Transmission System Expansion Planning:

Context of Clean Energy Transition and Cross Border Power Link

By

Dr. Netra P Gyawali

Rastriya Prasaran Grid Company Limited

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Agenda of Discussion

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1. **TS Expansion Plan: Overview**
2. **TS Expansion Plan: Nepal**
3. **TS Expansion Plan: SAR**
4. **Maximizing the Transmission Services**
5. **Outlook**

1. TS Planning: Purpose and Attributes

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- Purpose of Transmission Planning -
  - Determine the lowest possible cost, transmission and substation additions
  - which render the transmission network to be able to wheels power with given criteria
- Inputs
  - Load Forecast (Time, Location, Type, year, etc)
  - Generation Expansion Plan (Time, Location, Type, year, etc.)
  - Integration of Renewables
- Issues & Concerns
  - Economic and Financial Constraints
  - ROW Limitations
  - Various Uncertainties and Risks
  - Service Reliability and Cost Considerations

1. TS Planning: An Optimization problem

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TS expansion planning is basically the optimized solution among the alternatives

- Objective functions: *Cost (Transmission (O+M), Generation (O+M), Outage)*
- Constraints: *Generation Capability, Power Flow, Voltage regulation, Reliability, Network Capacity,..)*
- *Associated with the Generation Planning*

1. TS Planning: Network Analysis

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Normal Conditions

- All circuit in-service,
- No equipment loaded above 100 percent of normal *rating,*
- Voltage in the transmission system in the range of 95 *to 105 percent of rated kV.*

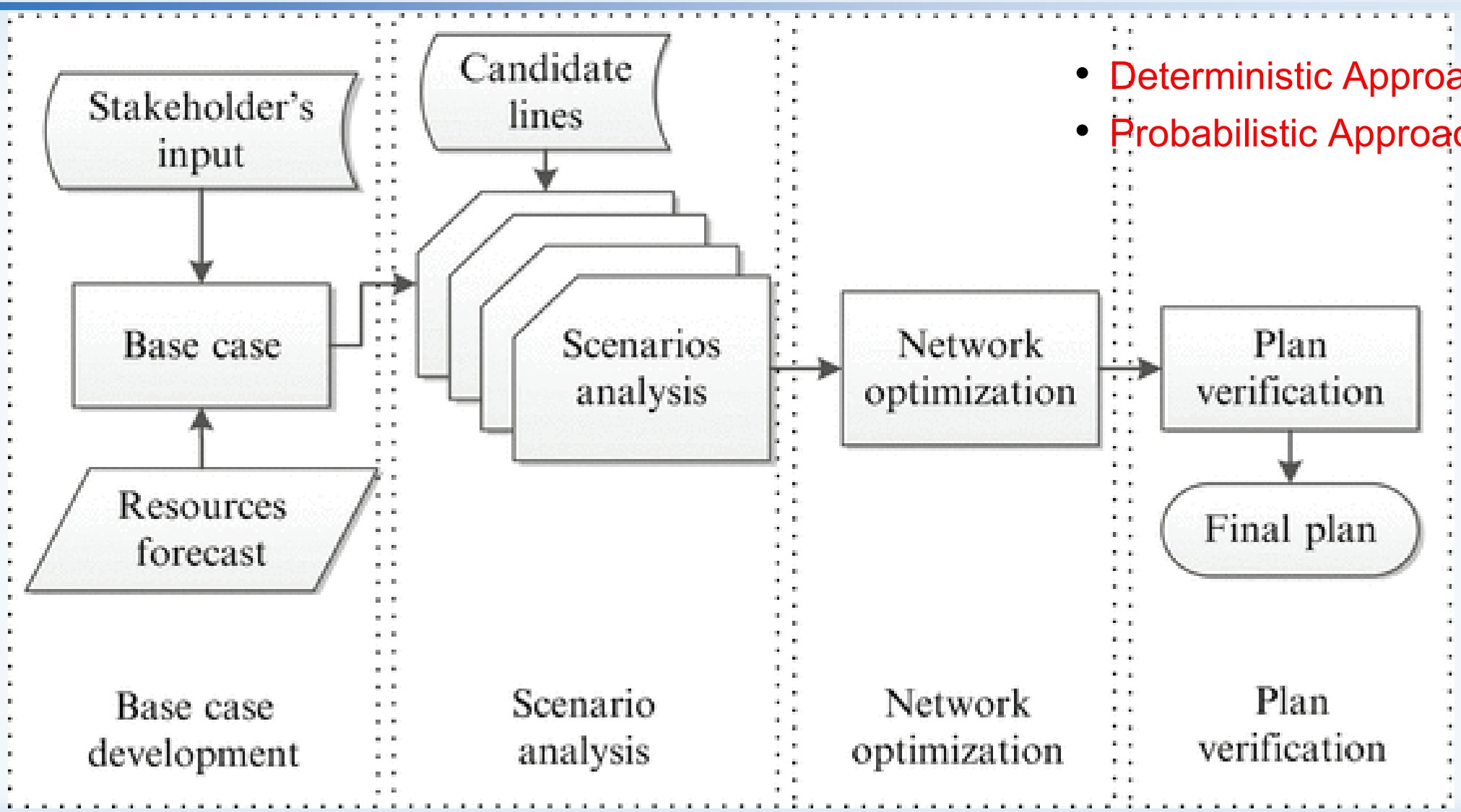
Faulted Conditions (N-1)

- Loss of any ONE unit among the N units
- Outage of one circuit, one bus bar, one generating unit etc
- Voltage throughout the system remain within the range of 90 to 105 percent of rated value
- No equipment loading shall exceed 120 of percent of normal rating,

Stress Condition(N-1-1):

- *Both circuit out (Tower collapse, both breaker out etc)*
- *No equipment loading shall exceed 120 (?) percent temporarily,*

1. TS Planning: Process



- Deterministic Approach
- Probabilistic Approach

1. TS Planning: Integrating Renewables

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Generators and Load connected with TLs (Before Renewables)

