviation Settlement – Deviation Settlement Mechanism and related matters Regulations, 2014 provide the guidelines for deviation/imbalance charges and settlement. For cross-border transactions, deviation settlement is also in some cases related to the intergovernmental agreements. For example, energy from Tala, Kurichhu HPPs in Bhutan are deemed to have always generated as per schedule, for their actual injection to India. In comparison, for Dagachhu HPP, there is an energy accounting and deviation settlement mechanism separatel specified by CERC. • Transmission line development – To be undertaken under Tariff Based Competitive Bidding, as per Government of India's Tariff Policy. However, there are a few exceptions for development of lines in the conventional regulated tariff route also (Exceptions can be allowed for specific categories of projects of strategic importance, technical upgradation etc. or for works required to be done to cater to an urgent situation). • Transmission pricing – Nodal pricing, sensitive to distance, quantum and direction under 'Point of Connection' methodology. • Transmission loss accounting – Transmission loss determined under 'Point of Connection' methodology, with losses revised on a weekly basis. **Nepal** • The Electricity Regulatory Commission Act, 2017 envisages open access to the electricity system, and establishment of a wholesale market. **Sri Lanka** • Transmission pricing is partially covered under PUCSL's 'Tariff Methodology' which defines the manner for arriving at revenue requirement for transmission function.

Parameters related to Investment of cross-border Transmission Lines	Key Insights
Institutional framework and stage of power sector reform	**Afghanistan** • Afghanistan is under a vertically integrated single buyer model of power sector where most of the generation, and the entire transmission and distribution of electricity is carried out by the Government owned Da Afghanistan Breshna Sherikat (DABS). Private sector involvement is limited to the generation sector. **Bangladesh** • Bangladesh has an unbundled power sector, where generation, transmission and distribution of electricity is undertaken by different entities. The Bangladesh Power Development Board (BPDB) plays the role of single buyer in the electricity market. • The Power Grid Company of Bangladesh (PGCB) undertakes transmission of electricity, while a National Load Despatch Center operated by it undertakes system operation **Bhutan** • Bhutan's power sector is mostly a monopoly, where only entities which are either fully or partly owned by the Government undertakes large generation projects, transmission and distribution of electricity. Bhutan Power Corporation (BPC) acts as the single buyer, transmission utility and distribution utility. Bhutan has created a separate department Druk Green Energy Trading (DGET) under Dr Green Power Company (DGPC) for trading of electricity and has plans to separate the same • The power sector is regulated by the Bhutan Electricity Authority. Bhutan Powe System Operator (BPSO), which works under BPC, is entrusted to coordinate and regulate power system operation. **India** • There is a well-developed institutional structure. The power market has wholesale competition, enabled through competitive bidding, power traders, power exchanges and open access. There is also retail competition in some of the areas. **Nepal** • Nepal has a mostly bundled structure of power sector, with private sector involvement only in power generation. Part of the power generation, entire transmission, and almost entire distribution of electricity is undertaken by the government owned Nepal Electricity Authority (NEA). NEA also acts as the single buyer for all PPAs. • The sector is regulated by the Electricity Regulatory Commission (ERC) while licensing is undertaken by the Department of Electricity Development (DOED). • Currently, a department within NEA is the custodian of all power trading related activities in Nepal. A dedicated entity - Nepal Power Trading Company Limited (NPTC') was incorporated in March 2017, with NEA as the major shareholder (51 percent). License for power trading has already been issued to NPTC. However, it is still not operational, due to lack of cross-border guidelines.

Parameters related to Investment of cross-border Transmission Lines	Key Insights
	• Pakistan has recently shifted from a single buyer model to a wholesale/ competitive electricity market model called as Competitive Trading Bilateral Contract Market (CBTCM). NEPRA has granted the market operator license under CTBCM to the Central Power Purchasing Agency (Guarantee) Limited (the CPPA-G). The market operator will be responsible to administer its operations, standards of practice and business conduct of market participants in accordance with the market commercial code approved by the Authority. • Transmission is undertaken by the National Transmission Dispatch Company (NTDC). Under CTBCM, there are two types of electric suppliers – competitive electricity supplier, and provider of last resort. Further, the bulk power consumers (BPC) have the option to buy electricity from a competitive supplier of his choice, or from the wholesale market. **Sri Lanka** • The Public Utilities Commission of Sri Lanka (PUCSL) regulates the energy sector, while larger policy decisions are undertaken by the Ministry of Power and Energy. The Ceylon Electricity Board (CEB), which is a legacy vertically integrated utility acts as the single buyer, procuring power from all generating stations, for supply to distribution companies.

5.4 Gap Analysis

Institutional frameworks

Compared to initiatives such as Greater Mekong Sub region (GMS), and Association of Southeast Asian Nations (ASEAN), the institutional frameworks for regional energy cooperation have not fully realized their potential in South Asia. For example, ASEAN has ASEAN Power Grid Consultative Committee (APGCC), Greater Mekong Subregion has Regional Power Trade Coordination Center (RPTCC), and SAPP has SAPP coordination center and Regional Electricity Regulators Association (RERA). In comparison, similar institutional arrangements are lacking in South Asia.

Regulatory Frameworks

Diverse regulatory frameworks and varying standards across the countries have been one of the major hindrances for cross-border transmission line projects. Harmonizing regulations and establishing effective cross-border energy trade policies are essential for ensuring the smooth operation and integration of transmission lines.

