

Energy Transition with Cross-Border Power Transfer



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2023 IEEE President & CEO

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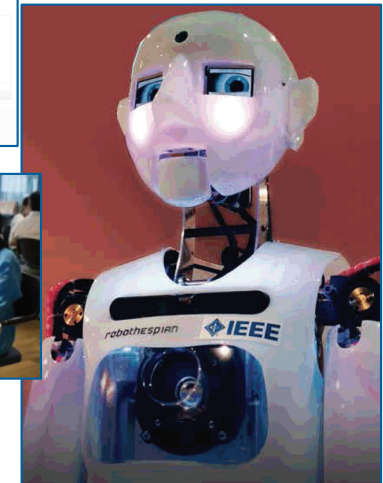
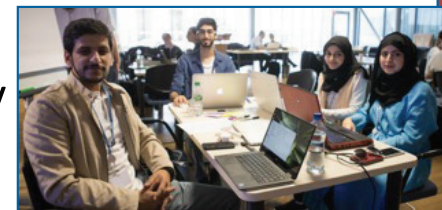
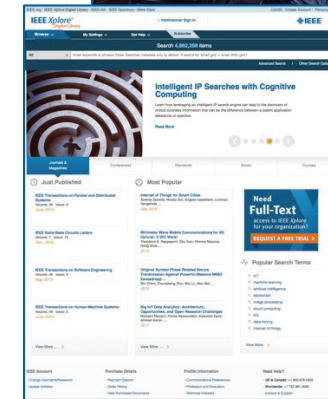


Invited Talk

Role of Transmission in Net Zero
EEI-GCCIA COP28 Transmission Summit
Abu Dhabi, UAE, 29-30 November 2023

IEEE at Glance

- **440,000** members in more than **190** countries
- **39** technical Societies and **seven** technical Councils representing the wide range of IEEE technical interests
- **5 million+** documents in the IEEE *Xplore*® digital library, with **15 million+** downloads each month
- **1,900** active standards and **1,000+** standards under development
- Publishes **240** transactions, journals, and magazines
- Sponsors **2,000+** conferences in **106** countries annually
- Continuing Technology Education Resources



Access to ideas and innovations developed in other disciplines

Electrical and electronic engineering, computer science, IT and beyond:

- ▶ Aerospace
- ▶ Biomedical Engineering
- ▶ Broadcasting
- ▶ Circuits
- ▶ Communications
- ▶ Computing
- ▶ Control and Automation
- ▶ Electronics
- ▶ Environment
- ▶ Industrial Systems
- ▶ Information Technology
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- ▶ Power and Energy
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- ▶ Smart Cities
- ▶ Smart Grid
- ▶ Transportation and Vehicles
- ▶ Nuclear Engineering
- ▶ **And more...**