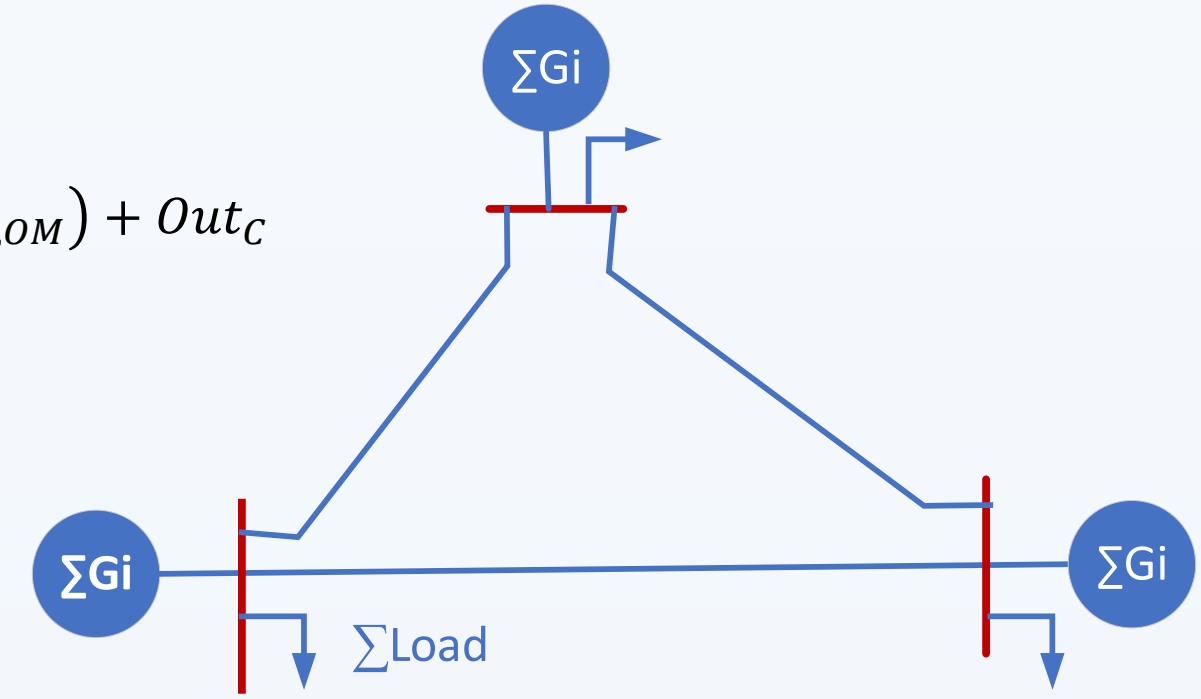
Optimization Problem

Min:

$$Total\ C = \sum_{i=1}^{n} \left(GC_{i,cap} + GC_{i,OM}\right) + \left(TC_{i,cap} + TC_{i,OM}\right) + Out_C$$

Constraints:

- **Generation constraints**
- **Power balance**
- **Network Constraint**



1. TS Planning: Integrating Renewables

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Integrating the Renewables on existing system

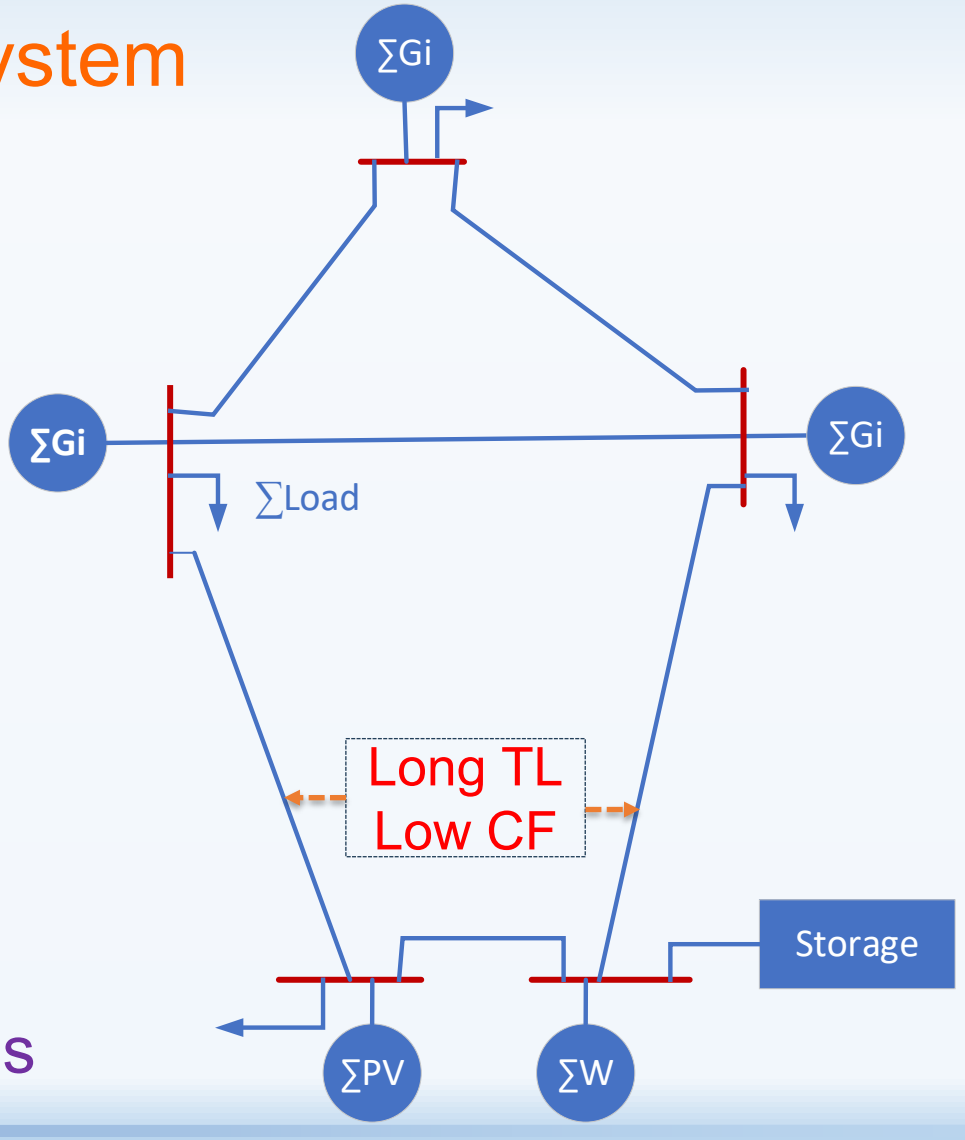
Optimization Problem

Min:

$$Total\ C = \sum \left(GC_{i,cap} + GC_{i,OM}\right) + \left(TC_{i,cap} + TC_{i,OM}\right) + EC + ESS + OutC$$

Constraints:

- **Generation constraints**
- **Power balance**
- **RPO constraints**
- **So on -**



TEP often be financially infeasible: need incentives

2. TS Master Plan of Nepal

Objective

- Identify and develop a robust, reliable and secure Integrated Nepal Power System (INPS) network to evacuate and transmit the power for meeting local demand and cross border export

2. TSMP of Nepal

- **TS Development Basis:**
  Technical and economical hydropower potential of Nepal