No Agreed Implementation model: Since there is no agreed implementation model, development of any new cross-border transmission line will lead to loss of time, leading to delays and issues.

Financial Constraints: Substantial investment is required for developing cross-border transmission lines. Financing these projects can be challenging due to limited financial resources, and the decision has to be signed-off by both the participating governments and it requires significant political will. There needs to overcome the inadequate infrastructure funding, and potential risks associated with political and economic stability in the region.

Different market models: In places like Europe, apart from bilateral contracts, energy is being traded in auction-based day ahead and intraday market which has resulted in a competitive marketplace omitting monopoly nature. South Asian countries have different market structures and regulatory frameworks, which hinder the establishment of a fully integrated regional electricity market. Contract based bilateral power trade is prevalent in the South Asian region. So, formation of a competitive power market similar to Europe is a challenge for cross-border power trade in this region.

Financial Viability and Revenue Models: Establishing cross-border transmission lines requires substantial capital investment, and the revenue models for these projects may be challenging to design. Determining cost recovery mechanisms, ensuring fair transmission tariffs, and addressing revenue allocation among participating countries can be complex tasks that impact the financial viability of such projects.

Technical Aspects: In order to reach a final tripartite agreement, such as the Nepal-India-Bangladesh, which is in the conceptualization stage, various technical and mechanical challenges need to be addressed. One such challenge is the synchronization of the central region of Nepal with the Indian system for efficient transmission of high-capacity electricity, despite having multiple cross-border connections between Nepal and India. Additionally, a significant concern is the limited capacity of the existing transmission lines, which mostly have single-phase connection. There are several additional technical challenges that need to be overcome, including the alignment of frequency standards, voltage standards, management of reactive power, ensuring real-time data availability at load dispatch centers, and establishing voice communication between these centers. These factors are essential for the successful implementation of the collaboration.

Administrative Delays: As a result of administrative delays in obtaining construction approval for project facilities, there have been subsequent delays or costs incurred during later stages of the project due to unforeseen problems that were not accounted for in the initial project design. This has been marked in the Dhalkebar-Muzaffarpur line between India and Nepal.

5.5 Opportunities for Development of Cross-Border Transmission Lines

In South Asia, there are various opportunities for the development of cross-border transmission lines. The eastern side of South Asia, comprising Bangladesh, Bhutan, India, and Nepal already have high voltage electricity interconnections.The countries in the region have also signed various bilateral power trade agreements / MoU such as those between India and Bangladesh, India and Nepal, and Nepal and Bangladesh. The growing bilateral cross-border power collaboration in South Asia, as demonstrated by recent events, is paving the way for expanded multilateral power cooperation in the region. India has played a crucial role in fostering this development.

Another opportunity is the ready availability/presence of large power exchanges in India, which can also support expansion of the market area by adding new regions, subject to approval of governmental and regulatory authorities. These exchanges offer week-ahead, day-ahead, intra-day and real time markets. This should also be seen in the context of the presence of traders as market intermediaries who can facilitate trilateral/multilateral trade involving India and other countries in the region.

Another key opportunity is the progress in development of explicit guidelines, regulations and rules relating to regional power trade, as is happening in the case of India. Such clarity in policy and regulatory provisions allow investors to better plan for utilizing the market opportunities in the region. Then there is also the potential for utilizing platforms such as South Asia Forum of Infrastructure Regulation (SAFIR) for regional discussions, till more dedicated regional regulatory cooperation frameworks are put in place.

Such opportunities can be tapped to further develop various trilateral/multilateral power trade arrangements such as:

- Planned new network under CASA-1000 from Central Asia to Pakistan through Afghanistan.
- Planned / future power trade between Nepal to Bangladesh and Bhutan to Bangladesh through India.
- Development of regional power plants and regional mechanisms for reserve sharing.
- Potential development of South Asian Power Exchange which can support the developmentof a multilateral power market in the region.
- Potential linking of the South Asian grid with Southeast Asia, through Myanmar.

Establishing supporting institutions

Consistent and transparent procedures for transaction settlements, capital raising, and allocation are essential for a well-functioning energy market. Therefore, the involvement of institutions like power exchanges, traders, and private sector participants can contribute to enhancing the performance of the domestic power sector and can advance the progress towards regional integration. For development of cross-border transmission lines within the region, a supporting institution which can oversee activities and standard procedures drawing experience of learnings from already operationalized cross-border transmission lines and can advise on transmission pricing, allocation of transmission capacity, cost sharing, dispute mechanism etc.

The regional market arrangement for development of cross-border transmission lines in South Asia is mostly bilateral. Talking about the energy market, Indian Energy Exchange (IEX) has begun trading of electricity hosting participants from Nepal and Bhutan on its platform; following operationalization of cross-border sale and purchase of electricity for which regulations have already been issued by the Central Electricity Regulatory Commission (CERC) and Central Electricity Authority (CEA).

Also, there have been developments of tripartite agreement in the region. Nepal and Bangladesh have agreed to make efforts to start trading of power from the wet season (June-November) with the export of 40–50 MW electricity from Nepal, through India, which lies in between the two countries. This was decided in the fourth working group meeting of Bangladesh and Nepal. The Nepal Electricity Authority, the Bangladesh Power Development Board and the NTPC Vidyut Vyapar Nigam Limited (NVVN) of India will finalize a tripartite agreement shortly.

