

Inter-regional Connectivity between South Asia and South-East Asia Benefits and Challenges

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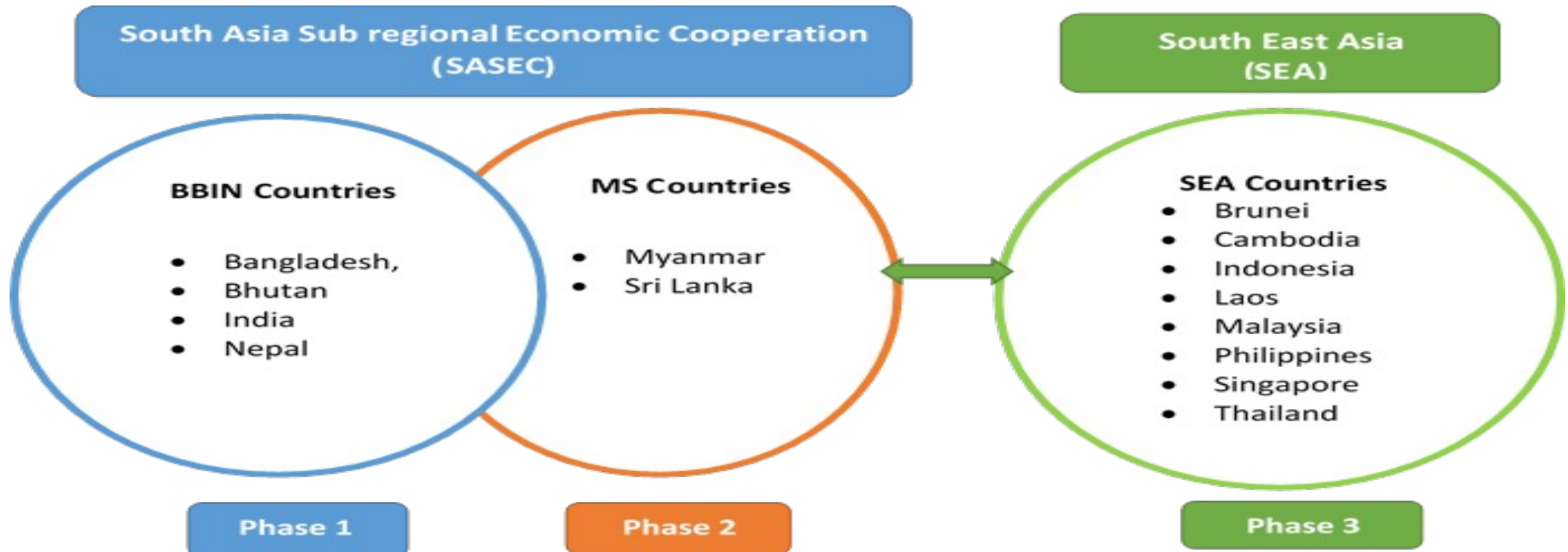
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Drivers of Connectivity

- Growth of Demand
- Diversity
- Time Diversity
- Seasonal Diversity
- Resource Diversity - more so , if Renewable
- Institutional cooperative Arrangements followed from political consensus

Approaches

- IRADe Modelling work done for BBINS
- Scenario Analysis for the SEA region by ASEAN and IRENA
- Work connecting the two regions in progress

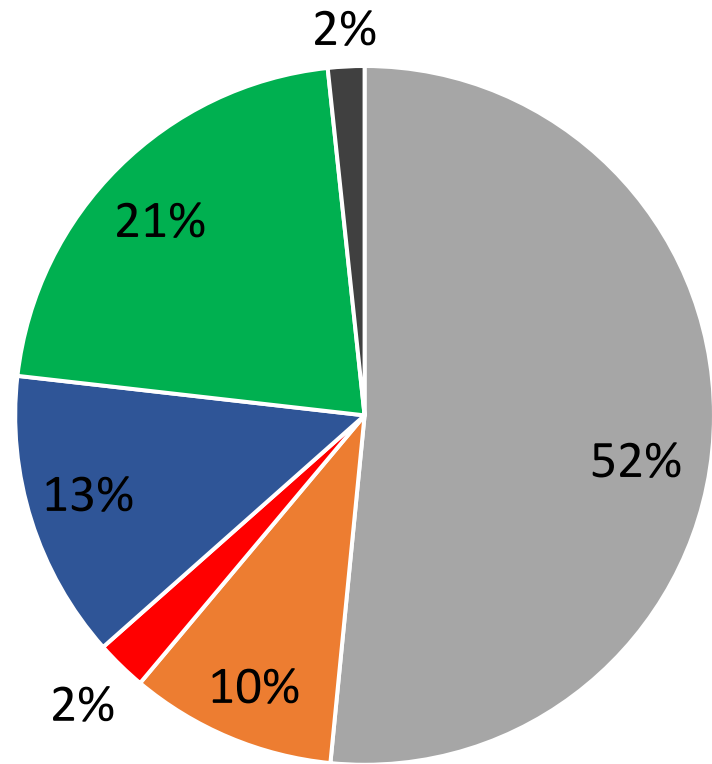


Driver-1 (GDP and Population Growth)

