Brief report

On

SARI/EI Participation in the Second in a 2021 series of webinar from the Clean Energy Ministerial's Regional and Global Energy Interconnection Initiative

South Asia Regional Initiative for Energy Integration

Presentation
on

One Sun One World One Grid : Energy Integration in South Asia

Presented by

Rajiv Ratna Panda
(Associate Director, SARI/EI,IRADe)

Clean Energy Ministerial's Regional and Global Energy Interconnection (RGEI) Initiative Webinar
4.30 PM (IST), Thursday, 4th March 2021

March 4, 2021

4.30 PM (IST)

Based on the invitation received Mr. Rajiv Ratna Panda, Associate Director, SARI/EI/IRADe participated as speaker in the second in a 2021 series of webinar from the Clean Energy Ministerial's Regional and Global Energy Interconnection (RGEI) Initiative held on 4th March,2021 and presented on "One Sun One World One Grid: Energy Integration in South Asia".

Mr. Panda made a comprehensive presentation which covered in detail which are a) One Sun One World One Grid (OSOWOG) b) OSOWOG-three phase approach, India at the fulcrum - enabler for OSOWOG & progress so far c) way forward for OSOWOG d) Experience of Energy Integration (EI) & Cross Border Electricity Trade (CBET) in South Asia (SA) e) Marco Economic Growth & Level of Economic Integration f) Overview of SA Power Sector g) Evolution of energy cooperation, EI & CBET h) Current & future scenario of CBET i) Challenges faced in EI & CBET j) Facilitating energy integration & CBET in coming future-four prong strategy and four phase approach k) Conclusion and way forward for facilitating EI & CBET in SA in coming future. The copy of the presentation is attached as Annexure-1.

Figure 1 One Sun One World One Grid' (OSOWOG)-A Grand Vision

Mr. Panda explained in detail the concept of One Sun One World One Grid. Renewable Energy (RE) grid parity has been achieved across countries in the world and this has triggered large scale RE deployment, worldwide (2537 GW in 2019 from 1227 GW of 2010). RE can help in economical energy transition, provided its distributed nature, intermittency and demand supply mismatch are addressed in a timely, geographically coordinated and an effective manner. OSWOGO is planned in three phases [Figure 2]. The Phase-1, OSOWOG plans to connect Middle East-South Asia-South East

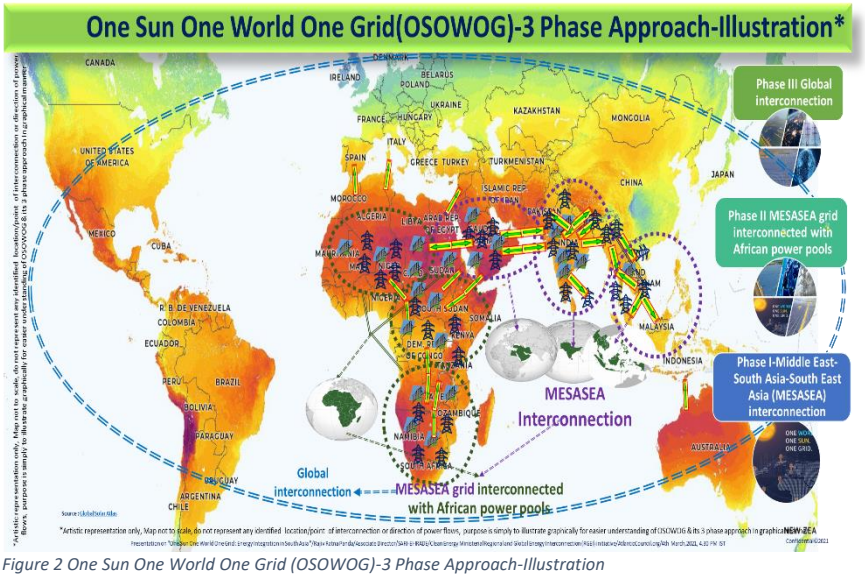

Figure 2 One Sun One World One Grid (OSOWOG)-3 Phase Approach-Illustration

Asia (MESASEA) interconnection, Phase -2, MESASEA will be interconnected with African power pools and in the Phase-3, plan is for global interconnection. He highlighted how India's transformational effort in power sector in recent past across power generation, transmission [Figure 3], renewable energy deployment, rapid expansion in electricity transmission system, market development and in making Indian power system flexible[Figure 4] will act as a strong enabler for regional grid integration and implementation of One Sun One World One Grid. As way forward he stressed on a) building regional, sub-regional, continental, and global consensus on interconnections b) feasible & credible inter-regional/continental pilots and further optimization of cost of transmission c) Policy, regulatory and market harmonization, and d) Mobilizing investment & finance and developmental implementation of ideas like World Solar Bank (WSB). He said that in SA Context, OSOWOG initiative will provide further impetus to Power System

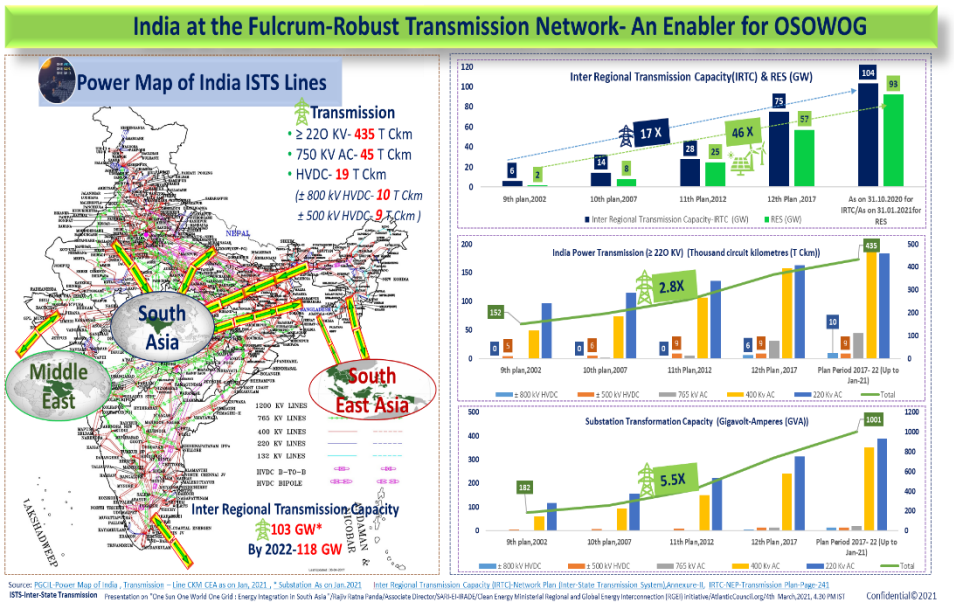

Figure 3 India at the Fulcrum-Robust Transmission Network- An Enabler for OSOWOG

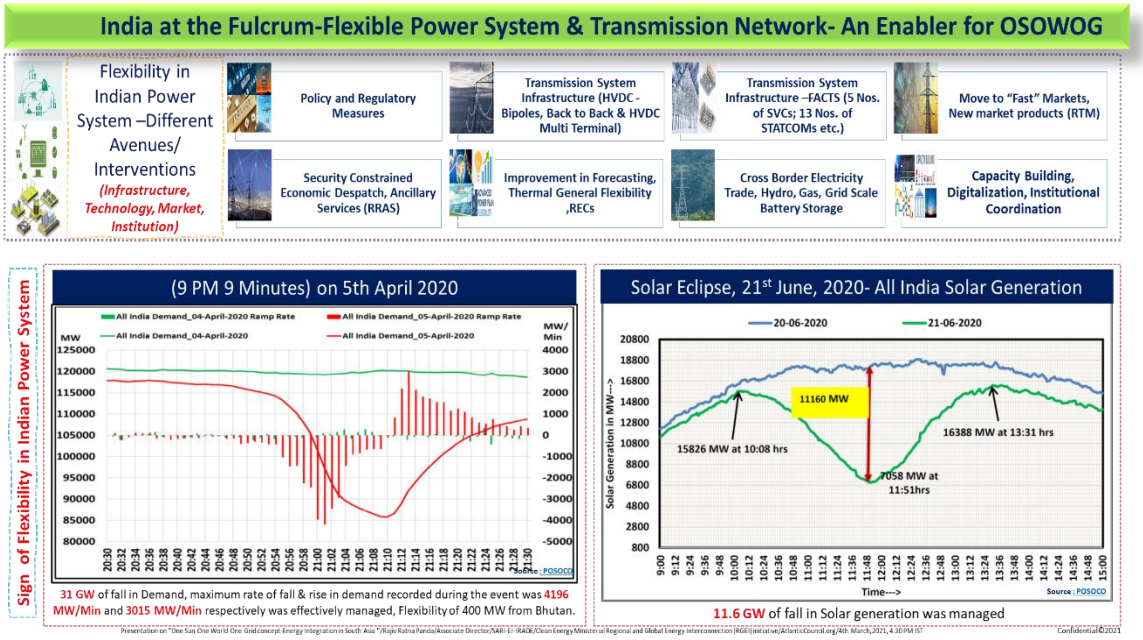

Figure 4 India at the Fulcrum-Flexible Power System & Transmission Network- An Enabler for OSOWOG

Integration & Greening the Cross Border Electricity Trade in the SA Region. Elaborating on the energy integration and cross border energy trade in the SA region, he explained the characteristics of power system of each South Asian Countries (SACs). SA countries have significantly increased their power generation capacity from 190 GW in 2010 to 449 GW by 2020[Figure 6]. However, the region's installed capacity continued to be dominated by fossil fuel (~ 63%). Highlighting on the Cross Border Electricity Trade, he explained that government of SA countries are cooperating among each other, particularly in the previous decade. The Cross Border Electricity Trade has increased from ~1400 MW to ~3700 MW by 2020[Figure 5]. Several cross-border interconnections have been planned/being considered among SA countries and it is expected that Cross Border Transmission interconnection capacity is expected to increase from current level of ~4 GW to ~ 43.8 GW by 2040[Figure 5]. This will lead to highly integrated and interconnected power system among SA countries, would facilitate and help in developing regional power market in the region. For

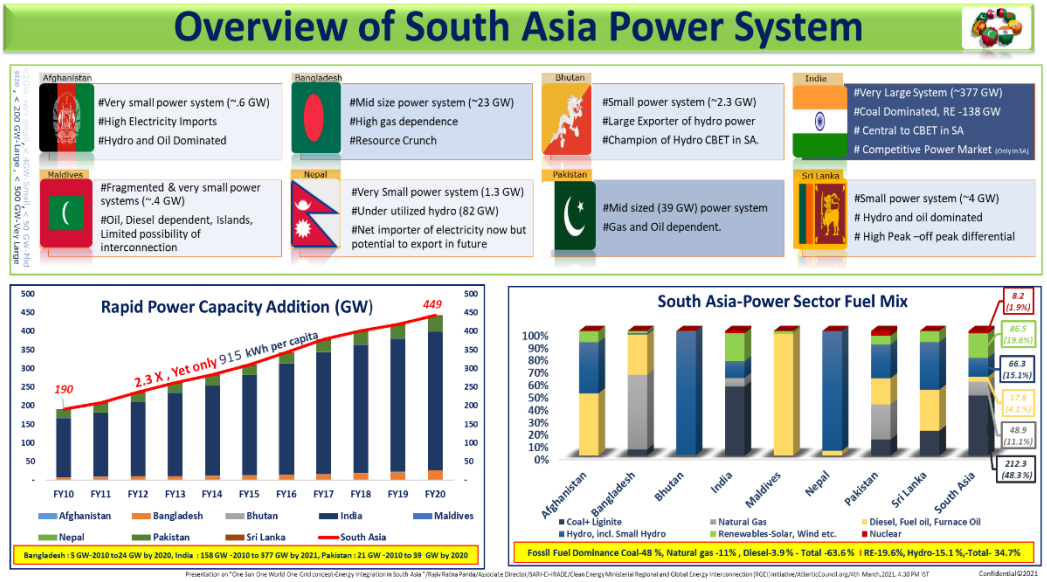

Figure 6 Overview of South Asia Power System

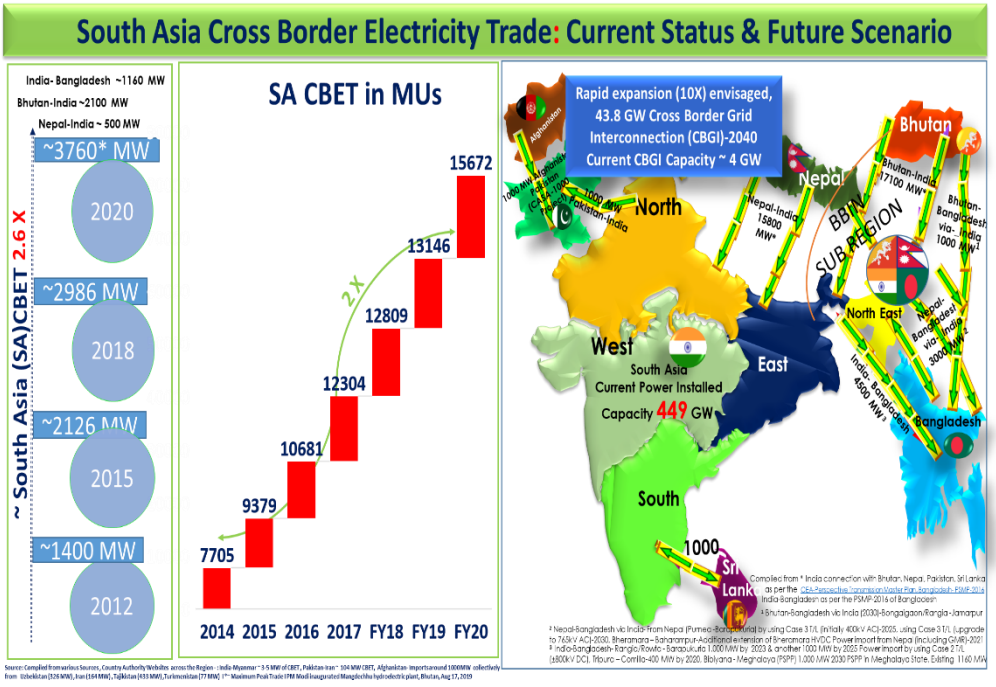

Figure 5 South Asia Cross Border Electricity Trade: Current Status & Future Scenario

facilitating energy integration in coming future, he laid out a four-prong strategy [Figure 7] covering a) Transitioning from bilateral to trilateral cross border electricity trade in SA b) Renewable energy based cross border electricity trade c) Commercial form of cross border electricity trade and d) Regional power market development & market integration and explained each of the above strategy in detail.

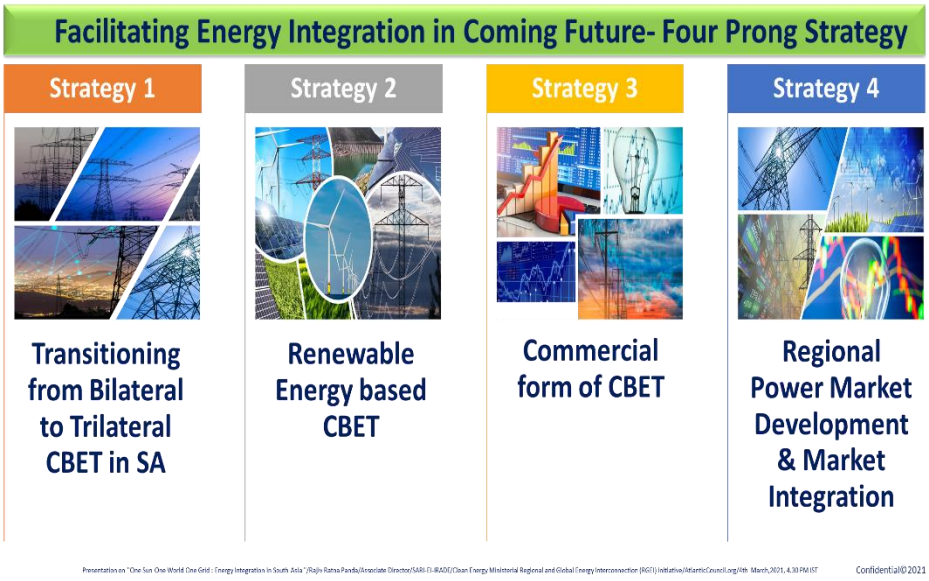

Figure 7 Facilitating Energy Integration in Coming Future- Four Prong Strategy

Mr. Panda laid out the four enablers for facilitating energy integration in coming future across political, regulatory, technical & commercial, and institutional front [Figure 8]. There is a need to develop a comprehensive regional outlook for energy integration and CBET and put in place implementation and monitoring mechanism for assessing the progress of energy integration and cross border energy trade in the region. On regulatory front, it would be desirable to work on rules on the permissibility to use intermediary transmission network under open access, rules for identification of transmission capabilities & congestion, rules for measurement of imbalance and settlements, developing conducive & friendly ecosystem for investors and power market development.