The 21st meeting of the Bangladesh-India Joint Steering Committee held in Khulna, India agreed on hydropower trade from Nepal to Bangladesh via India. The two countries also agreed to sign a tripartite power purchase agreement (PPA) to import 500 MW of hydropower to Bangladesh through India from GMR in Nepal. However, in exchange Bangladesh will have to offer a corridor through its territory for the transmission of electricity from one state of India to another state.

However, in Europe, there is no transmission pricing as is observed in South Asia. There is a pooled pricing concept followed in the cross-border transmission lines. A regional approach is followed with the establishment of regional transmission system operators (TSOs) and regional coordination centers. The European Union has implemented market coupling mechanisms and capacity allocation is hence enabled. Pooled transmission pricing is also followed. Pooled transmission pricing is a mechanism used for cross-border transmission lines which involves the pooling of transmission costs across different countries or regions to determine a common tariff structure for utilizing the cross- border transmission infrastructure. In the context of South Asia, while there are differing regulatory frameworks, varying levels of infrastructure development, and geopolitical considerations in the South Asian region, the same can be adopted to some extent in the region.

6. Key Recommendations for South Asia Based on Research

Based on the review of international experiences, and existing practices for development of cross-border electricity transmission infrastructure in South Asia, a few key recommendations are identified below. Of course, it is up to the policy makers to deliberate on these options and choose these with or without customizations or reject these recommendations. However, it is hoped that these recommendations provide adequate reference and guidance materials, as policy makers and decision makers in South Asia try to improve upon the framework for development of cross-border electricity transmission infrastructure.

I. Structuring of line ownership across-borders: Models beyond the existing border-based approach

In South Asia, irrespective of the business model, all cross-border electricity transmission lines have been developed considering the geographical limitations imposed by national borders. Thus, entities incorporated in each country (Government, private, or JV) develop, own and maintain the line segment and infrastructure within their territory. This model is well suited in the South Asian context, in the absence of overarching mandatory/ binding regional cooperation frameworks and regional institutions with mandatory powers. However, this shall not preclude the decision makers from exploring alternate options.

In the future, it may be considered to allow a single entity to construct line segments spanning cross-borders, rather than having to rely on two different entities. At the end of BOOT concession period, the line segments and land could of course revert back to respective countries. For the development of lines, the option of a single entity is also possible, as has been successfully implemented in the case of Cambodia Thailand Power Transmission Limited (CPTL), Nemo Link (Belgium-UK) and MOTRACO. This model of common ownership across the borders is illustrated in the figure below. In case of restrictions that require national incorporation, the example of the Garabi interconnector can be adopted, which allows a single organization to have separate subsidiaries within each of the countries. Another option is to have a single project which gets packaged jointly by the countries, get converted into an SPV, and auctioned/ bid out to entities for developing on a BOOT basis

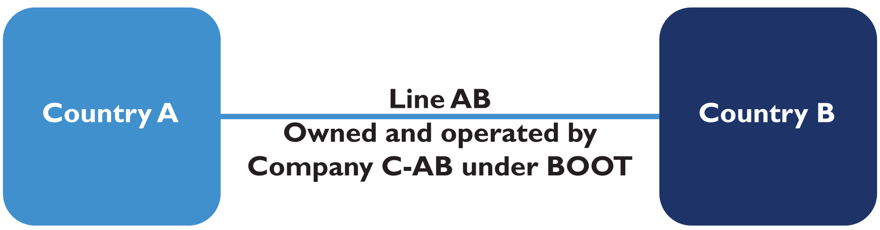


Figure 58: Illustration of common ownership across borders

- Company C-AB can be JV of transmission utilities of A and B; or an entirely private third party.
- If legal provisions prevent foreign incorporated entities from operating, Company C-AB can set up full owned subsidiaries in Country A and Country B, which then look after the respective line segments.

Such single-entity models will provide the following advantages:

1. It is easier to package the single project for awarding a BOOT based contract, which will be attractive for investors also.

2. There could be separate revenue and tariff mechanisms for the cross-border line, and from each end of the line, interfacing and metering can be done with the respective national grids. It may be noted that the single entity need not necessarily be privately owned. If countries prefer, it could also be a JV of respective national transmission utilities, as has been done in the case of NEMO link, Itaipu Binacional etc. Examples:

- Nemo Link Limited (UK-Belgium): 50:50 JV of National Grid (Great Britain) and Elia (Belgium)
- Cambodia Thailand Power Transmission Limited (CPTL)
- MOTRACO (South Africa-Eswatini-Mozambique)
- Transmission lines of Itaipu Binacional Ltd.
- Argentina-Brazil Garabi Interconnector, owned by Endesa

For this mechanism to work, it is however important to ensure the following aspects:

1. In some countries, foreign registered entities are not allowed to operate transmission lines or obtain a transmission license. In this case, unless laws and regulations are amended, thecompany will still have to set up subsidiaries in each of the countries.

2. Payment security still needs to be ensured, with assurance of revenue recovery linked to line availability on both sides of the border. This will still need arrangements such as Bulk Power Transmission Agreement (BPTA) and Implementation and Transmission Service Agreement (ITSA) as practiced currently.

3. There will be a question on which country will then package the project and bid it out. There are examples from Africa, where countries set up a "Project Management Office/Unit" which takes care of the bidding and procurement.