Major River Basins	Theoretical Potential in MW			Technical Potential		Economical Potential	
	Major river courses having catchments areas above 1000 km²	Small river courses having catchments areas 300-1000 km²	Total	Number of Project Sites	Technical Potential in MW	Number of Project Sites	Economical Potential in MW
Sapta Koshi	18750	3600	22350	53	11400	40	10860
Sapta Gandaki	17950	2700	20650	18	6660	12	5270
Karnali and Mahakali	32680	3500	36180	34	26570	9	25125
Southern River	3070	1040	4110	9	980	5	878
Country Total	**72450**	**10840**	**83290**	**114**	**45610**	**66**	**42133**

2. TSMP of Nepal

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Required Load for the 7.2% GDP (WECS report, 2017)

Table 6: Total load demand in different scenarios[5]

	BAU 4.50%	Reference Scenario 7.20%	High Scenario 9.20%	7.2% growth with policy intervention	9.2% growth with policy intervention
2020	4338.32	2225.65	2338.80	4080.75	4199.67
2025	7419.09	4078.60	4540.37	6155.51	6658.61
2030	11457.67	6848.43	8195.05	9696.24	11323.55
2035	16977.56	11171.23	14539.20	14206.80	18017.18
2040	24552.9	**18137.67**	26028.24	22490.50	31638.14

2. Transmission Plan Nepal: Present

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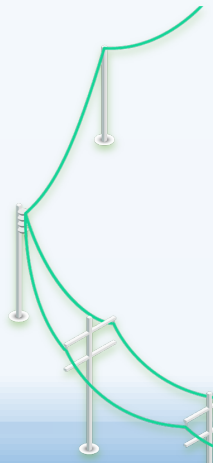
Item	Capacity in MW
Installed Capacity	2600+
Applied for PPA	11000+
Application for Survey	7600+
IBN Projects	4200
Expected Installed (2030-2035)	17000
Available for Export (2030-2035)	10000+
Solar PV (Survey+UC)	900



2. TSMP of Nepal: Scope of Work

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- **Design of the INPS transmission network considering the generation, load and export for the year 2040**
  - Generation capacity: 38 GW
  - Domestic Load Demand: 18GW
  - Export :17GW
  - Spinning Reserve: 3GW
- **Power System Analysis using software techniques to examine the effectiveness of the proposed network**
  - Load Flow Analysis
  - Contingency Analysis
  - Short Circuit Analysis
  - Dynamic Study

2. TSMP of Nepal: (Year 2025)

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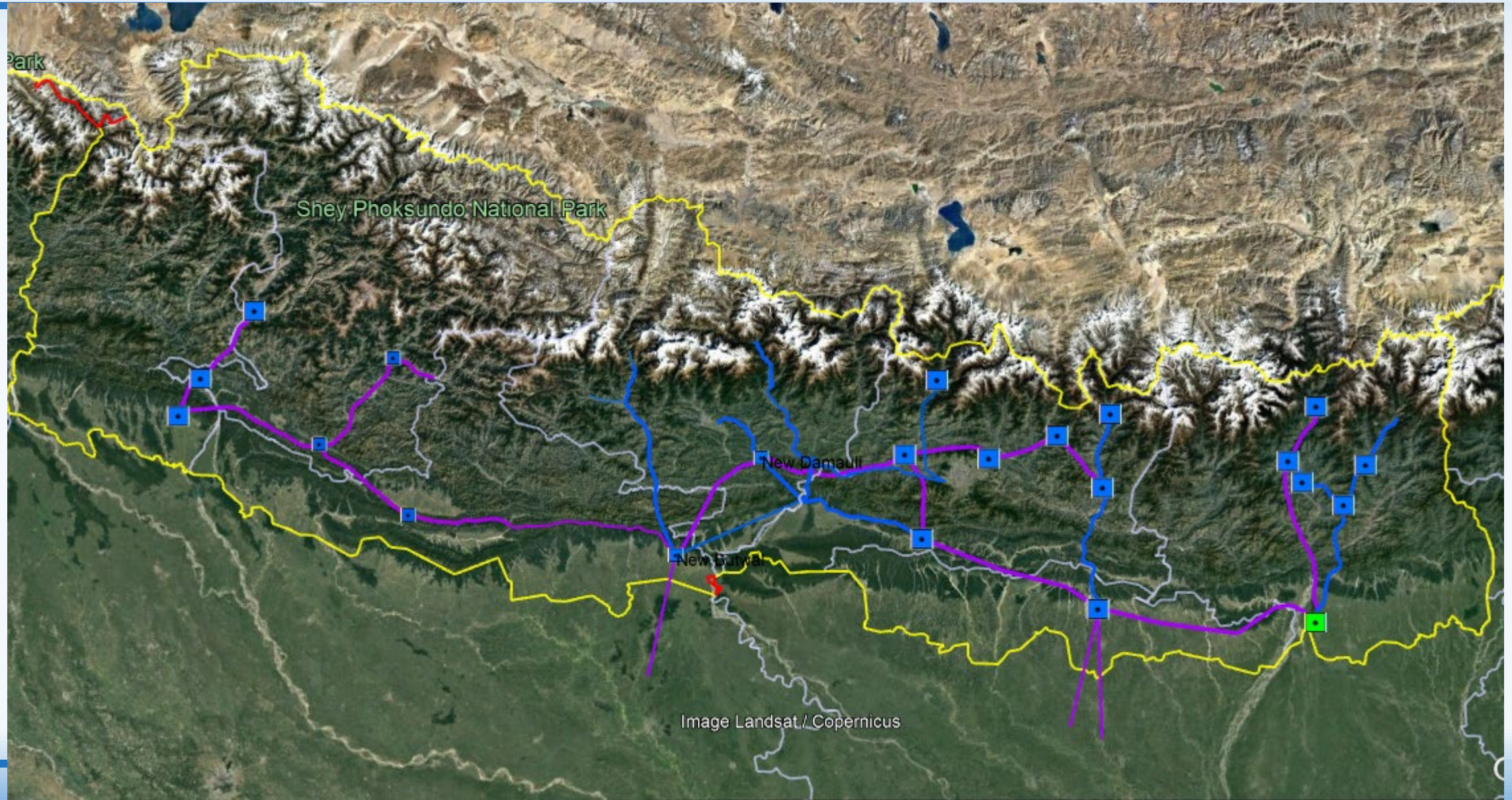

