

2nd Capacity Building Program - SARPEX Mock Exercise
4th - 5th October, 2017
New Delhi, India



System Operation Aspects

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DGM (Market Operations)
NLDC, POSOCO, India
05th October, 2017

21st Century Indian Grid



All India Synchronous Grid

Bulk transfer through HVDCs

High Capacity Green Energy Corridors

Transmission as a Common Carrier

765 kV High Capacity Network

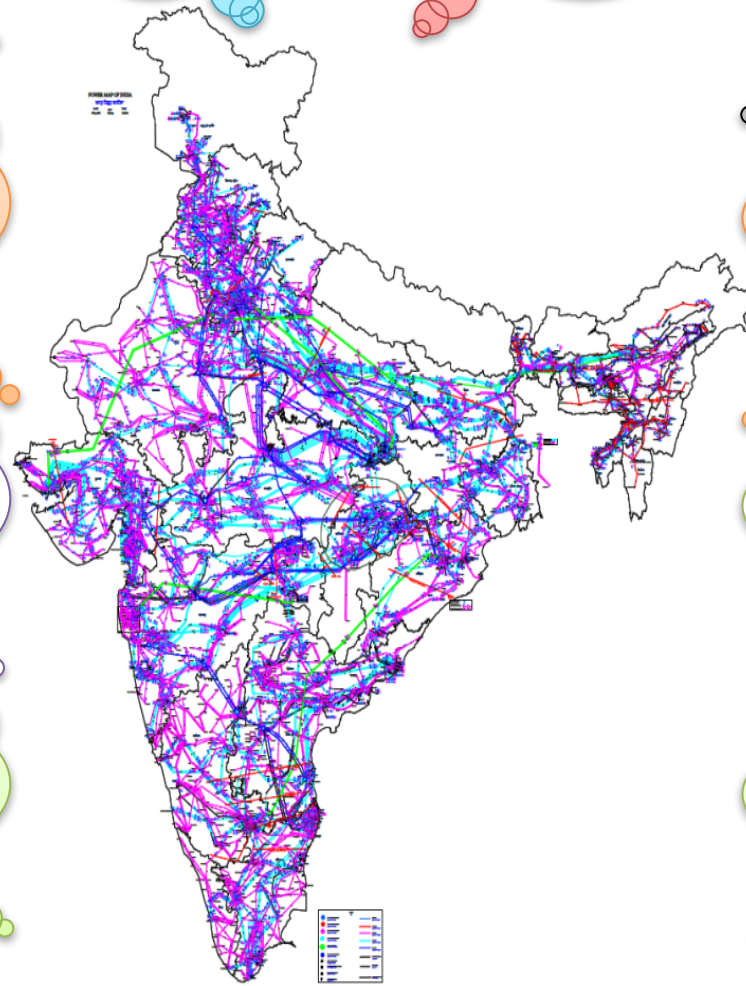
Pan India Market Open Access

400 kV Backbone Network

Robust Settlement Mechanisms

> Million Transmission Towers

Trans-National Exchange of Power



Typical Numbers...