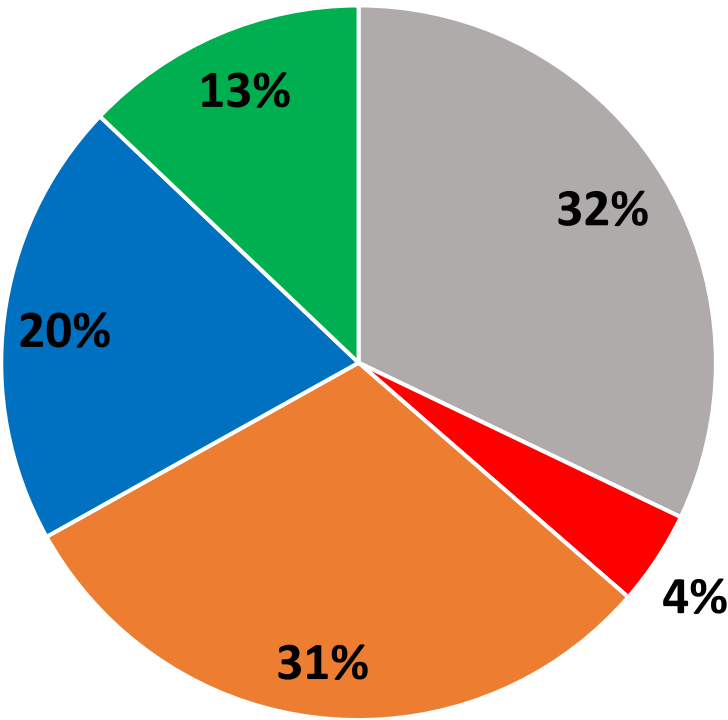
GDP and Population (2019)			
SASEC		SEA Region	
Bangladesh, Bhutan, India, Nepal, Maldives, Myanmar, Sri Lanka		Brunei, Cambodia, Indonesia, Laos PDR, Malaysia, Philippines, Singapore, Thailand	
Population (Mn)	1635	Population (Mn)	606
GDP (US\$ billion)	3171	GDP (US\$ billion)	2926
<u>CAGR (2010-2020)</u>			
GDP	5%		4%

Current Status of Electricity Sector in SASEC and SEA Region

Installed Capacity (SASEC)