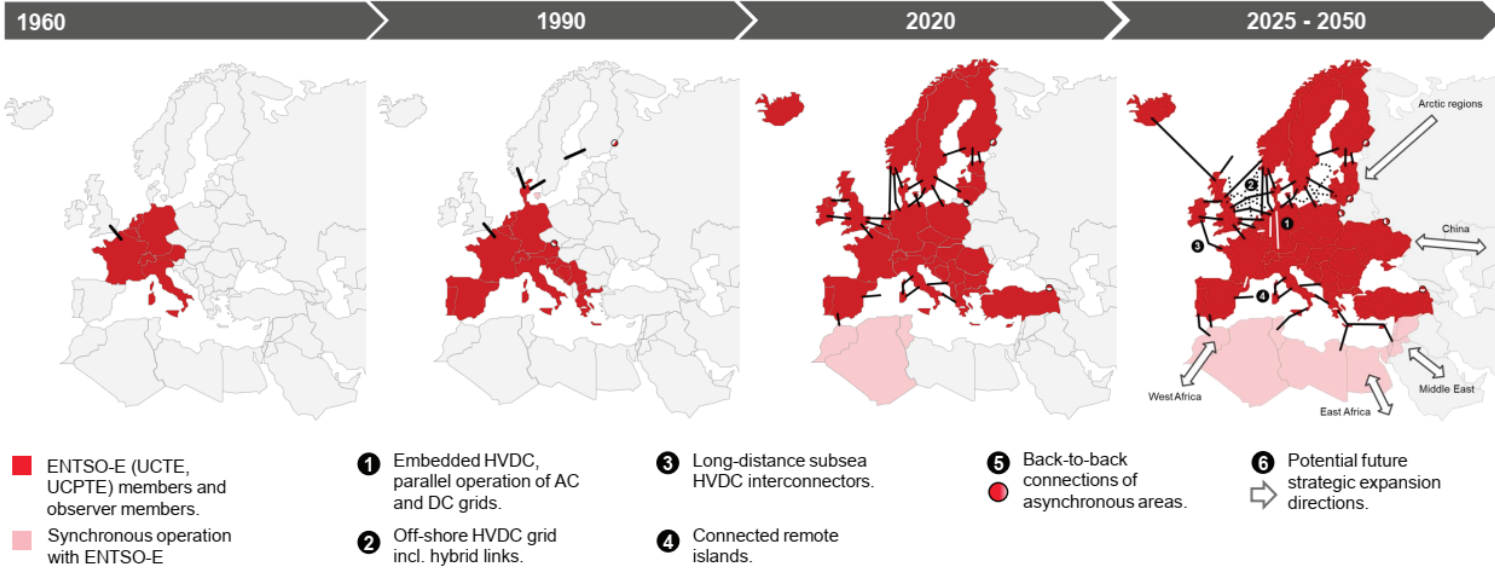
No Transition without Transmission

Grid Interconnection improves
Power System Flexibility

Some Case-specific Examples

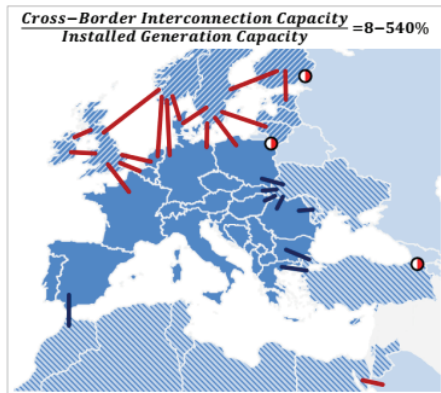
Best Practices and Need-based Developments

Connecting beyond the national borders – example Europe



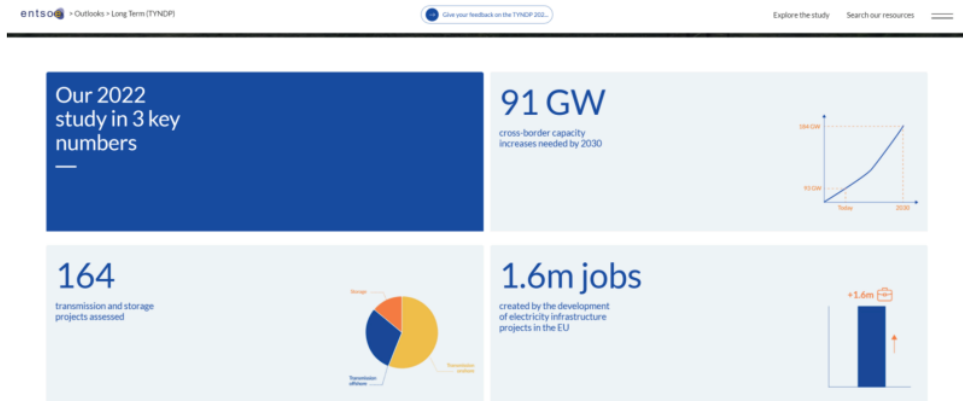
Technically speaking – and looking beyond Europe – a global electricity network is also feasible.

Interconnected power systems – pathways towards net zero



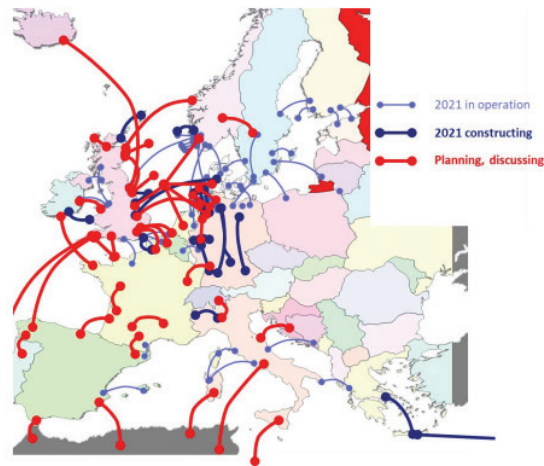
- Continental synchronous area of ENTSO-E
- Asynchronously connected ENTSO-E members
- Countries synchronously connected to ENTSO-E
- Countries asynchronously connected to ENTSO-E
- HVDC connections
- HVAC connections
- HVDC Back-to-back connections