2. Business Model: More PPP based business models can be introduced in the region

It is an opportune time for South Asia to move towards more PPP in cross-border electricity transmission. India's policy framework already allows PPP in electricity transmission, and the same has been successfully implemented in the case of Dhalkebar-Muzaffarpur transmission line. If conditions are suitable, this can offer an investment avenue for private investors to get reasonable returns on their investment.

For other countries also, BOOT based PPP options will provide an option to utilize their capital and resources elsewhere. It is well understood that this may require amendments in the legal and/or policy framework of countries. However, considering the successful experience of PPP in electricity transmission in even developing economies, such as the case with Cambodia-Thailand Power Transmission, Garabi interconnector, and Basslink interconnector, a case for such amendments exists. An illustration of the PPP model for cross-border transmission interconnections is shown in the following figure.

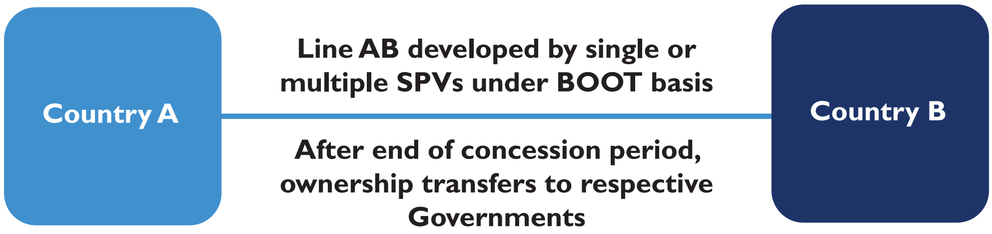


Figure 59: Illustration of PPP model

Examples:
- Cambodia-Thailand Power Transmission
- Garabi interconnector (Argentina-Brazil)
- Central American Interconnection (SIEPAC)

Alternate Option If the limitations in legal or policy framework precludes the possibility of 100 percent private ownership, JV models can be explored, which has already been implemented in the case of 400 kV Dhalkebar - Muzaffarpur. A good example of such a public-private joint venture in the international context is the Central American interconnection. The example is also very relevant, as it was the involvement of Spain's Endesa company, which provided additional comfort to the financiers such as IDA to support the project.

For this mechanism to work, it is however important to ensure the following aspects:

1. Payment security still need to be ensured, with assurance of revenue recovery linked to line availability on both sides of the border. This will still need arrangements such as Bulk Power Transmission Agreement (BPTA) and Implementation and Transmission Service Agreement (ITSA) as practiced currently.

2. Reasonable risk allocation between developers and Governments needs to be ensured.

3. Decision on building cross-border lines: Continued relevance of existing bilateral governmental mechanisms and transitioning to a regional planning approach for cross-border transmission

In case of cross-border lines involving India, there is a clearly defined procedure and institutional framework towards identifying and agreeing on the need for lines in the form of Joint Steering Committee, Joint Working Group and the Designated Authority.

In the longer term, such arrangements could also be supported by regional coordination mechanisms such as a South Asia Forum of Transmission Utilities (SAFTU) or other regional mechanisms, probably under BIMSTEC, are set up. In this context, the uniqueness of the South Asian context will need to be acknowledged, as opposed to a direct adoption of regional models in other parts of the globe and develop in a coordinated manner the South Asia Regional Transmission Interconnection Master Plan for facilitating trilateral and multilateral cross-border electricity trade.

4. Investment decision: In the absence of firm PPAs for full capacity between Governments, and Intergovernmental or Inter-utility MoUs, anchor customers can be identified who can commit to a major share of line usage

One of the key issues which delay the development of cross-border electricity transmission lines in South Asia is the negotiations relating to which country will ensure the line utilization and associated commercial impacts. This could get complex in some scenarios, as some of the lines will have seasonal import/export trends, or some of the lines will have power flow in one direction for a few years, after which power flows may reverse. Intergovernmental and inter-utility arrangements may take substantial time to negotiate in such cases.

However, when countries or state-owned utilities are unable to arrive at a consensus in such issues, it could be ventured to identify an anchor customer, who can be a large industrial consumer, or a group of such anchor customers, who can ensure blocking and utilization of a substantial portion of line capacity, as illustrated in the figure below. This has been successfully tested in the case of MOTRACO interconnection, which facilitates purchase of energy from Eskom of South Africa, for sale to the Mozal aluminum smelter in Mozambique. The "anchor" customer was the Mozal aluminum smelter plant, 20 km outside Maputo. The aluminum plant had significant electricity demand and was willing to pay MOTRACO a wheeling charge for the reliable energy it received. The aluminum plant also paid the cost of electricity purchased from ESKOM.

