

South Asia Regional Energy Partnership (SAREP)

Presentation

on

South Asia as the Regional Energy Hub for facilitating Trans-Regional Grid Interconnection for Integrating South Asia, ASEAN, GCC, and Africa Region for Enhanced Energy Security

Roundtable Dialogue: Electricity Regulatory Cooperation Framework for Trans-Regional Grid Interconnection for Enhanced Energy Security and Climate Prosperity: Integrating South Asia, ASEAN, GCC, and Africa Region through a Coordinated and Harmonized Regulatory Framework

SAFIR-SAREP Regional Regulatory Dialogue on “Electricity Regulatory Cooperation Framework for Trans-Regional Grid Interconnections for Enhanced Energy Security and Climate Prosperity”, 10.00-13.00 Hrs, 12th December 2024, Delhi, India

Presented by
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USAID’s South Asia Regional Energy Partnership (SAREP) Program

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01

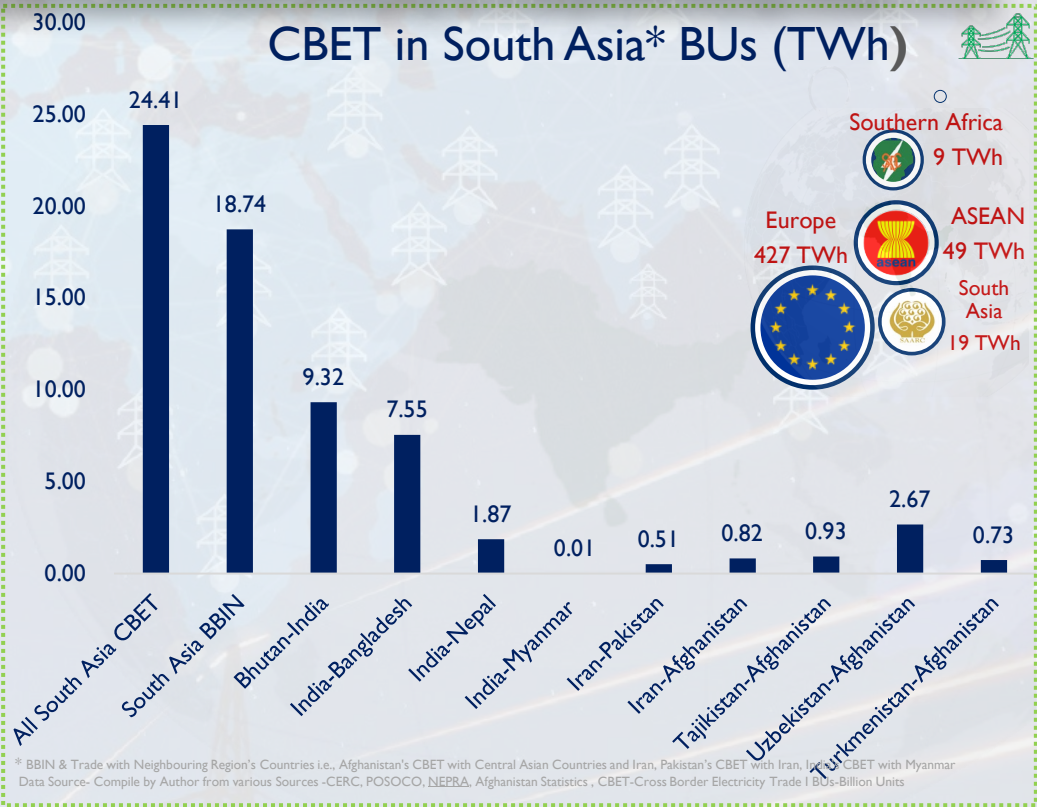
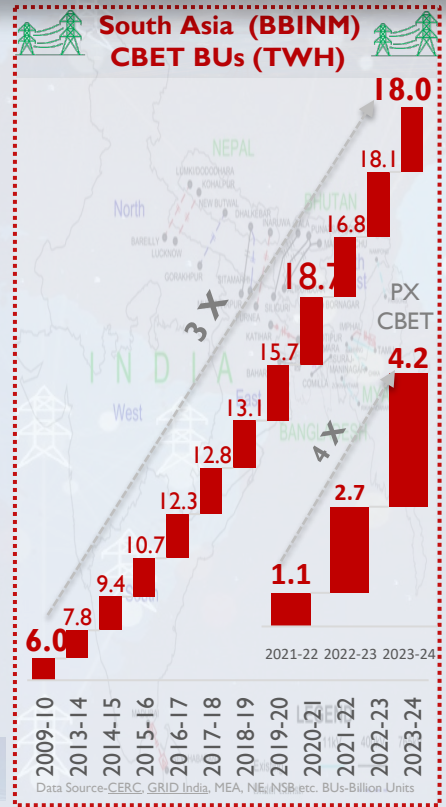
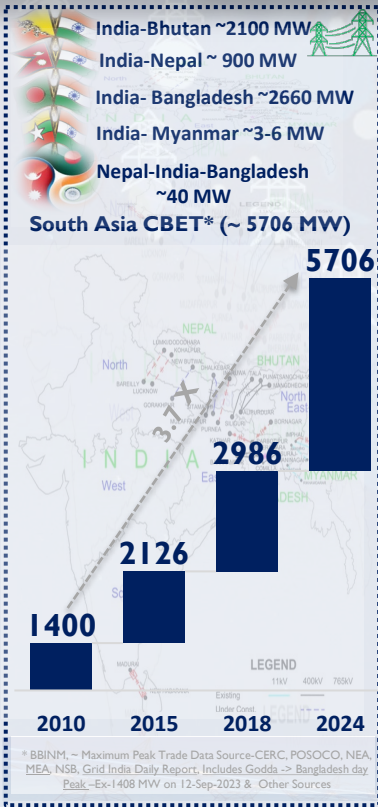
Electricity Grid Integration in South Asia

{Current Scenario and Future Outlook for Cross Border Electricity Trade (CBET)}



Electricity Grid Integration in South Asia : Current Scenario

{Rapidly Increasing CBET (4 X) India at the Fulcrum and Emerging as a Regional Energy Hub}



* BBINM - Maximum Peak Trade Data Source-CERC, POSOCO, NEA, MEA, NSB, Grid India Daily Report, Includes Godda -> Bangladesh day Peak-Ex-1408 MW on 12-Sep-2023 & Other Sources

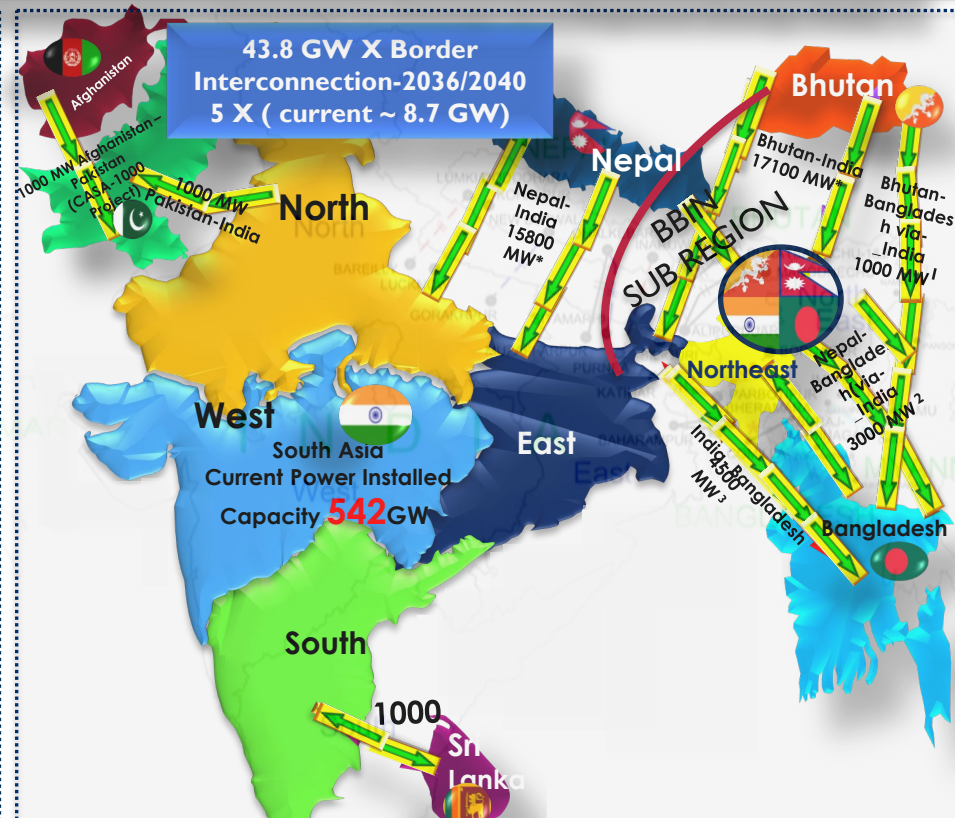
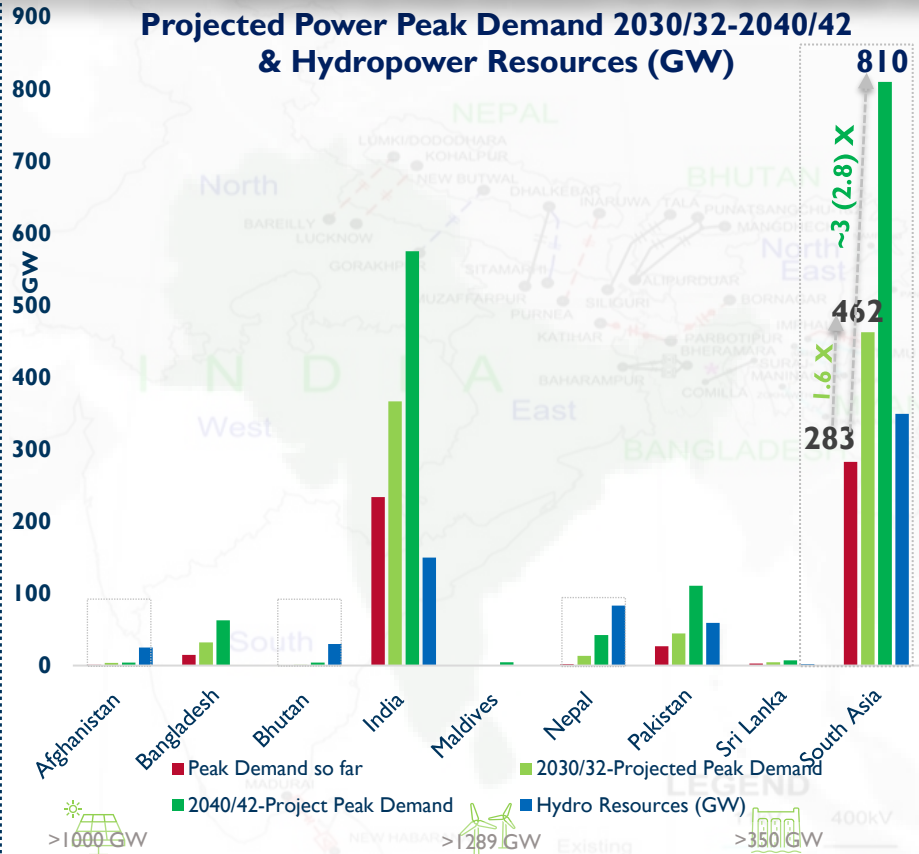
* BBIN & Trade with Neighbouring Region's Countries i.e., Afghanistan's CBET with Central Asian Countries and Iran, Pakistan's CBET with Iran, India's CBET with Myanmar
 Data Source- Compile by Author from various Sources -CERC, POSOCO, NIEPRA, Afghanistan Statistics , CBET-Cross Border Electricity Trade I BUS-Billion Units