2. TSMP of Nepal: Year 2030

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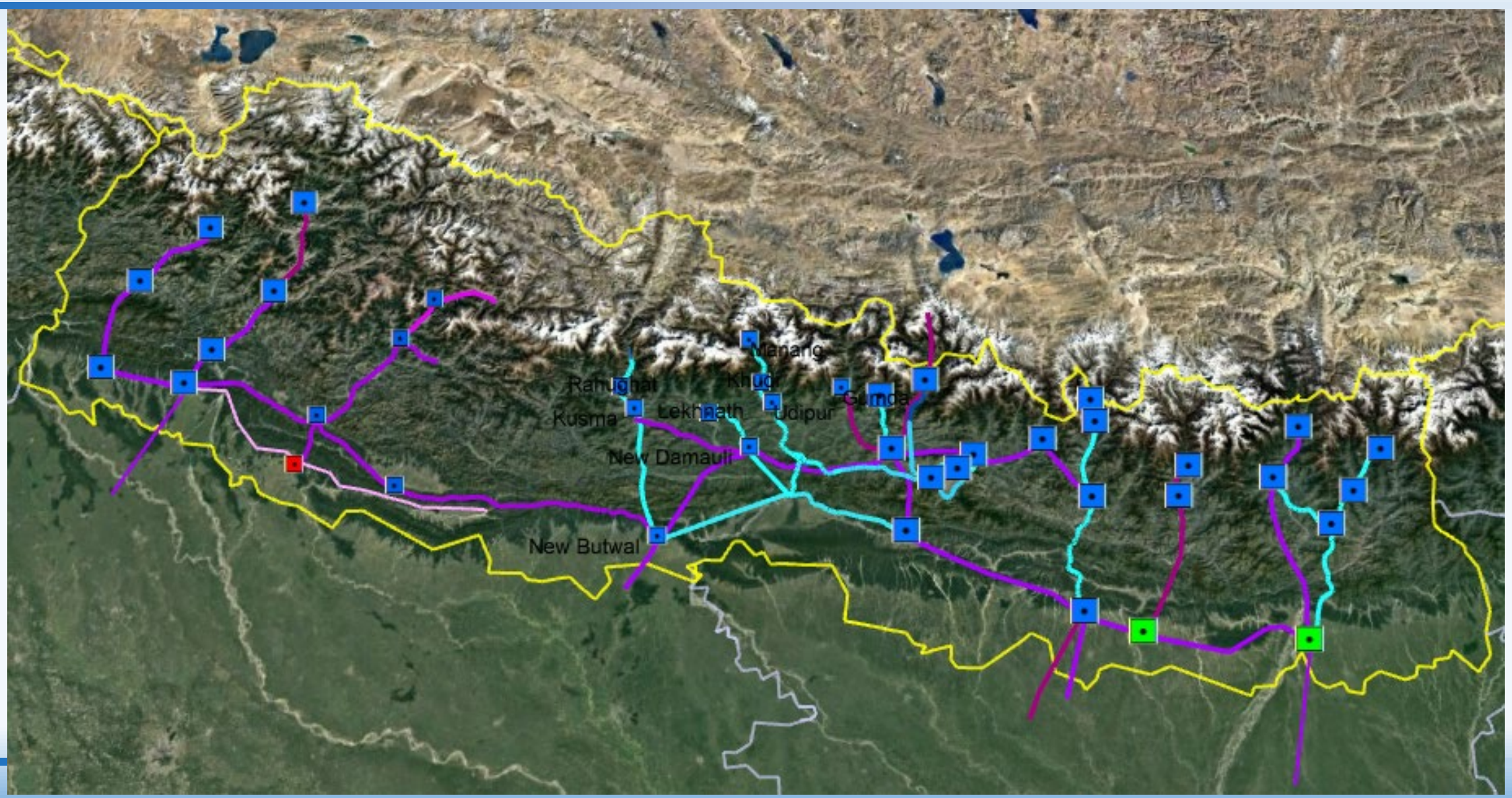