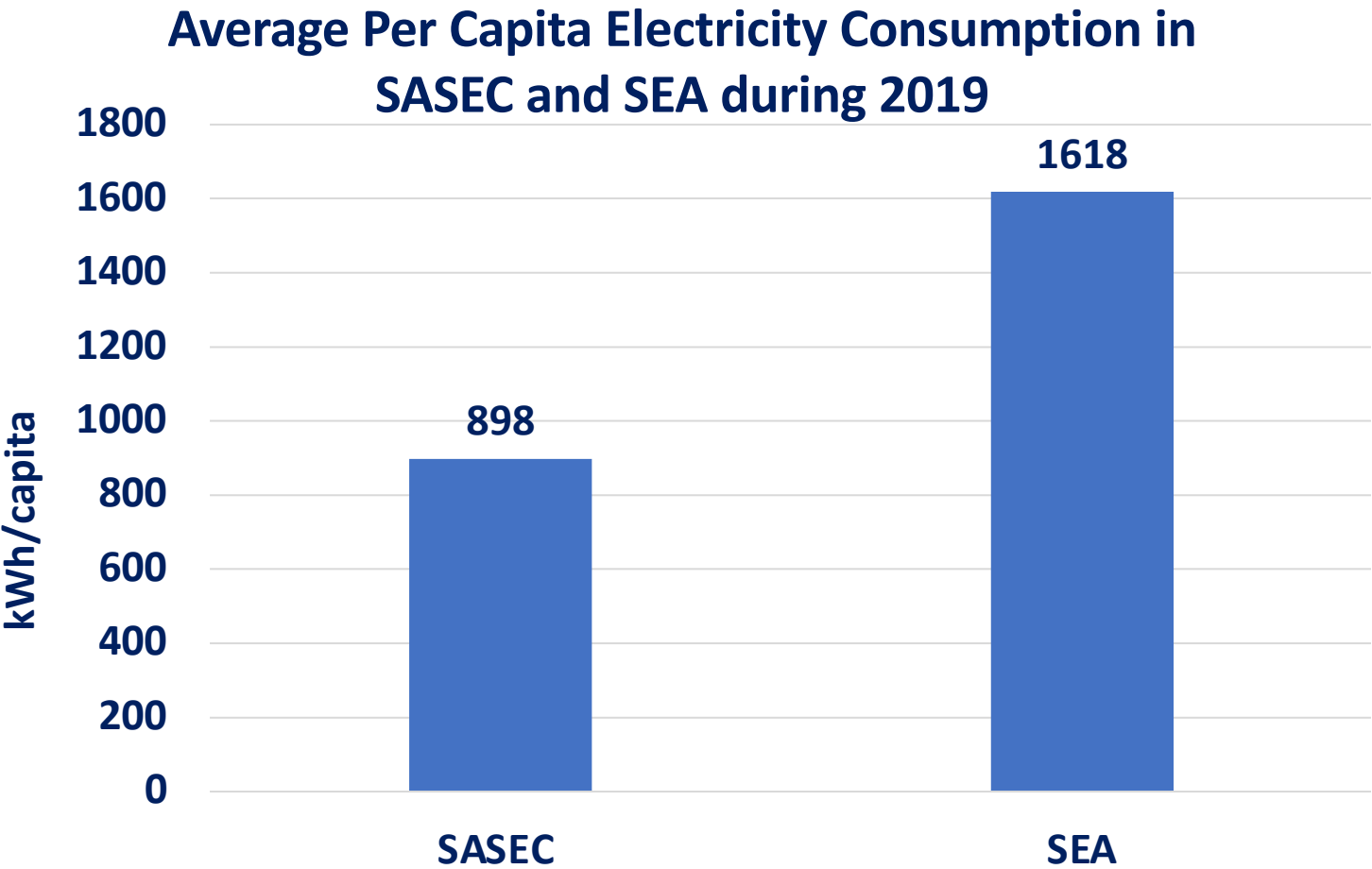
Installed capacity (SEA)



Electricity Sector		
	SASEC	SEA Region
Installed Capacity (GW)	402	286
Fossil Share	64%	67%
No-Fossil Share	36%	33%

■ Coal ■ Natural Gas ■ Diesel ■ Hydropower ■ Renewables ■ Nuclear

Driver-3 (Access and consumption of Electricity)



Electricity Sector		
	SASEC	SEA Region
Generation (TWh)	1911	1105
Consumption (TWh)	1435	980

Driver-4 (Resource Potential)

Resource Availability (GW)				
Renewable Potential	SASEC		SEA	
	Total Potential	Tapped Potential	Total Potential	Tapped Potential
Solar	799	35 (4%)	2288	23 (1%)
Wind	477	38 (8%)	1253	3 (negligible)
Hydropower	375	59 (16%)	222	56 (25%)
Total	1651	132 (8%)	3763	82 (2%)