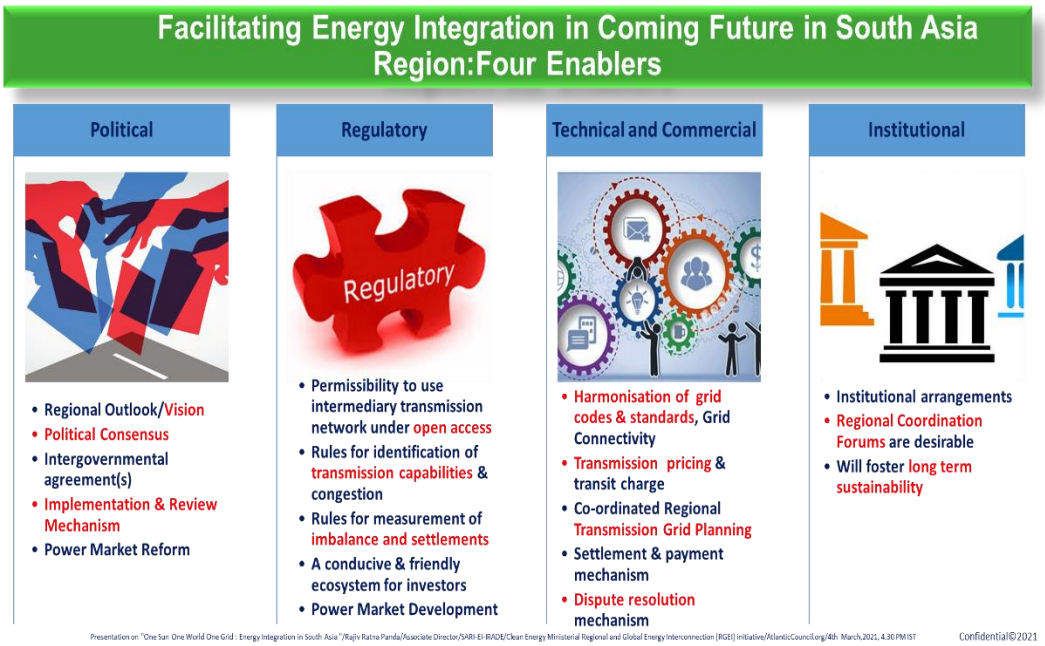

Figure 8 Facilitating Energy Integration in Coming Future in South Asia Region: Four Enablers

Mr. Panda concluded the presentation [Figure 9] stressing on the following, which are a) Political will & Implementation of various political consensus-inter-governmental agreements, bilateral, trilateral, multilateral b) Complementary policy, regulatory, market framework development c) establishing the regional institutional platforms for regulations, planning agencies/authorities, system operation, market development d) South Asia Energy Grid-regional transmission master plan, investment plans e) Steering energy security & energy interdependence debate, reasonable energy interdependence f) De-risking; viability & bankability of projects , investment facilitation, mobilization . He said that reasonable realism along with a long-term vision is key to deepening cross border energy trade, energy market integration, leads to economic clean energy transition, sustainability, regional stability, and prosperity in South Asia.

Figure 9 Conclusion & Way forward for Facilitating Energy Integration in Coming Future in South Asia Region

The RGEI Initiative was established at the 9th Clean Energy Ministerial meeting in Copenhagen/Malmö in May 2018. RGEI's objectives are to a) Discuss conducive policy and regulatory framework regarding regional and global power system integration b) Build consensus on facilitating energy transition via increased proportion of renewable energy in energy consumption and enhanced grid interconnection and c) Encourage CEM member countries to engage in the process of RGEI and seize collaborative opportunities.

The Clean Energy Ministerial (CEM) is a high-level global forum to promote policies and programs that advance clean energy technology, to share lessons learned and best practices, and to encourage the transition to a global clean energy economy. Initiatives are based on areas of common interest among participating governments and other stakeholders. The Framework for the Clean Energy Ministerial, adopted at the seventh Clean Energy Ministerial in 2016, defines the CEM governance structure and outlines the mission statement, objectives, membership, and guiding principle.

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Annexure-1

South Asia Regional Initiative for Energy Integration

Presentation

on

One Sun One World One Grid : Energy Integration in South Asia

Presented by

Rajiv Ratna Panda

(Associate Director, SARI/EI,IRADe)

CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together

Clean Energy Ministerial's Regional and Global Energy Interconnection (RGEI) Initiative Webinar
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REGIONAL & GLOBAL ENERGY INTERCONNECTION
AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL

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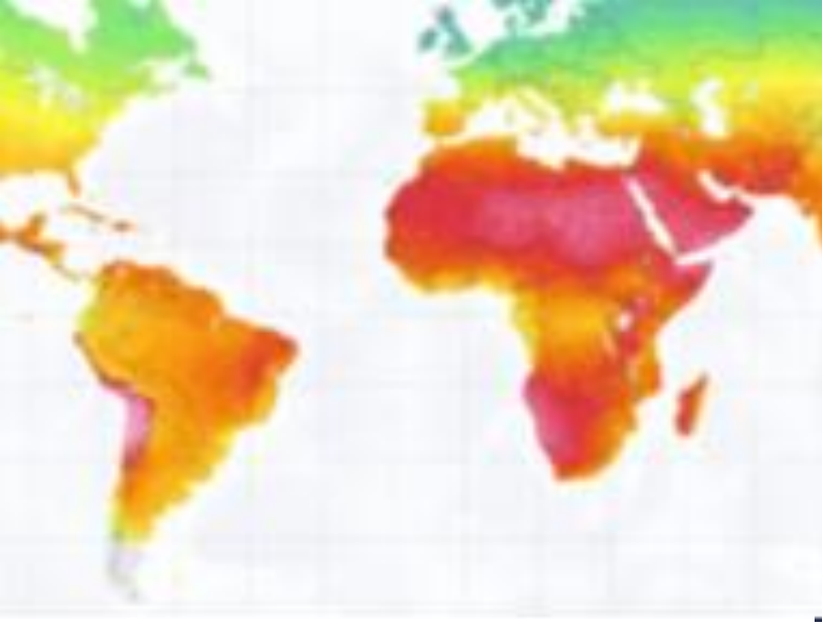

01 One Sun One World One Grid' (OSOWOG)-A Grand Vision

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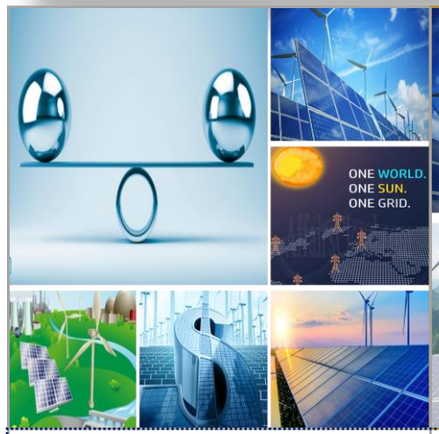
01 One Sun One World One Grid-A Grand Vision:- Concept



Renewable Energy (RE) grid parity across countries

RE Cost decline 2010-19

Solar PV 82%, CSP-47%

Onshore-40%

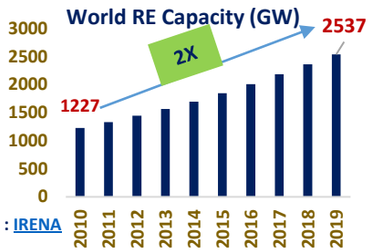
Offshore wind 29%

India-Lowest Solar Tariffs- 1.99 Rs/Kwh (US cent 2.7/Kwh)

Source : IRENA

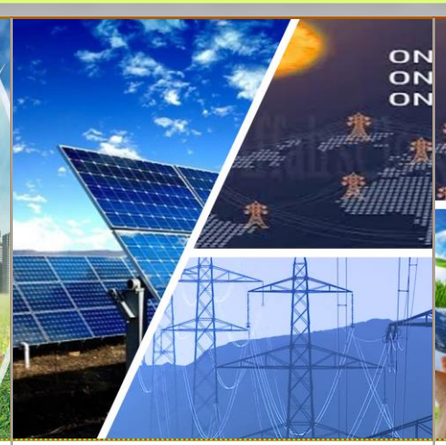
Has triggered accelerated large-scale RE deployment, worldwide

2537 GW of RE-2019- 1227 GW of RE-2010



Source : IRENA

RE can help in Economical Energy Transition



Provided its distributed nature, intermittency and demand supply mismatch are addressed in a timely, geographically coordinated and an effective manner

A larger grid based interconnectivity across geographies has the potential to overcome these challenges

Enabling the world to transition to clean energy in a sustainable manner

Global Package for Addressing Energy Affordability, Accessibility and Sustainability

In one hour, the Earth's atmosphere receives enough sunlight to power the electricity needs of every human being on Earth for a year

Source : NG

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01 One Sun One World One Grid(OSOWOG)-Grand Vision & Concept

Idea Announced in October 2018

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 etc. 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. Source : RFP OSOWOG

Matching the demand and supply centre across geographies

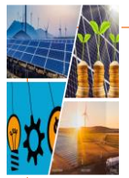
Interconnectors as a mean/solution to manage intermittencies

Reduce Curtailment, Exploiting the time zone difference.

Grid safety and security

Economies of Scale

Resulting economic benefits would positively impact



Attracting investments

Poverty alleviation

Reduced project costs

Support in mitigating water, sanitation, food and

Higher efficiencies and increased asset utilization

Other socioeconomic challenges.

Source : Based on RFP OSOWOG

OSOWOG- Potential for Regional & Trans-Region Transmission Interconnection, Interconnectors among countries

While plan is grand, we have various proven regional grid interconnection exist around the globe such as Europe etc. backed with HVDC technologies

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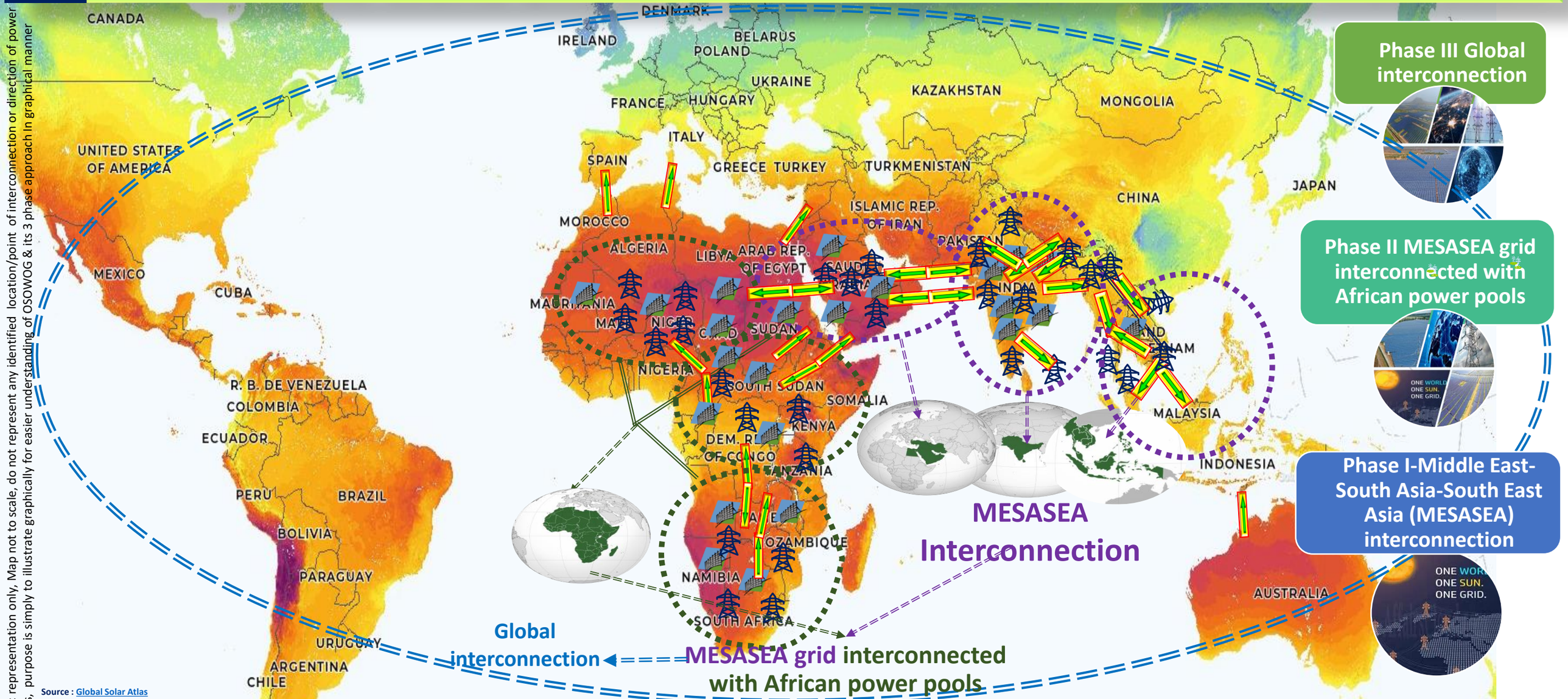
02 One Sun One World One Grid(OSOWOG)-3 Phase Approach-Illustration*



Source : Global Solar Atlas

*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

*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

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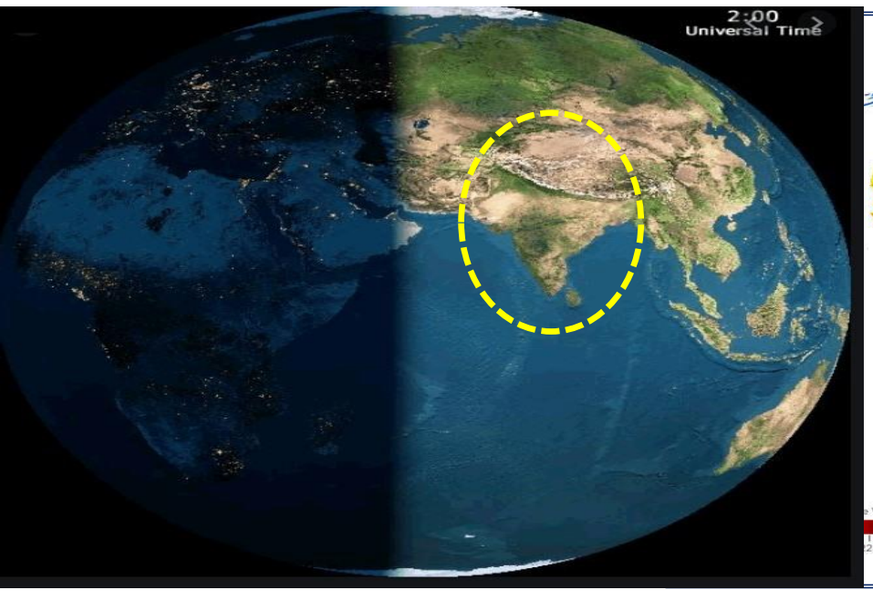
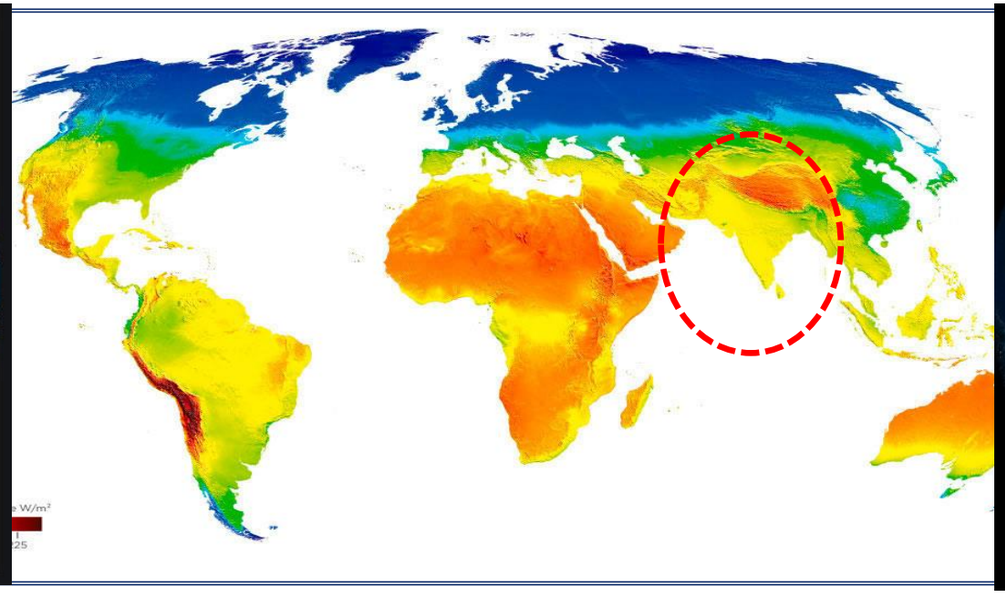
03 India at the Fulcrum - Enabler for OSOWOG & Progress so far





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03.1 India at the Fulcrum-Renewable Energy Growth-Solarising India: An Enabler for OSOWOG

Ambitious Plans

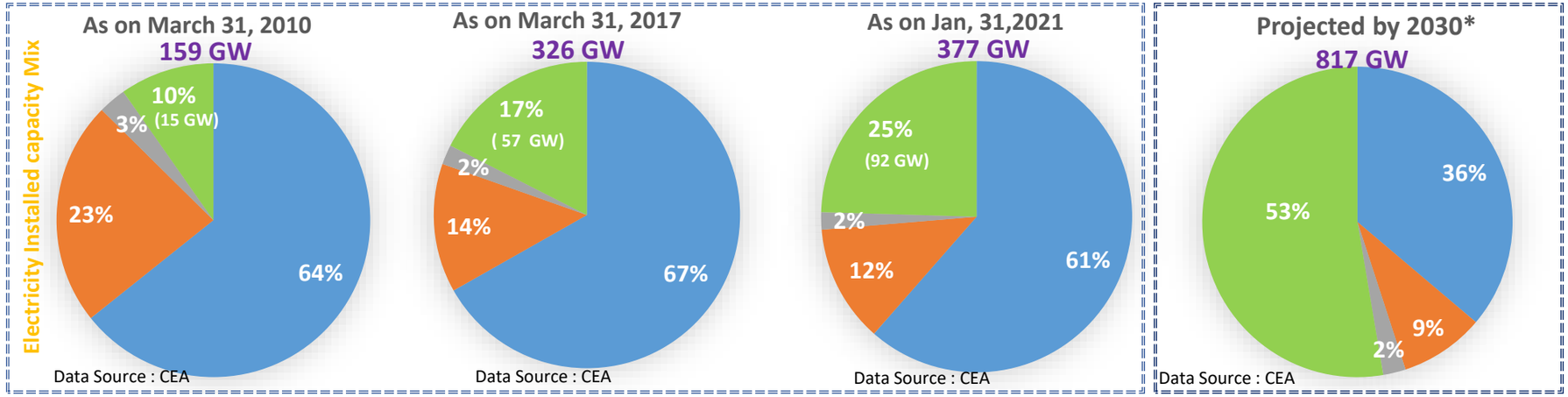
175 GW of RE by 2022
450 GW of RE by 2030

De-carbonisation of Power Sector

40 % from non-fossil fuel sources^ by 2030

Non Fossil fuels Capacity could be 64% by 2030^^

^ Non-Fossil Fuel – Hydro (including imports), Nuclear and Renewable Energy Sources (RES)
^^ Source:-Table 8 As per the CEA report on report On Optimal generation Capacity mix-2029-30



* Source :- Table 5 As per the CEA report on report On Optimal generation Capacity mix-2029-30

Thermal(Coal/Lignite+Gas+Diesel) Hydro Nuclear RES

RES (Small Hydro, Biomass, U&I, Solar, Wind)