CBET Tripled | Potential Remain Large | 350 GW Hydro Power Potential | EU (ENTSOe)-427 TWh | CBET PX- 8 BUs* | Trilateral Trade | PX CBET Quadrupled
 Win-Win Proposition Competitive Price (₹/Kwh)-FY24-Buy (Nepal @ 4.43 ₹, Bhutan @ 3.74 ₹) Sale (Nepal @ 5.61 Bhutan @ 5.78)

Electricity Grid Integration in South Asia : Future Outlook

{810 GW of Peak Demand | 44 GW of X Border Interconnection | Potential to Emerge as a Regional Energy Hub}

Projected Power Peak Demand 2030/32-2040/42 & Hydropower Resources (GW)



Compiled from * India connection with Bhutan, Nepal, Bangladesh, Sri Lanka as per the CEAA's 2015-2030 Regional Master Plan, Bangladesh: PSMP-2016, India-Bangladesh as per the PSMP-2016 of Bangladesh, 1 Bhutan-Bangladesh via India (2030)-Bhanganagar/Rangpo-Jamrapur, 2 Nepal-Bangladesh via India-From Nepal (Purnea-Biropukuta) by using Case 3 T/L (Initially 400kV AC)-2025, using Case 3 T/L (Upgrade to 765kV AC)-2030, Bheramara - Baharampur-Additional extension of Bheramara HVDC Power import from Nepal (including GWB/2021, 3 India-Bangladesh-Rangpo/Rowta-Biropukuta 1,000 MW by 2023 & another 1000 MW by 2025 Power import by using Case 2 T/L (±800kV DC), Tripura - Comilla-400 MW by 2020, Bibiyana - Meghalaya (PSPF) 1,000 MW 2030 PSPF in Meghalaya State, Existing 1160 MW, Compiled by Author from various Sources, Ravi Pandya/SAR/IEV, Presentation on "Deepening Power System Integration & Cross-Border Electricity Trade in SAARC Region: Current Status & Future Outlook" by Ravi Ratan Pandya, 3 India-Bangladesh: Rangpo/Rowta - Biropukuta 1,000 MW by 2023 & another 1000 MW by 2025 Power import by using Case 2 T/L (±800kV DC), Tripura - Comilla-400 MW by 2020, Bibiyana - Meghalaya (PSPF) 1,000 MW 2030 PSPF in Meghalaya State, Existing 1160 MW.

Recent Announcement are Encouraging- Prime Minister Shri Narendra Modi during the visit of Prime Minister of Nepal June 01, 2023, said, India to Import 10,000 MW of Power from Nepal in Next 10 Years

Net Zero & RE Goals/Ambitions

❖ **World's 1st Carbon Neutral Country-Bhutan**

❖ **Net Zero**



- ❖ 2030-Maldives
- ❖ 2045-Nepal
- ❖ 2050-Sri Lanka (Carbon Neutral)
- ❖ 2070-India

❖ **Renewable Energy by 2030**

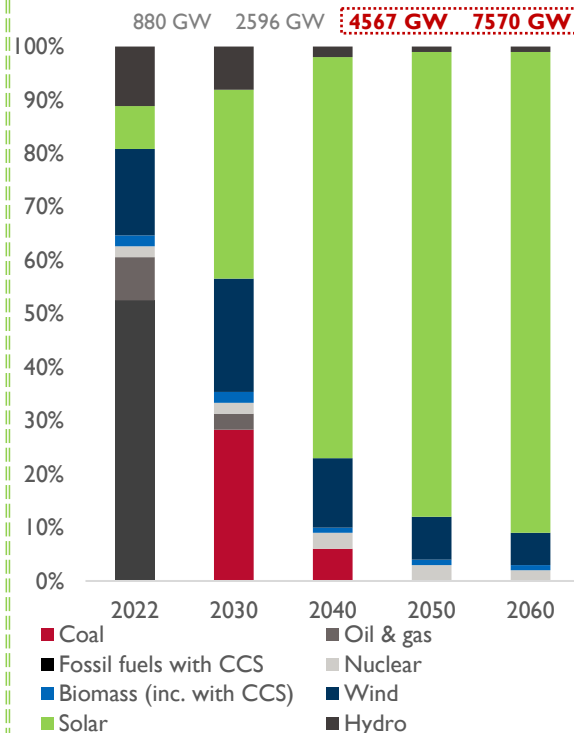
- ❖ 500 GW-India
- ❖ 35 GW-Pakistan
- ❖ 16 GW-Bangladesh
- ❖ 15 GW-Nepal
- ❖ 9.3 GW-Bhutan
- ❖ 8.7 GW-Sri Lanka



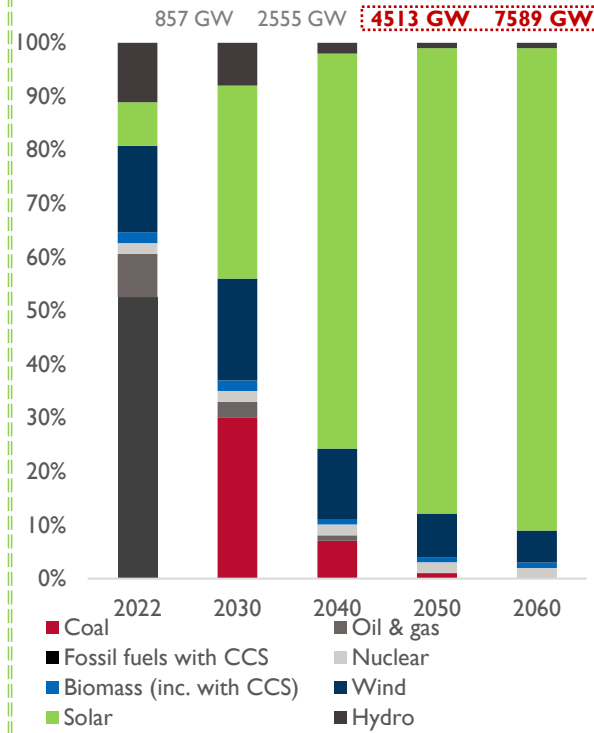
584 GW RE by 2030

Note: RE=Renewable+Hydro/Clean Energy/Non-Fossil Hydro as the case in a Country Context. BD-14 (GH:MCPP-M Scenario) (Page: 82); India-Pakistan-IEEEP Plan 2018-40 (Page 78 of 147, MCPP (Page 82); Sri Lanka-CEB LGTEP 2023-2042, Nepal-WAM Scenario- Page: 27 of Nepal's LTS for Net-zero, Bhutan- NTGM-2018, (Page 17, Graph -2)

India-Projected-Power Capacity (GW) mix in 2070 Net Zero (Regulation Focus) Scenario



India-Projected-Power Capacity (GW) mix in 2070 Net Zero (Market-Based Focus) Scenario

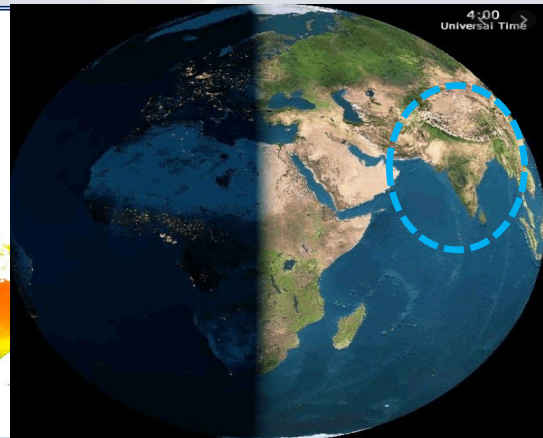
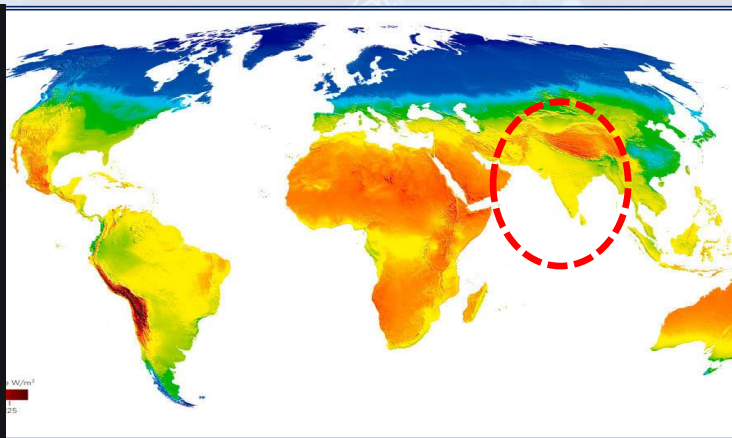
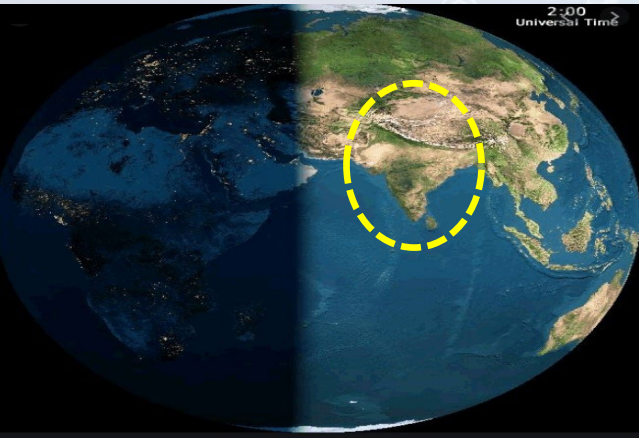