ENTSO-E: Ten-year network development plan



Regions are ramping up interconnection capacity to accommodate more time varying generation while maintaining high standard of reliability and resilience

HVDC in ENTSO-E area



Europe already has more than 30 HVDC links in operation & further 50 planned in the next 10 years

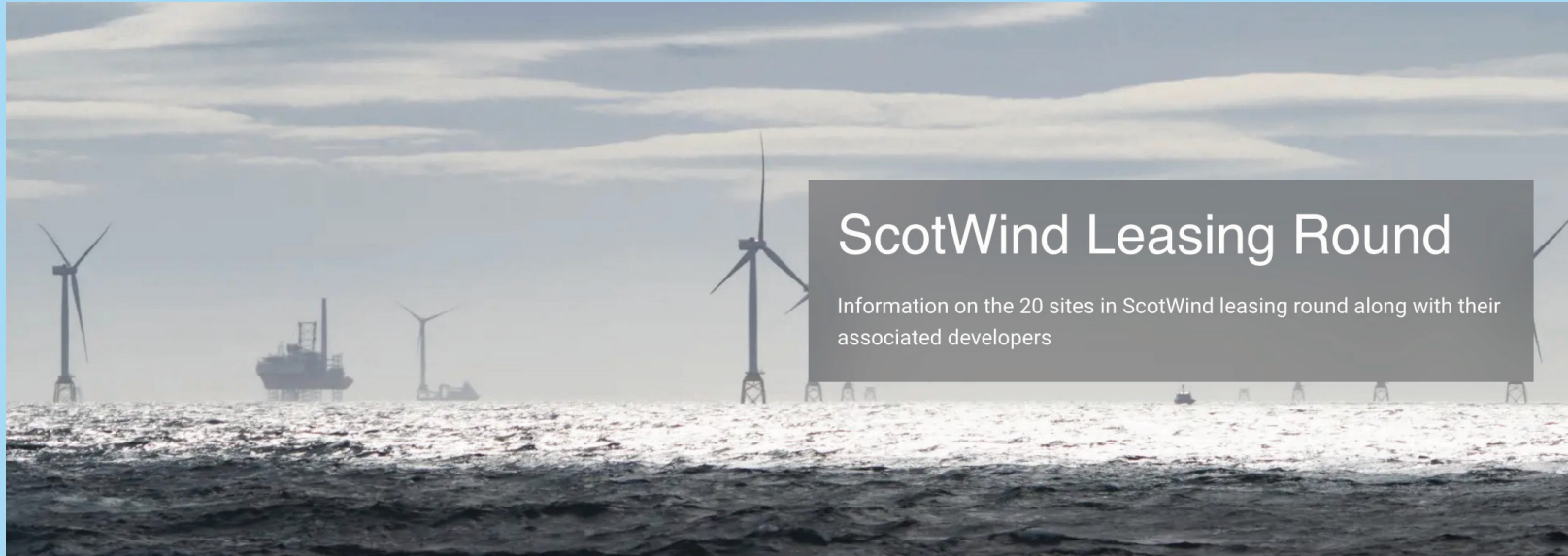
HVDC applications today and in the future

- Renewable integration
- Remote generation/load
- Interconnection
- DC links in AC grid & upgrades
- City center infeed
- Power from shore



IEA commentary on interconnection, August 2023: “In Europe, for example, cross-border trade of electricity is estimated to have delivered EUR 34 billion of welfare benefits in 2021 compared to if national markets were isolated.”