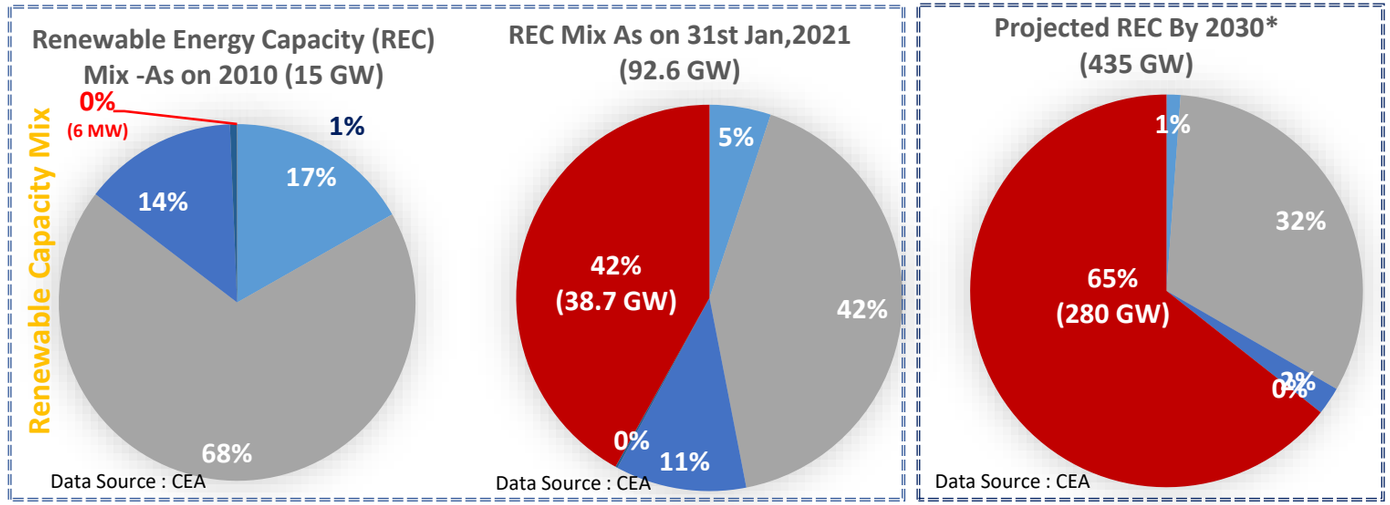
Rapid RE Growth 6x **(15 GW in 2010 to 92 GW in 2021)**

Solar (6 MW in 2010 to 38.7 GW in Jan,2021)

Solar could be (280-300 GW by 2030)

Solarising Power, 34.28% of Total Capacity by 2030
(As of Jan, 2021, solar is around 10% of total power installed capacity)

Lowest Solar Tariffs-1.99 Rs/Kwh (US cent 2.7/Kwh)



SHP WIND BIOMASS U & I SOLAR

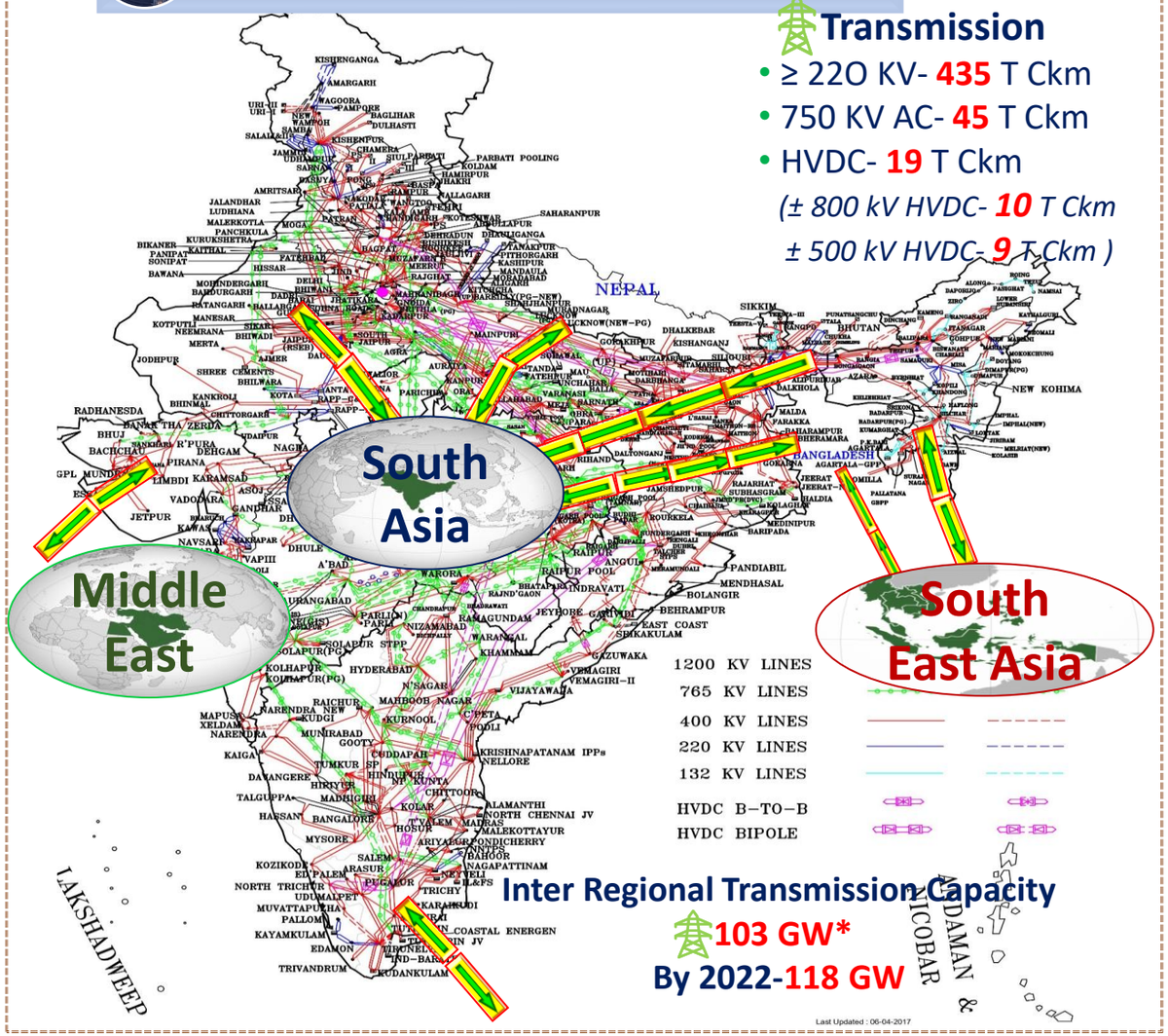
In the past 2-3 years, the lowest tariffs among various countries/ regions such as Portugal, Abu Dhabi, Brazil, Jordan, etc. have ranged between US cent 1.32-2.49 per kWh, Source: JKM research and Analytics

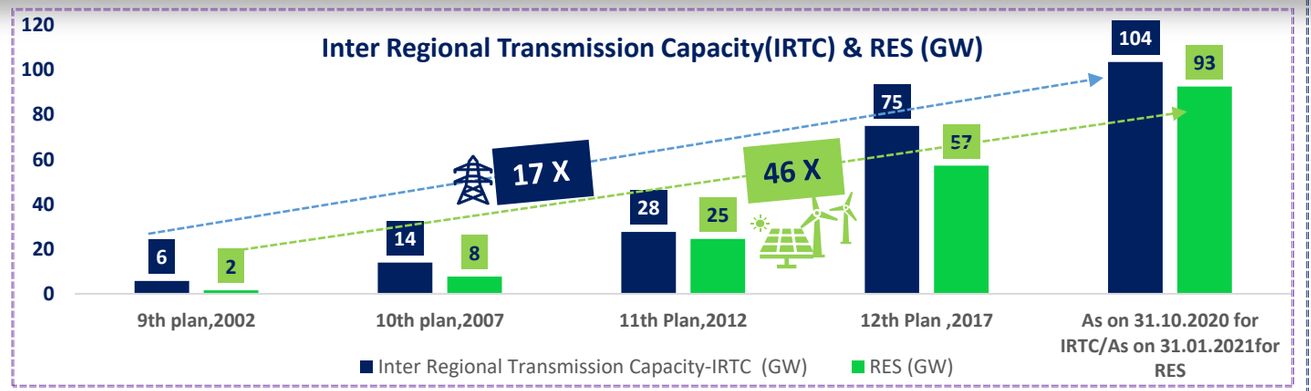
* Source:-Table 5 As per the CEA report on report On Optimal generation Capacity mix-2029-30

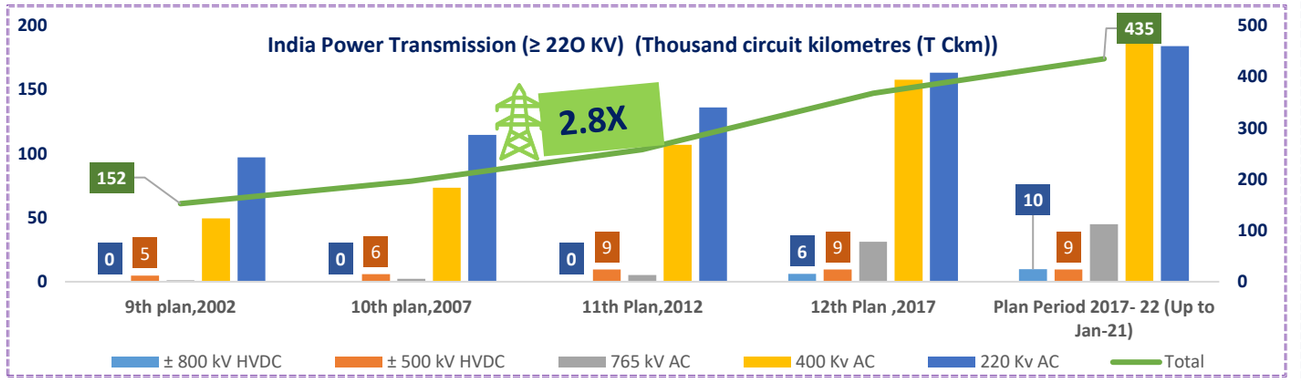
Note- Table 10 As per the CEA report on report On Optimal generation Capacity mix-2029-30 , Additional Scenario Analysis, Increase in Demand by 5% from base case demand –Solar by 2030-299 GW

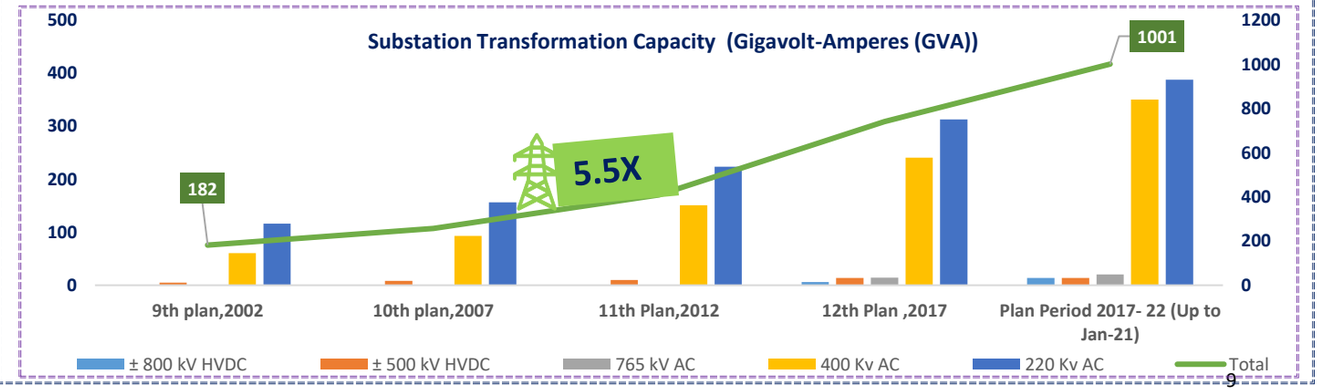
03.2 India at the Fulcrum-Robust & Flexible Transmission Network- An Enabler for OSOWOG

Power Map of India ISTS Lines









Source: PGCIL-Power Map of India , Transmission – Line CKM CEA as on Jan, 2021 , * Substation As on Jan.2021 Inter Regional Transmission Capacity (IRTC)-Network Plan (Inter-State Transmission System),Annexure-II, IRTC-NEP-Transmission Plan-Page-241

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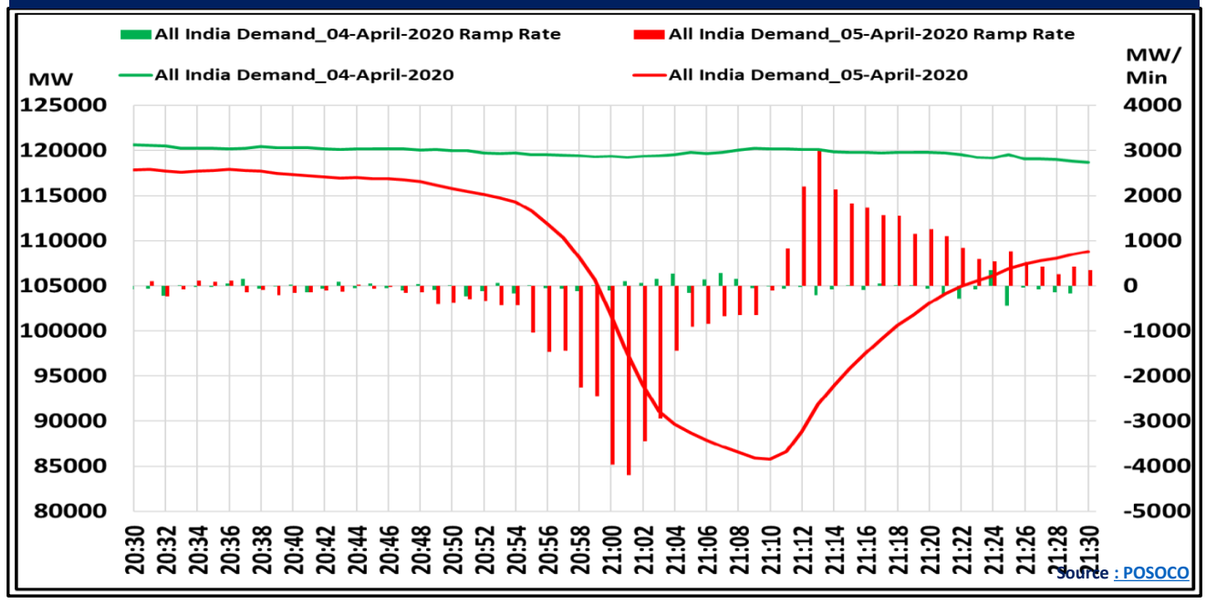
03.3 India at the Fulcrum-Robust & Flexible Transmission Network- An Enabler for OSOWOG

Flexibility in Indian Power System –Different Avenues/ Interventions *(Infrastructure, Technology, Market, Institution)*

- Policy and Regulatory Measures
- Transmission System Infrastructure (HVDC - Bipoles, Back to Back & HVDC Multi Terminal)
- Transmission System Infrastructure –FACTS (5 Nos. of SVCs; 13 Nos. of STATCOMs etc.)
- Move to "Fast" Markets, New market products (RTM)
- Security Constrained Economic Despatch, Ancillary Services (RRAS)
- Improvement in Forecasting, Thermal General Flexibility ,RECs
- Cross Border Electricity Trade, Hydro, Gas, Grid Scale Battery Storage
- Capacity Building, Digitalization, Institutional Coordination

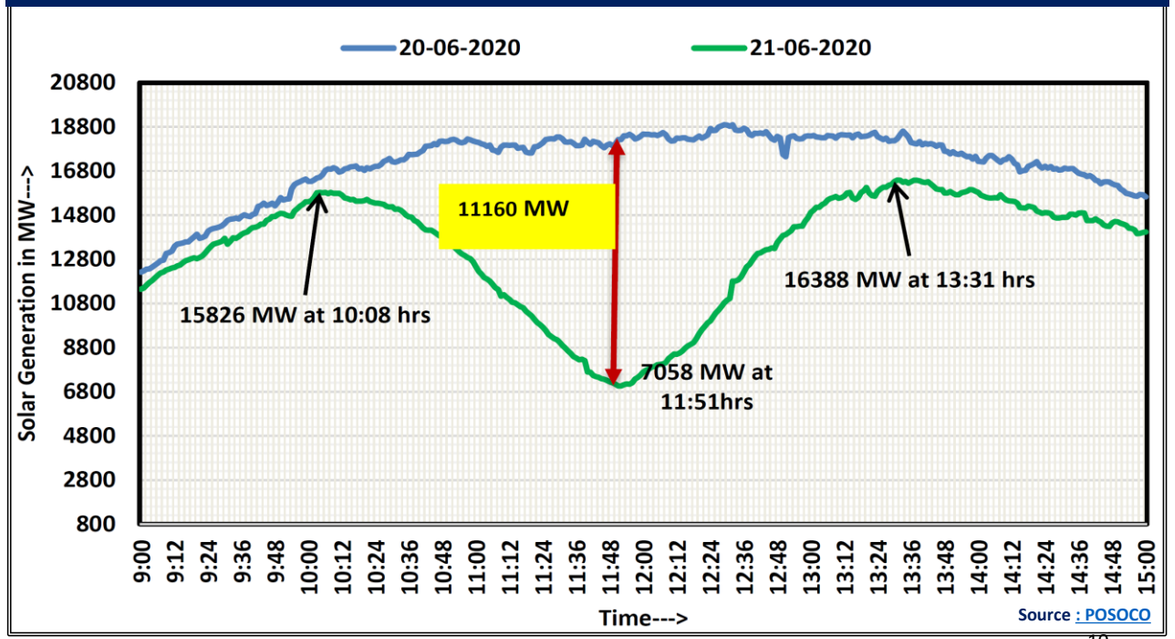
Sign of Flexibility in Indian Power System

(9 PM 9 Minutes) on 5th April 2020



31 GW of fall in Demand, maximum rate of fall & rise in demand recorded during the event was **4196 MW/Min** and **3015 MW/Min** respectively was effectively managed, Flexibility of 400 MW from Bhutan.