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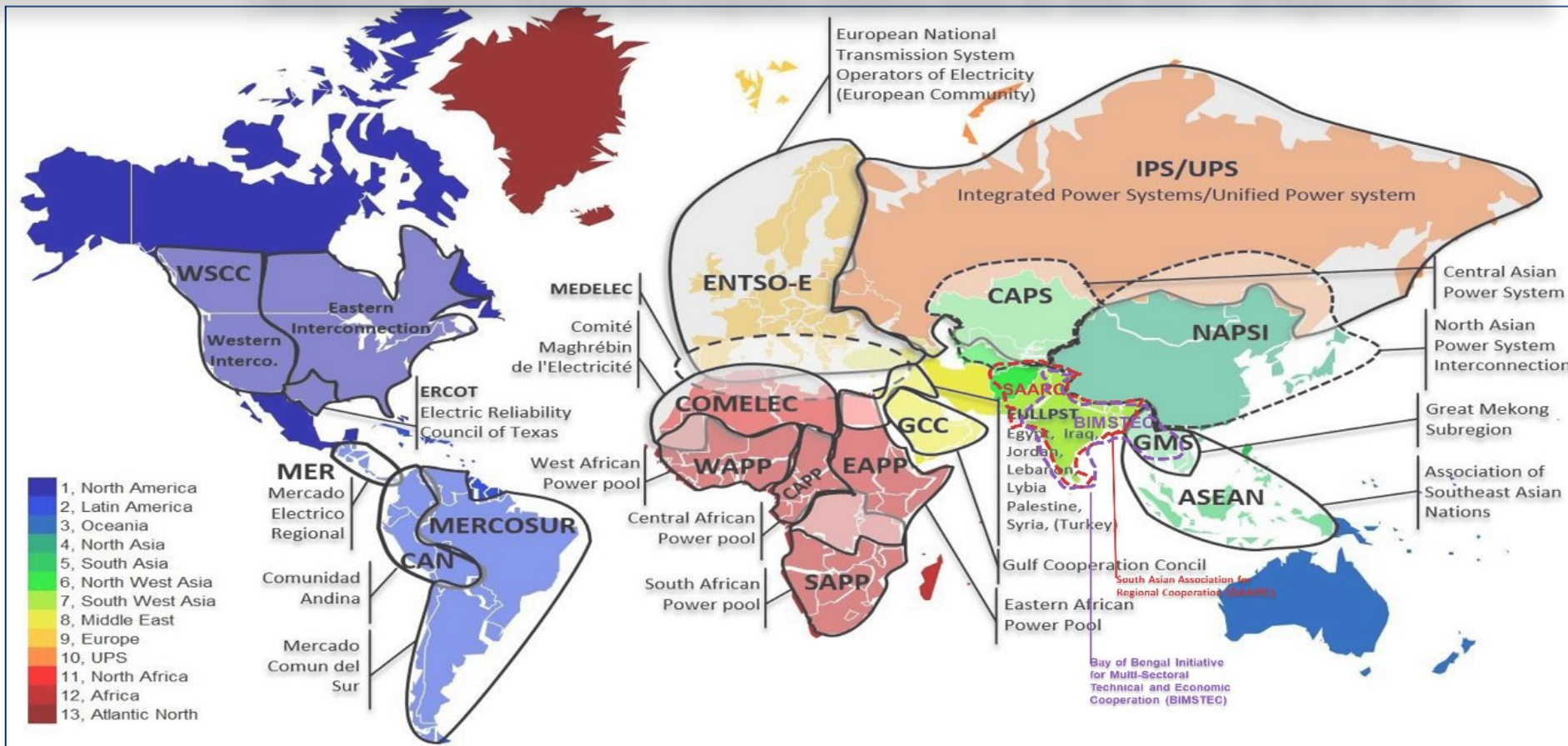
One Sun One World One Grid, Trans-Regional Grid Integration

{Background, Prospects, Linking Regional Grids of AFRICA-GCC-South Asia-ASEAN, Potential Benefits}



One Sun One World One Grid, Trans-Regional Grid Integration

{ Background : Various Regional Grid Integration Initiatives across the Globe Exist | ~20 Regional Grids }



Source : Power system development and Economics, Global electricity network Feasibility study, Reference: 775, September 2019, CIGRE report on "Global electricity network-Feasibility study", and further modification on the image by adding SAARC and BIMSTEC Region

One Sun One World One Grid, Trans-Regional Grid Integration

{ Background : Vision and Concept | linking Regional Grids through a Common Grid | Sun Never Sets }

Idea Announced by Honourable Prime Minister of India in the First Assembly of International Solar Alliance

The "Sun Never Sets", globally, at any given point of time

Building a Global Ecosystem of Interconnected RE, Seamlessly Shared for Mutual Benefits & Global Sustainability

With India at the fulcrum, the Solar Spectrum can easily be Divided into two Broad Zones viz. Far East and Far West

Far East include countries like Myanmar, Vietnam, Thailand, Lao, Cambodia etc. and far West which would cover the Middle East and the Africa Region.

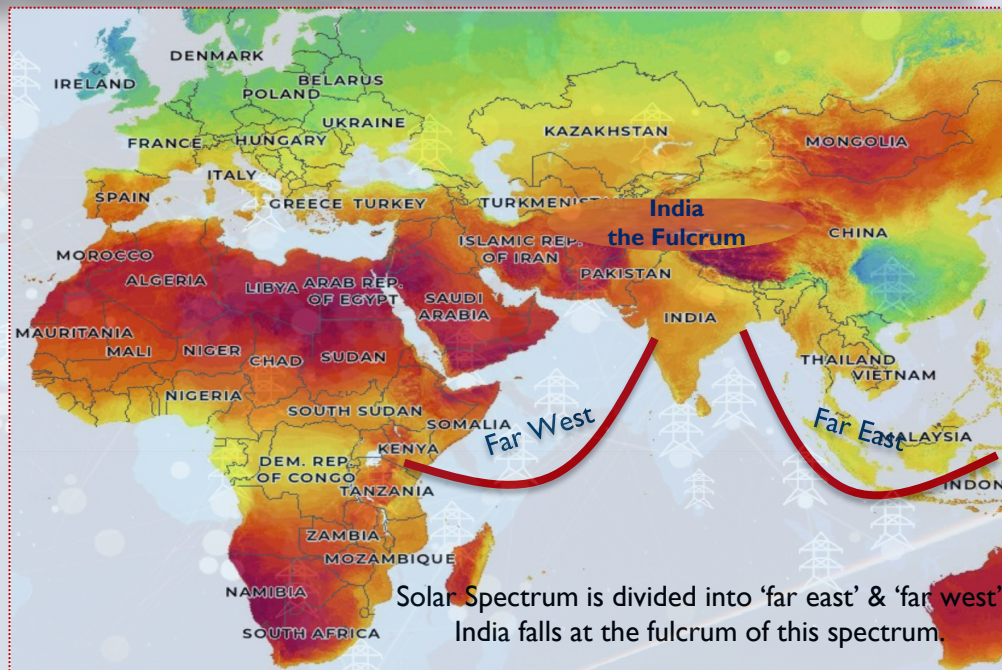
Matching the Demand and Supply Centre Across Geographies

Interconnectors as a Mean/Solution to Manage Intermittencies

Reduce Curtailment, Exploiting the Time Zone Difference

Global Grid Safety, Resilience and Security

Source : Based on RFP OSOWOG



Solar Spectrum is divided into 'far east' & 'far west' India falls at the fulcrum of this spectrum.

Economies of Scale

Attracting investments

Reduced project costs

Higher efficiencies and increased asset utilization

Resulting economic benefits would positively impact

Poverty alleviation

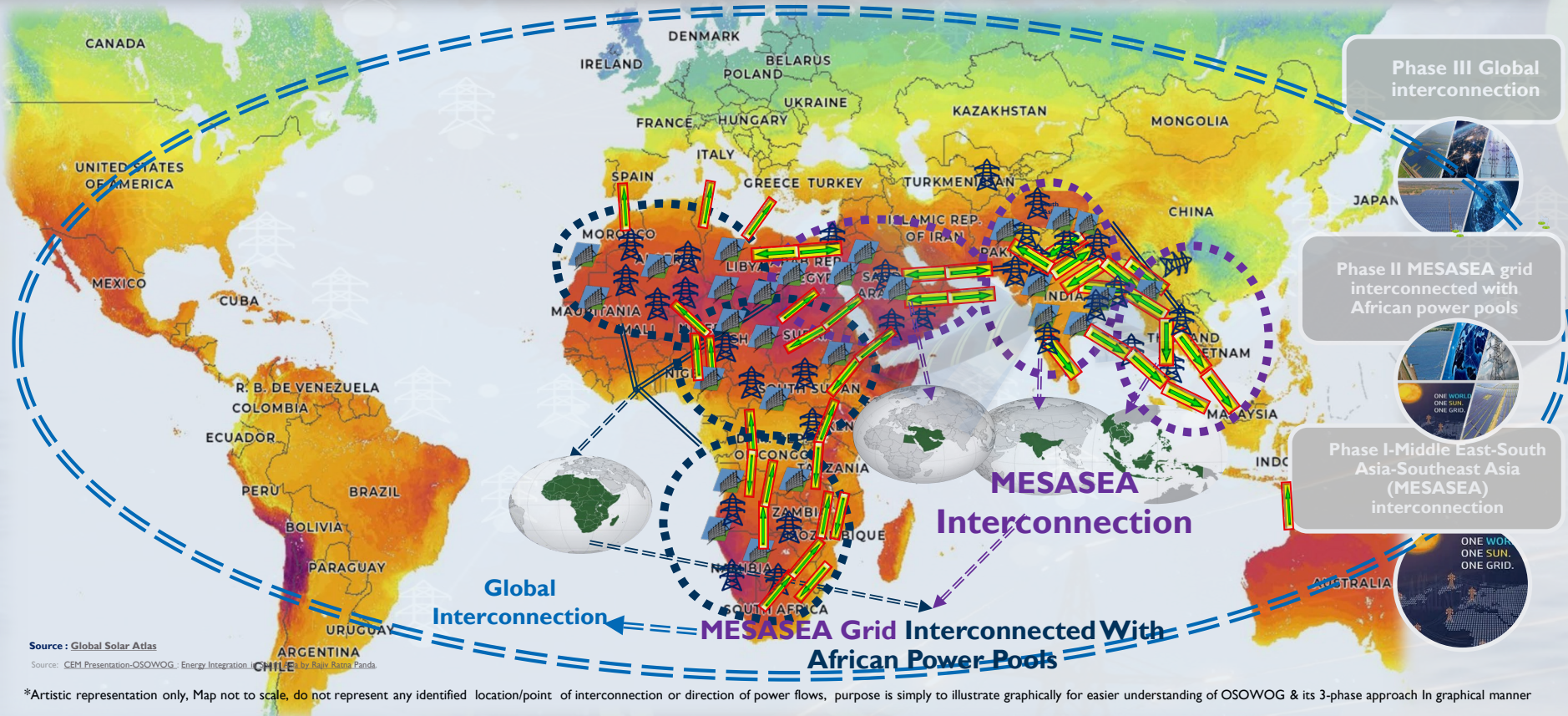
Support in mitigating water, sanitation, food

Address Other socioeconomic challenge

OSOWOG- Initiative will Connect Different Regional grids through a Common Trans-Regional/Trans-Continental Power Grid While plan is grand, we have various **proven regional grid interconnection exist around the globe** such as Europe etc. backed with HVDC technologies

One Sun One World One Grid, Trans-Regional Grid Integration

{ Background : Vision and Concept | linking Regional Grids through a Common Grid | Sun Never Sets }