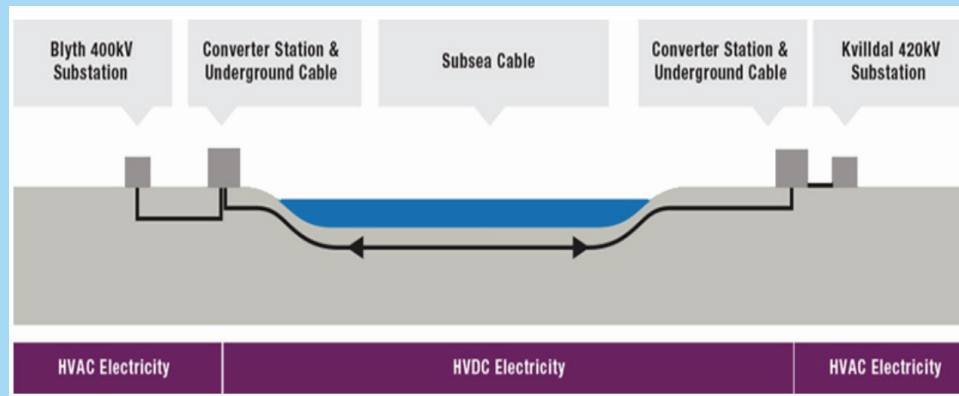


ScotWind leasing round on the 17th of January 2022: **25 GW**

Demand for Electricity in Scotland in 2030: **6 GW**

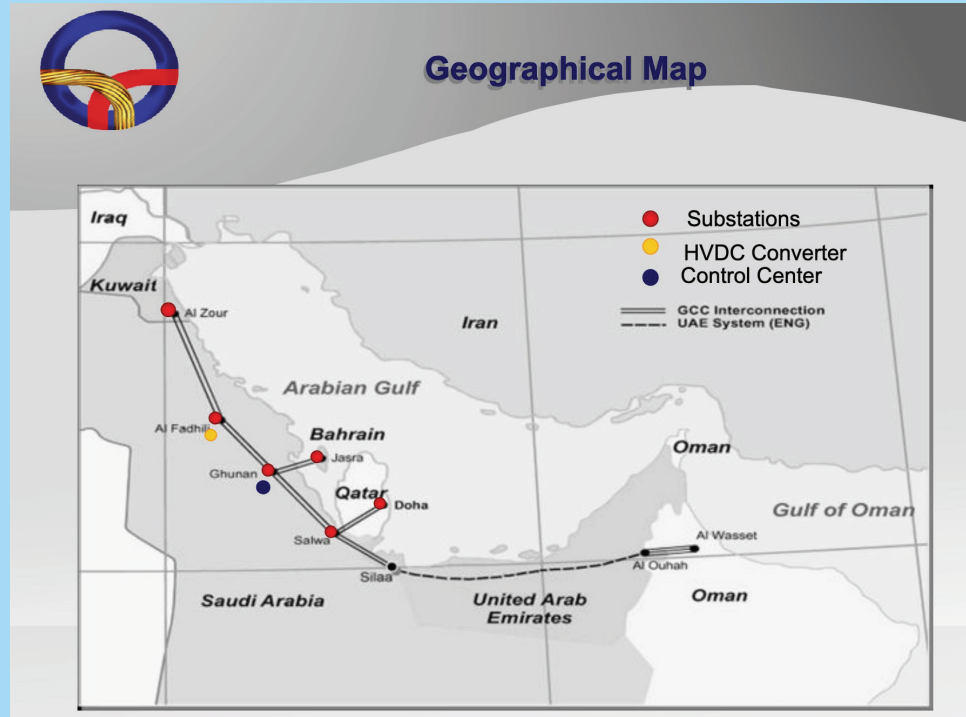
LONDON, Aug 24 (Reuters) - British authorities have given planning consent for a new 2 gigawatt (GW) subsea power link between Scotland and England

The Eastern Green Link 2 will be developed by National Grid and Scottish and Southern Electricity Networks Transmission.



The 1400 megawatt interconnector stretches from Blyth in the UK, across the North Sea, to Kvilldal in Norway.