Solar Eclipse, 21st June, 2020- All India Solar Generation



11.6 GW of fall in Solar generation was managed

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03.4 One Sun One World One Grid (OSOWOG)-Progress So far

Hon'ble Prime Minist of India, Shri Narendra Modi, Announced One Sun One World One Grid, First assembly of International Solar Alliance

(October 2018)

COP-24

Theme of India Pavilion

One World One Sun One Grid

(Dec, 2018)

MNRE–OSOWOG-RFP Developing a long-term vision, implementation plan, roadmap, institutional framework for Implementing OSOWOG

(May 2020)

ISA First World Solar Technology Summit, MoU- signed among the ISA, the Government of India and the World Bank. ***(ISA to act as Nodal Agency)***

(Sept, 2020)

The first plenary on OSOWOG

Side-lines of the Third Assembly of ISA-Member countries

(October 2020)

Consortium Awarded the work -Developing a long-term vision, implementation plan, road map, institutional framework for Implementing OSOWOG

(January,2021)

Expected to be released in next Conference of the Parties (COP 26)

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03.5 Study "Developing a Long-term vision, Implementation Plan, Road Map and Institutional Framework for Implementing "One Sun One World One Grid"

Phase I Assessment stage

- Demand supply scenario till 2050.
- Renewable energy resource potential assessment (including decentralized sources).
- Power market assessment.
- Comprehensive vision & road map for OSOWOG.

Phase II: Potential assessment and pilots identification

- Identify 2-3 cross-border projects (that can be initiated within 1 or 2 years)
- Preferably one with each of Middle East, South East and Africa regions considering India as the grid fulcrum.
- Detailed policy and regulatory scan of the identified countries, to identify readiness

Phase III: Full scale roll out

- Develop institutional framework for international co-operation, steering arrangements and governance
- Support in developing an implementation roadmap
- Includes the establishment of a framework for Project Management Office (PMO) as per MNRE's requirement

INTERNATIONAL SOLAR ALLIANCE

The International Solar Alliance (ISA) Acts as a Nodal Agency for all activities including implementation of the OSOWOG study for developing a long-term vision, implementation plan, road map and institutional framework for implementing the initiative.

Source : Based on RFP OSOWOG dated May 2020 and first corrigendum dated 28th Sep. 2020

Source : Based on INTERNATIONAL SOLAR ALLIANCE Background Note

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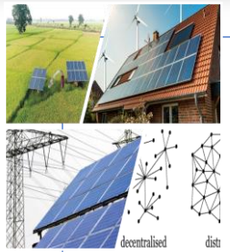
04 One Sun One World One Grid- Way Forward

Building Regional, Sub-Regional, Continental and Global Consensus on Interconnections



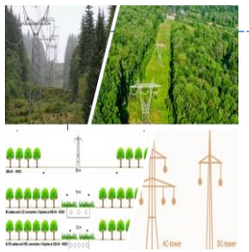
Navigating Centralised ~ Decentralised Approach~ Combination

Deepening International Energy Cooperation and Navigating Geopolitical realities

Feasible & Credible Inter-Regional/Continental Pilots, Further Optimisation of cost of Transmission

Navigating Economies of Scale ~ Economies of Large Numbers

Policy, Regulatory and market harmonization, Mobilising Investment & Finance, World Solar Bank



Non Engineering Cost

(Right of Way, Environmental, Land Acquisition, Compensation)

Commercial Feasibility, Cost and Benefit sharing

New Technological & Threat Trade off -Energy Storage, Hydrogen & Cyber Security

In South Asia Context, OSOWOG will provide further impetus to Power System Integration in South Asia Region & Greening the Cross Border Electricity Trade in the SA Region.

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05 Experience of Energy Integration (EI) & Cross Border Electricity Trade (CBET) in South Asia (SA)


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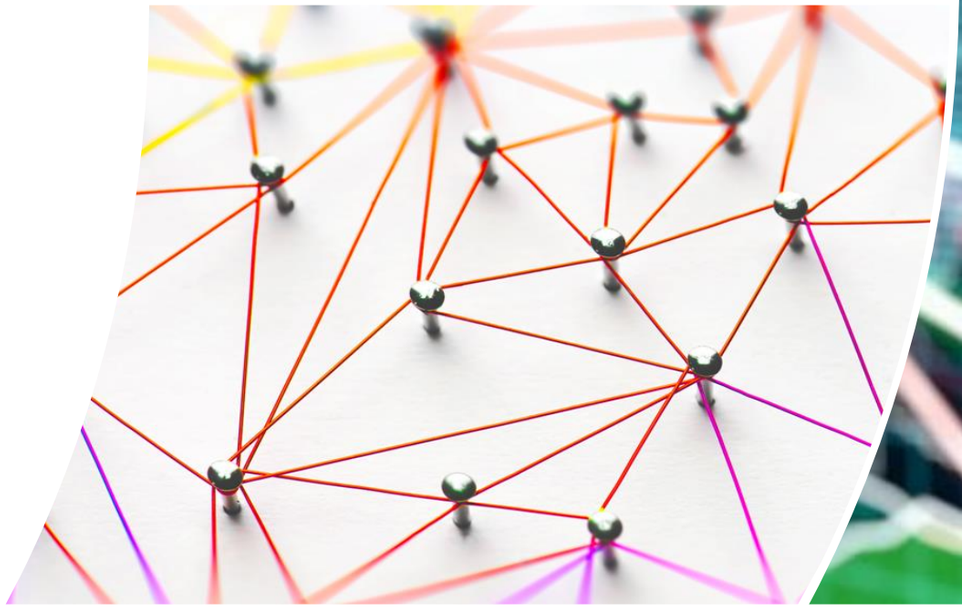
05.1 Marco-Economic Growth & Level of Economic Integration in South Asia



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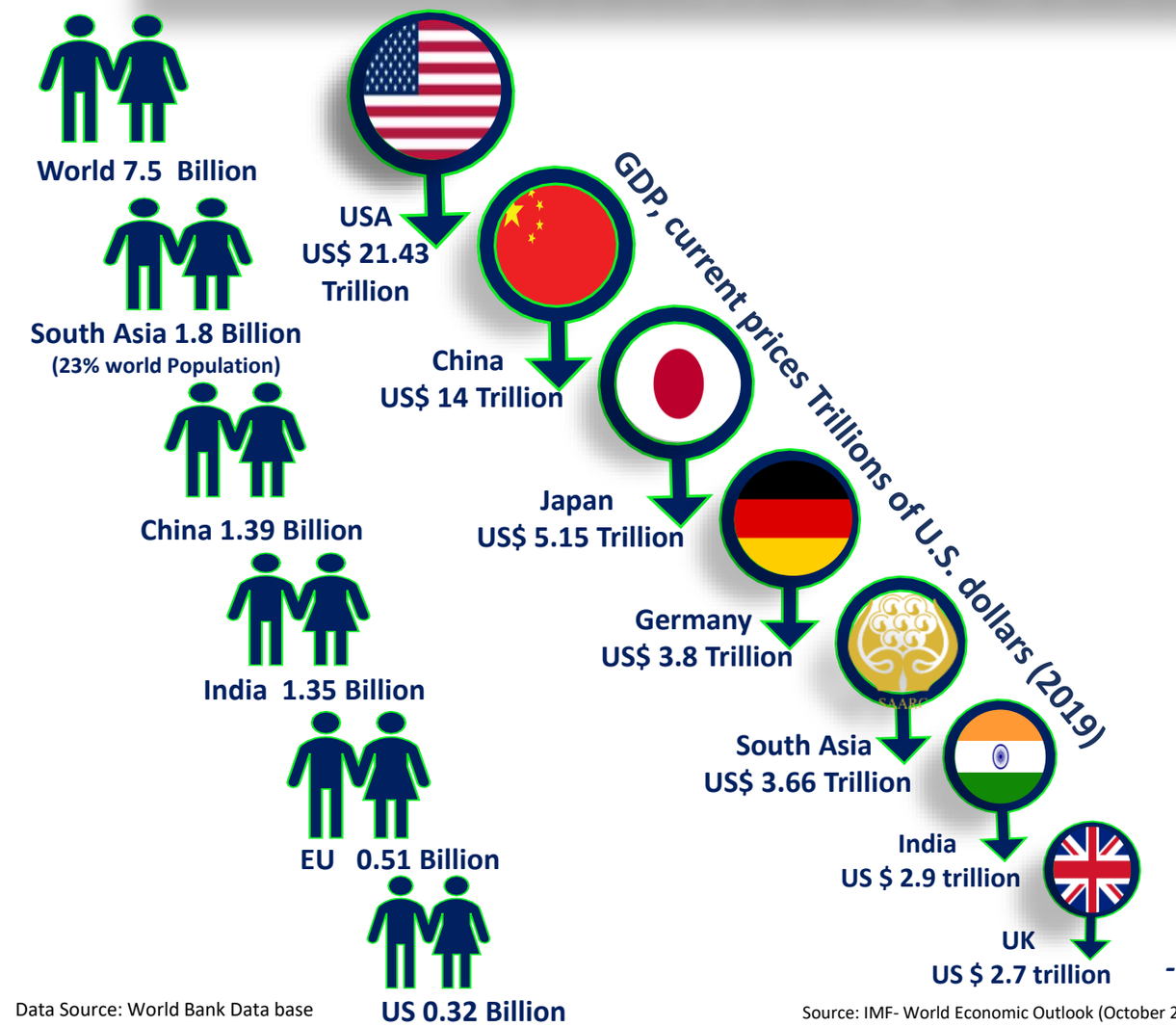
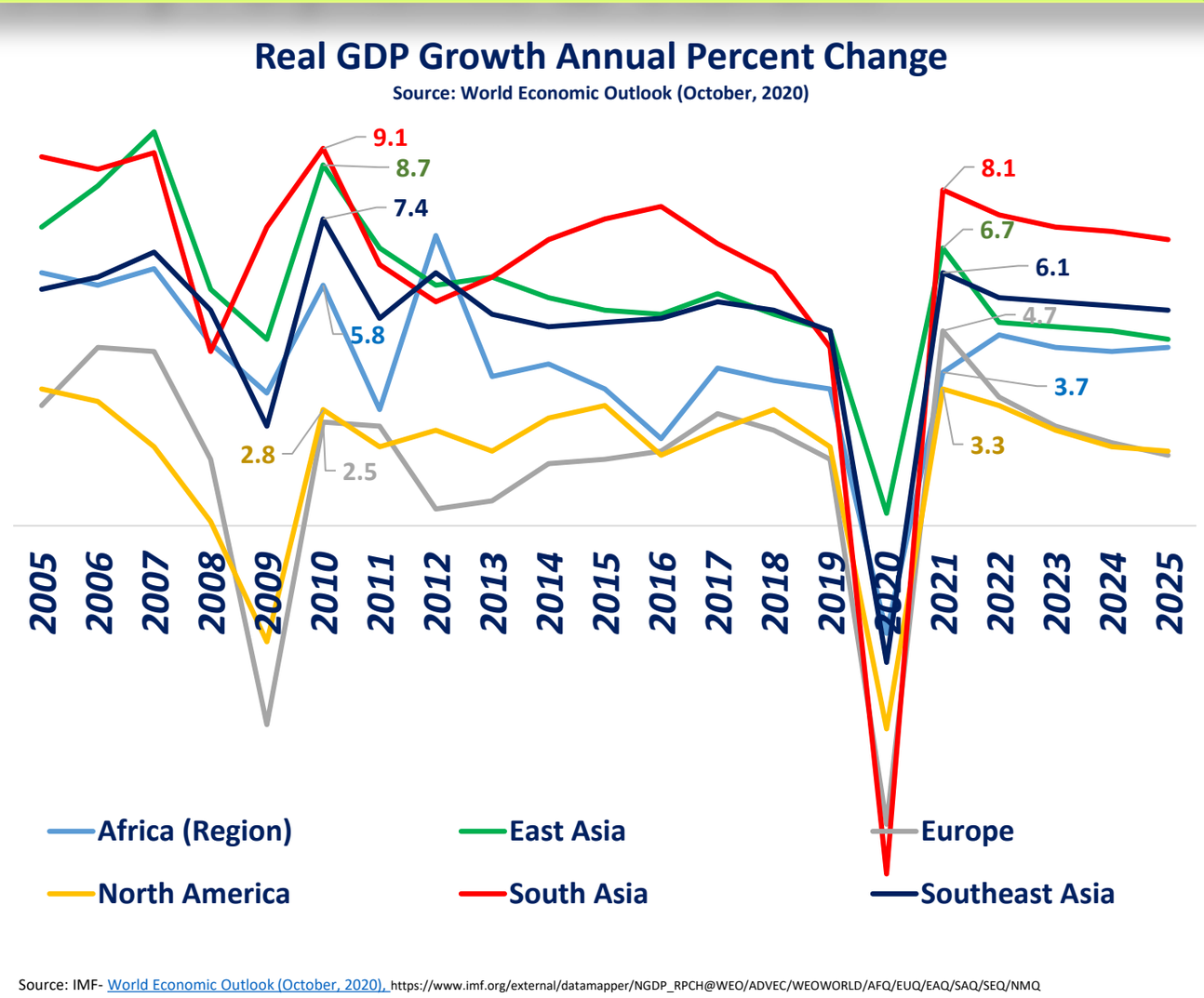
05.1 South Asian Growth Story : Dynamic & Vibrant



Data Source: World Bank Data base

Source: IMF- World Economic Outlook (October 2019



Source: IMF- World Economic Outlook (October, 2020), https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/ADVEC/WEOWORLD/AFQ/EUQ/EAQ/SAQ/SEQ/NMQ

South Asia : Fastest growing region in the world in recent past & expected to remain so in future

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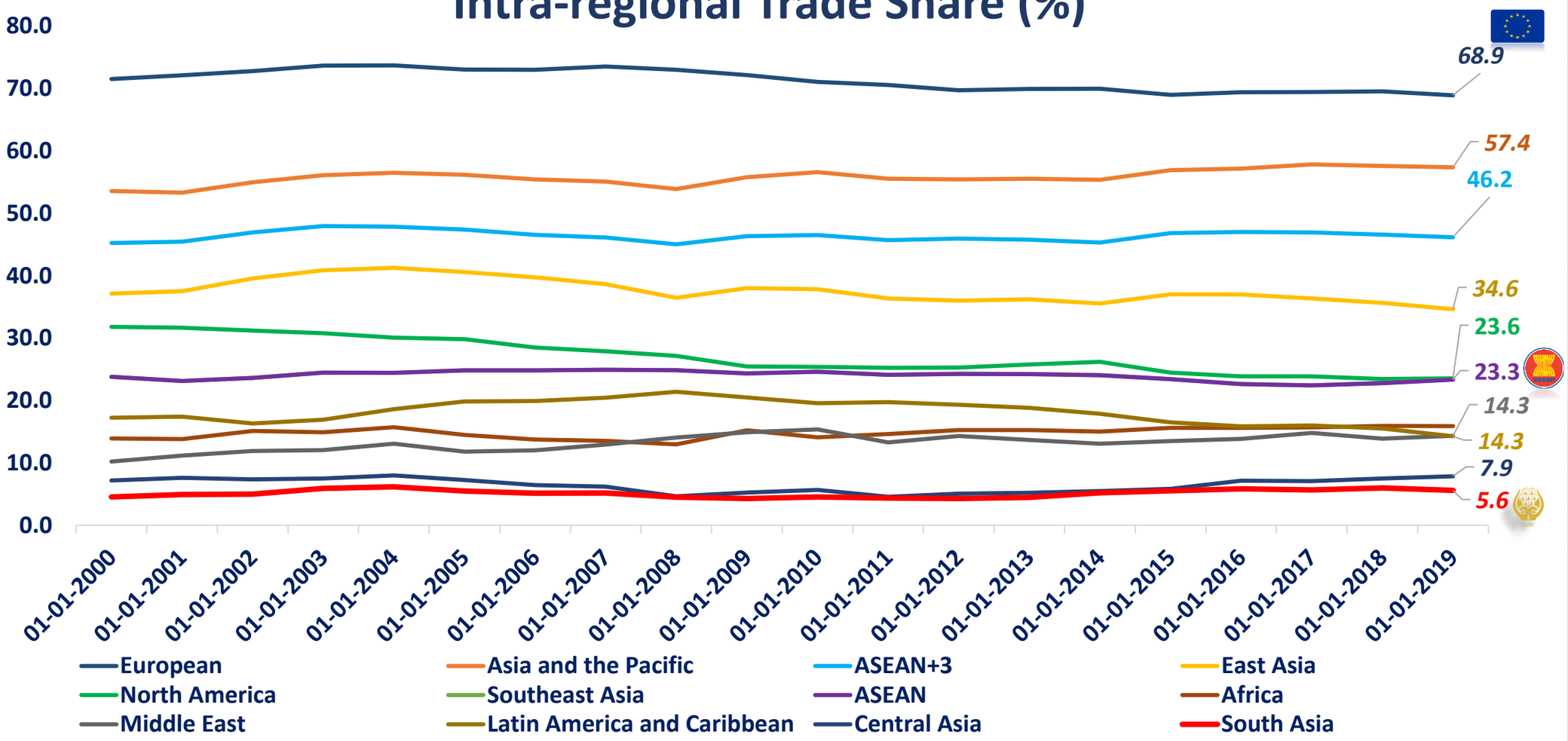
05.1 South Asia : Yet Least Integrated

Intra-regional Trade Share (%)



Region	Intra-regional Trade Share (%) 2019
European	68.92
Asia & the Pacific	57.36
ASEAN+3	46.17
East Asia	34.61
North America	23.56
Southeast Asia	23.37
ASEAN	23.34
Africa	15.88
Middle East	14.34
Latin America & Caribbean	14.26
Central Asia	7.87
South Asia	5.59

Source: The Integration Indicators Database https://aric.adb.org/database/integration ASEAN+3 consists of the 10 ASEAN member economies, the People's Republic of China (including Hong Kong, China), Japan, and the Republic of Korea.
Intra-regional Trade Share -Intra-regional trade to total trade of the region

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05.2 Overview of South Asian Power Sector

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05.2 Overview of South Asia Power System

<2GW-very small, < 4GW-Small, < 50 GW-Mid size, < 200 GW-Large, < 500 GW-Vey Large

Afghanistan

#Very small power system (~.6 GW)
#High Electricity Imports
#Hydro and Oil Dominated

Bangladesh

#Mid size power system (~23 GW)
#High gas dependence
#Resource Crunch

Bhutan

#Small power system (~2.3 GW)
#Large Exporter of hydro power
#Champion of Hydro CBET in SA.