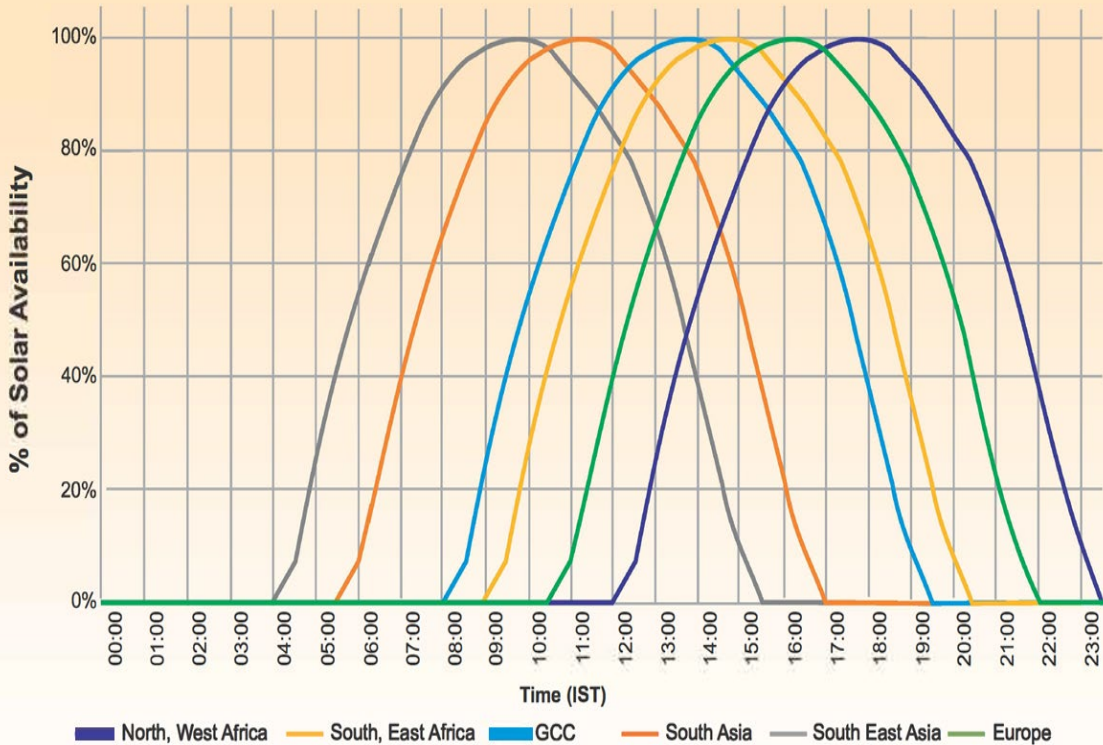
*Artistic representation only, Map not to scale, do not represent any identified location/point of interconnection or direction of power flows, purpose is simply to illustrate graphically for easier understanding of OSOWOG & its 3-phase approach In graphical manner

Building Regional, Sub-Regional, Continental and Global Consensus on Interconnections will be the key

One Sun One World One Grid, Trans-Regional Grid Integration

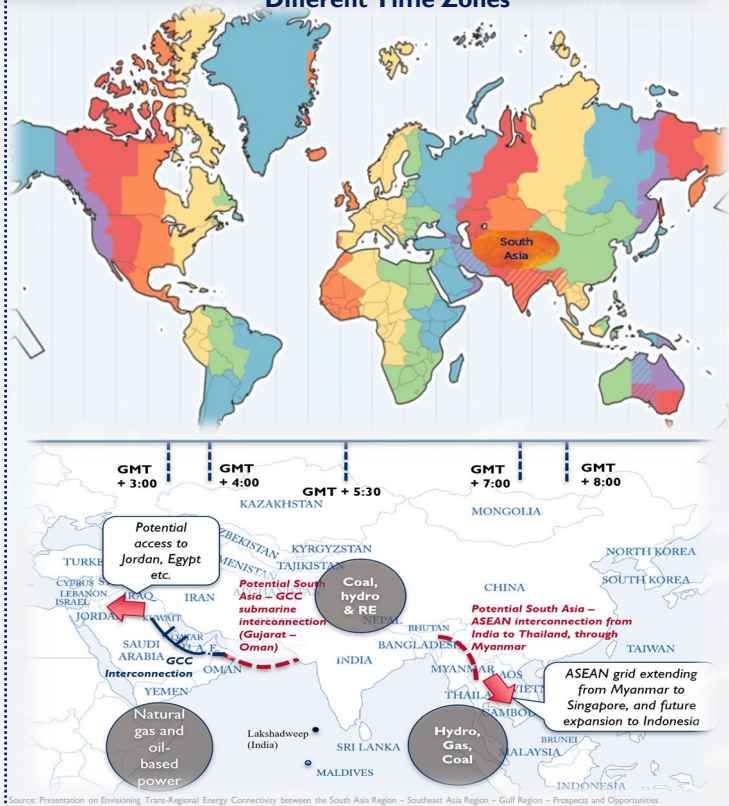
{ Background : Vision and Concept | linking Regional Grids through a Common Grid | Sun Never Sets }

Diversity in Solar Availability Across GCC, AFRICA, South Asia, South East Asia and Europe



Source: Transnational Grid Connections for Enhanced Energy Security

Different Time Zones

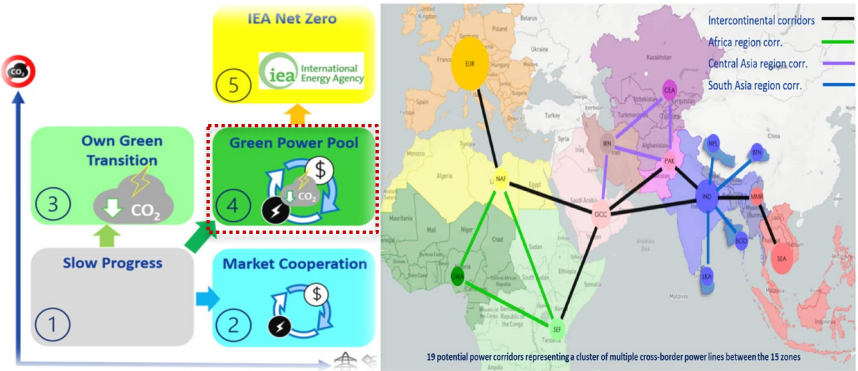
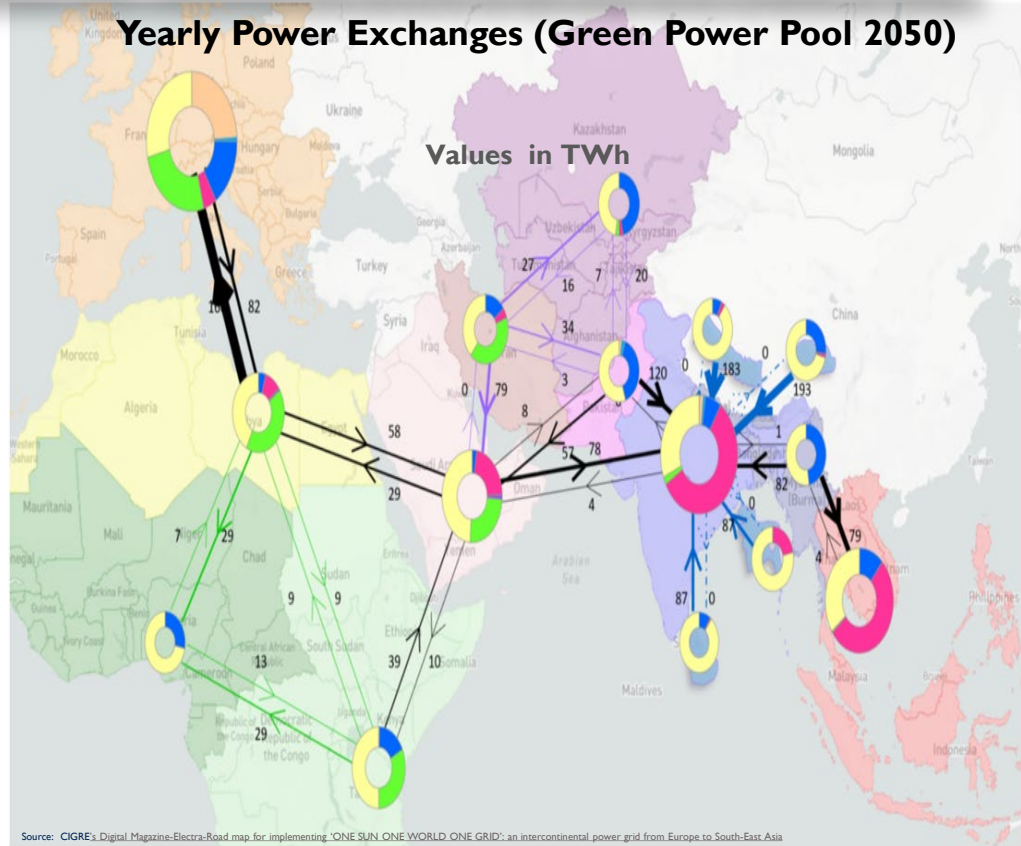


Source: Presentation on Breaching Time-Regional Energy Connectivity between the South Asia Region - Southeast Asia Region - Gulf Region - Prospects and Opportunities

Time Zone Variation, Reserve Sharing, Resource Complementarity, Diversity of Peak Demand, Optimum Utilization of RE Resources and increased reach to additional markets

{Potential Benefits of Trans-Regional Grid, Green Power Pool : Electricity Cost decrease by 60% from 20 to 9 \$/MWh by 2050}

- ❖ **Global Study:** The study perimeter incorporates an heterogeneous electricity power landscape from Europe, via Africa, the Middle East to Asia including **117 countries representing 33% of the load, growing to reach 40% in 2050.**
- ❖ **Global Power Pool Embryo:** **South Asia GDP growing, become the main load center.**
- ❖ **Intercontinental green power corridors (ICPC):** By 2050, sum of ICPC could hit 49 GW for \$25 billion investment.
- ❖ **In green Power Pool Scenario,** the overall unit electricity cost (\$/MWh) decrease by **60% from 20 to 9 \$/MWh.**



2022-2050 Roadmap: An eco-sustainable intercontinental power system to be developed between Europe, Africa, Middle East, and Asia, with India as the fulcrum of a Global Power Pool Embryo

As per CEA, India By 2047 to have 708 GW of Peak Demand, 2053 GW of Installed Capacity, 1200 GW of Solar, 436 GW of Wind

ONE WORLD.
ONE SUN.
ONE GRID.