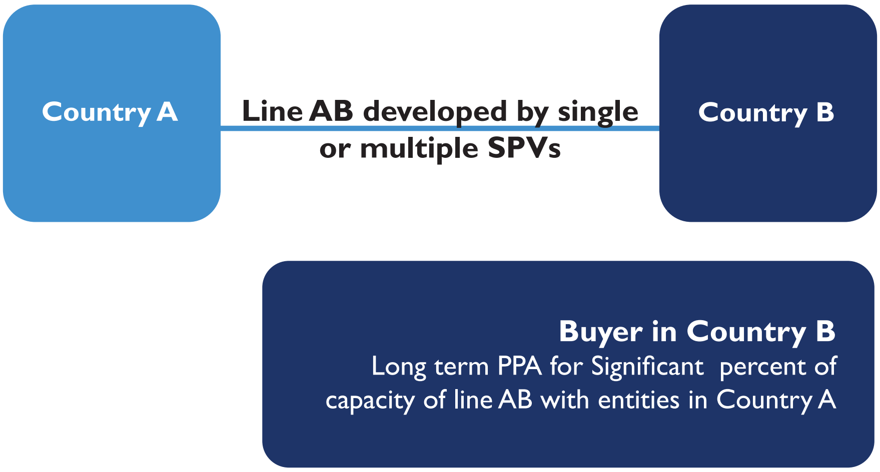


Figure 60: Illustration of investment with anchor consumers

This model has a high significance of cross-border lines running to India, as there are large corporate groups which look for options beyond solar and wind power, i.e., large quantum of hydropower from countries such as Nepal and Bhutan, to meet their corporate commitments towards reduction of their Green House Gas (GHG) emissions and achievement of net-zero emissions. If such customers can be identified and brought into discussions in an early stage, PPAs for adequate quantum of line capacity with assurance of transmission tariff/ annuity payments to the transmission line can be achieved.

It is to be noted that the consumers will have to agree for recovery of transmission costs irrespective of line utilization, as hydro and other RE projects may have challenges in intra-day and seasonal utilization.

5. Tariff

CB interconnections ultimately require assurance of an annuity payment, which could be collected in any form. Most international examples follow a Regulated Tariff or bilaterally agreed tariff model. The model is already in practice in the case of the Indian portion of Dhalkebar - Muzaffarpur line, where annual transmission payment calculation methodology is specified in the Implementation and Transmission Service Agreement (ITSA). There is also potential for extending Tariff Based Competitive Bidding (TBCB) regime to cross-border lines also, as shown below. This basically extends India's domestic TBCB regime to the cross-border context. A sample of this model is illustrated in the following figure:

Figure 61: Illustration of tariff mechanisms

Example:
- Central American Interconnection (SIEPAC) – Annuity Payment determined by regulator CRIE
- GCC Interconnection – Tariff determined by Advisory and Regulatory Committee
- NEMO link – Tariff determined by UK Regulatory OFGEM under a cap and floor pricing regime
- Cambodia-Thailand Interconnection – Tariff specific in commercial agreement.

All enabling conditions mentioned in points (1) and (2) earlier are equally applicable here, especially in terms of ensuring cost recovery, payment security etc. These aspects were also stressed upon by the stakeholders during the stakeholder consultations held on 28 February 2024. There is interest from the private sector for undertaking cross-border transmission projects, provided aspects such as ensuring proper transmission cost recovery (availability linked recovery), and ensuring proper demarcation between the functions of transmission and grid control are addressed.

6. Cost and revenue sharing

The cost and revenue sharing options are linked to the model adopted for development of the line. When different entities in each country, develop their own line segments within each territory, associated costs and revenues also get shared as per respective costs and revenues of those segments. However, in the case of Joint ventures, such as Central American Interconnection, GCC Interconnection etc., there have been different options.

In the Central American Interconnection, each of the participating countries have equal equity contribution. In GCC, the costs have been shared in the ratio of benefit accruing to those countries, due to reserve sharing. However, as arrangements such as Central American Interconnection and GCC Interconnection wherein a single line traverses across more than two countries are not very relevant in the South Asian context, this aspect of cost and revenue sharing may continue on a territorial approach as is the current practice. Thus, in case of different entities owning different segments of the line, current practice of cost sharing based on infrastructure within each of the boundaries may continue.

In case of a single private entity owning the entire cross-border line, this point becomes moot anyway, as capital expenditure of respective state-owned utilities are avoided.

7. Regional Markets

The availability of regional markets for energy trade has been a key enabler in various regional interconnections such as the Central American Interconnection, Nemo link etc. Adequate access to a regional electricity market reduces the need for entire line capacity to be tied up under 100 percent long term PPAs. However, it may be noted that South Asia is also moving towards an improved regional electricity market, and therefore this aspect is already being addressed by the countries.

In the longer term, even transmission line capacity of CB lines can be auctioned out through market platforms. This is already practiced in some of the lines such as:

- Use of market platform for trading in the Central American Interconnection
- Auction of line capacity through market platforms in Nemo link

8. Regional Financing of Transmission Lines

Some of the cross-border transmission lines have benefits that extend beyond the countries at the two endpoints of such lines. There could be additionalities that could benefit the region as a whole, in the form of improved reliability, or improved evacuation of renewable energy etc. In Europe, such projects are covered under a "Projects of Common Interest" (PCI) mechanism, which makes them eligible for substantial grants from a Connecting Europe Fund (CEF) maintained by the European Union. In the South African Power Pool also, the context of a "Regional Transmission Infrastructure Financing Facility" (RTIFF) is being explored. In the medium to long-term, South Asian countries may also explore such options, which provide some form of viability gap support or concessional loans or grants to cross-border lines that have regional benefits, spanning beyond the beneficiary countries.