2. TSMP of Nepal: (Year 2040)

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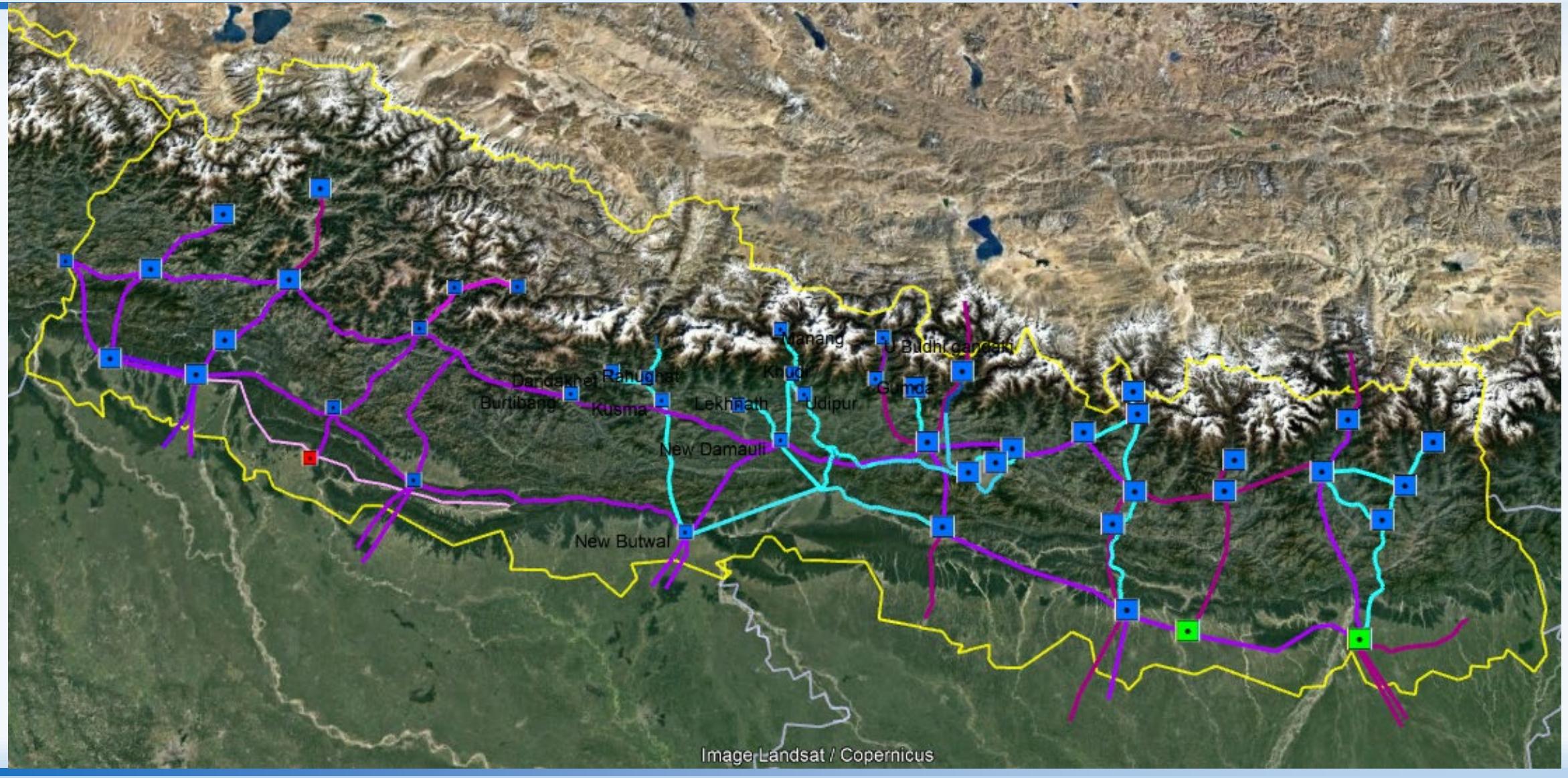
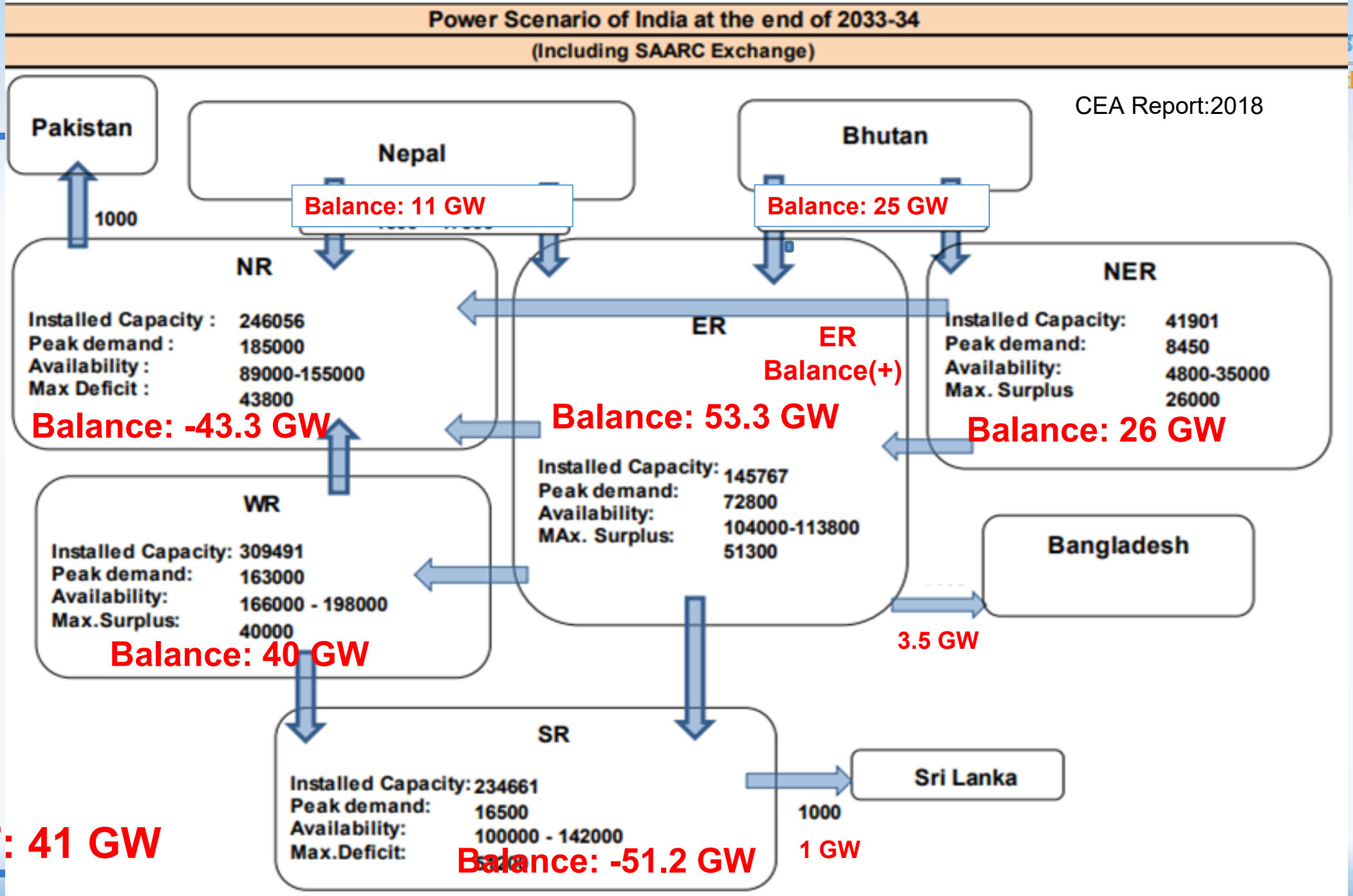


2.TS Master Plan: Integrating Other Renewables

- Hydro is major electricity generation source, as the low hanging fruit;
- Solar Power is uniformly distributed and relatively untapped;
- Solar and Hydro are Complementary in Transmission Use, no additional EHV needed.