India

#Very Large System (~377 GW)
#Coal Dominated, RE -138 GW
Central to CBET in SA
Competitive Power Market (Only in SA)

Maldives

#Fragmented & very small power systems (~.4 GW)
#Oil, Diesel dependent, Islands, Limited possibility of interconnection

Nepal

#Very Small power system (1.3 GW)
#Under utilized hydro (82 GW)
#Net importer of electricity now but potential to export in future

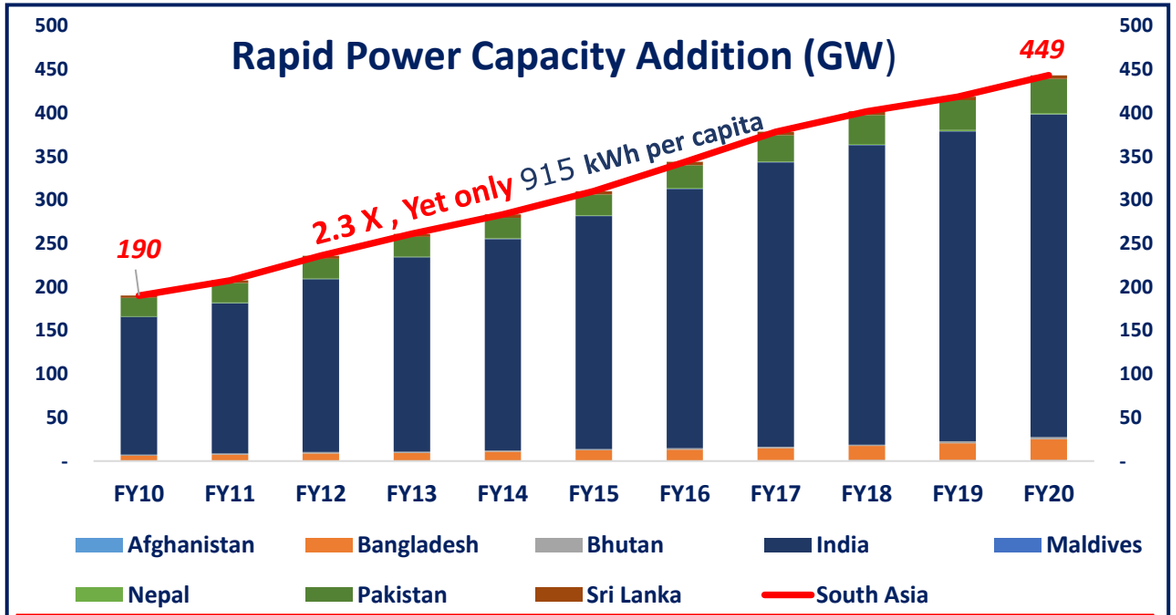
Pakistan

#Mid sized (39 GW) power system
#Gas and Oil dependent.

Sri Lanka

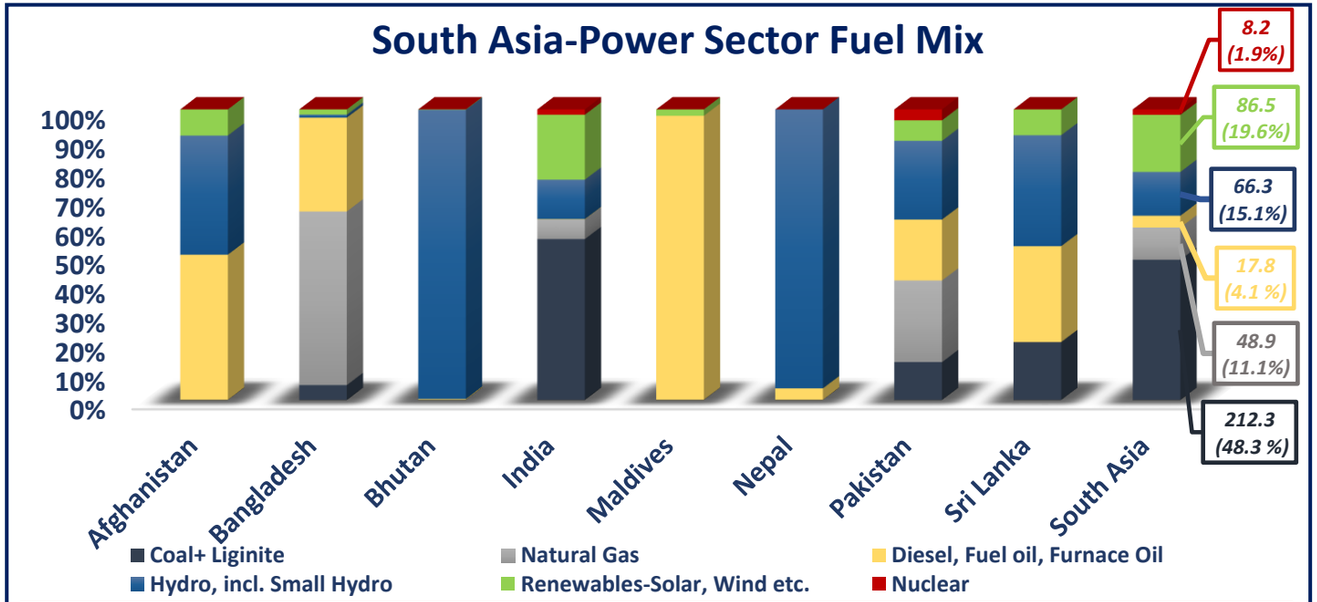
#Small power system (~4 GW)
Hydro and oil dominated
High Peak –off peak differential

Rapid Power Capacity Addition (GW)



Bangladesh : 5 GW-2010 to24 GW by 2020, India : 158 GW -2010 to 377 GW by 2021, Pakistan : 21 GW -2010 to 39 GW by 2020

South Asia-Power Sector Fuel Mix



Fossil Fuel Dominance Coal-48 %, Natural gas -11% , Diesel-3.9 % - Total -63.6 % I RE-19.6%, Hydro-15.1 %,-Total- 34.7%

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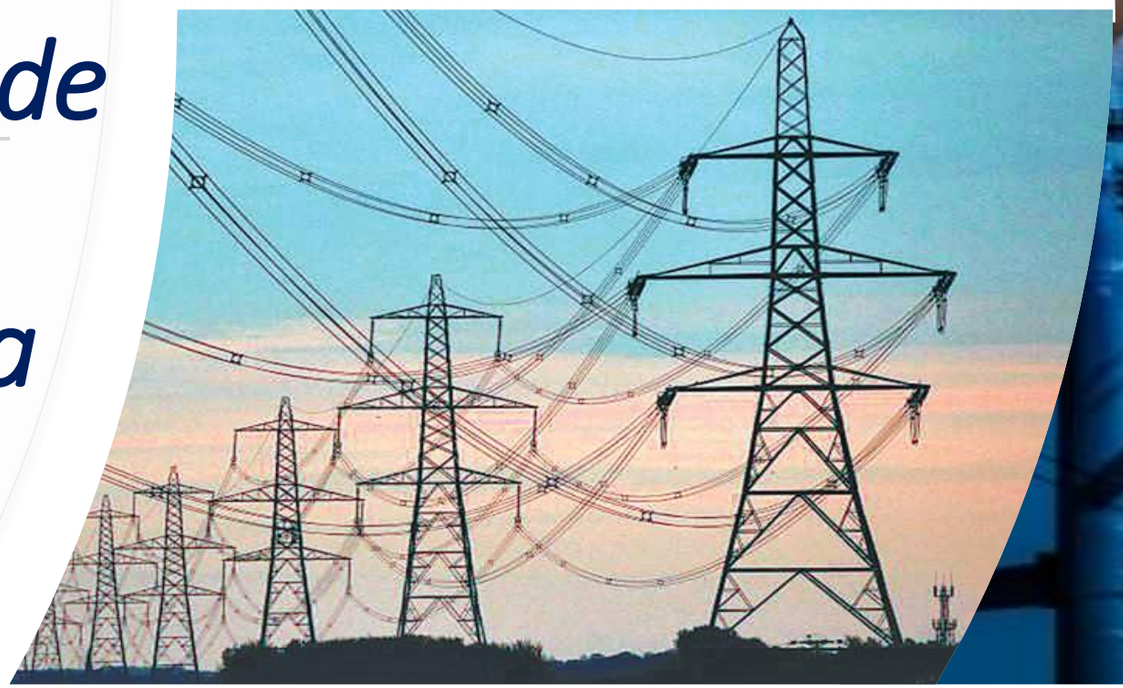
05.3 *Evolution of Energy Integration & Cross Border Electricity Trade (CBET) in South Asia*



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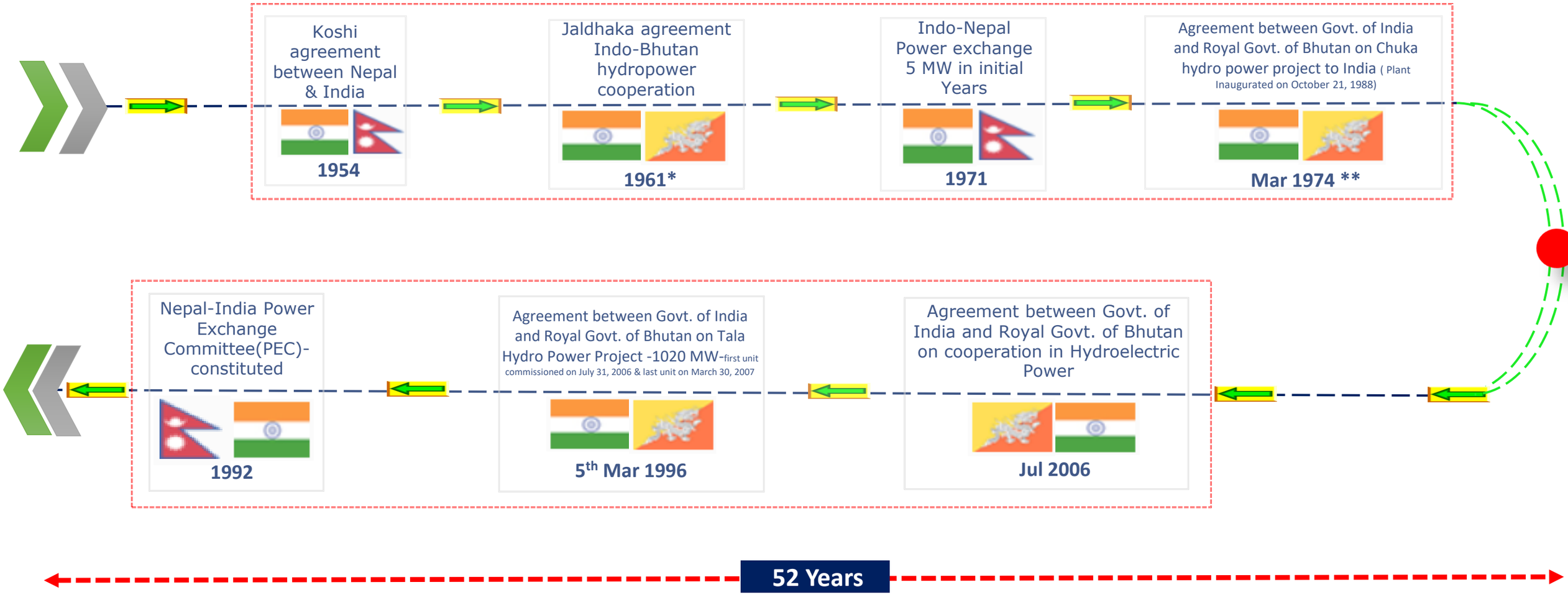
05.3 Evolution of Energy Cooperation, CBET- Key Policy & Regulatory Development



* http://www.mfa.gov.bt/rbedelhi/?page_id=28

** http://www.mea.gov.in/bilateral-documents.htm?dtl/6349/agreement

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05.3 Significant Developments in Energy Cooperation, CBET- Key Policy & Regulatory Initiative

- **Jan 2010** — MoU between Govt. of India and Govt. of Bangladesh, on cooperation in power sector (500 MW trade started on 5th October,2013)
- **Jun 2010** — MoU for carrying out a feasibility study for interconnection of the India-Sri Lanka electricity grids (Signed among GOSL, GOI, CEB & PGCIL)
- **20th Sept 2011** — MoU on CASA 1000 Project signed among 4 participating countries* (Project was conceived in 2008)
- **Apr 2014** — Inter-Governmental Agreement between Bhutan and India on development of JV Hydropower Projects
- **Sept 2014** — Indo-Nepal Power Trade Agreement
- **Nov 2014** — SAARC Inter-governmental Framework Agreement on Energy Cooperation
- **Oct 2015** — Sub-Regional Cooperation Bangladesh, Bhutan , India and Nepal (BBIN)
- **Oct 2016** — MoU on Cooperation in the field of Power Sector Myanmar & India
- **Dec 2016** — Ministry of Power Designates Nodal agency for CBTE
- **Dec 2016** — Guidelines on Cross Border Electricity Trade (CBTE) issued
- **Feb 2017** — CERC draft notification on CBET Regulations
- **June 2017** — NEPRA (Import of Electric Power Regulations)
- **Aug 2018** — MoU between Nepal & Bangladesh, on co-operation in power sector
- **Aug 2018** — MoU on BIMSTEC Grid Interconnection
- **Dec 2018** — New CBTE Guidelines Issued (Repealed 2016 Guideline)
- **March 2019** — CERC Notifies (Cross Border Trade of Electricity) Regulations, 2019
- **April 2019** — CEA-Draft Conduct of Business Rules (CBR) for CBTE
- **17th Aug,2019** — Mangdechhu hydroelectric power plant (720 MW) inaugurated
- **April, 2020** — Draft Electricity (amendment) Bill, 2020 defines "CBTE"
- **May,2020** (Idea Announced in October 2018) — One Sun One World One Grid' (OSOWOG)-A grand Vision
- **June 29, 2020** — 1st Indo-Bhutan joint venture hydroelectric project Concession Agreement for 600MW Kholongchhu
- **Feb 26, 2021** — The process of approving & facilitating the import / export (cross border) of electricity

10 Years-Decade of Action & Cooperation

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05.4 Cross Border Electricity Trade in South Asia: *Current Status* and *Future Scenario*

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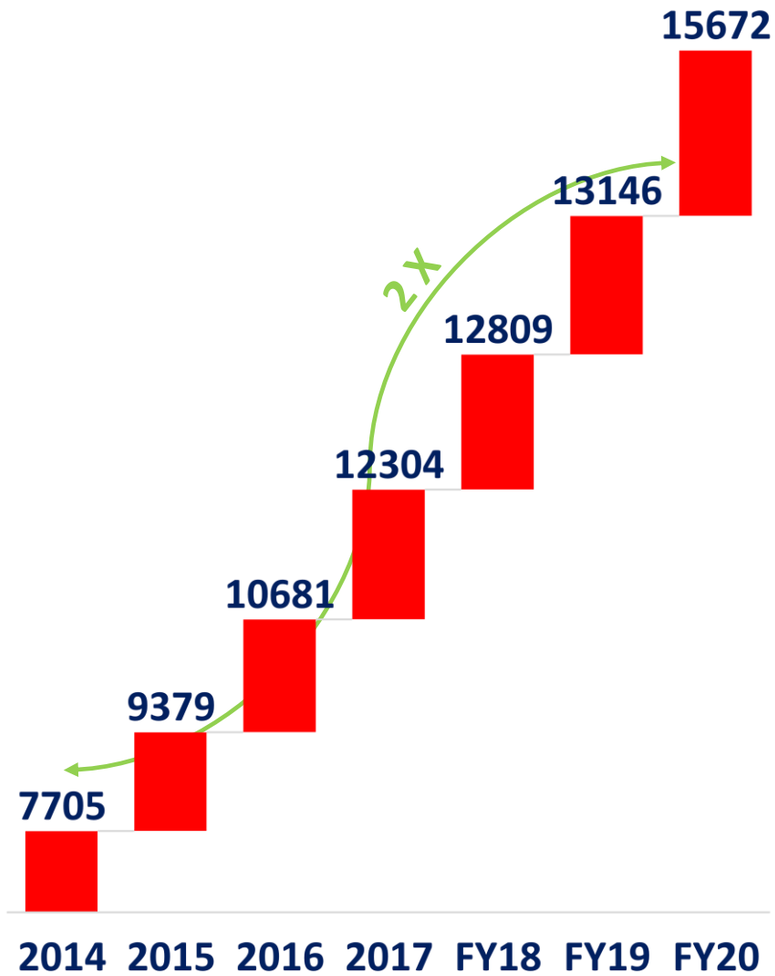
05.4 South Asia Cross Border Electricity Trade: Current Status & Future Scenario