Gulf Coordination Council Interconnection



Major Benefit: Reduction of Reserve Requirements
Also helpful in dealing with Intermittent sources (PV)

Low-carbon, cheaper and non-intermittent electricity

Champion Hudson Power Express: 1250 MW
(Quebec to New York City)

545 km of underwater-underground transmission line
from Québec, Canada to New York City, about 500 km in NY State

Industry tends to locate in areas of low-carbon electricity to help
meet their own net-zero targets for scope II and scope III emissions

Degrees of Cross-border Power System Integration

Bilateral, unidirectional power trade

- Thailand imports from Lao PDR

Bilateral, bidirectional power trade

- Malaysia–Singapore (non-financial)

Multilateral, multidirectional trade among differentiated markets

- Southern African Power Pool (SAPP)

Multilateral, multidirectional trade among harmonised markets

- European Union Internal Energy Market

Unified (pooled) market structure, differentiated operations

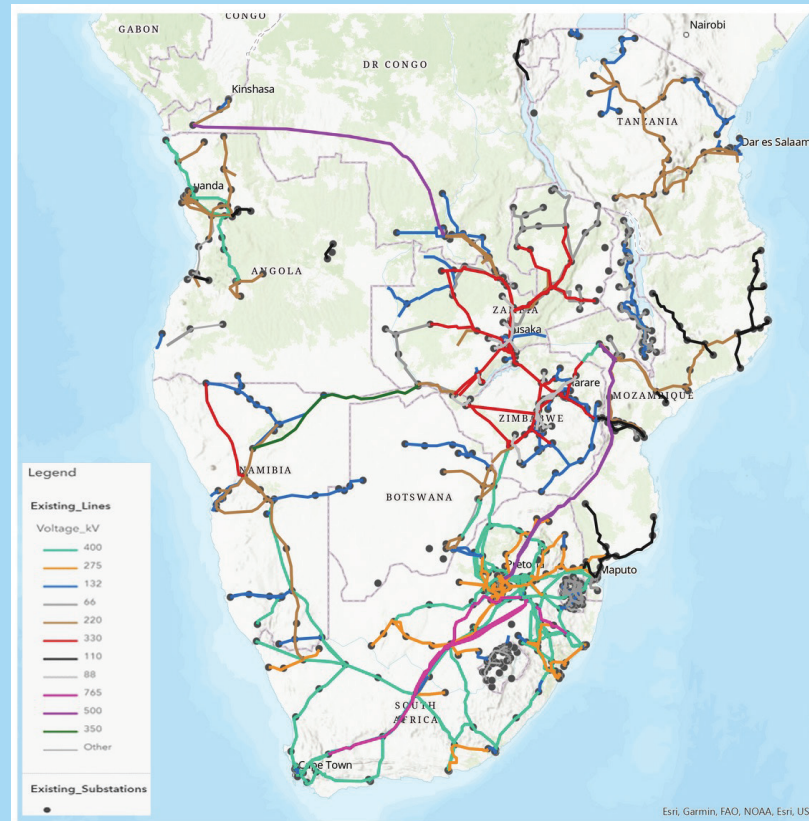
- Nord Pool

Unified market and operations

- PJM

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Source: International Energy Agency



Southern Africa Power Pool (14 countries)
 Inadequate power transfer capacity

Minimum Requirements for Establishing Multilateral Power Trades



Political

- Political will
- Intergovernmental agreement(s)
- Common working language



Technical

- Harmonised technical standards (grid codes)
- Harmonised wheeling charge methodology
- Third-party access for external resources
- Data and information sharing
- Interconnector capacity calculation methodology

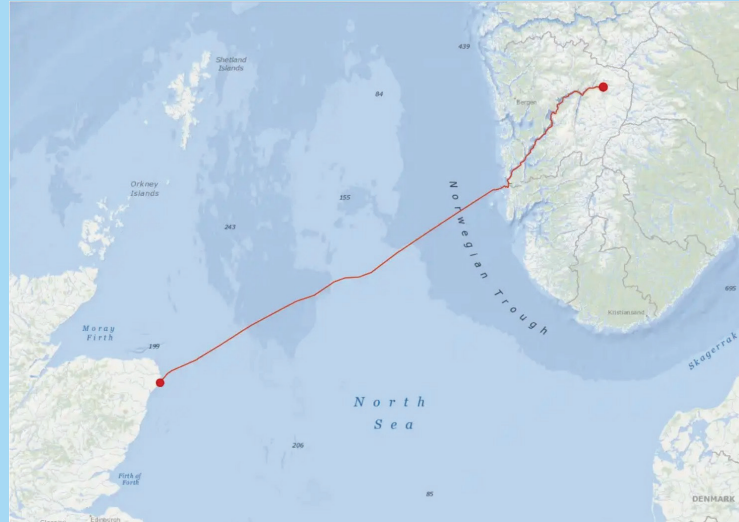


Institutional

- Institutional arrangements
- Settlement and payment mechanism
- Dispute resolution mechanism