2. TS Master Plan:SAR

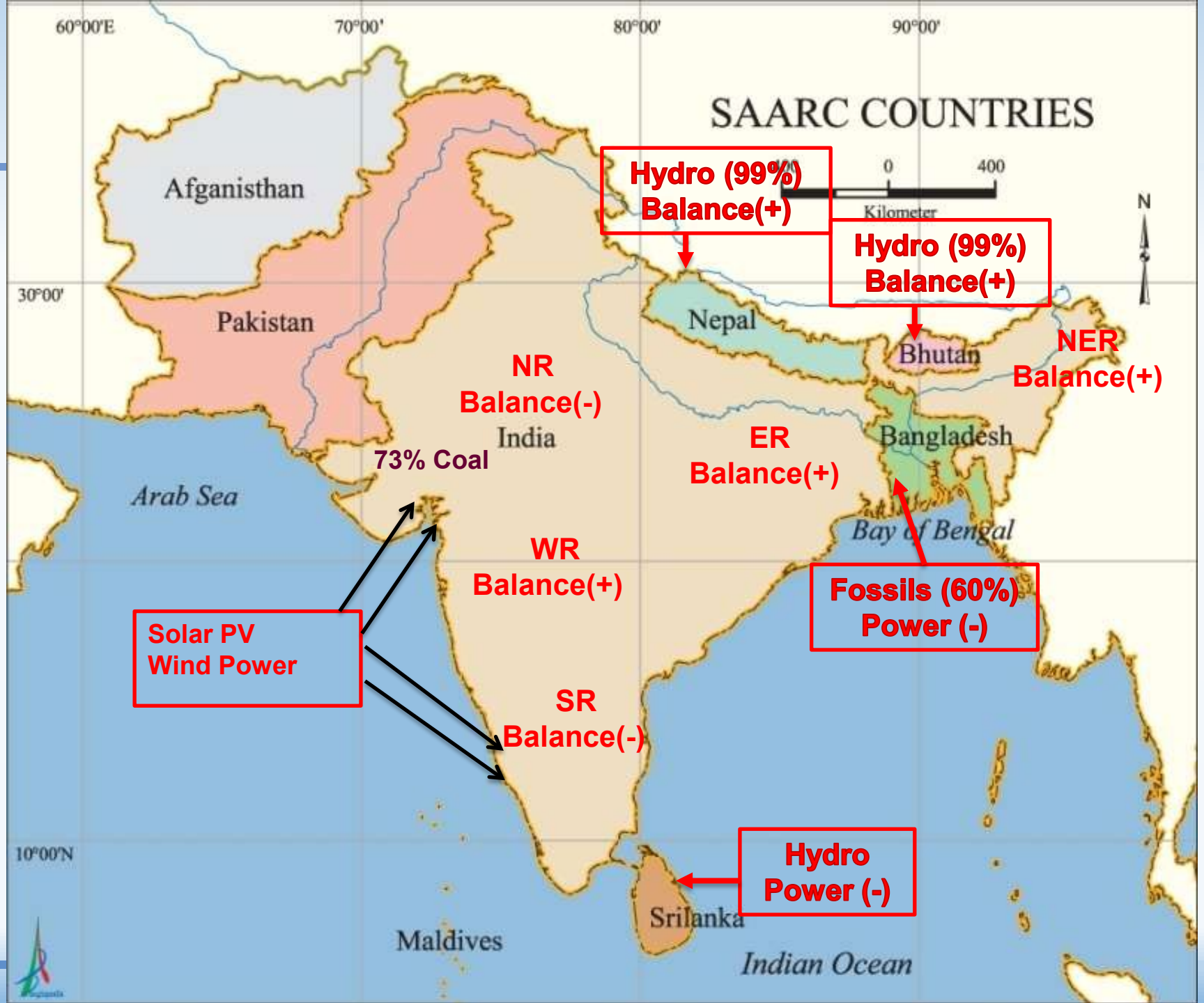
2. Transmission System Plan: SAR

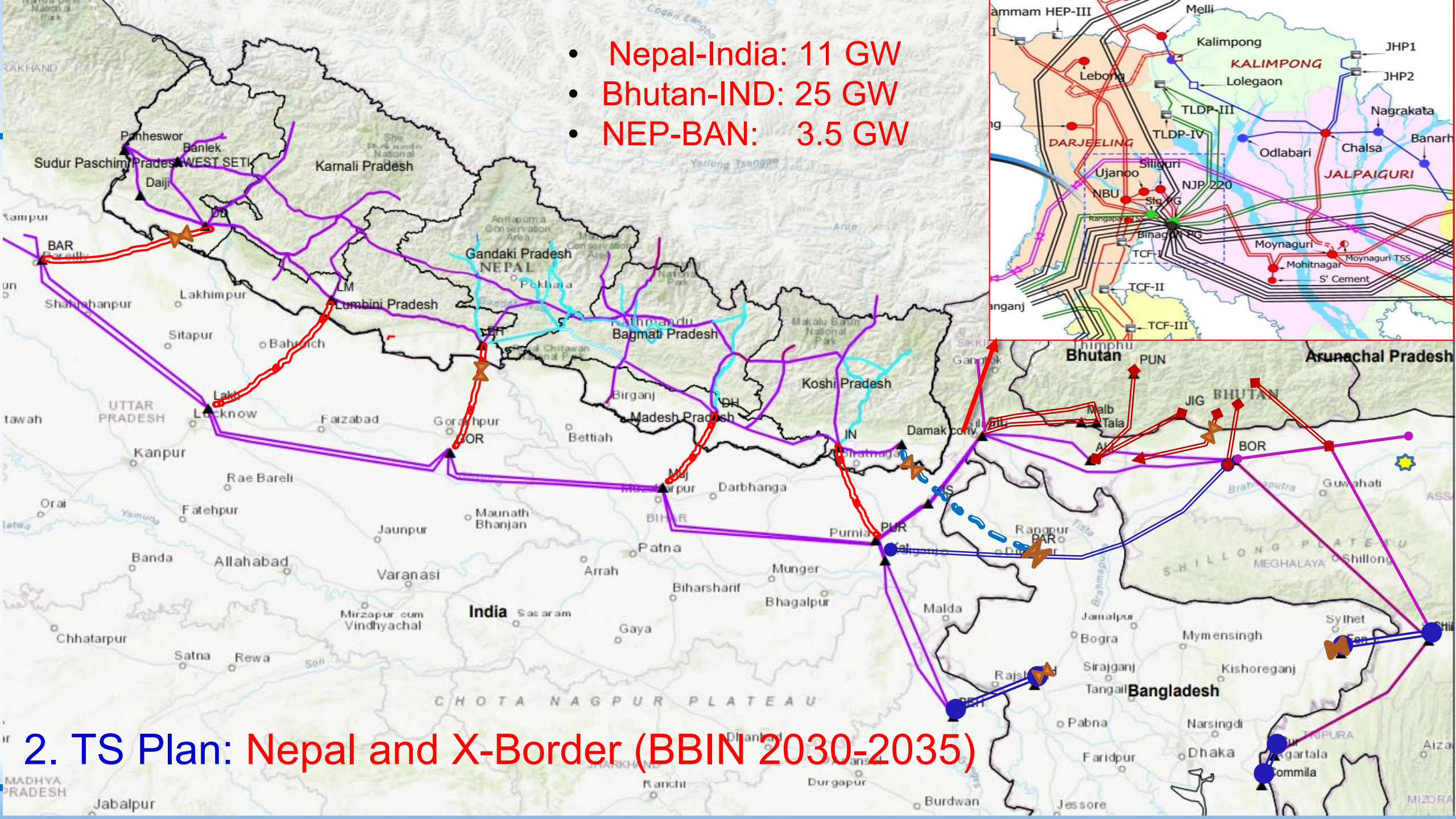


CBET: 41 GW

Integrating Other Renewables

- Energy Mix in SAR
- Hydro in Nepal and Bhutan support
  - Grid Sustainability
  - Increase Penetration level of Wind Solar in SAR