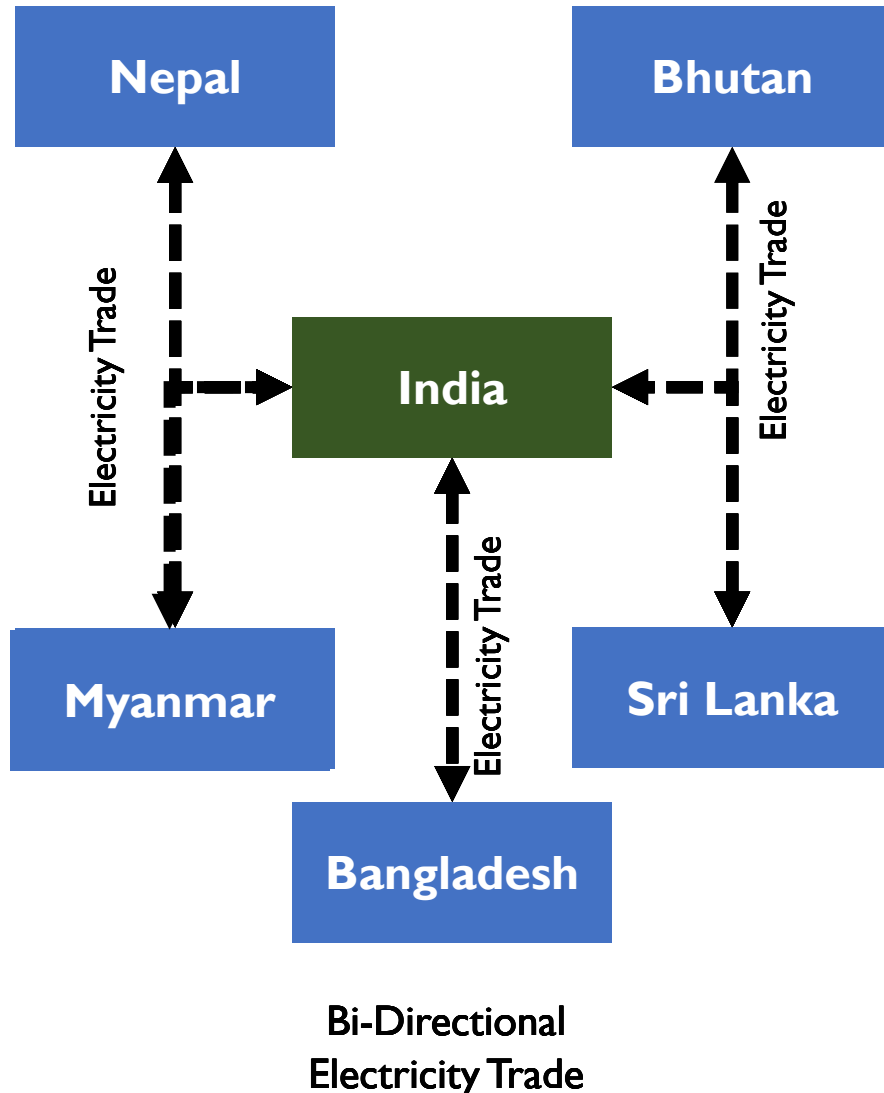
CBET in the SASEC and the SEA Region

	SASEC Region		SEA Region	
Power Market	BBIN Sub-Region	BIMSTEC	Greater Mekong Sub-region (GMS Power Market)	ASEAN Power Market (HAPUA)
Signed in	No Formally Adopted	2005	2002	2004
Member Countries	4	7	6	9
	Bangladesh, Bhutan, India, Nepal	<ul style="list-style-type: none"> Bangladesh, Bhutan, India, Nepal, Sri Lanka Thailand, Myanmar (SEA) 	<ul style="list-style-type: none"> Cambodia, Lao PDR, Thailand, Vietnam Myanmar (part of SASEC) China (Yunnan Province and Gaungxi Zhoung Autonomous region) 	<ul style="list-style-type: none"> Brunei, Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Philippines, Singapore, Thailand, Vietnam Myanmar (SASEC)
Number of Interconnections	16	17	10 Total capacity-5000 MW, at 220/230 KV and 500 KV	16
Nature of Trade	Bilateral	Bilateral	Bilateral and Trilateral PPAs	Bilateral and Trilateral PPAs
Total Electricity Trade (TWh) 2020	16		34	