03

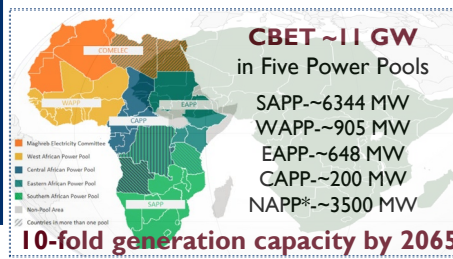
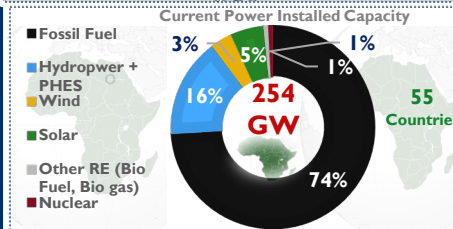
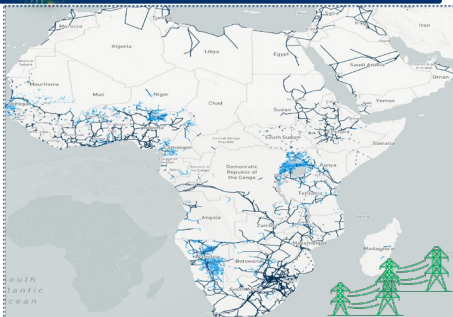
Trans-Regional Grid Interconnectors and Super Grids

{Potential Trans-Regional Grid Interconnectors and Super Grid Projects}

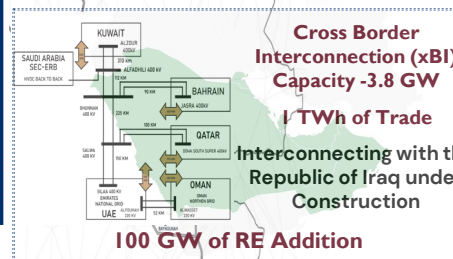
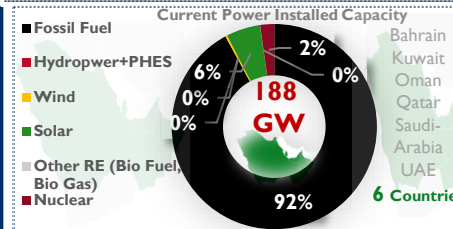
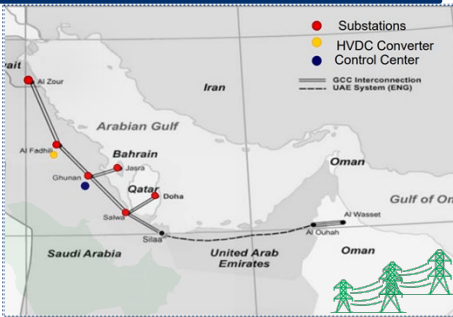
International corridors
Africa region corr.
Central Asia region corr.
South Asia region corr.

03.1 Trans-Regional Grid Interconnectors : Africa-GCC-SA-ASEAN Power Sector Snapshot

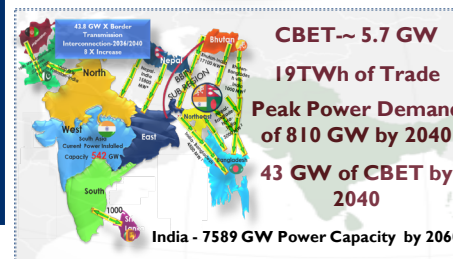
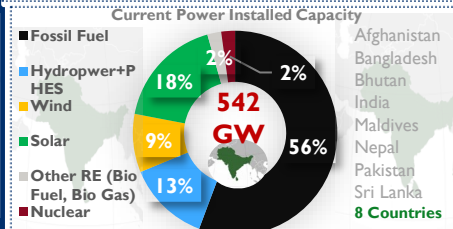
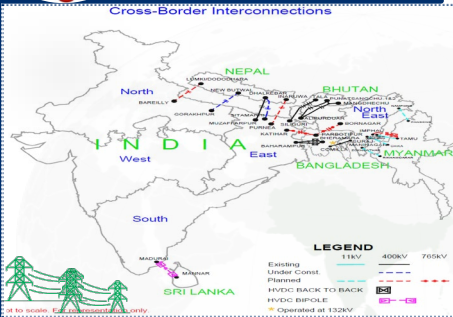
AFRICA



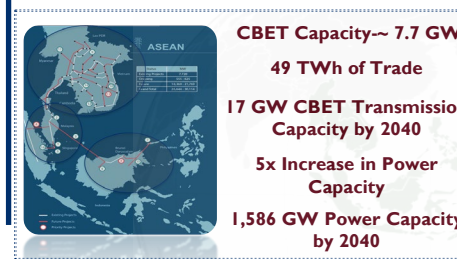
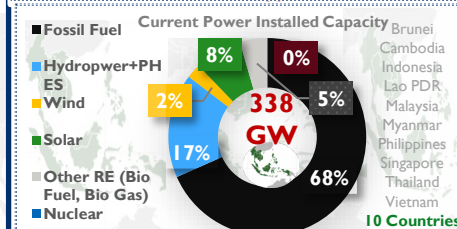
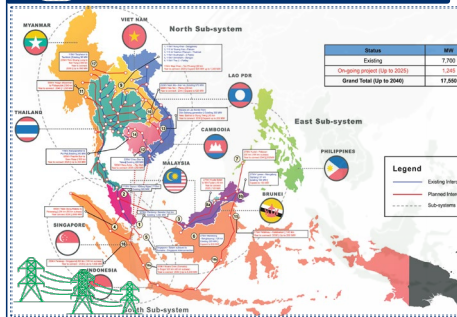
GCC