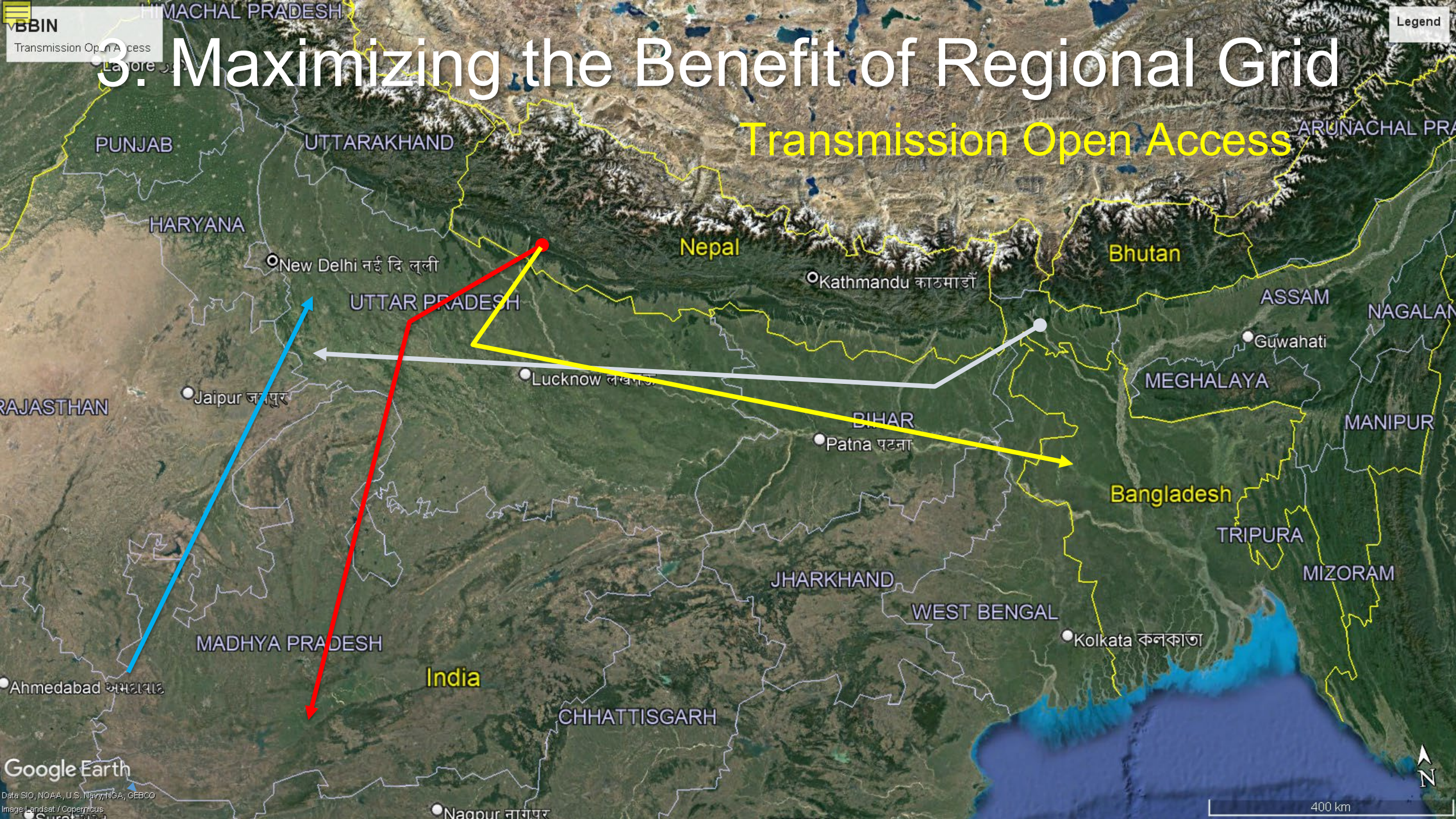




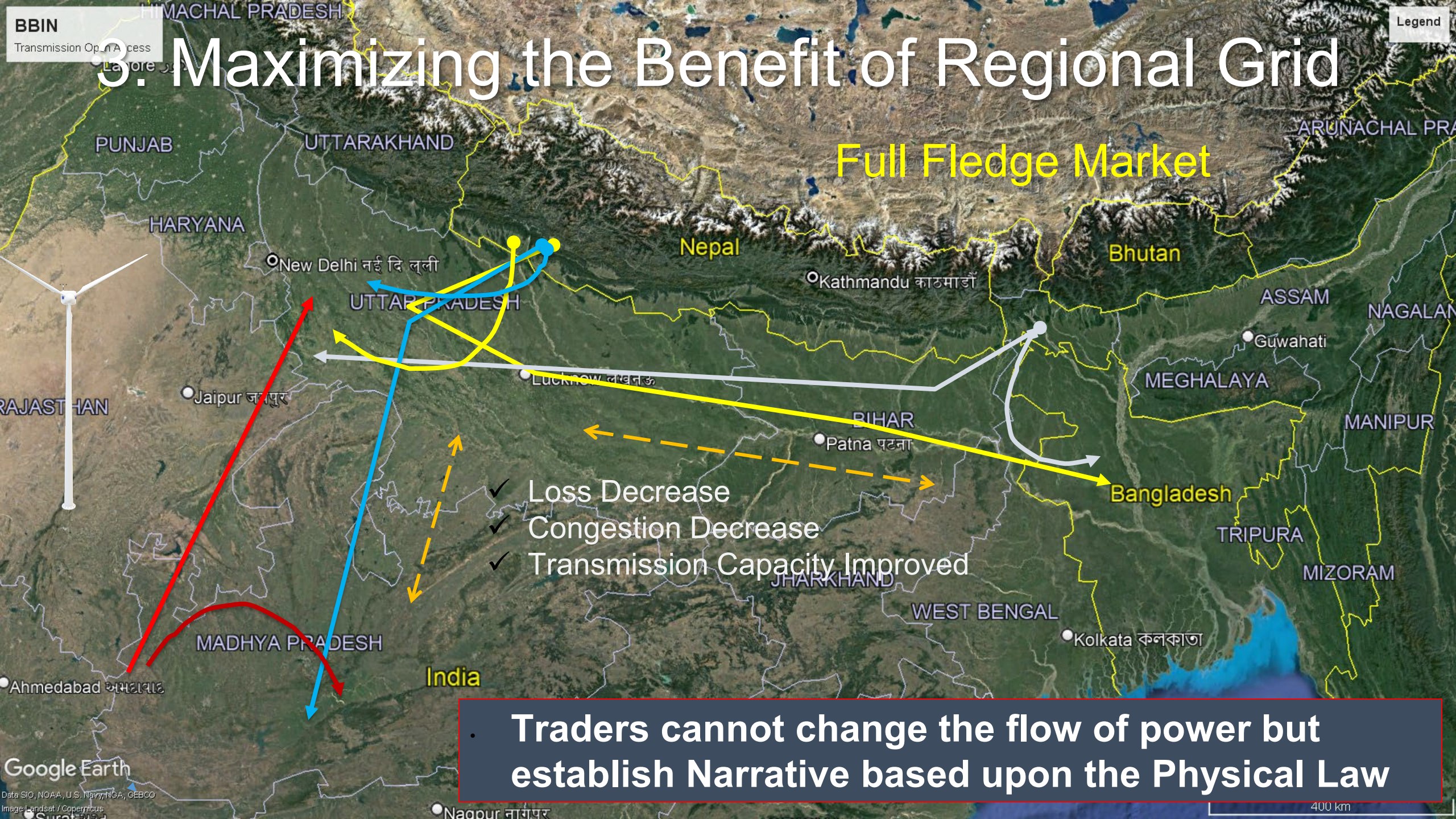
2. TS Plan: Nepal and X-Border (BBIN 2030-2035)