European Union – Projects of Common Interest (PCI)

Grants from Connecting Europe Fund (CEF) with over €5 billion budget
PCI eligibility determined by European Commission, assisted by ACER
Eligibility requirement: increase market integration OR help the EU's energy security OR contribute to the EU's climate and energy goals by increasing renewables integration

Stakeholder Feedback

This is one area where a number of public sector and private sector stakeholders had shown substantial interest, during the stakeholder consultations held on 28 February 2024. It may be noted that Mr. Stephen Dihwa, Coordination Center Executive Director, South African Power Pool highlighted various financing challenges being faced by regional lines, and how SAPP was developing Regional Transmission Infrastructure Financing Facility (RTIFF) as a potential way to circumvent this barrier. This aspect has been further supported by private and public sector utility representatives from India and other countries in the region

9. Other Recommendations

In addition to the recommendations derived from review of international case studies and comparison with South Asian context, there are also a few recommendations that have come from stakeholders, as part of the stakeholder consultations held on 28 February 2024. This includes the following:

- Irrespective of models to be adopted, the focus should be on faster decision making on transmission interconnections

- Strong institutional / regulatory frameworks at regional level are desired in the longer term, such as seen in the case of Central America

- Regional entities may work towards facilitating higher levels of commitment among governmental stakeholders for regional energy cooperation

In the longer term, the recommendations could also be used to facilitate the scaling up of cross-border interconnections to aid towards development of trans-continental infrastructure such as OSOWOG.

Annexure I: Summary of International Interactios and Key Discussion Points

1 Introduction

During the course of preparation of the study report, one-to-one interactions were undertaken with a few of the regional entities. Summary of discussions with those entities are provided in the following sections.

2 Empresa Propietaria De La Red (EPR)

1. SIEPAC was created as a result of the intergovernmental MARCO treaty. However, how did individual countries obtain the confidence that their investment in the line will yield adequate returns?

In the 1980s, all six countries in the region suffered from rationing due to shortages of power and transmission lines. All countries – Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama – saw the project as an opportunity to support each other to have energy from other countries in cases of rationing, as well as export surpluses.

Studies were conducted by Power Technologies Incorporated (PTI) and the University of Comillas of Spain, financed by the IDB, which indicated that the project provided the benefits and adequate return on investment. With these studies, the voltage level, 230 kV, the capacity, 300 MW, and a single-circuit line were initially defined. After ten years, and before starting construction, the project was expanded and a line planned for two circuits was made, one installed and another future to double the transmission capacity to 600 MW.

2. After the signing of the MARCO treaty, what key agreements were signed between the countries, and with EPR, for the line to get constructed and commissioned?

The MARCO Treaty provides for the creation of a private company with mixed capital but formed with capital from the six countries of the region, through its six national electricity companies. This allowed the IDB to grant soft loans to SOVE-guaranteed, transferred to EPR. It allowed the EPR to function as a private company and with the sole objective of building the SIEPAC Line. Subsequently, shareholders from three more countries, Italy (Spain), Colombia and Mexico, were incorporated through three electricity companies.

3. How was the equity contribution required to be provided by each of the countries arrived at?

The MARCO Treaty indicated that each country would designate the entity to capitalize the mixed-capital EPR for the implementation of the project. For the execution of the project, an equity contribution of USD 6.5 million per shareholder was necessary, with nine shareholders for USD 6.5 million, and a total of USD 58.5 million. Against the total cost of the project of USD 505 million, the equity represented approximately 11.5 percent and the rest are credits mostly from development banks, IDB, CABEI, CAF, BANCOMEXT, etc.

Table 20: SIEPAC Equity Contribution

Préstamo	Garante	Fecha de Firma	Fecha última Amotización	Monto en US$
BID-003/SQ-CR	COSTA RICA	26-02-02	15-12-36	10 000 000
BID-004/SQ-ES	EL SALVADOR	15-02-03	15-12-37	10 000 000
BID-005/SQ-GU	GUATEMALA	17-09-02	15-06-36	10 000 000
BID-006/SQ-PN	PANAMA	12-04-02	15-12-36	10 000 000
BID-007/SQ-HO	HONDURAS	18-03-02	15-12-36	15 000 000
BID-008/SQ-NI	NICARAGUA	19-03-02	15-12-36	15 000 000
BID-1368/OC-CR	COSTA RICA	26-02-02	15-12-26	30 000 000
BID-1369/OC-ES	EL SALVADOR	15-02-03	15-12-27	30 000 000
BID-1370/OC-GU	GUATEMALA	17-09-02	15-06-27	30 000 000
BID-1371/OC-PN	PANAMA	12-04-02	15-12-26	30 000 000
BID-1095/SF-HO	HONDURAS	18-03-02	15-12-41	25 000 000
BID-1096/SF-NI	NICARAGUA	19-03-02	15-12-41	25 000 000
BID-1908/OC-CR (ICE)	COSTA RICA	08-12-09	10-05-34	4 500 000
BID 2016/ BL-HO (ENEE)	HONDURAS	02-12-10	31-12-49	4 500 000
BID 2421/BL-NI	NICARAGUA	01-11-10	15-12-40	4 500 000
BANCOMEXT	CFE	28-06-10	31-08-30	44 500 000
BCIE-1690 (BEI)	ENEL	30-09-05	19-05-28	44 500 000
BCIE-1810 A	ISA	29-06-07	14-09-27	44 500 000
BCIE-1810 B	EPR	19-03-07	05-06-27	20 000 000
CAF-01	EPR	10-02-09	10-02-29	15 000 000
DAVIVIENDA	EPR	22-05-14	23-05-26	11 042 500
INDE	EPR	09-03-10	16-12-24	4 500 000
CEL	EPR	19-02-10	07-01-22	4 500 000
ETESA	EPR	25-01-10	14-04-26	4 500 000
ENATREL-BEI FI-26001-NI	NICARAGUA	14-07-16	15-06-27	6 553 884
		TOTALES		453 096 384

4. Can a table of list of equity shareholders at the time of commissioning (2014) and present equity shareholding be provided?