India- Bangladesh ~1160 MW
Bhutan-India ~2100 MW
Nepal-India ~ 500 MW

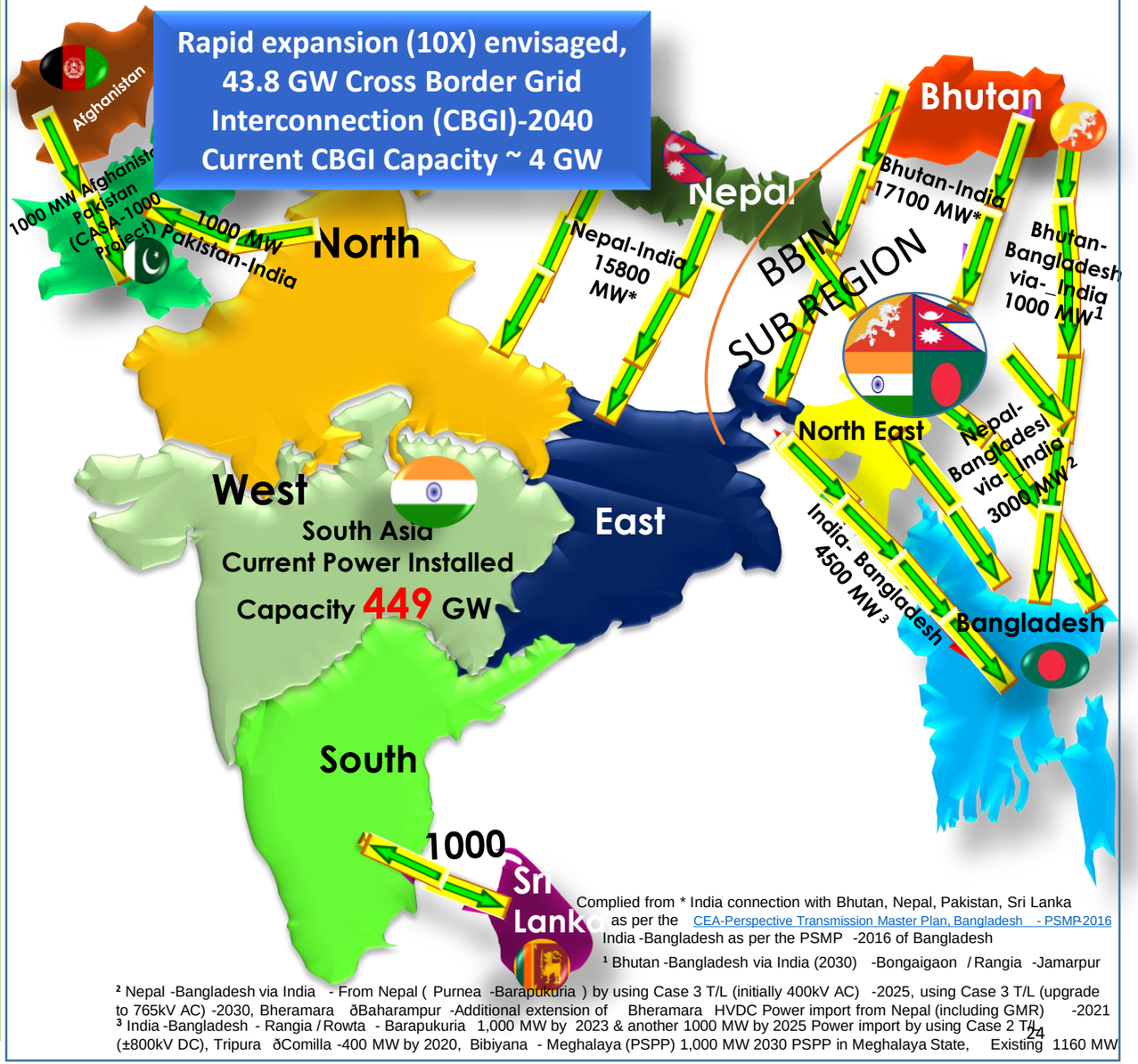
~ South Asia (SA)CBET 2.6 X

~3760* MW — 2020
~2986 MW — 2018
~2126 MW — 2015
~1400 MW — 2012

SA CBET in MUs



Rapid expansion (10X) envisaged,
43.8 GW Cross Border Grid Interconnection (CBGI)-2040
Current CBGI Capacity ~ 4 GW



Complied from * India connection with Bhutan, Nepal, Pakistan, Sri Lanka as per the CEA-Perspective Transmission Master Plan, Bangladesh - PSMP-2016 India -Bangladesh as per the PSMP -2016 of Bangladesh

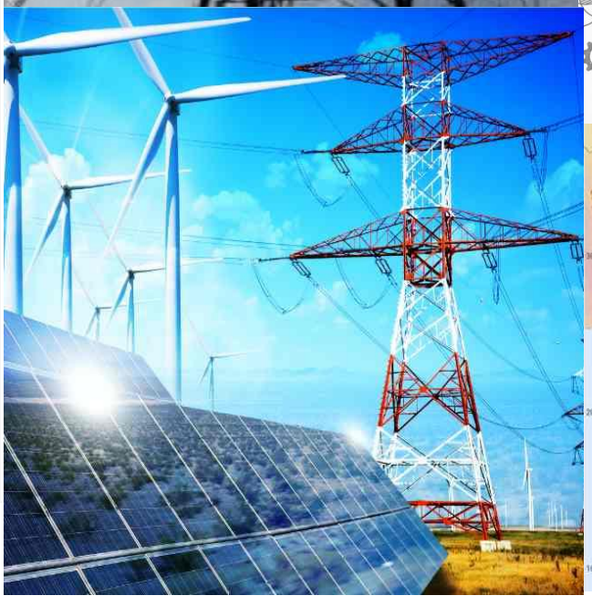
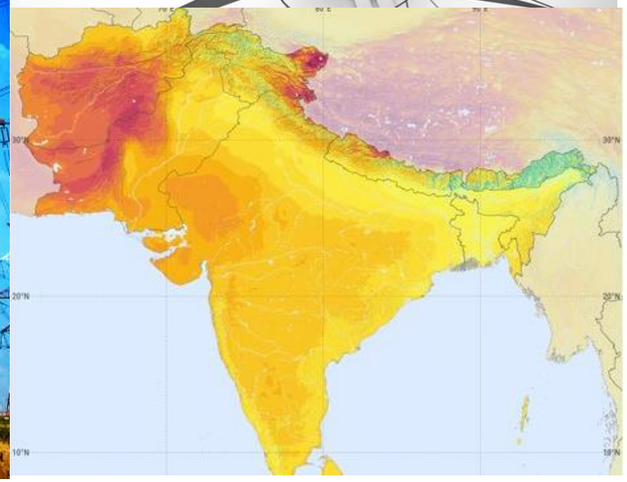
¹ Bhutan -Bangladesh via India (2030) -Bongaigaon / Rangia -Jamarpur

² Nepal -Bangladesh via India - From Nepal (Purnea -Barapukuria) by using Case 3 T/L (initially 400kV AC) -2025, using Case 3 T/L (upgrade to 765kV AC) -2030, Bheramara ðBaharampur -Additional extension of Bheramara HVDC Power import from Nepal (including GMR) -2021

³ India -Bangladesh - Rangia / Rowta - Barapukuria 1,000 MW by 2023 & another 1000 MW by 2025 Power import by using Case 2 T/L (±800kV DC), Tripura ðComilla -400 MW by 2020, Bibiyana - Meghalaya (PSPP) 1,000 MW 2030 PSPP in Meghalaya State, Existing 1160 MW

Source: Compiled from various Sources , Country Authority Websites across the Region - : India-Myanmar ~ 3-5 MW of CBET , Pakistan-Iran ~ 104 MW CBET, Afghanistan- Imports around 1000 MW collectively from Uzbekistan (326 MW) , Iran (164 MW) , Tajikistan (433 MW) ,Turkmenistan (77 MW) I *~ Maximum Peak Trade I PM Modi inaugurated Mangdechhu hydroelectric plant, Bhutan, Aug 17, 2019



05.5 Challenges Faced in Energy Integration & CBET in South Asia Region

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05.5 Challenges Faced in Energy Integration & Cross Border Electricity Trade

Political, Political-Economy, Consensus Building

- *Process of building Consensus takes time*
- *Trust Building, Geopolitical Realties*
- *Political Capital & Will, Cooperation Spirit*
- *Required sustained efforts, Continuity*

Policy, Regulatory, Market, Technical

- *Different level/stage of Policy, Regulatory, Market, Technical (PRMT) Frameworks, Harmonisation*
- *Implementation of agreements, lack of clear PRTM framework*
- *Power Market Development & Competition*

Financial/Commercial feasibility, Investment attractiveness, focused Investment Facilities

- *Project Feasibility, Financial Challenges of building Hydro*
- *Sharing of cost of cross border transmission*
- *Policy, Regulatory Risks Amplifies viability*
- *Lack of Dedicated Investment Facilities*

Trilateral, Multilateral, Regional Institutional Platforms

- *Moving from Bilateral, Building consensus on Trilateral took time*
- *Sharing of cost of cross border transmission*
- *Lack of Dedicated Regional Institutional Platforms*
- Enabling Procedure

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06 Facilitating Energy Integration in Coming Future in South Asia Region

Four Prong Strategy & Four Enablers


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06 Facilitating Energy Integration in Coming Future- Four Prong Strategy

Strategy 1

Transitioning from Bilateral to Trilateral CBET in SA

Strategy 2

Renewable Energy based CBET

Strategy 3

Commercial form of CBET

Strategy 4

Regional Power Market Development & Market Integration

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06.1.1 Strategy -1

Transitioning from Bilateral to Trilateral CBET

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06.1.1 Gradual Transition to Trilateral Cross Border Power Trade

$2 billion ,1125 MW Dorjilung Project

Proposed Trilateral Project

(The DPR of the project approved by RGoB)

Bangladesh will import 500 MW of electricity from 900 MW Upper Karnali (GMR) in Nepal @ 7.72 cents/unit for 25 years##

(Price Negotiation is Concluded, Discussion on transmission is under consideration)

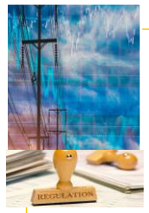
Bangladesh Master Plan# envisaged to import from Bhutan (1 GW) & Nepal (3 GW) through India

Enabling the Frameworks

Guidelines for the Import / Export (Cross Border)-2018 of Electricity

Clause 3.1, Clause 8.6

Source: Ministry of Power, India



Central Electricity Regulatory Commission (Cross-border Trade of Electricity) Regulations, 2019

Clause 3. (2) , Clause 12. (6)

Source: CERC, India

Procedure for approval and facilitating Import/Export (Cross Border) of Electricity by the DA Authority-February, 2021

Clause 8. , Annex-V

Source: CEA, India

Power System Master plan 2016 (Final)- https://powerdivision.gov.bd/site/page/f68eb32d-cc0b-483e-b047-13eb81da6820/Power-System-Master-Plan-2016

https://kathmandupost.com/money/2020/02/09/bangladesh-issues-letter-of-intent-to-purchase-500-mw-from-upper-karnali-hydro-project

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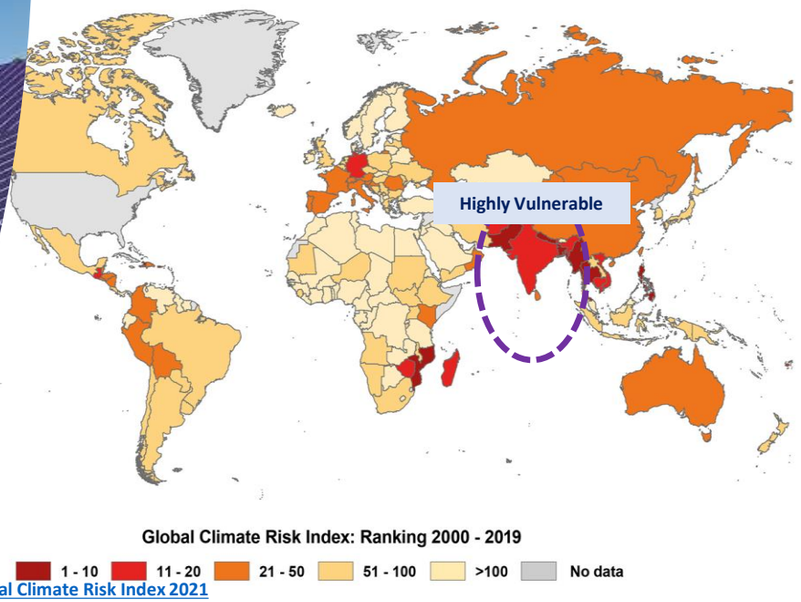
06.1.2 Strategy - 2

Renewable Energy based CBET



Source: Global Climate Risk Index 2021

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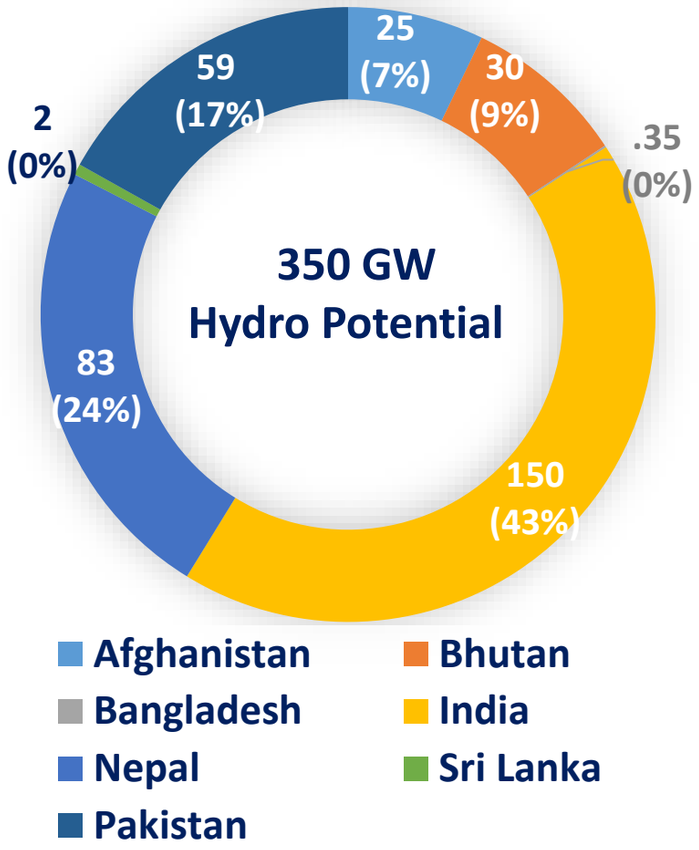
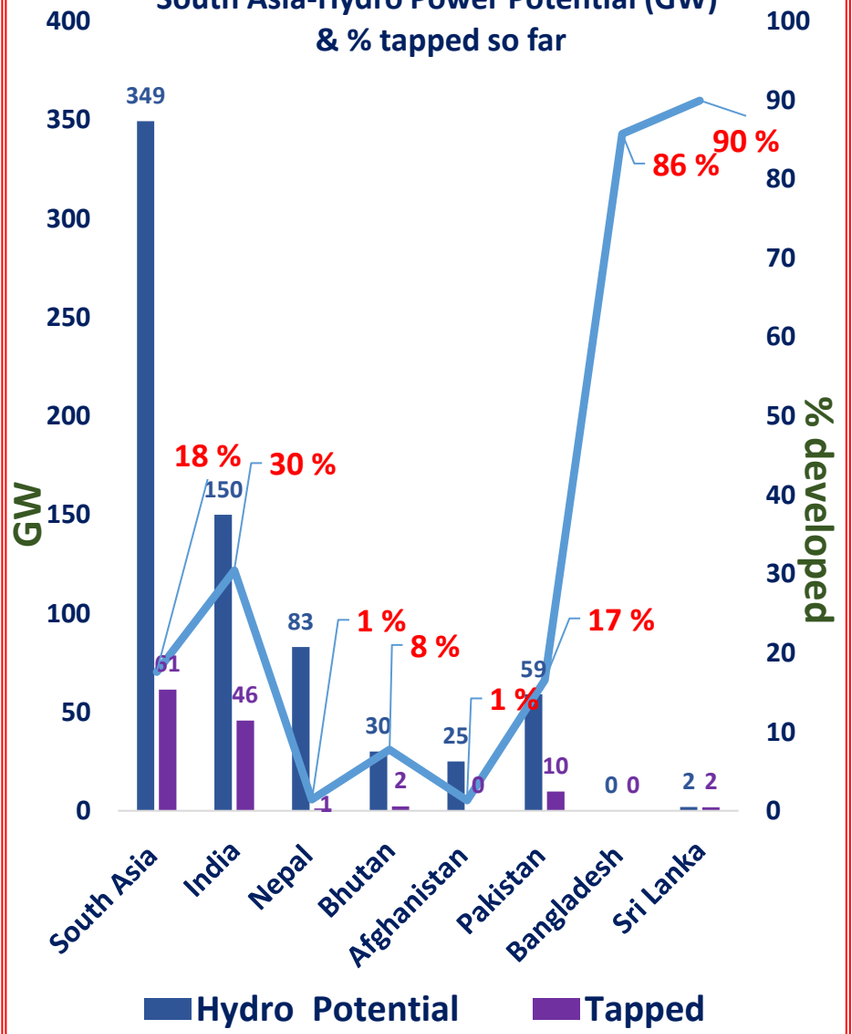
06.1.2 South Asia-Blessed with huge Clean Energy Resources

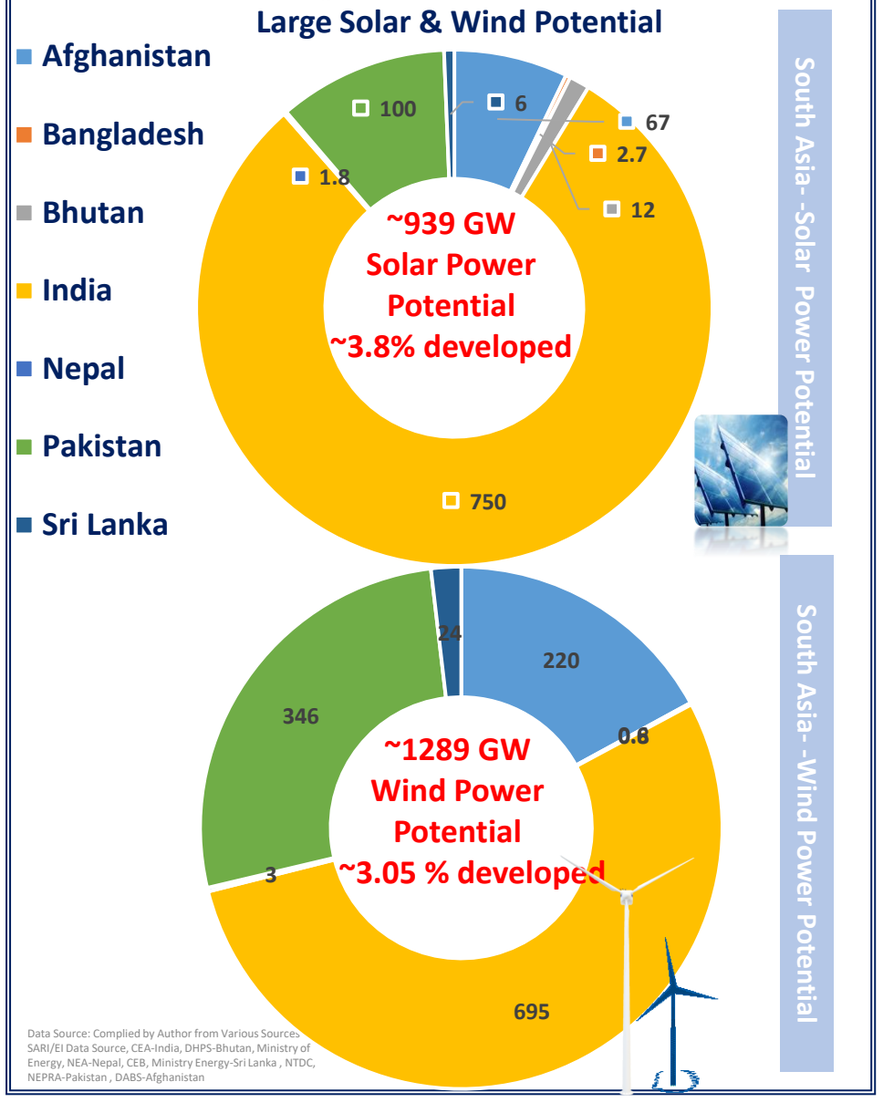
South Asia Hydro Power Potential in GW (%)