3. Maximizing the Transmission Service in SAARC

- Open Access in SAARC Network
- Full Fledged Electricity Trading


BBIN
Transmission Open Access
Legend
3. Maximizing the Benefit of Regional Grid
Transmission Open Access
HIMACHAL PRADESH
PUNJAB
UTTARAKHAND
HARYANA
New Delhi नई दिल्ली
Nepal
Kathmandu काठमाडौं
Bhutan
UTTAR PRADESH
Lucknow लखनऊ
Jaipur जयपुर
RAJASTHAN
BIHAR
Patna पटना
ASSAM
Guwahati
MEGHALAYA
NAGALAND
MANIPUR
Bangladesh
TRIPURA
MIZORAM
JHARKHAND
WEST BENGAL
Kolkata কলকাতা
MADHYA PRADESH
India
Ahmedabad અમદાવાદ
CHHATTISGARH
Nagpur नागपुर
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
400 km
N

3. Maximizing the Benefit of Regional Grid



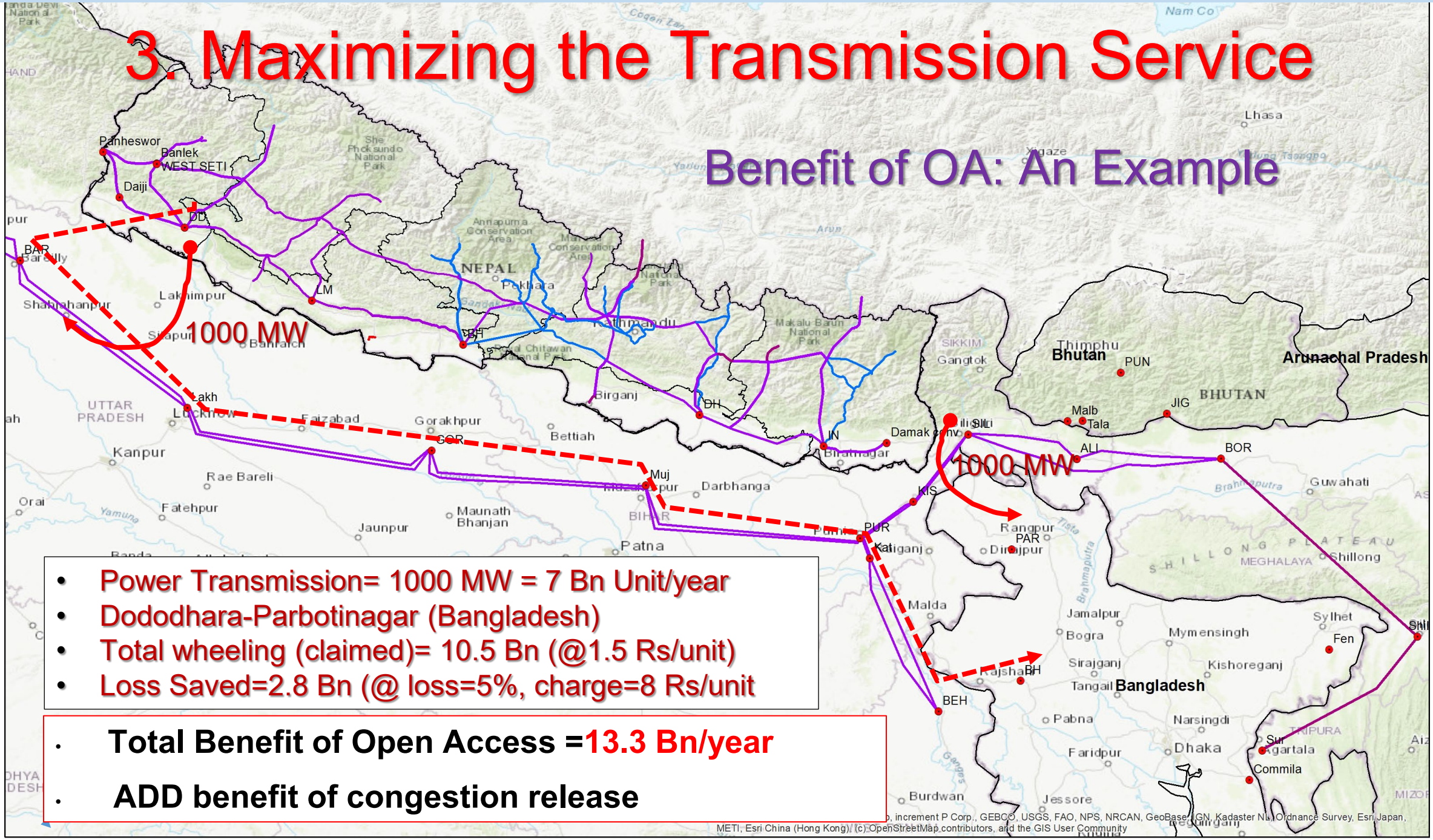
Full Fledge Market

- ✓ Loss Decrease
- ✓ Congestion Decrease
- ✓ Transmission Capacity Improved

- **Traders cannot change the flow of power but establish Narrative based upon the Physical Law**

3. Maximizing the Transmission Service

Benefit of OA: An Example



- Power Transmission= 1000 MW = 7 Bn Unit/year
- Dododhara-Parbotinagar (Bangladesh)
- Total wheeling (claimed)= 10.5 Bn (@1.5 Rs/unit)
- Loss Saved=2.8 Bn (@ loss=5%, charge=8 Rs/unit

- **Total Benefit of Open Access =13.3 Bn/year**
- **ADD benefit of congestion release**

5. Outlook and Way forward

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- **Go beyond Cost Minimization in TEP and implement a multi-value benefit framework;**
  - Clean Energy Integration
  - Complementary Benefits
  - Resilience Benefits
  - Competitive Market
- **Get comfortable with uncertainty and adopt established methods to deal with it;**
- **Move for Open Access in SAARC Grid**

THANK YOU!