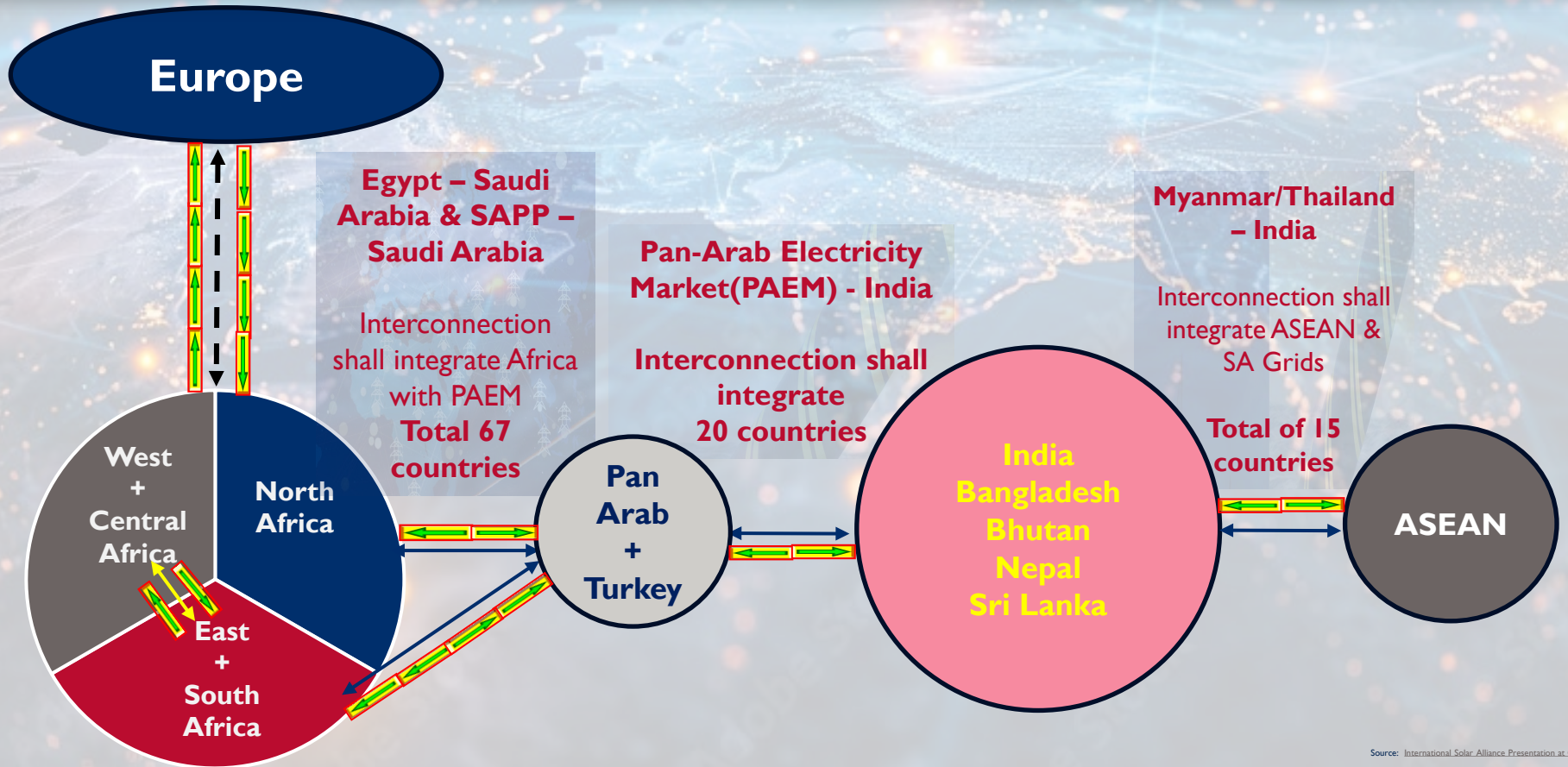
South Asia



ASEAN

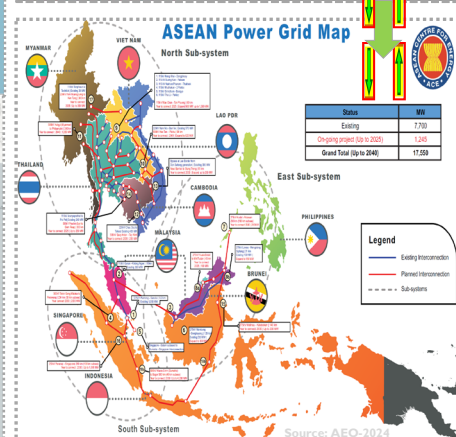
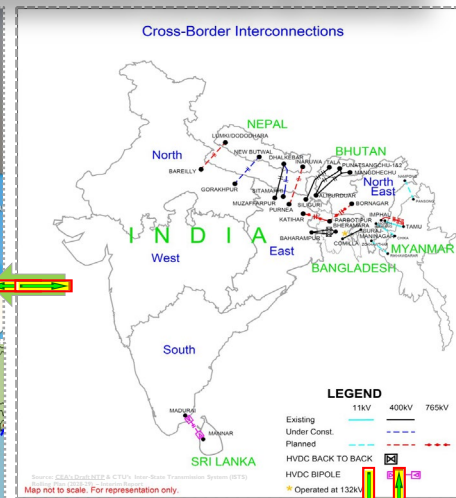
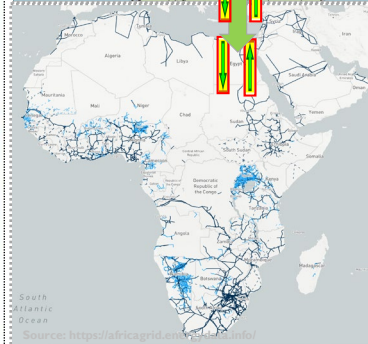
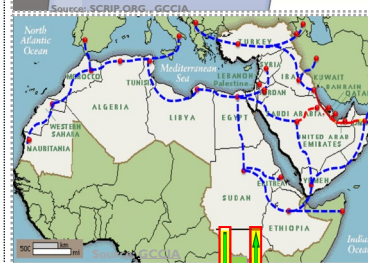
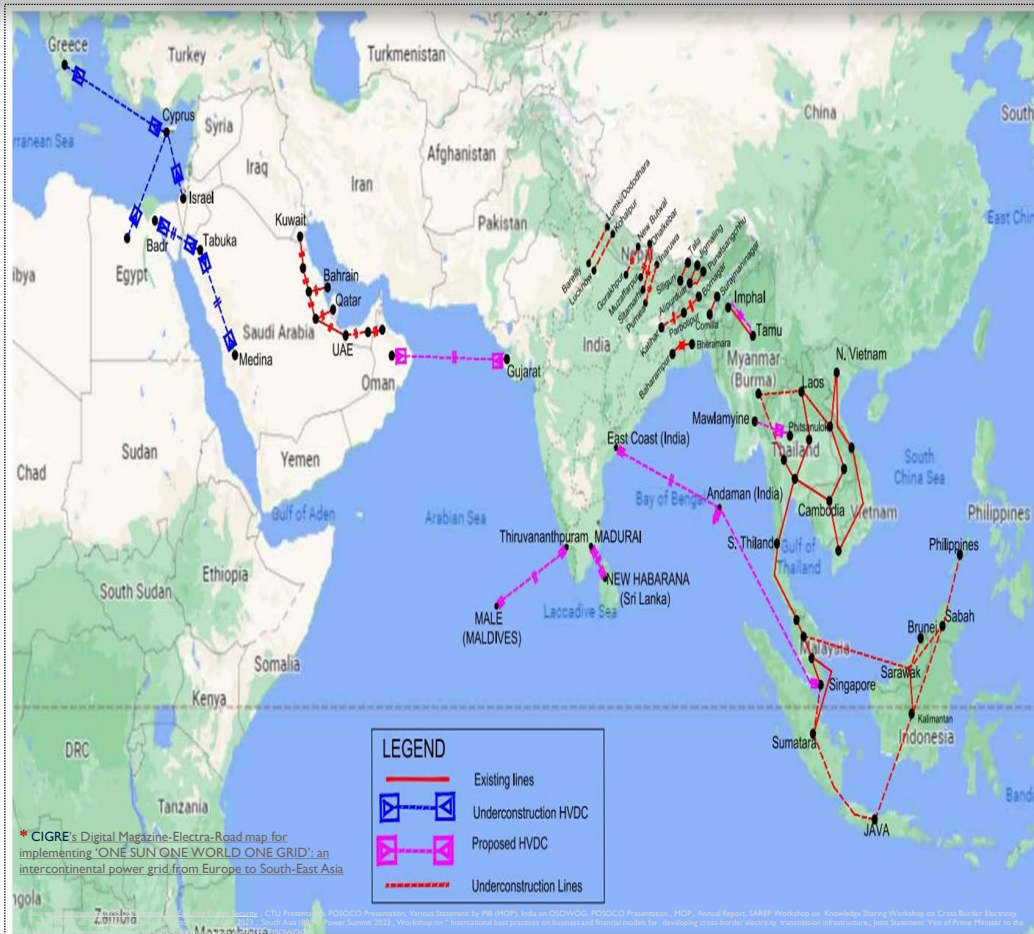


Source: Mohamed A. Elshir Elbabb, Laurens de Vries, and Correda. African power pools and regional electricity market design. The Development of African Power Pools by Mohamed A. Elshir Elbabb, February 2023, IIT Comillas University | Energy projections for African countries | Trade Capacity | GCC-Source: GCCCA Annual Reports | IRENA | ASEAN Energy Outlook | Presentation on "Envisioning Trans-Regional Energy Connectivity between the South Asia Region - Southeast Asia Region - Gulf Region"



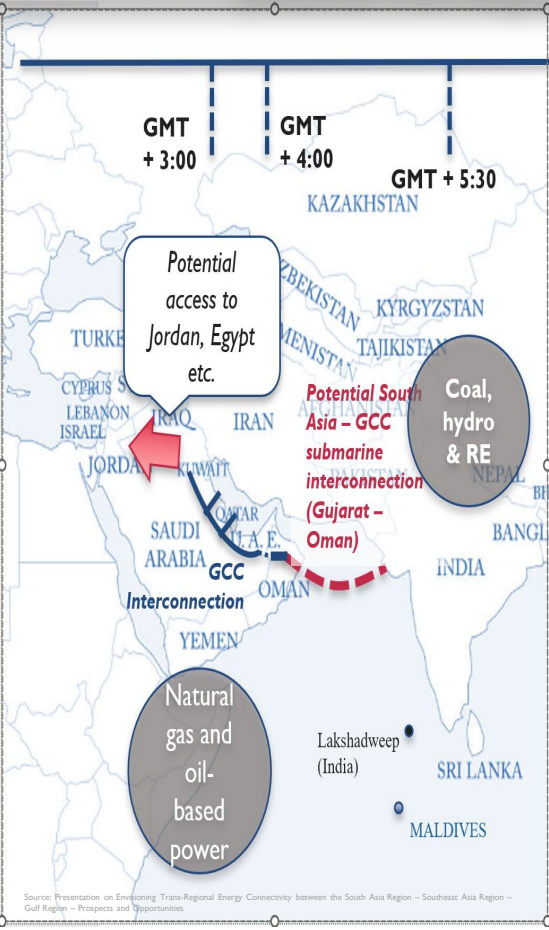
Trans-Regional Grid Integration-GCC-South Asia-ASEAN

{Potential Trans-Regional Grid Interconnectors : Massive 49 GW (US\$25 billion) of Intercontinental Corridor by 2050*}



Trans-Regional Grid Integration-GCC-South Asia Interconnection

{Potential Trans-Regional Grid Interconnectors : Massive 24 GW Corridor around Middle East by 2022-2050*}



India (Gujarat) – GCC (Oman) Interconnection

HVDC Submarine Cable

Oman is connected to GCC Grid

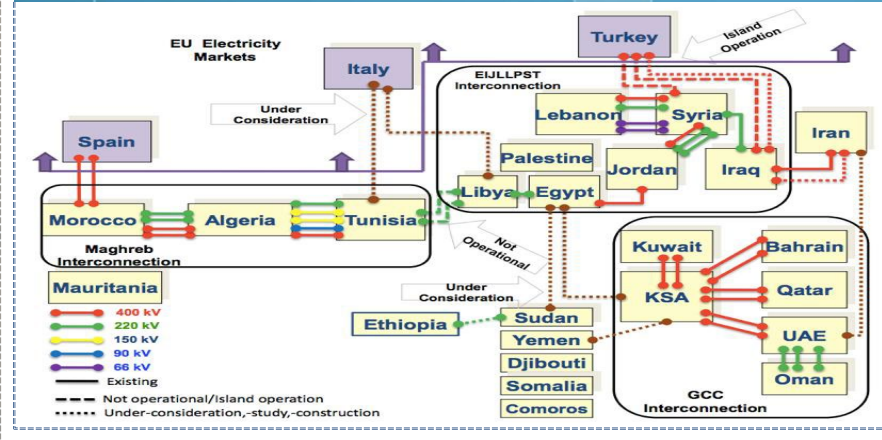
Oman–India transmission 2300 km (1000 km across sea) while the Maximum Depth 3500 Meter.

For a 3000 MW GCC-India Interconnection via Sub-sea Cable is Estimated to be 3.5 billion US \$

GCC Grid Plans to Connect with PAEM-Pan-Arab Electricity Market, Maghreb, Mashreq (EIJLLPST)

A Solar Park in Egypt can Sell Excess Green Peaking Power to India (given the 3.5-hour time difference)

6599 Km of Power Submarine cable world wide | Viking Link- 1400 MW, 765 Km (650 Km under sea) UK-Denmark



03.5 Super Grid & Trans-regional Green Energy Corridors : Planned Futuristic Projects

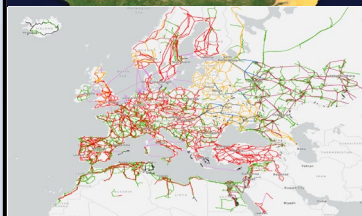
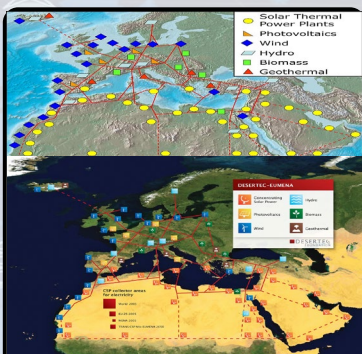
X Links: Morocco-UK Power Project



- **4000 km line** evacuating solar and wind generation from Morocco to UK.
- **11.5 GW** of RE, 22.5 GWh of battery storage and a **3.6 GW HVDC interconnector (2031/32)**
- Would supply up to **8% of the UK's electricity consumption.**
- If built, will be the second longest **undersea power cable in the world**

Source: X Links

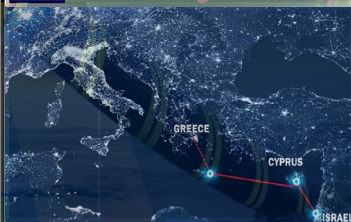
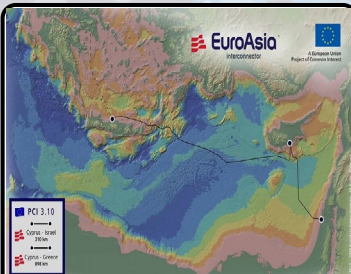
European Super Grid (ESG)



- A conceptual plan of a ESG linking renewable energy projects like **DESERTEC & Medgrid across North Africa, the Middle East and Europe**
- Also named as **Super Smart Grid (SSG)**

Source: www.DESERTEC.org, EPS

Great Sea Interconnector (Formerly Euro Asia Interconnector) Greece - Cyprus - Israel



- **1200 km HVDC submarine cable, 3 KM deep**
- **1000 MW** in phase I, and **2000 MW** in phase II
- Voltage Source Conversion (VSC) technology which will allow for transmission in both directions. Expected to be completed in 2028-2029.

Source: ITPO, Great Sea Interconnector, EU

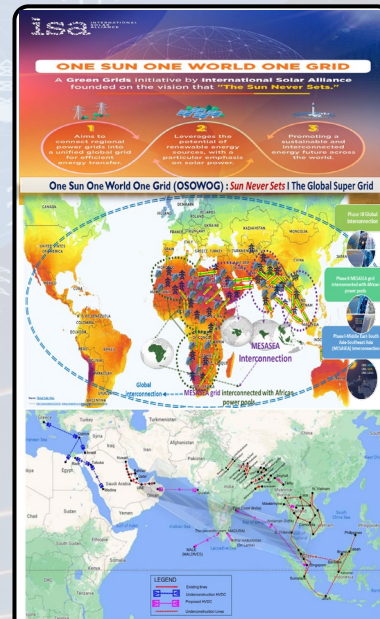
Australia-Singapore Link



- An ambitious project concept to set up solar power plants in Australia and evacuate the power to Singapore,
- **4500 KM submarine cable (3 GW)** route, through Indonesia.
- **Received in-principle approval** from Singapore's (EMA) for import of power, in 2024

Source: Sun cable, Australia-Asia Power Link

OSOWOG Super Grid



- Phase-I: Indian grid with **Middle East, South Asia & ASEAN Grid**
- Phase-II: Functional **first phase Grid** with the African Power pools
- Phase-III: The third and final phase aims to achieve a **global Grid**

Source: MNRE, OSOWOG REP, ISA, OSOWOG Presentation, Trans-Regional Connectivity, Workshop on Best Practice on x.border, transmission

04

Challenges & Risks of Building Trans-Regional Electricity Grids Africa-GCC-South Asia-ASEAN Grid Interconnectors

{Finding a Balancing Act for Political, Policy and Regulatory Design}

Challenges of Trans-Regional Electricity Grid-Africa-GCC-South Asia-ASEAN Grid

{Finding a Balancing Act for Political, Policy and Regulatory Design}

Political Trust

Regional & National Interest ?