South Asia-Hydro Power Potential (GW) & % tapped so far



Large Solar & Wind Potential



Data Source: Complied by Author from Various Sources SARI/EI Data Source, CEA-India, DHPS-Bhutan, Ministry of Energy, NEA-Nepal, CEB, Ministry Energy-Sri Lanka , NTDC, NEPRA-Pakistan , DABS-Afghanistan

South Asia : Large Renewable Energy Resource within the Region-Potential for clean energy transition, sustainability & energy security

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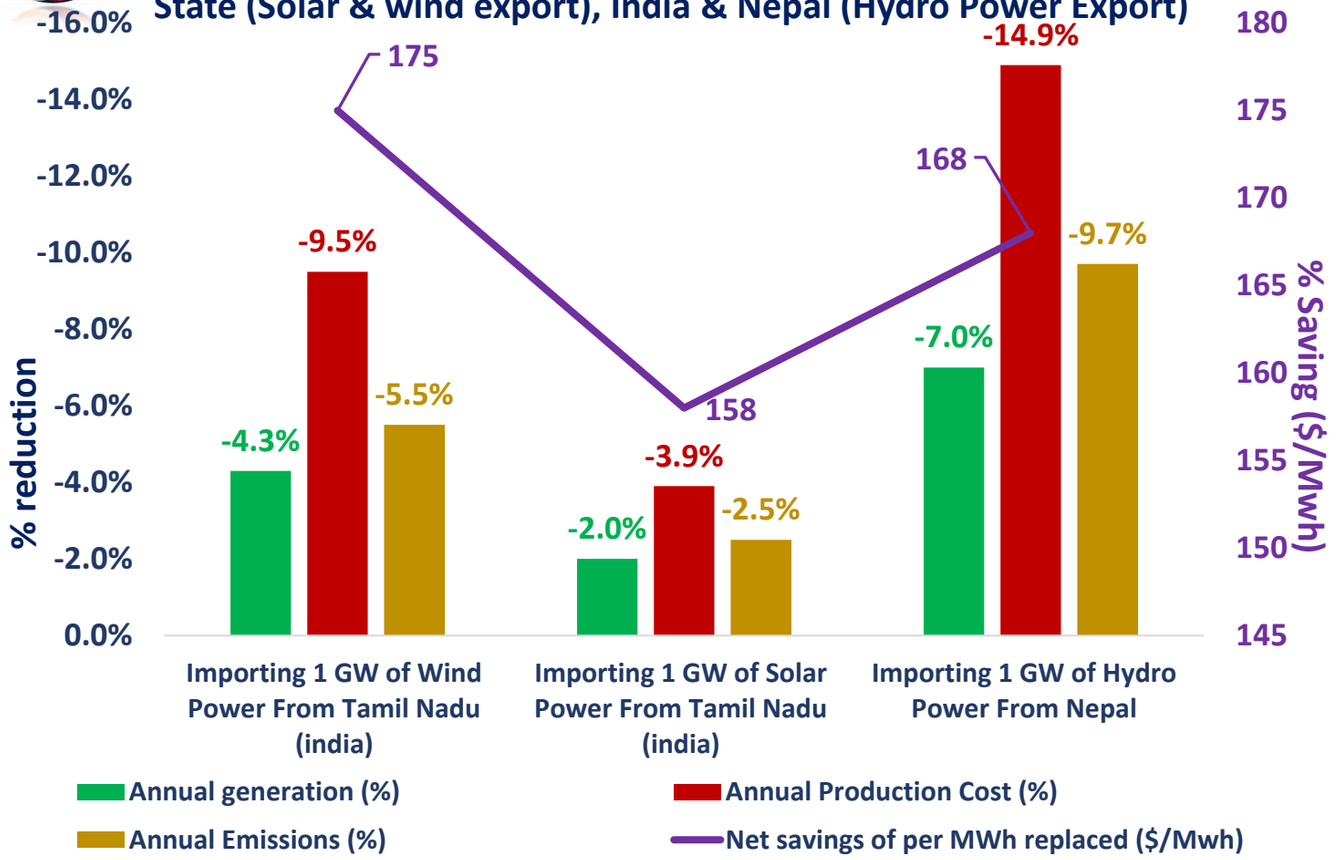
06.1.2 South Asia : Cross Border Electricity Trade From Renewable Energy Zones

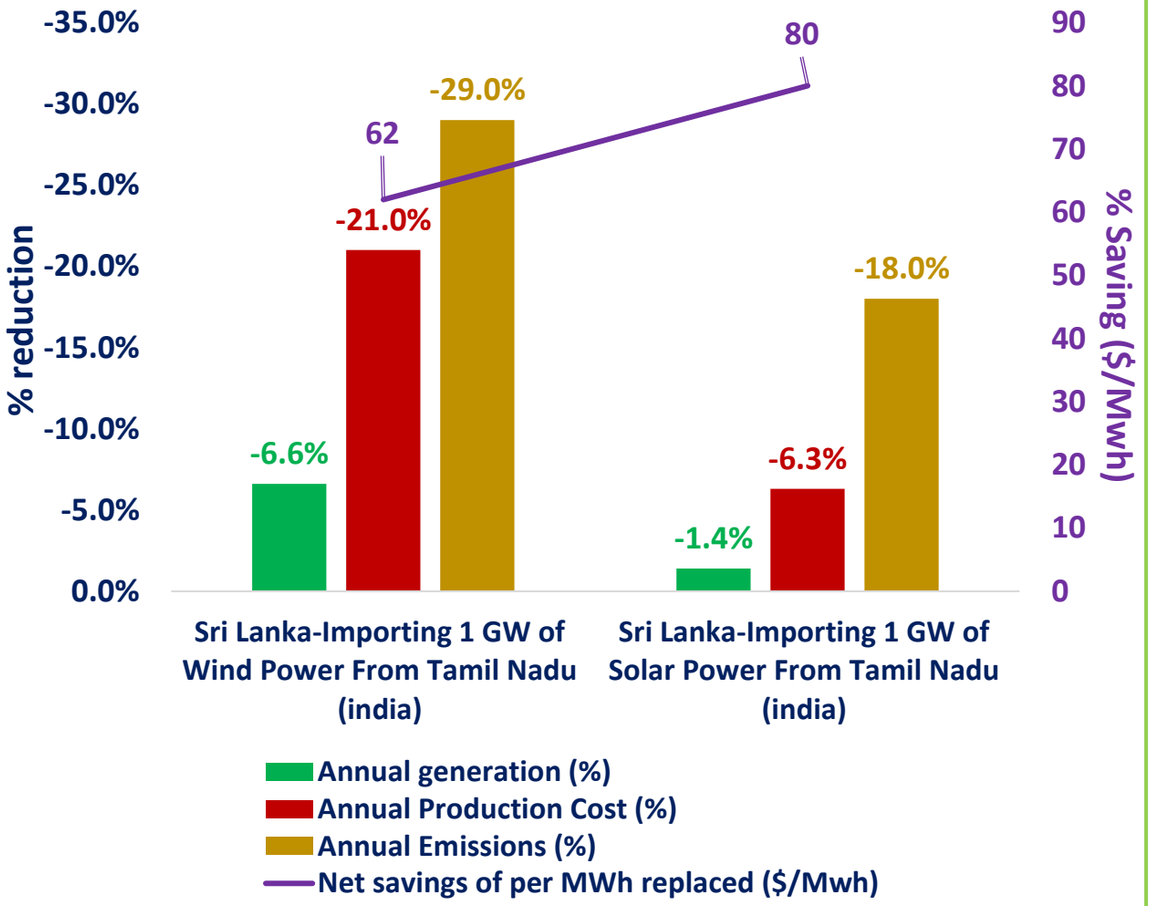
Bangladesh Importing from Renewable Energy Zones (Tamil Nadu State (Solar & wind export), India & Nepal (Hydro Power Export)



Source: NREL Report on "Cross-Border Electricity Trading and Renewable Energy Zones" https://www.nrel.gov/docs/fy20osti/76919.pdf https://www.nrel.gov/docs/fy20osti/77029.pdf

1 GW of solar capacity in Tamil Nadu generates less energy than 1 GW of Nepal hydropower or 1 GW of Tamil Nadu wind power. Also, because solar's sunrise to-sunset profile is less correlated with Bangladesh load, the savings per unit of energy was also less— $158 per MWh replaced.

Sri Lanka Importing from Renewable Energy Zones (Tamil Nadu State (Solar and wind export), India)



South Asia : GW scale RE based trilateral CBET offers cost saving, clean energy transition:-leads to enhance energy affordability & sustainability

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06.1.3 Strategy -3

Commercial form of CBET

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06.1.3 South Asia : Commercial form of Cross Border Electricity Trade

Initially all CBET, G-G negotiated tariff

Comml. CBET

2010-0 MW, 2020-1266 (~33%*)

Commercial approach brings business value

Competition, better price discovery

Foster mindset change, will help to transit to market

Commercial CBET

2020

1226 MW

2010

0 MW

Country	Source	Type	Trader	Tenure Years
Bhutan- India (~2262 MW) G-G-2136 Comml-126	1020 MW Tala	G-G	PTC	35
	336 MW Chhukha	G-G	PTC	
	60 MW Kurichhu	G-G	PTC	
	720 MW Mangdechhu	G-G	PTC	
	126 MW Dagachhu	Commercial	TPTCL	25
India – Bangladesh (~1160 MW) G-G-410 Comml-790	250 MW NTPC	G-G	NVVNL	25
	160 MW Tripura	G-G	NVVNL	5
	250 MW Market	Commercial	PTC	3
	500 MW Market	Commercial	NVVNL/ Sembcorp	15
	40 MW Market	Commercial	PTC	2
India-Nepal (~587 MW) G-G-237 Comml-350	237 MW India	G-G		Long Term
	80-190 MW Market	Commercial	PTC/NVVNL	---
	160 MW Market	Commercial	NVVNL	Renewed Every year

South Asia : Commercial form of CBET leads to the busines case, help in fostering private sector engagement & investment

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06.1.4 Strategy -4

Regional Power Market Development & Market Integration

06.1.4 Regional Power Market, Power Exchange (PX)-Transitioning to Market form of CBET in SA

Demand Diversity- Daily, weekly ,Monthly, Seasonal

PXs– Fair, Transparent, Neutral Market Place- Competitive price discovery

PXs offers a platform for trilateral/multilateral CBET

SARI-Study on Gains from BBIN Multilateral electricity Trade(Capex reduces by USD 17 billion due to regional trade)

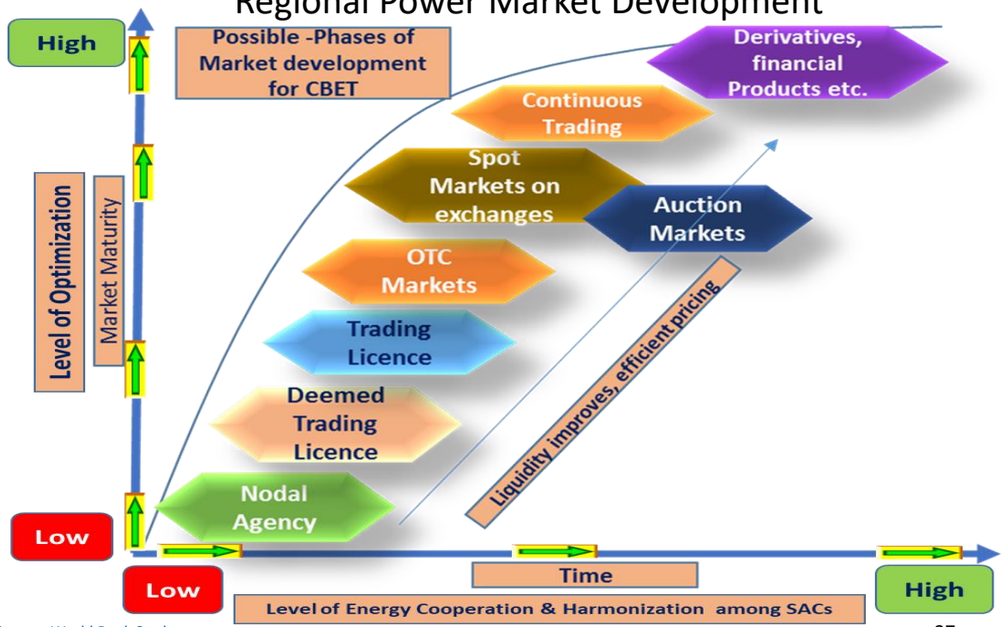
SARI/EI Study-SARPEX- Pilot Market Exercise- DAM in PX Platform. Bangladesh, Nepal, Bhutan in PXs, the quantum of MCV increased in the range of 5-7% (2015-16).

New power market initiatives in India also offers an opportunity to leapfrog in Cross Border Front.

Seasonal complementarity– Monthly Electricity Load Profiles across South Asia [2]

	January	February	March	April	May	June	July	August	September	October	November	December
Bangladesh												
India-North East												
Bhutan												
India-East												
Nepal												
India-North												
India-West												
Pakistan												
India-South												
				Low	Medium	High						

Regional Power Market Development



[2] Source: World Bank Study

[1] Government of India (GoI) ,Ministry of Power (MoP) guidelines- Import/Export Cross Border Electricity

SACs-South Asian Countries

SARPEX-South Asia Regional Power Exchange -addition of BBN to the Indian domestic market resulted in an increase of 1,918 MUs (5.3%) and 2,550 MUs (7.0%) in the MCV for the unified & sequential modes, respectively, over the Indian domestic market.

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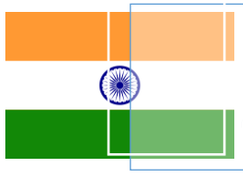
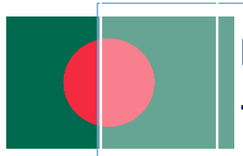
06.1.4 SA Regional Power Market -Benefits of Regional Grid Balancing & RE Grid Integration

Rapid Renewable Energy Expansion in the horizon in SA



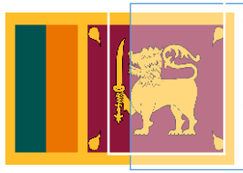
175 GW by 2022

450 GW[1] 2030



Bangladesh

7.9 GW[2] by 2041

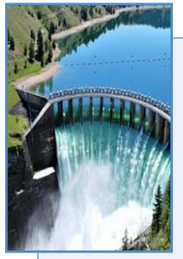


Sri Lanka

50% Generation[4] from RE by 2030

Pakistan

16 GW[3] by 2040



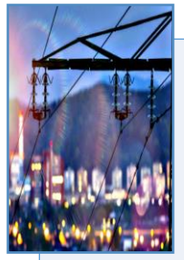
Hydro Power through CBET for optimised grid balancing

CBET as a tool for flexibility, managing RE Intermittency

Opportunity-Developing Regional Power Market (Trading of balancing services, Ancillary Market)

One Sun One World One Grid' (OSOWOG)-A Grand Vision

Successful 9 PM, 9 Minute-A generation flexibility of ~ 400 MW was achieved from hydropower plants in Bhutan[5]



New power market initiatives in India also offers an opportunity to leapfrog

In 2016, 80% of Denmark's wind generation[6] was balanced through CBET through the utilization of Norway's hydro resources

[1] http://cea.nic.in/reports/others/planning/irp/Optimal_generation_mix_report.pdf [3] https://nepra.org.pk/Admission%20Notices/2019/09-September/IGCEP%20Plan%20(2018-40).pdf [2]https://powerdivision.portal.gov.bd/sites/default/files/files/powerdivision.portal.gov.bd/page/4f81bf4d_1180_4c53_b27c_8fa0eb11e2c1/Revisiting%20PSMP2016%20%28full%20report%29_signed.pdf [3] https://nepra.org.pk/Admission%20Notices/2019/09-September/IGCEP%20Plan%20(2018-40).pdf [4] For Sri Lanka 50% renewable energy (including major hydro) by year 2030, https://www.pucsl.gov.lk/wp-content/uploads/2020/06/PUC-LI-AP19-01-May-28-PUC-reply-to-revised-LCLTGEPrev1-3.pdf [5] Successful 9PM, 9 minutes event Highlights the Outstanding Cooperation in Electricity Grid Management in South Asia https://posoco.in/download/report-on-pan-india-lights-off-event-9-pm-9-minutes-on-5th-april-2020/?wpdmdl=28819

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06.2 Four Enablers for Facilitating Energy Integration & CBET in Coming Future

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06.2 Facilitating Energy Integration in Coming Future in South Asia Region:Four Enablers

Political

- Regional Outlook/Vision
- Political Consensus
- Intergovernmental agreement(s)
- Implementation & Review Mechanism
- Power Market Reform

Regulatory

- Permissibility to use intermediary transmission network under open access
- Rules for identification of transmission capabilities & congestion
- Rules for measurement of imbalance and settlements
- A conducive & friendly ecosystem for investors
- Power Market Development

Technical and Commercial

- Harmonisation of grid codes & standards, Grid Connectivity
- Transmission pricing & transit charge
- Co-ordinated Regional Transmission Grid Planning
- Settlement & payment mechanism
- Dispute resolution mechanism

Institutional

- Institutional arrangements
- Regional Coordination Forums are desirable
- Will foster long term sustainability

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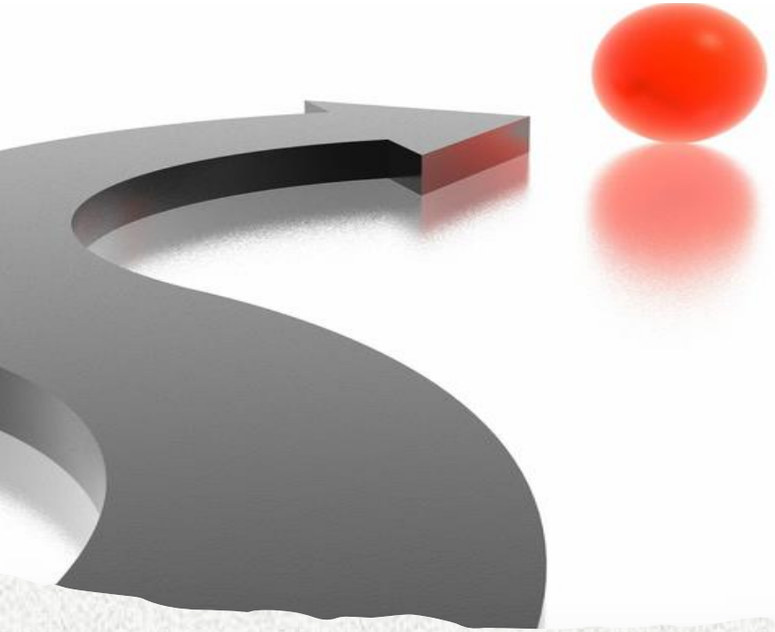

Conclusion and Way forward for Facilitating EI & CBET in SA in Coming Future

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07 Conclusion &Way Forward

Political Will, Implementation of various Political Consensus

(inter-governmental agreements, bilateral, trilateral, multilateral)

Navigating the Political-Economy, Energy Geopolitics & Strategic Risk.