YEAR 2014

Table 21: SIEPAC Shareholding

Utility	Country	Share percent
INDE	Guatemala	11,11 percent
CEL	El Salvador	11,06 percent
ETESAL	El Salvador	0,05 percent
ENEE	Honduras	11,11 percent
ENATREL	Nicaragua	11,11 percent
ICE	Costa Rica	10,36 percent
CNFL	Costa Rica	0,75 percent
ETESA	Panamá	11,11 percent
ENDESA	España	11,11 percent
ISA	Colombia	11,11 percent
CFE	México	11,11 percent
Total		100 percent

YEAR 2014

Utility	Country	Amount/No.	Share percent
INDE	Guatemala	6500	11,11 percent
ENTE	El Salvador	6 470	11,06 percent
ETESAL	El Salvador	30	0,05 percent
ENEE	Honduras	6 500	11,11 percent
ENATREL	Nicaragua	6 500	11,11 percent
ICE	Costa Rica	6 061	10,36 percent
CNFL	Costa Rica	439	0,75 percent
ETESA	Panamá	6 500	11,11 percent
ENDESA	España	6 500	11,11 percent
ISA	Colombia	6 500	11,11 percent
CFE	México	6 500	11,11 percent
	Total	58 500	100 percent

5.Can any information be provided on risk management principles adopted by EPR, to manage investment related risks?

Table 22: SIEPAC Risk Assessment Framework

Risk	Risk Assessment	EPR Comment
Social	Very Low	Business activity is perceived as a development necessity. The infrastructure and transmission service are of public interest and EPR has just completed the works of Derivación la Virgen in Nicaragua and is not currently in the construction stage of new lines. There is social projection, although there are different social realities in the member countries of the MER, which makes it difficult to identify a social panorama.
	Very Low	With climate change, social changes are projected that will affect the way in the use and management of resources in the medium term.
Suppliers	Very Low	There are enough experienced suppliers of goods supply. There are no relevant technological changes. However, the number of maintenance service providers on transmission lines is limited, this creates dependency and extended times in the availability of suppliers to execute works.
Market, Competition, Mergers and Acquisitions	Very Low	It is a highly regulated market, so changes are very slow. The shareholders are mostly national state-owned enterprises and therefore a good guarantee for proper operation. There are no perceived market conditions that could affect the current functioning of the MER.
Deficiency in the Consol-idation of the Regional Electricity Market	High	Growth is very difficult, because of the decision-making structure in the region. There is weakness in national transmission reinforcements. There are no in-centives for regional plants but for the self-sufficiency of countries. There are deficiencies in the national transmission infrastructure of MER member coun-tries that may affect the operation of the regional transmission line. Guatemala's denunciation of the Framework Treaty would diminish the possibility of EPR venturing into new regional projects since Guatemala's generators, particularly the generators of Guatemala, will continue with their business strategy in favor of local benefits leaving aside regional benefits.
Errors or Omissions	High	The organization is small and has a lot of manual procedure. There is a process in development for the standardization of processes in the organization, it can induce errors or omissions in the organization.

6. We understand that cost recovery for the line is ensured through regional transmission rates, which consist of Variable Transmission Charge (VTC), the Toll and the Supplementary Charge. Can the latest rates be provided?

IAR YEAR 2023

The regulation authorizes Regional Authorized Entry to the Company. It is an annuity that ensures income for: Administration, Operation and Maintenance; Debt Service; Profitability on Equity; Taxes; and VEI quality regime. It is not yet authorized.

Table 23: EPR - Approved Revenue for 2023

Categoría	Aprobado CRIE-28-2022	Ajustes	Total
AOM	16 828 998	-	16 828 998
Servicio de Deuda	32 132 756	-	32 132 756
Rentabilidad	8 186 697	-	8 186 697
Tributos	6 339 219	-	6 339 219
VEI	-	-	-
Total IAR	63 487 670		63 487 670

7. If there is a plan for capacity expansion or line extension, what business model may EPR follow?

The regional transmission expansion plan is carried out by the EOR, Regional Operator Entity, which directs the operation of the transmission from El Salvador. The transmission expansion plan is subsequently approved by the regulator. With this plan, the works of the SIEPAC Line are assigned to EPR so that it can carry them out. It also defines the national works to be carried out by the countries.

8. Do the users of SIEPAC provide any payment security to EPR?

The approximately 300 users or customers of the SIEPAC Line, to operate in the Regional Electricity Market, must deliver executable bank guarantees to the EOR that cover the cost of one and a half months of their operations in the MER, including the charges of the SIEPAC Line. For ten years EPR has not had any type of defaults or late payments. Users of the SIEPAC Line do not have contracts signed with EPR. The MER Regulation is the one that provides the regulations, mechanisms and implicit guarantee that ensures the income to EPR.

9. Additional information:-
- Took seven years to construct the line.
- Inter-American Development Bank (IDB) played a major role in implementation and financing of the project.
- Main company or the private company is registered in Panama and then with different subsidiaries, companies and all this comes under one umbrella, EPR.