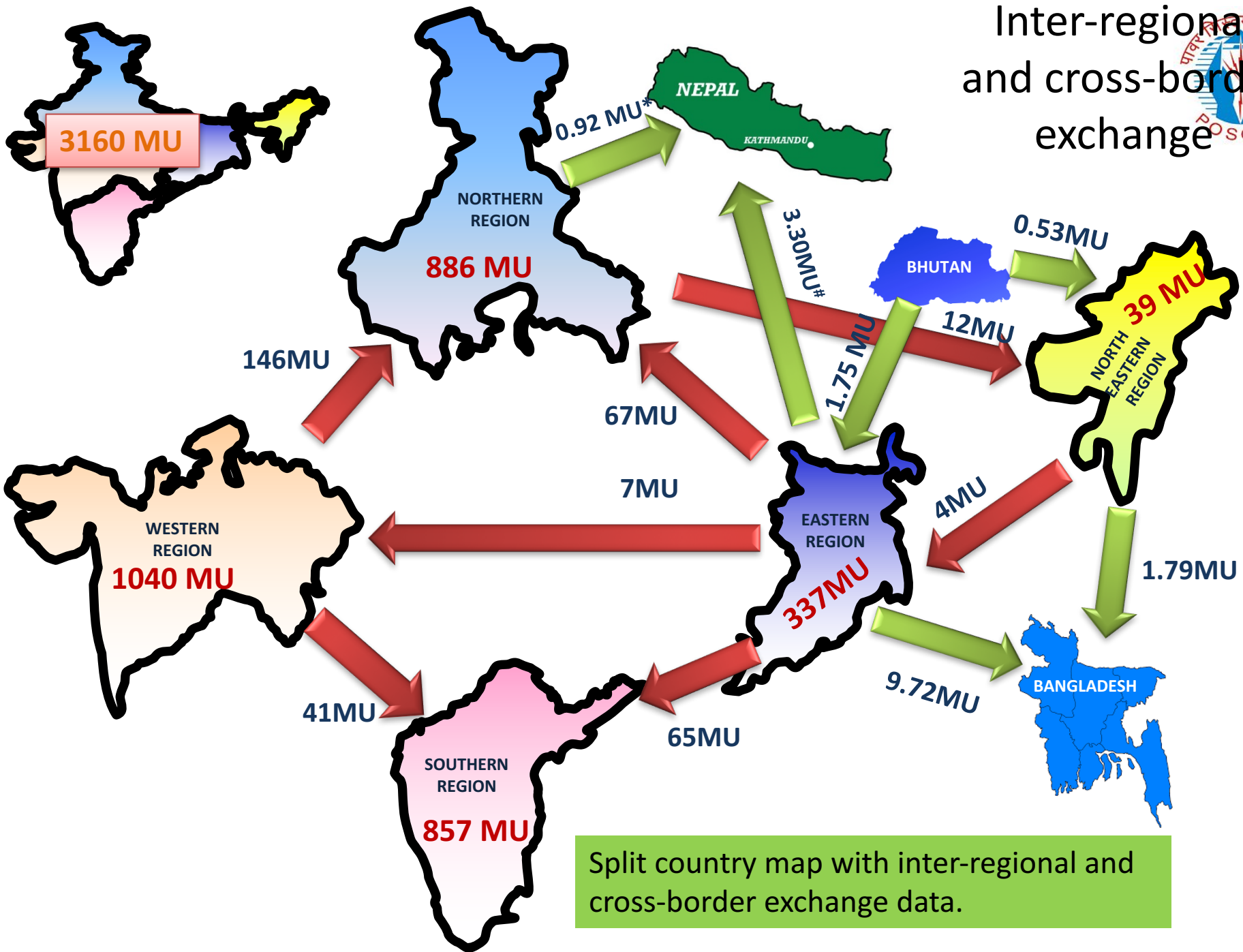
Indian Power System

- Peak Demand ~ 160 GW
- Energy Met ~ 3.5 BUs/day
 - Hydro Gen. ~ 712 MU/day (Max.)
 - Wind Gen. ~ 379 MU/day (Max.)
- Installed Capacity – 330 GW
 - Thermal:
 - Coal-195 GW, Gas-25 GW
 - Hydro – 44 GW, Nuclear – 6.7 GW
 - Wind-32 GW
 - Solar-13 GW, Bio-8 GW
- Gen. Stations: 1378 Nos,
- 11 Nos. HVDC Bi-pole/BtB
- 1 MTDC (HVDC)
- > 125 nos. 765 kV
- > 1475 nos. 400 kV

Indian Power Market

- Licensed Traders - 43 Nos.
- Market Participants > 3000 Nos.
- Two Power Exchanges (PXs)
 - Indian Energy Exchange
 - Power Exchange of India Ltd.
- Open Access Volumes
 - Transactions ~ 45,000 Nos./yr.
 - Bilateral ~ 14,000 Nos.
 - Collective (PX) ~ 31,000 Nos.
- Energy ~ 100 BUs/yr.
 - Bilateral ~ 65 BUs
 - Collective (PX) ~ 35 BUs
- Short Term ~ 10 %