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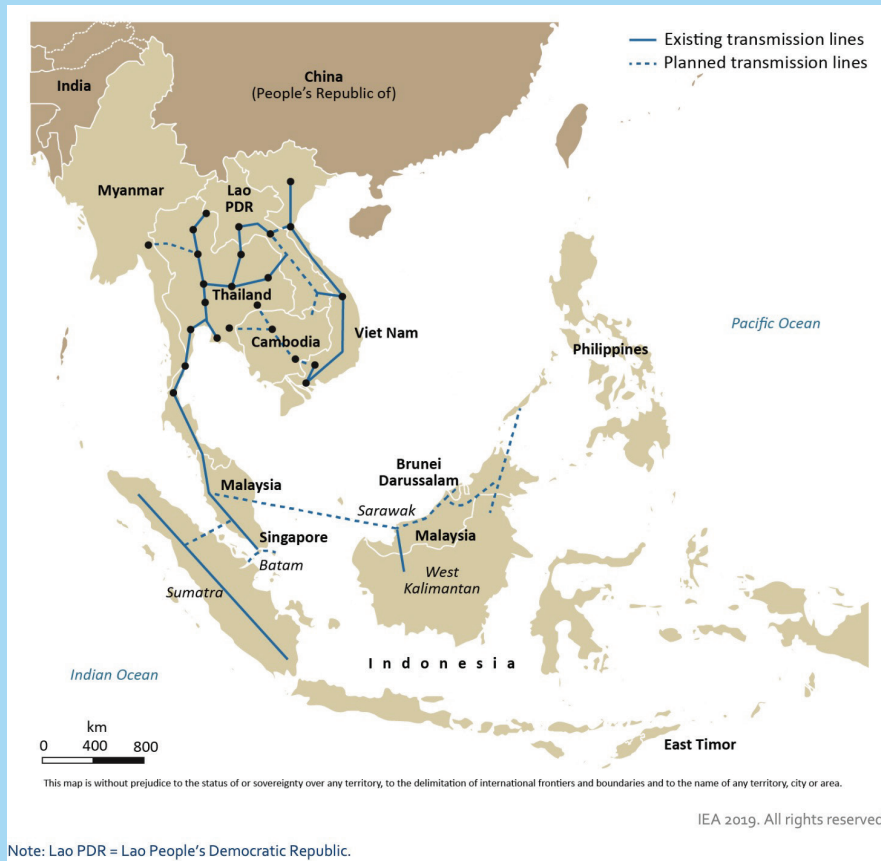
Source: International Energy Agency



The NorthConnect project was meant to build a 1.4 GW undersea interconnector between Norway and Scotland. This 665-kilometer hybrid electric cable would have allowed exchanges between Scottish wind power and Norwegian hydropower

Not approved: Uncertainty of exposure to Norway's power grid to energy systems of other countries

ASEAN Power Grid (APG)



The ASEAN member states (AMS) have had a long-standing goal of integrating their power systems. ASEAN Power Grid (APG). It is composed of a series of cross-border (AC) and (DC) interconnectors. Power trade across the APG lines that currently exist is primarily bilateral.