(How to Balance ? Which one to Prevail ?
Finding Win-Win Proposition)

Energy Security

Energy-Interdependency or Co-dependency

(How much? Green Attribution to whom ?)

Navigating Geopolitical Realities

(Idealism vs Realism, Managing Uncertainty)

Energy Resource Nationalism & State Governance

(How Much State Control ?
Resource Sharing at what cost ?)

Competitive & Cooperative Principle

(Relying on Competition ?
Sharing of Burden of Grid Integration ?)

Policy, Regulatory and Market Harmonization

Political Economy of Market Reform

(How to steer CBET market integration in the absence of adequate market reform ?)

Common Agreed Principle for Equitable Sharing of Cost & Benefits

(How ? Setting the Expectations ?)

Limited Public Resource & Investment Strategy

(How to attract investment while in a dominant State Control Environment ?)

Market & Developmental Approach

(Limitation of Markets ? Is developmental approach is a better for Trans-Regional Grid)

Trans-Regional Electricity Grid & Market Integration Policies & regulations often needs to Navigate various long-term consideration and depends on the political economy of the jurisdiction that creates it, it requires Policy and regulatory leaders to navigate these difficult trade-offs in a balanced manner.

Nature of Trans-Regional Electricity Grid Interconnections

{Uniqueness and Risks}



Long Term

Political and
Country Risk

Financing
Risks

Off-taker Risk
(Including
payment Risk)

Irreversible



Policy &
Regulatory
Risk

Construction
/ Operation
Risk

Technical and
Cyber Risks



Multiple
Jurisdiction

Dispute
Resolution
Risk

Security Risk

Pricing Risks

Diversity of Existence of Electricity/Energy Regulators

{Regulators in Africa-GCC-South Asia-ASEAN}

■ No Sector Regulator ■ Regulator Exist ■ Sector Regulator Planned



South Asia has Regulatory Institutions in all Countries except for Afghanistan : well-positioned to be the Regional Energy Hub

Source: Updated by the Author with the Adaptation from the World Bank_Akura, Elcin. 2024. "Global Power Market Structures Database"

Diversity of Transmission and System Operation Structure

{ Africa-GCC-South Asia-ASEAN Region }

■ No Unbundling ■ Ownership Unbundled ■ Functionally Unbundled ■ Legally Unbundled/ITO ■ ISO

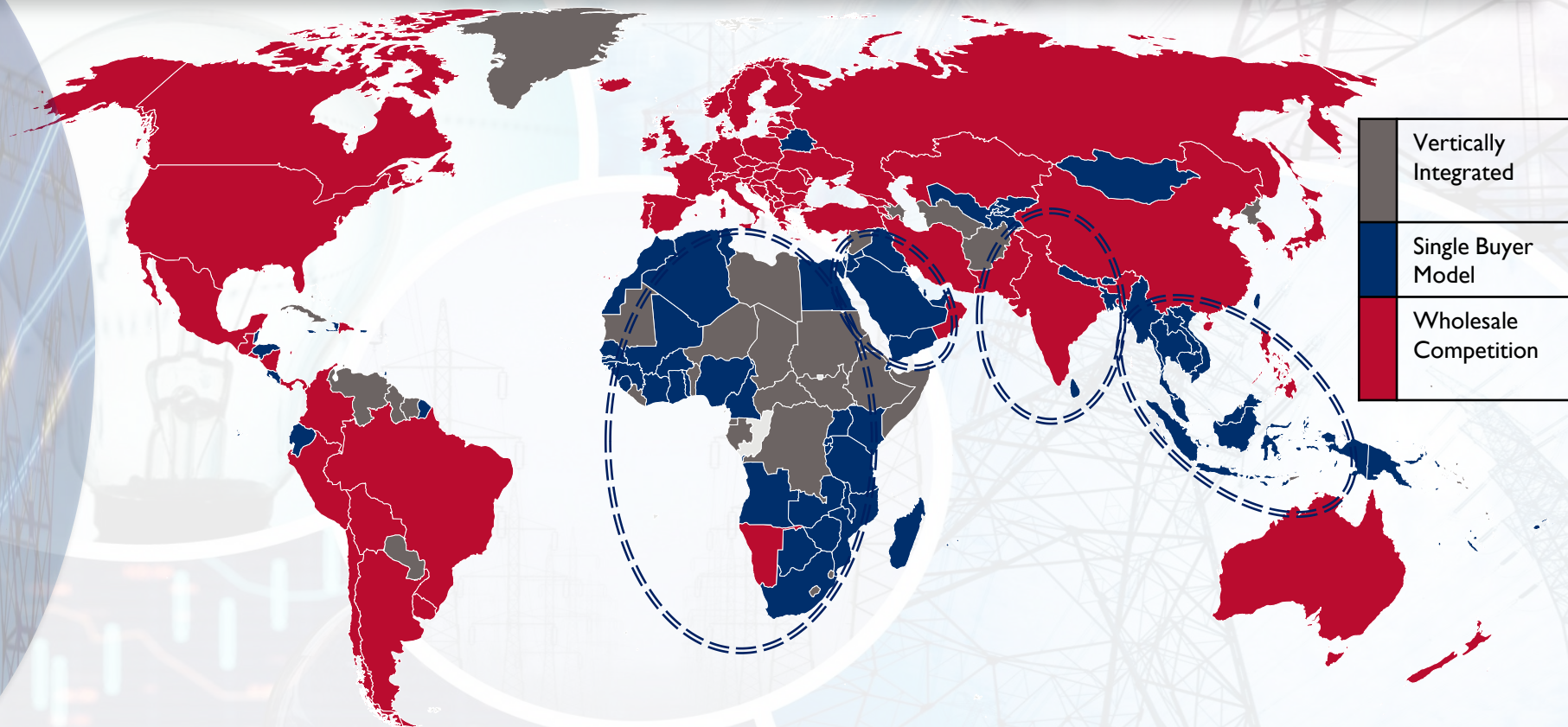


Two of South Asian Countries have ISO out of total 3 such countries of AFRICA-GCC-South Asia-ASEAN Region : well-positioned to be the Regional Energy Hub

Source: Updated by the Author with the Adaptation from the World Bank, Akura, Ucin, 2024. "Global Power Market Structures Database"

Diversity of Power Market Model

{ Africa-GCC-South Asia-ASEAN Region }

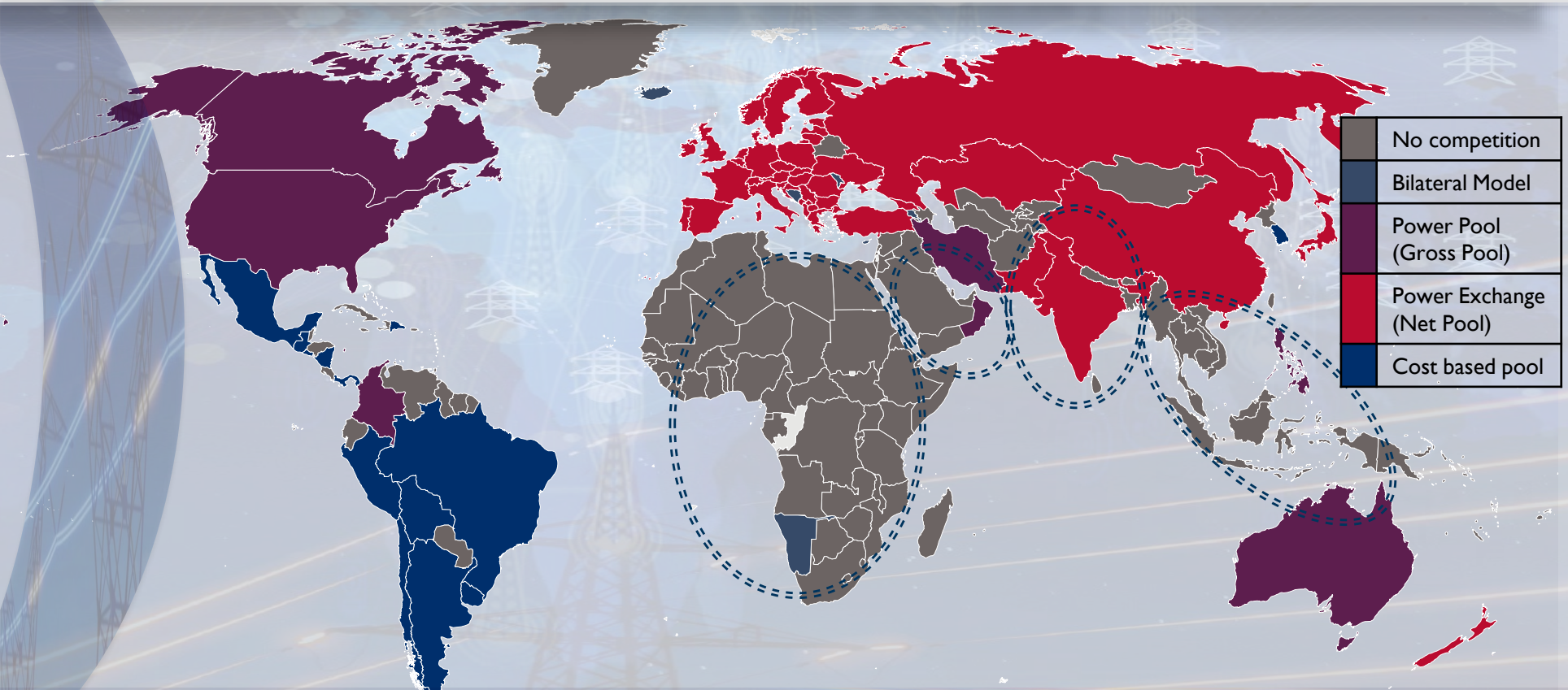


Two Large South Asian Countries have Wholesale Competition out of total 7 such countries of AFRICA-GCC-South Asia-ASEAN Region : well-positioned to be the Regional Energy Hub

Source: Updated by the Author with the Adaptation from the World Bank, Akcira, Elcin. 2024. "Global Power Market Structures Database"

Diversity of Wholesale Competition Models

{ Africa-GCC-South Asia-ASEAN }



Only Two South Asian Countries have Power Exchange (Net Pool) out of total 3 such countries of AFRICA-GCC-South Asia-ASEAN Region : well-positioned to be the Regional Energy Hub