Navigating Idealism vs realism, being practical

Being familiar with Energy market principles, commercial frameworks & market expectation

Complementary Policy, Regulatory, Market Framework

Steering Energy Security & Energy Interdependence debate, reasonable energy interdependence

Regional Institutional Platforms for Regulations, Planning, System Operation, Market Development

South Asia Energy Grid-Regional Transmission Master Plan, Investment Plans

De-Risking; viability & bankability, Investment facilitation, mobilisation

Reasonable Realism along with a long term vision is key to deepening Cross Border Energy Trade, Energy Market Integration, leads to Economic Clean Energy Transition, Sustainability, Regional stability and Prosperity in South Asia

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Thank You

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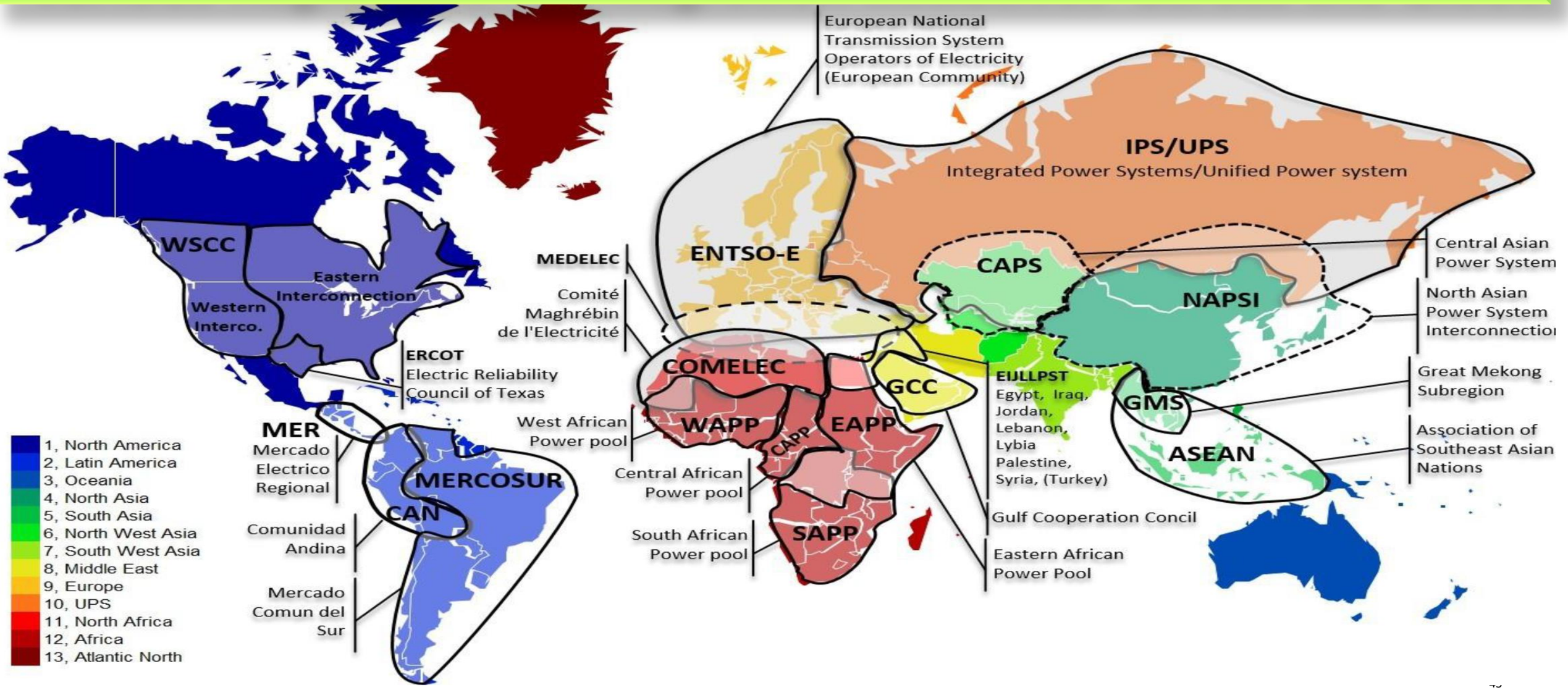
Various Regional Grid Integration Initiatives across the Globe



Source : Power system development and Economics, Global electricity network Feasibility study, Reference: 775, September 2019

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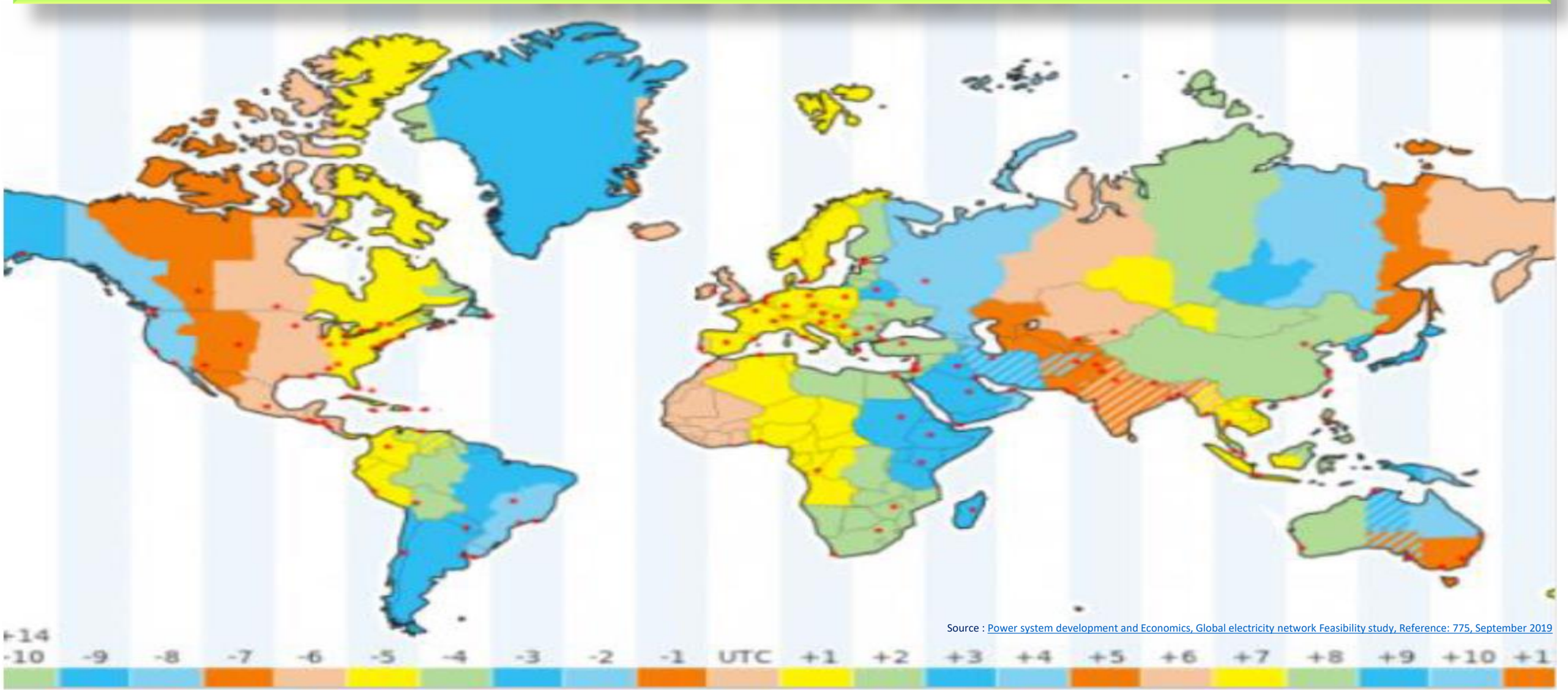
World Time Zones



Source : Power system development and Economics, Global electricity network Feasibility study, Reference: 775, September 2019

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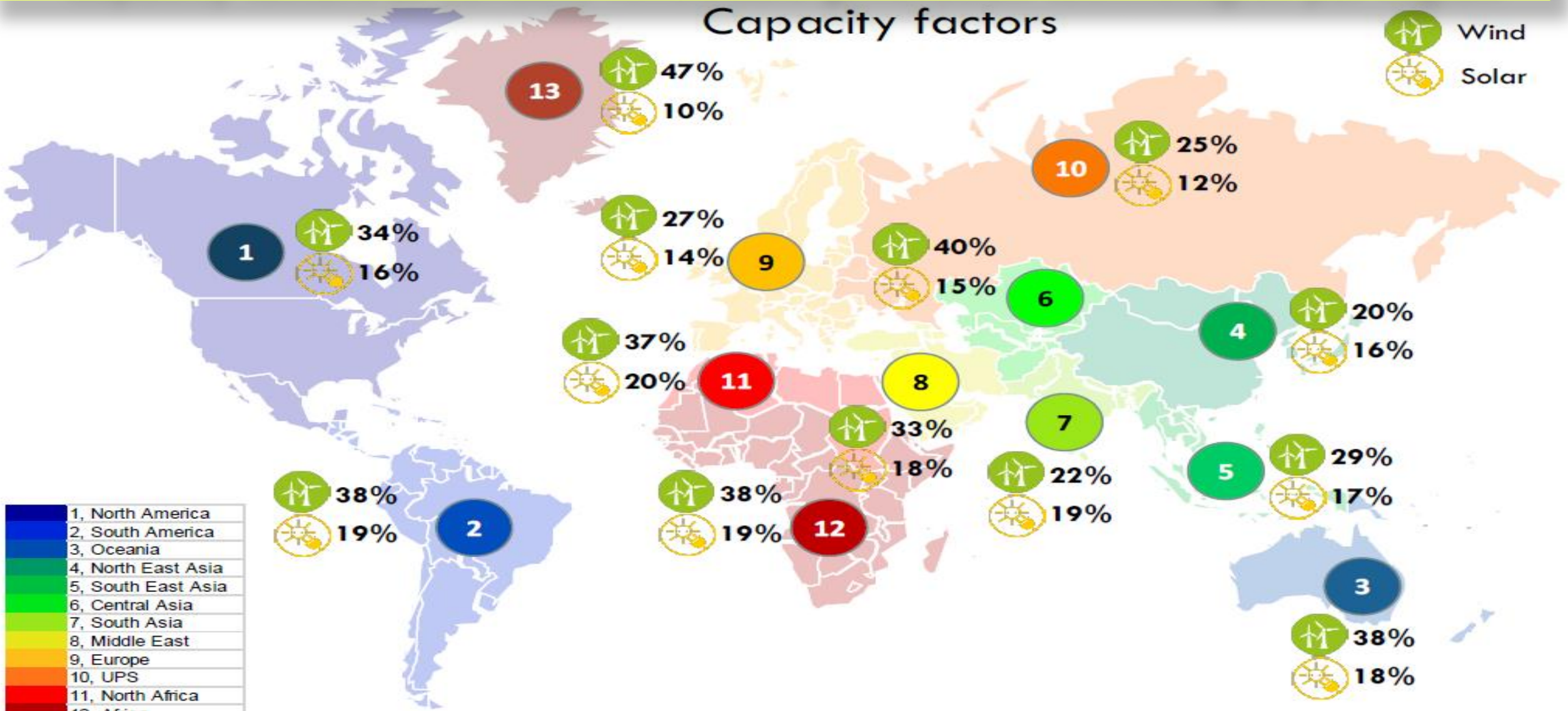
Capacity factors of variable renewable generation technologies per region



Source : Power system development and Economics, Global electricity network Feasibility study, Reference: 775, September 2019

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Key Policy & Regulatory Enablers in SA

SAARC Framework Agreement for Energy Cooperation (Electricity) [1]
(Nov,2014)

MoU on BIMSTEC Grid Interconnection[2]
(August 2018)

Guidelines for Import/Export (Cross Border) of Electricity[3]
(Dec, 2018)

CERC (Cross Border Trade of Electricity) Regulations[4]
(March,2019)

Draft Electricity (amendment) Bill, 2020 defines "CBTE"[5]
(April, 2020)

One Sun One World One Grid' (OSOWOG)- A grand Vision[6]
(May,2020)

(Idea Announced in October 2018)

Procedure for approval and facilitating Import/Export (Cross Border) of Electricity) by the DA Authority
(February, 2021)

CBTE-Cross Border Trade of Electricity [1] Emphasized the need to promote regional power trade , Enables CBTE based on bilateral, trilateral & mutual agreements [2] Encourages Cross Border Energy Trade, Enables cross border grid interconnection based on bilateral/trilateral/multilateral mutual agreements [3] Enables trilateral power trade, CBTE through PXs [4] Comprehensive regulation- address connectivity ,open access , planning, system operation, Metering, Energy Accounting & Settlement etc. [5] "CBTE" means transactions involving import or export of electricity between India and any other country and includes transactions related to passage of electricity through our country in transit between two other countries " [6] India's Prime Minister called for connecting solar energy supply across borders Hon'ble Prime Minister Shri Narendra Modi during first assembly of the International Solar Alliance on October 2018. , On May 2020 , MNRE issues RFP on On OSOWOG which Envisages large scale trans-regional grid integration **Phase-I** Middle East-South Asia-South East Asia (MESASEA) interconnection): Indian Grid interconnection with MESASEA, **Phase-II** MESASEA Grid with Africa Power Pools , **Phase-III** (Global interconnection): to achieve the OSOWOG vision

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Current Power market development and Integration in South Asian Countries (SACs)

Country	Power Trading and market Structure	Single Buyer	IPPs	Open access Frame work	Transmission System operation (as a part of Transmission Agency)	Independent transmission system operator	Competitive Power Market Power/Gas Exchange Platform	Cross Border Electricity Trade Through Power market
Afghanistan	**Single Buyer** (SB)-DABS, VIU-DABS	■	■		■			
Bangladesh	**Single Buyer** (SB)-BPDB, Multiple Seller ^Partial Unbundling of Transmission	■	■		■			
Bhutan	**Single Buyer** (SB)-BPC ^^Un-bundled transmission	■	■		■			
India	**Multiple Buyer & Seller Competitive Power Market** Platform Power Exchange (PXs) Completely Un-bundled transmission		■	■		■	■	^^^^
Maldives	**Single Buyer** (SB), VIU-FENAKA	■	■		■			
Nepal	**Single Buyer** (SB)-NEA, Multiple Seller VIU-NEA	■	■		■			
Pakistan	**Single Buyer** (SB)-CPPA-G (Market Operator)^^^, Multiple Seller	■	■		■			
Sri Lanka	**Single Buyer** (SB)-CEB, Multiple Seller	■	■		■			

Power markets in SACs other than India **has not progressed a lot beyond** allowing IPPs & competition in generation.

On cross border, India has **allowed cross border trade of power through Indian Power exchange^^^^**.

India's Energy market platform (Power and Gas exchange) can help in leap frogging towards a **regional energy market development**

Pakistan*, Bangladesh , Bhutan are taking some steps* which can be helpful for future for market transition.

* The CPPA-G is facilitating the power market transition from the current single buyer to competitive market , * Bhutan & Bangladesh working on independent transmission system operator formation.

^Bangladesh- PGCB owns and operates the transmission grid, PGCB is a subsidiary of BPDB which undertakes generation and distribution ^^Bhutan- BPCL owns and operates the transmission grid, undertakes system operation. BPCL does not have generation assets, but undertakes distribution of electricity

^^^Pakistan -The CPPA-G is facilitating the power market transition from the current single buyer to competitive market ^^^^ India has allowed the participation of in India power exchange through Indian Power trader for Eligible Applicant , Clause 6.5 of Procedure for approval and facilitating Import/Export (Cross Border) of Electricity) by the Designated Authority.

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South Asia Cross Border Electricity Trade-Evolution in thinking and general discourse

Preconceived Notions & Dominant Thoughts

- *CBET only when county in Absolute Surplus*
- *No need of Comprehensive Regulatory framework, regional institutions , Ad hoc measures are fine*
- *Restrict electricity imports for Energy Security (ES)*
- *No need of Regional Approach and Planning*
- *Notion of Not getting the benefits of Export-Won't get a fair deal*
- *Geo-Politics rather than Economics the Driver*
- *No Consensus on Trilateral Approach*

Changed/Changing Thoughts

- *CBET can Happen by Exploiting Diversity, absolute surplus not a pre-conditions*
- *Need of Comprehensive Regulatory framework, regional institutions desirable, Avoid Ad hoc measures, negatively impacts Investment*
- *ES continue to be a concern, but reasonable energy interdependence is a better approach*
- *Better Appreciation for Regional Approach and Planning*
- *Can get a fair deal, Learning the art of deal making*
  More positive and practical understanding
- *Mix of Geo-Politics and Economics the Driver*
- *Understanding/Consensus on Trilateral Approach*

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