Source: International Energy Agency

Success Stories

Singapore commences first renewable electricity import from Lao PDR

HIGHLIGHTS

Imports up to 100 MW of hydropower

Pathfinder towards establishing inter-connected, regional power grid

Up to 4 GW of imported electricity to power Singapore by 2035

June 2023

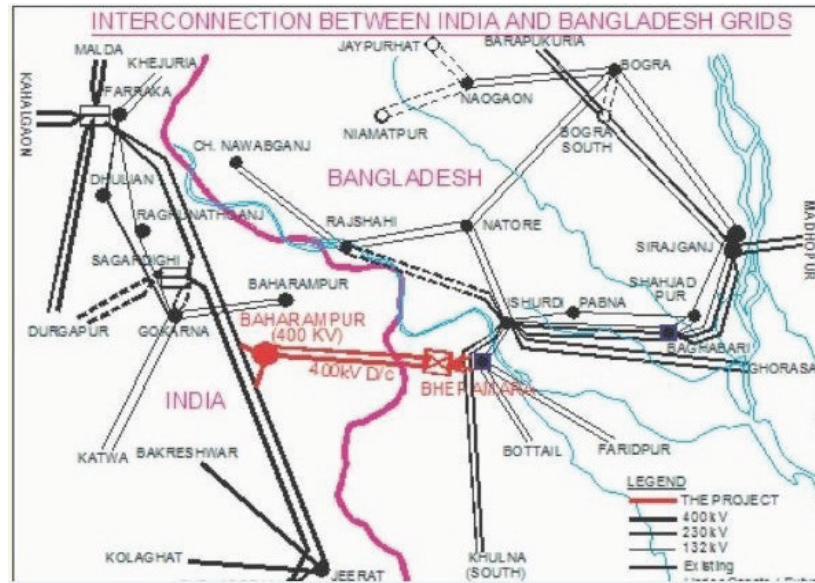
Laos-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP)

The LTMS-PIP is a “pathfinder” project that is meant to demonstrate that multilateral power trading is possible in an ASEAN context. As it stands today, the LTMS-PIP involves the sale of electricity from Lao PDR to Malaysia, with Thailand acting as a transit, or wheeling, country

Source: International Energy Agency

Vietnam has opted to boost hydroelectricity imports from Laos. The limited electricity transmission capacity from the South to the North poses a major challenge. It is easier to import hydro electricity from Laos to shore up power supply for the North, given the shorter transmission distance.

Bangladesh-India Interconnection (HVDC link)



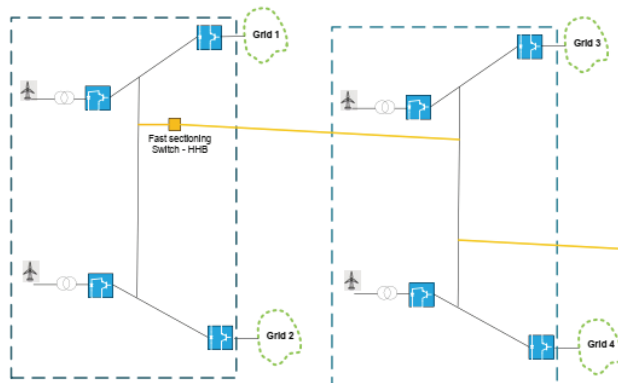
Bangladesh-India 400 KV Double-Circuit 1,000 MW Line

Allows Bangladesh to buy cheaper electricity
and solar electricity when available

Cross-border Multi-purpose HVDC systems: Interoperability is key

Multipurpose / Multiterminal interconnection – towards HVDC grids

Regional HVDC grids can be further extended by connecting multiple Multiterminal interconnections, and using HVDC Breaker technology for protection



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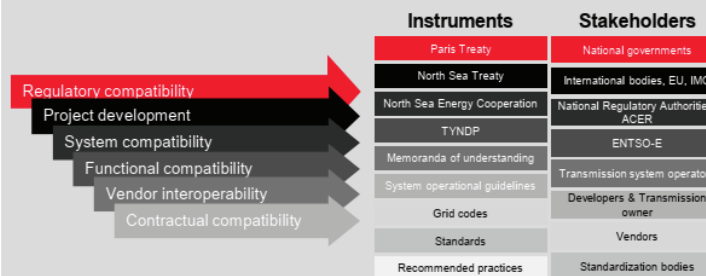
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1. Source: EU Horizon 2020 funded project PROMOTION



Interoperability is much more than technology ...

Voice of the offshore wind European Industry¹



- Technologies have reached a maturity level calling now for an industrial scale demonstration, with special attention on **Grid Code Functional Specification** (TSO driven) and **DC Grid Control** (OEM driven)
- A system, staged and functional approach shall be taken to implement Interoperability with all industrial stakeholders.