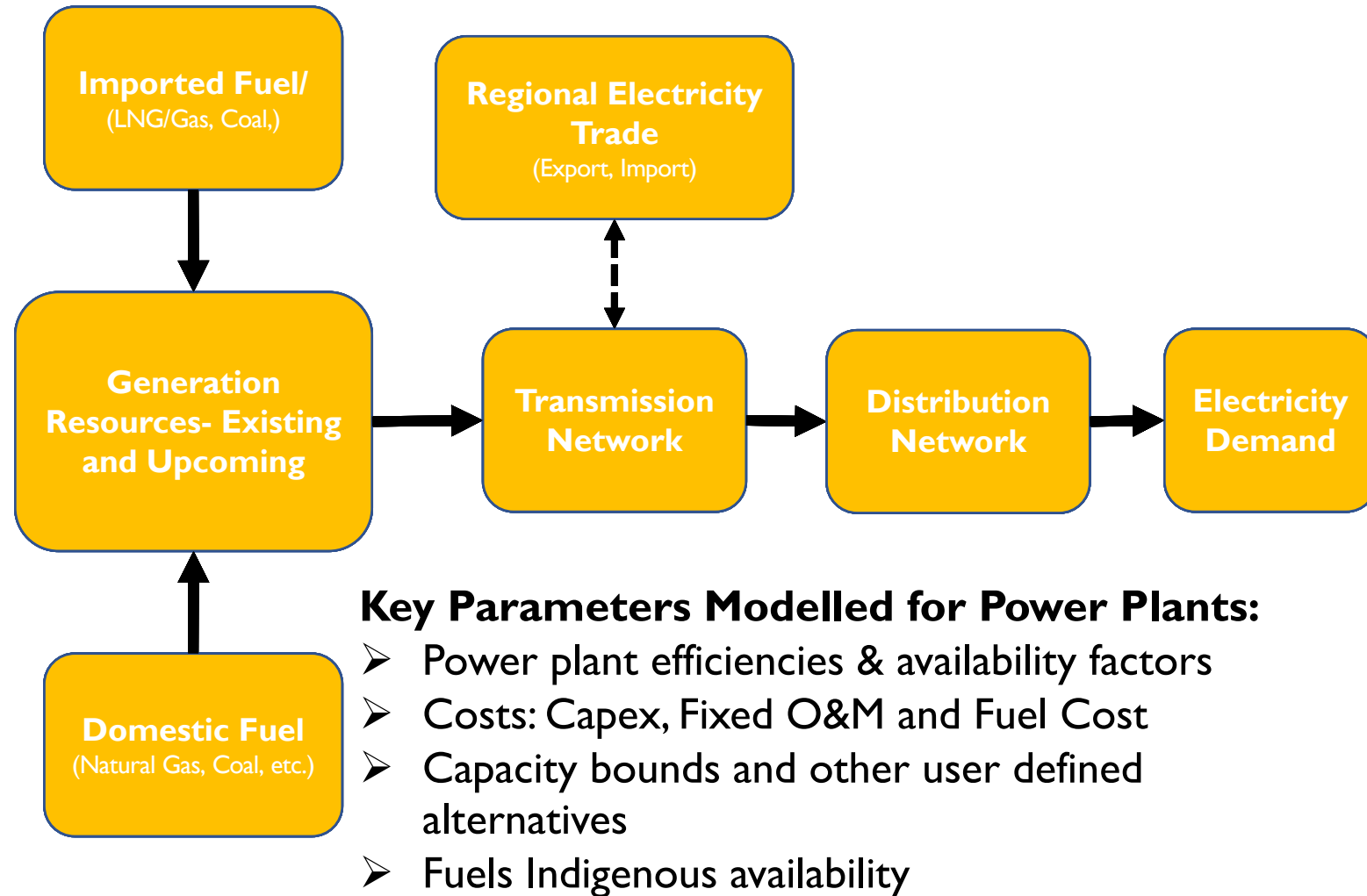
IRADe Model BBIN Interconnectivity (Scenarios and Results)

Reference Energy System (RES) for SASEC model

Regional Level



Country Level



Key Parameters Modelled for Power Plants:

- Power plant efficiencies & availability factors
- Costs: Capex, Fixed O&M and Fuel Cost
- Capacity bounds and other user defined alternatives
- Fuels Indigenous availability

Model Summary

- Macros economic model maximizes discounted cost of private consumption
- Technology model Minimizes discounted cost of operating and capital costs
- Meets demand till 2030, 2040, and 2050
- Daily load curves for 24 hours for every month for 4 countries BBIN
- Resource potentials and costs

Outputs

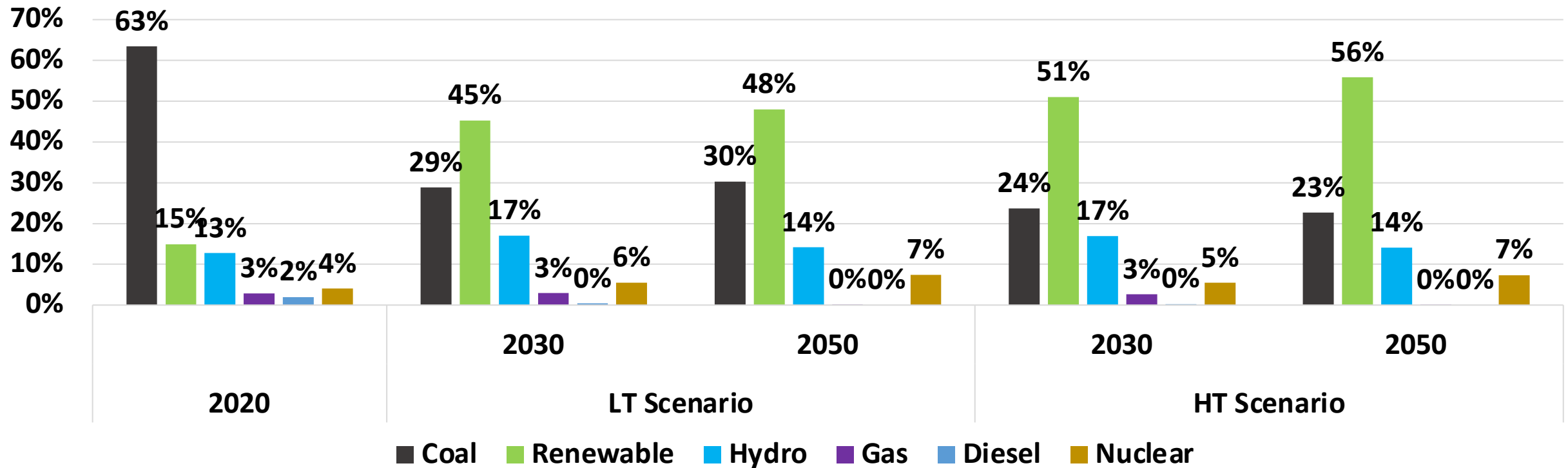
- Iteration between the two models gives economically viable and technologically feasible results
- Capacity mix, costs
- CO2 emissions
- Benefits- Impact on GDP, Consumption, max capacity utilization, CO2, air pollution