3 Kenya Electricity Transmission Company (KETRACO)

About Ethiopia Kenya and Kenya Tanzania Interconnections

- Developed through inter-government and inter-utility consultations
- PPA was not a pre-condition for transmission line construction
- Costs shared by each country for infrastructure falling under their territory
- Cost recovery is done for utility level, not specifically for a single line
- Joint Project Coordination Unit was set up with representation from both countries

4 South African Power Pool

About MOTRACO

- 400 kV Transmission line passing through Eswatini (Swaziland) to Mozambique supplying an aluminum smelter load in Mozambique with full capacity of 900 MW
- Investment decision: Jointly discussed and agreed between two governments, along with identification of anchor customer
- Governments signed the IG-MOU, and a special purpose vehicle company was formed. Concession contracts were entered between the governments and the SPV covering constriction and ownership of the line, the transportation of energy among the participating utilities. The governments provided the guarantees. Debt was provided by the international banks to the participating power utilities.
- Set up as a Joint venture between public and private entities. The single legal entity owns the entire transmission infrastructure across countries
- Dedicated customer and load (MOZAL) assured asset utilization and cost recovery. Capacity booked on a long-term basis. Cost recovery through transmission tariff, determined through process specified in transmission agreements.
- Investment sources: Private investment, loans and grants
- At the end of contract tenure, assets will be handed over/ transferred to the respective governments.

Annexure II: Summary of Inputs Shared During Stakeholder Workshop

In the stakeholder discussion session organized by USAID's SAREP program on February 28, 2024, representatives from international power pools and cross-border transmission lines' operators, key policy makers and utility officials from South Asian countries, multilateral agencies, private transmission utilities etc. participated, and provided valuable suggestions and comments. The workshop aimed to bring key decision makers and stakeholders relating to cross-border electricity transmission infrastructure in South Asia together, on a hybrid model, with the following objectives:

1. Disseminate the key findings of the study on "International best practice on business and financial models for developing cross-border electricity transmission infrastructure projects".

2. Provide a platform for discussions relating to the study findings, and to collect the feedback and inputs of key stakeholders.

3. Provide a platform where a few international stakeholders provide their perspectives and insights on development of cross-border electricity transmission infrastructure.

Deliberate on way forward to modify the study findings in consonance with aspirations of South Asian stakeholders, and on a plan to adapt such findings for implementation.

During the workshop, after the study team's presentation on key findings of the report, representatives of SAPP, EPR (SIEPAC), GCCIA and Nemo Link presented their learnings and experience in development and structuring of cross-border electricity transmission infrastructure.
This was followed by a larger roundtable discussion of key regional stakeholders from both public and private sectors. During the discussions, the following points emerged as the key factors for enabling cross-border electricity transmission infrastructure:

- While structuring of line ownership across-borders, it is important to package as a single project, so that it is easier for a single developer to bid for it
- Advanced models such as EPR – a regional level transmission utility supported by regional market, regional transmission operator and regional regulator
- Potential for more PPP models in CBET in the region
- Relevance of inter-governmental and inter-utility MoUs, including an intergovernmental treaty such as MARCO Treaty in Central America
- Importance of revenue assurance and anchor customers
- Importance of creating empowered regional institutions, which can help move away from bilateral to multilateral mechanisms
- Relevance of regional financing mechanisms such as Regional Transmission Infrastructure Financing Fund in SAPP

Availability of unique regulated tariff models such as cap and floor tariff model of Nemo Link.

A summary of key inputs and suggestions on the report and study from these stakeholders are provided in the following table.

Table 24: Summary of key inputs and feedback from stakeholders

Category of stakeholders	Key suggestions / feedback	Action taken
International power pools and cross-border transmission line operators	Acknowledged the importance and relevance of the study. Shared information relating to their experience.	The provided information has been incorporated, and detailed presentations are available in a separate "Proceedings" report
Government utilities, ministries and other administrative bodies	Stressed on the need for complying with guidelines already available in countries, wherever such guidelines are present. Welcomed the idea of a regional fund for cross-border transmission lines.	No further action required
State transmission utilities in India bordering Nepal	Decision involving cross-border lines will be taken under the guidance and directions of Government of India	No further action required
Private sector representatives – Transmission line EPC and IPP entities	There are a few international transcontinental lines that are planned / under construction that can also be considered in the case studies.	High level overview of such lines included in section on international case studies

The following key aspects may also be highlighted further based on the discussions, as these have been repeatedly focused upon by various stakeholders:

- Establishment of a robust institutional framework and a dedicated funding pool would help in the development of cross-border electricity transmission interlinks
- Private sector engagement through innovative models such as concessional mechanisms and JV can help to improve the infrastructure development
- Ensuring appropriate revenue assurance mechanisms to investors
- Promoting private sector participation in cross-border electricity transmission, by ensuring proper transmission cost recovery (availability linked recovery), and ensuring proper demarcation between the functions of transmission and grid control
- Importance of building mutual consensus and trust between countries Importance of strong institutional / regulatory frameworks at regional level
- Exploring alternate business and financial models for transmission infrastructure for the SA region
- Working towards facilitating higher levels of commitment among governmental stakeholders for regional energy cooperation
- Potential for scaling up the cross-border interconnections to aid towards development of trans-continental infrastructure such as OSOWOG
- Potential for a Regional financing facility for regional transmission projects.

Figure 62: Stakeholder Consultation Workshop

A detailed "Proceedings" report on the workshop is available separately. A summary of consultations along with copy of presentations are available at
https://sarepenergy.net/events/workshop-on-international-best-practice-on-business-and-financial-models-for-developing-cross-border-electricity-transmission-infrastructure/

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1300 Pennsylvania Avenue, NW
Washington, DC 20523

Tel: (202)71-0000
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