Back-to-back HVDC Stations installed for stability due
to Grid Code incompatibility

USD 400 Million investment could have been avoided
with a compatible Grid Code

Similar Grid Code incompatibility exists between
US and Mexico

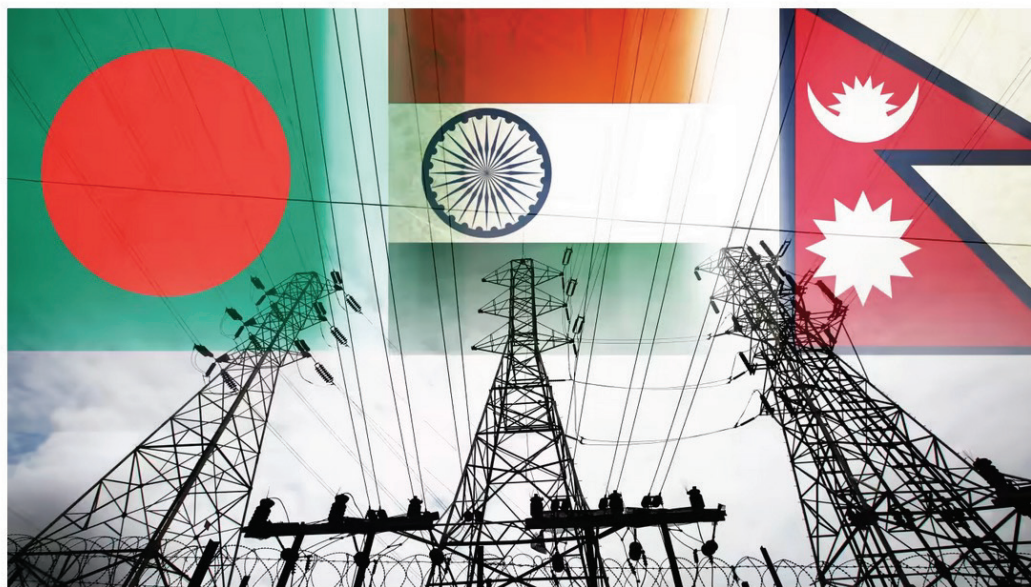
Nepal, India reach 'milestone' deal on trade, transmission of electricity

Nepal to be permitted to participate in real-time trade in the Indian market, an upgrade from existing day-ahead energy trade.



Import of Hydropower will Reduce
India's Dependency on Coal-fired
Power Stations

Source: Kathmandu Post



Bangladesh, India and Nepal are expected to soon finalize an agreement that would allow power sharing across Indian transmission lines. (Source photos by AP and Reuters)

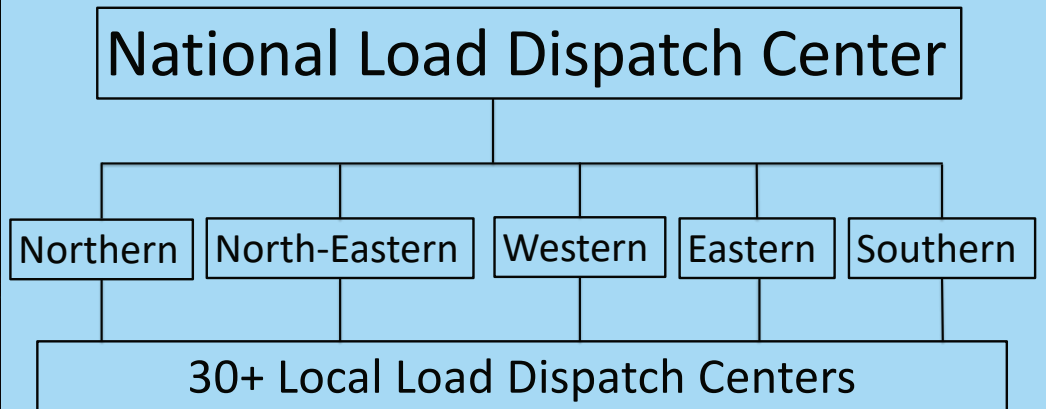
Nepal needs to attract investment by developing a market outside the country

Nepal needs less electricity in summer than in winter

It is opposite in India and Bangladesh due to high air conditioning load



Hierarchy of Load Dispatch Centers



What Needs to Be Done?

(Issues: Politics, Technology, Institutions and Economics)



- Build platform for information exchange
- Identify benefits and risks
- Expand cross-border infrastructure
- Develop a wheeling price model
- Complement national regulation by regional coordination
- Remain cost conscious to maintain political support

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Power System Flexibility



Thank you

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