IRADe Model BBIN Interconnectivity (Scenarios and Results)

	Low Trade Scenario	High Trade (HT) Scenario
RE Potential	High	Low
Trade Restriction	20% of total domestic demand	No Trade Restriction
Price fall of RE & Storage tech	High	Low

Electricity Generation under LT and HT Scenario

Electricity Generation by Source

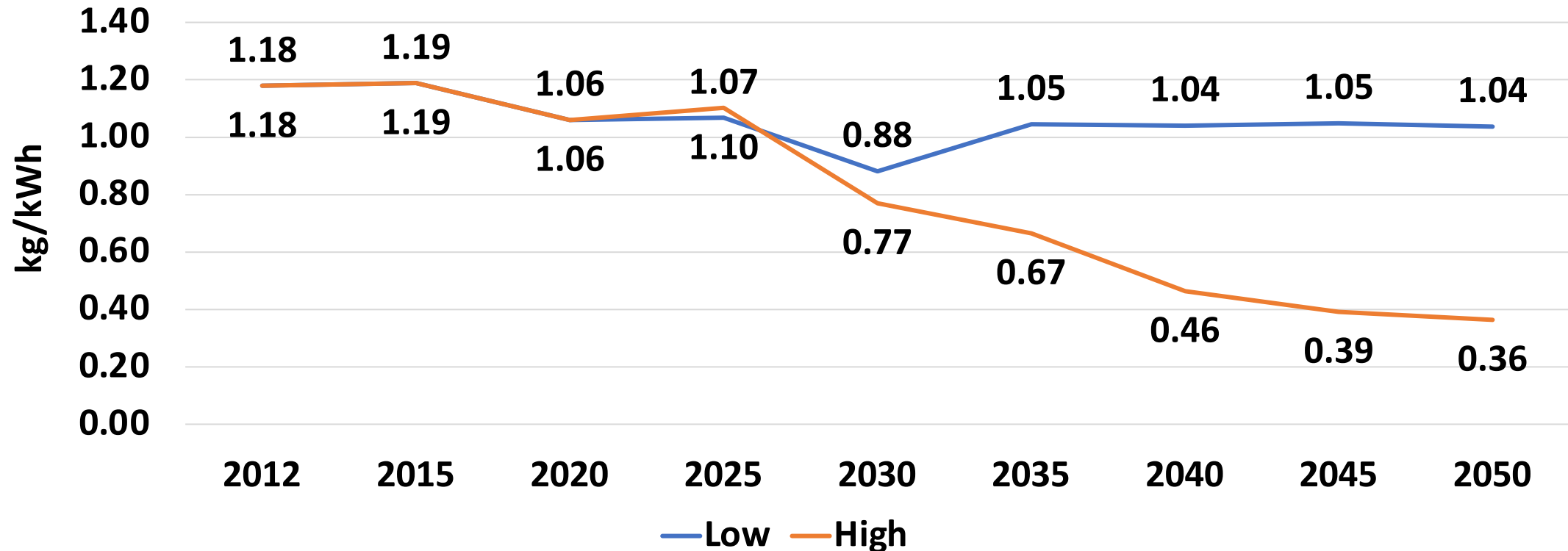


	2050	
	LT Scenario	HT Scenario
Installed Capacity In 2020- 394 GW	1948 GW	2205 GW
Total Generation (TWh)	5882	5916

CO₂ savings in BBIN region

- The energy system of Nepal and Bhutan is highly renewable-based therefore the carbon emissions are already low
- In HT scenario BBIN region saves approximately **405 MT of annual CO₂ from power sector.**