Source: Updated by the Author with the Adaptation from the World Bank, Akcira, Elcin. 2024. "Global Power Market Structures Database"

RECOMMENDATION

Recommendation and Way Forward

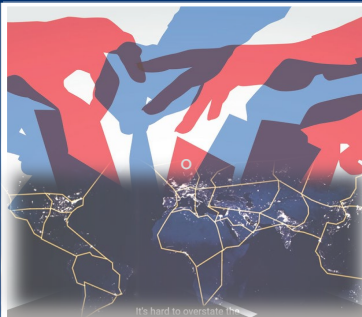
05

{South Asia as the Regional Energy Hub for facilitating Trans-Regional Grid Interconnection for Integrating South Asia, ASEAN, GCC, and Africa Region}



{South Asia as the Regional Energy Hub for facilitating Trans-Regional Grid Interconnection for Integrating South Asia, ASEAN, GCC, and Africa Region}

Political & Policy



- **International Political Treaty** Trans-Regional Grid Interconnections (TRGI)
- **Protocol Agreement on “Principles for Trans-Regional Grid Development and Implementation**
- **Regional Policies** on TRGI

Regulatory and Electricity Market



- **Regulatory Coordination and Harmonisation** Cooperation Framework for TRGI
- **Regional Regulators Working Group on TRGI**
- **Trans-Regional Power Exchange (TRPX) Design through Coupling**

Technical and Commercial



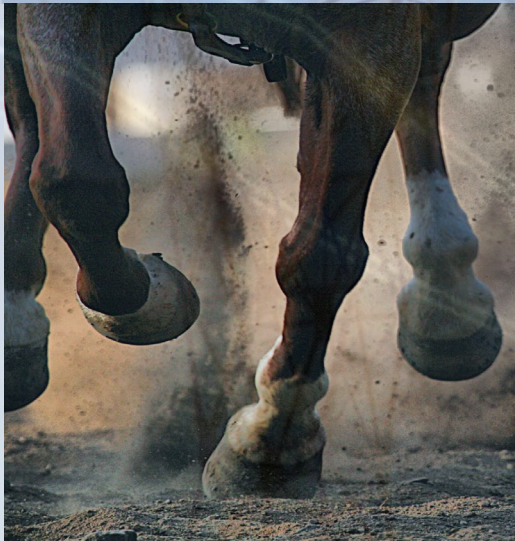
- **Interregional Corridor Planning- Trans-Regional Grid Interconnection Master Plan**
- **Harmonisation of grid codes**
- **Common TRGI Operational and Security Protocol on Grid Emergencies**
- **Hardware:** DC breakers, DC protection systems, HVDC cables, DC switchgears, AC–DC interconnections

Institutional and Financial



- **Inter-Regional Institutional Partnership** arrangements
- **Trans-Regional Grid Planners and Operators Forums are desirable**
- **MDB/Concessional Funding Facilities** for Trans-Regional Grid Interconnections (TRGI) projects

Thank You



“

Change is inevitable, but
transformation is a choice.

HEATHER ASH AMARA

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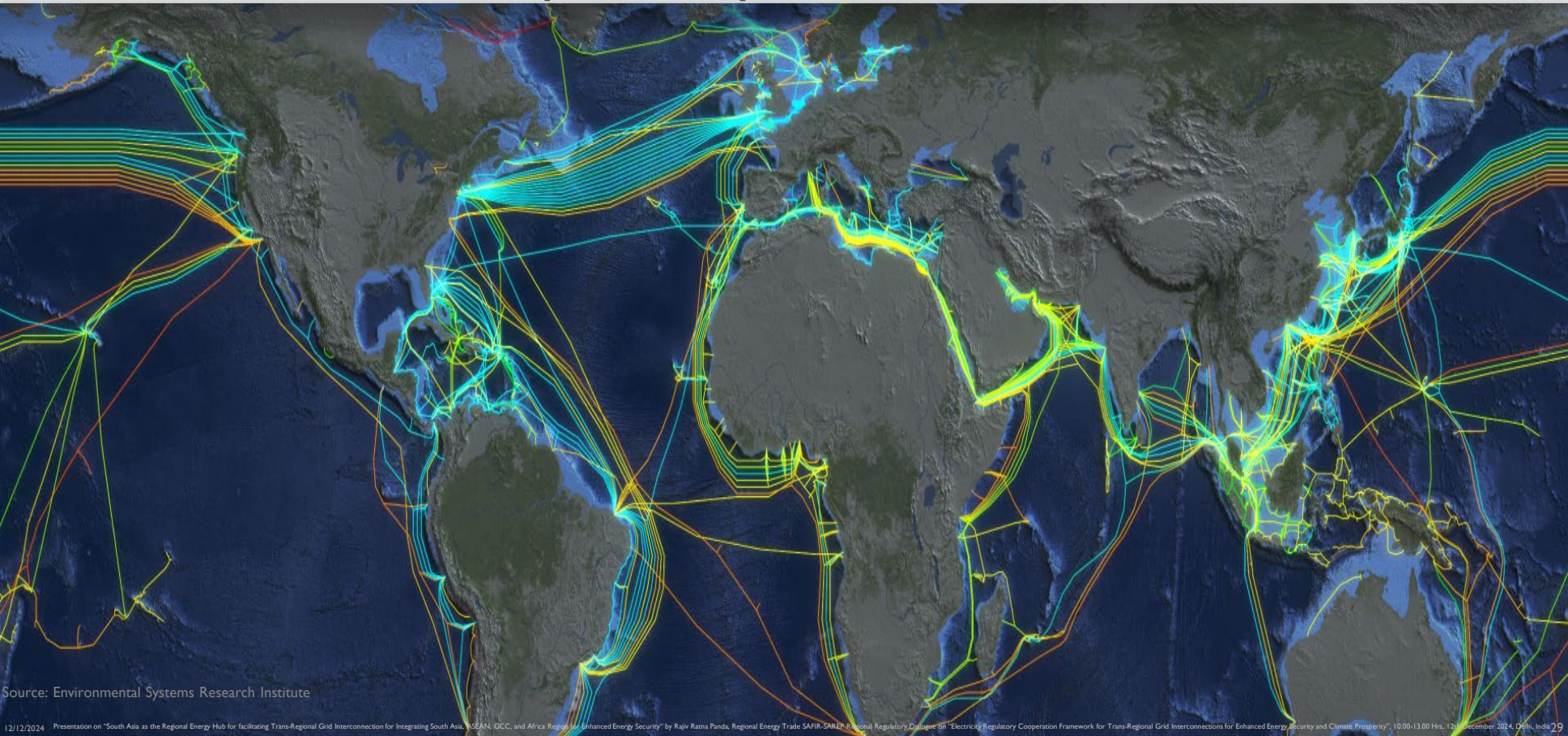
“It always seems
impossible until
it's done.”

- Nelson Mandela

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Submarine Cable Map

1.4 Million Kilometers of Submarine Cables in Service Globally
Laid up to the Depth of 8000 Kilometers



Source: Environmental Systems Research Institute

Disclaimer

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{Cross-Border Electricity Trade dependency provides relatively better Energy Security as compared Fossil Fuel import Dependencies}

❖ International Renewable Energy Agency (IRENA) **suggests cross-border electricity trade dependency** provides relatively **better energy security as compared fossil fuel import** dependencies.

❖ While cross-border electricity trade creates dependencies, these **differ from the dependencies of the fossil fuel world**.

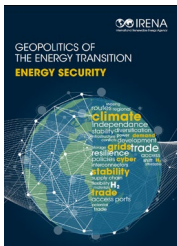
❖ Since electrons can flow both ways, it is best to think about **electricity trade as co-dependency, rather than the asymmetrical dependency of oil and gas relationships**.

❖ The fact remains that the **effects of a cross-border electricity disruption are different from those of an oil or gas disruption**.

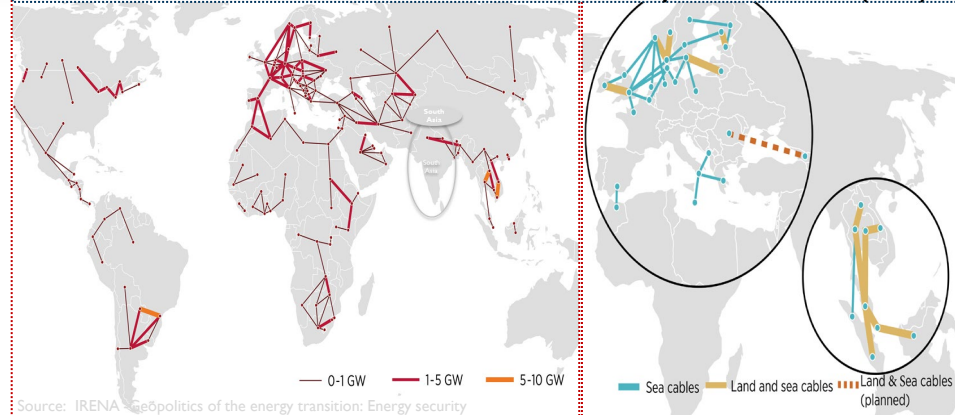
❖ First, because **electricity imports are grid-bound**, their loss can be made up **only to the extent the existing grid allows**. (Conversely, the exporter's capacity to reroute electricity exports to another country depends on infrastructure availability.)

❖ Second, as of now, **electricity is difficult to store** in significant volumes and for long time periods. Therefore, **non-delivered amounts of electricity** would probably require the **curtailment of energy-generating capacities**.

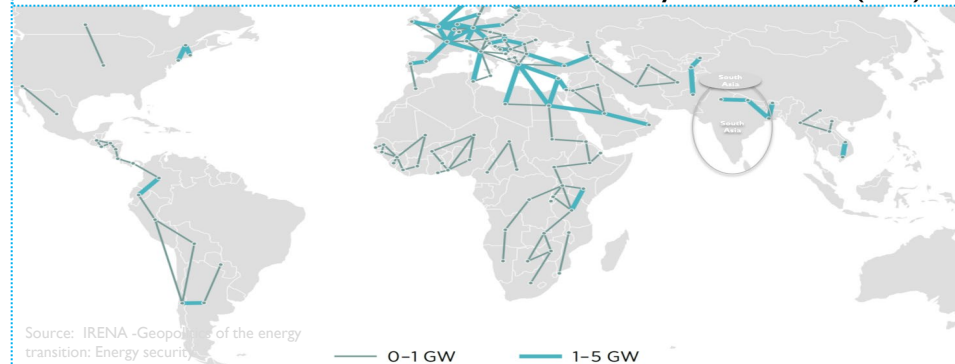
❖ Third, since electricity has to be sold and consumed the instant it is produced, the **effects of an export boycott would be immediate and could have significant economic and social effects**.



Current Scenario of Cross Border International Electricity Interconnection (2024)



Planned Scenario of Cross Border International Electricity Interconnection (2024)



Regional Power Grid & Markets Provides Reduced Exporter Dominance : During 2023, none of the 27 member countries was an exporter all of the time (ACER, 2024).