CO₂ emission Kg/kWh in BBIN Region in LT and HT scenarios



- In IRENA the share of Non-fossil is higher because of High RE potential, CO2 reduction and less fossil potentials.
- Demand is considered higher in IRENA, therefore installed capacity is much higher than the ATS scenario

Electricity Generation in ASEAN Region in ASEAN and IRENA scenarios (TWh)

	2030		2050	
	ATS Scenario	IRENA TES Scenario	ATS Scenario	IRENA TES Scenario
Non-Fossil share	524	885	1294	3932
	35%	46%	50%	76%
Fossil Share	965	1020	1273	1253
	65%	54%	50%	24%
Total	1489	1905	2567	5186

Annual CO2 Emissions from Electricity Sector in SEA region

	2030		2050	
	ATS Scenario	IRENA TES Scenario	ATS Scenario	IRENA TES Scenario
CO2 from power sector (MT)	736	848	860	74
CO2 emissions kg/kWh	0.49	0.45	0.34	0.01

- Due to high renewable shares in IRENA TES scenario, CO2 emissions fall drastically in 2050.
- IRENA scenario saves **786 MT CO2 annually in 2050**.
- SASEC and SEA can lead to higher penetration of RE in power system and save more CO2

Electricity Generation in SASEC and ASEAN Region

Installed Capacity (GW)	2020		2030		2050	
	SASEC	ASEAN	SASEC	ASEAN	SASEC	ASEAN
			LT Scenario	TES Scenario	LT Scenario	TES Scenario
Non-Fossil	37%	33%	72%	53%	82%	83%
Fossil	63%	67%	28%	47%	18%	17%
Total	393	278	971	591	1950	2537
Electricity Generation (TWh)						
Non-Fossil	31%	24%	40%	46%	53%	76%
Fossil	68%	77%	60%	53%	46%	24%
Total	1506	1126	2594	1905	5880	5186
	<u>CO2 Emissions</u>					
Co2 Emissions power sector (MT)	1125	697	735	848	1533	7
co2/kg	0.75	0.62	0.28	0.45	0.26	0.01

- **More number of interconnections is required for effective trade of electricity.**
- Informal or formal groups within BIMSTEC, ASEAN, HAPUA, GMS countries can deliberate to build consensus and agree on the institutional arrangements
- Recognize that regional connectivity with international co-operation has a legitimate place in the power sector planning and promote it in all decisions, policies and actions
- Develop power markets for spot trading, day ahead and term ahead markets. Use them to maximize RE capacity in all the countries of both the regions, allowing power to flow from the neighboring countries
- Carry out capacity building and awareness programs amongst all levels of power system stakeholders, planners, grid operators, investors, consumers, politicians and decision makers

- **Less storage to Support Renewables**

- Non-fossil share increases upto 78% in BBIN by 2050.
- Non-Fossil share increases 50 to 75% in ASEAN region by 2050.

- **CO2 Reduction**

- **Saves 405 MT of annual CO₂ from power sector in BBIN region in 2050**
- **786 MT CO₂ annually in 2050 in ASEAN.**

- **Higher System Efficiency**

- **Time Diversity**

- **Immediate availability of power without Gestation for Economic Needs**

Economic Benefits

- **Transformation for Small Countries**
- **Another Growth Path- Nepal, Bhutan Accelerating Economic Growth**
- **Bangladesh, Thailand Save Costs**
- **Efficiency increases India**
- **Everyone Benefits to varying Degrees.**



Thank You
This was Supported by ADB

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Existing transmission interconnections

• India – Bangladesh

- Baharampur (India) – Bheramara (Bangladesh) 400kV D/C lines along with 2x500 MW HVDC back-to-back terminal at Bheramara.
- Surajmaninagar (Tripura) - Comilla (Bangladesh) 400kV (operated at 132KV) interconnection.

• India – Bhutan

- Presently the Cross Border connections are as below (132 KV and above).
- **Connected to Eastern Region (ER) of India**
 - 400kV, 2xD/C Twin Moose line, Tala-Siliguri with LILO of one circuit at Malbase S/S;
 - 220kV, 1xD/C line, Chukha- Birpara
 - 220kV, 1xS/C line, Chukha- Malbase-Birpara
 - 400kV, 1xD/C Quad Moose, Jigmeling to Alipurduar.
 - 400kV, 1xD/C Quad Moose line Punatsangchu II - Lhamoizingkha – Alipurduar
- **Connected to North Eastern Region (NER) in India**
 - 132 kV, 1xS/C line, Motanga-Rangia
 - 132kV, 1xS/C line, Gelephu-Salakati

Existing transmission interconnections

- **India – Nepal**

- Presently the Cross Border connections are as below (132 KV and above).
- **Connected to ER (Eastern Region) in India** : Muzaffarpur (India) - Dhalkebar (Nepal) - 400kV D/C transmission line.
- **Connected to NR (Northern Region) in India** : Tanakpur (India)- Mahendranagar (Nepal) 132KV Line
- Kataiya (ER of India) - Kusaha I – 132 kV
- Kataiya (ER of India) - Kusaha II– 132 kV
- Ramnagar (ER of India) – Gandak– 132 kV
- Raxual – Parwanipur (ER of India) – 132 kV

- **India-Myanmar**

- Moreh (NER) -Tamu 11 kV

Existing Transmission Connections in SEA region

Laos – Thailand		Laos – Vietnam	
1	Vientiane – Nong Khai	18	Xekaman 3 – Thanmy
2	Pakxan – Bueng Kan	19	Xekaman 1 – Pleiku
3	Thakhek – Nakhon Phanom	Cambodia – Vietnam	
4	Savannakhet – Mukhadan	20	Chau Doc – Phnom Penh
5	Bang Yo – Sirindhorn	Laos – Cambodia	
6	Na Bong - Udon Thani 3 50	21	Ban Hat – Khamponsalao
7	Nam Theun 2 – Savannakhet, Rot Et 2	Thailand – Cambodia	
8	Hoouay Ho – Ubon Ratchathani 2	22	Watthana Nakhon – Siam Preap
9	Thakhek – Nakhon Phanom 2	Thailand – Malaysia	
10	Houay Ho - Ubon Ratchathani 2	23	HDVC Khlong Ngae – Gurun
11	Hongsa – Nan	24	Sadao – Bukit Keteri/Chuping
12	Xaiyaburi – Thali	Malaysia – Singapore	
13	Thanaleng – Nong Khai	25	Plentong – Senoko
14	Phone Tong – Nong Khai	Malaysia – Indonesia	
15	Pakbo – Mukdahan 2	26	Mambong – Bengkayan
16	Xe-Pain Xe-Namnoy – Ubon Ratchathani 3		
17	Bangyo – Sirindhorn 2		

India and Bangladesh

Year	S.No	Name of Link
2030	Katihar (India) - Parbotipur (Bangladesh) - Bornagar (India) 765 kV D/C with 1500MW 765/400kV S/s at Parbotipur	
2035	3 rd	500 MW HVDC (BTB) Terminal at Bheramara
	Operation of Surajmaninagar (Tripura, India), Comilla (Bangladesh) 400kV	

India and Nepal

Year	S.No	Name of Link
2030	(i)	Purnea (New)- Inaruwa 400kV D/c (Quad Moose) line
2035	(i)	Bareilly - New Lumki (Dododhara) 400kV O/c (Quad Moose) line
	(ii)	Lucknow (India) - Kohalpur (Nepal) 400 kV D/c

India and Bhutan

Year	S.No	Name of Link
2030	i	Alipurduar - Sankosh 400kV O/C Quad Moose
	ii	Near Rangia/Rowta - Yangbari 400kV O/C Quad Moose
	iii	Near Rangia-Phuntshothang 400kV D/C Twin Moose
2035	i	Near Rangia/Rowta - Yangbari 400kV D/C Quad Moose

India and Sri Lanka

Year	S.No	Name of Link
2030	(i)	India (Madurai New) :... Sri Lanka (New Habarana)
2035	(i)	±320 kV, 500MW VSC Bipole HVDC based link
	(ii)	±320kV, 500MW VSC Bipole HVDC based link

Myanmar and Thailand

Year	S.No	Name of Link
2030	(i)	Mawlamyine (Myanmar) - Phitsanulok (Thailand) 500 kV D/c line with 1_x250MW HVDC (BTB) Terminal at Phitsanulok
		OR
		Mawlamyin e (Myanmar) - Mae Sot (Thailand)500kV D/c line with 500MW HVDC (BTB) at Mae Sot
2035	(i)	2nd 250 MW HVDC (BTB) Terminal at Mae Sot/ Phitsanulok (Thailand)

India and Myanmar

Year	S.No	Name of Link
2030	i	Imphal - Tamu 400kV O/c line Twin ACSR Conductor
	ii	1st 500MW HVDC (BTB) Terminal at Tamu
	iii	Low Voltage Radial Connection from Arunachal Pradesh, Manipur and Nagaland
2035	i	2nd 500MW HVDC (BTB) Terminal at Tamu