Inter-regional and cross-border exchange



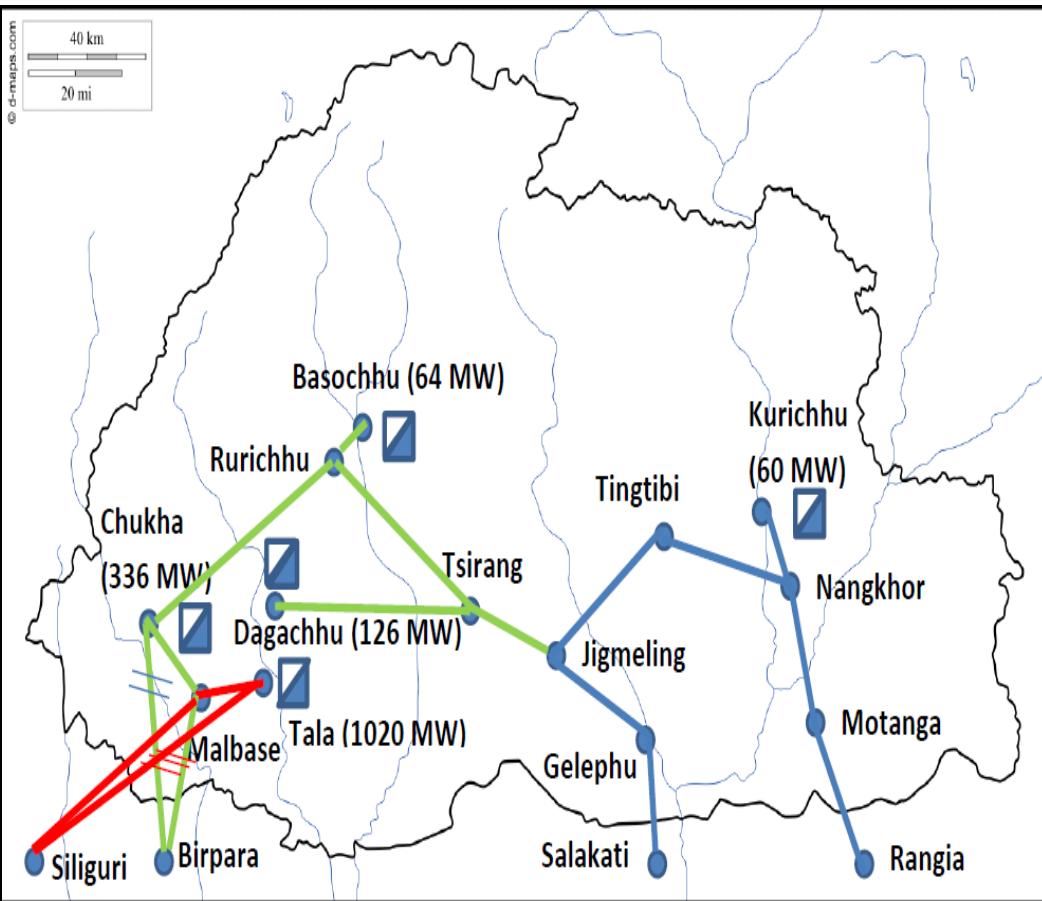
Split country map with inter-regional and cross-border exchange data.

Summary



2016-17	Bhutan	Bangladesh	Nepal	Myanmar
Energy (Export/ Import)	5863 MU (Import)	4420 MU (Export)	2022 MU (Export)	3 MW (Export)
Transaction Type	Gol Allocation (LTA), STOA	Gol Allocation (LTA), MTOA, STOA	Gol Allocation (LTA), STOA	Bilateral b/w Manipur and Myanmar (LTA)
Scheduling	NLDC/ERLDC	NLDC/ERLDC/ Tripura SLDC	NLDC/NRLDC/ ERLDC/Bihar SLDC	Manipur SLDC
Metering	ERLDC	ERLDC/Tripura	NRLDC, ERLDC, Bihar	Manipur
Nodal Agency for Accounting and Settlement	PTC (ER Pool)	NVVN (ER Pool) / Consumer of Tripura	PTC (NR Pool), NVVN (ER Pool), Consumer of Bihar	Consumer of Manipur
Payment of ISTS Transmission Charges (PoC)	STOA	STOA	STOA	Nil

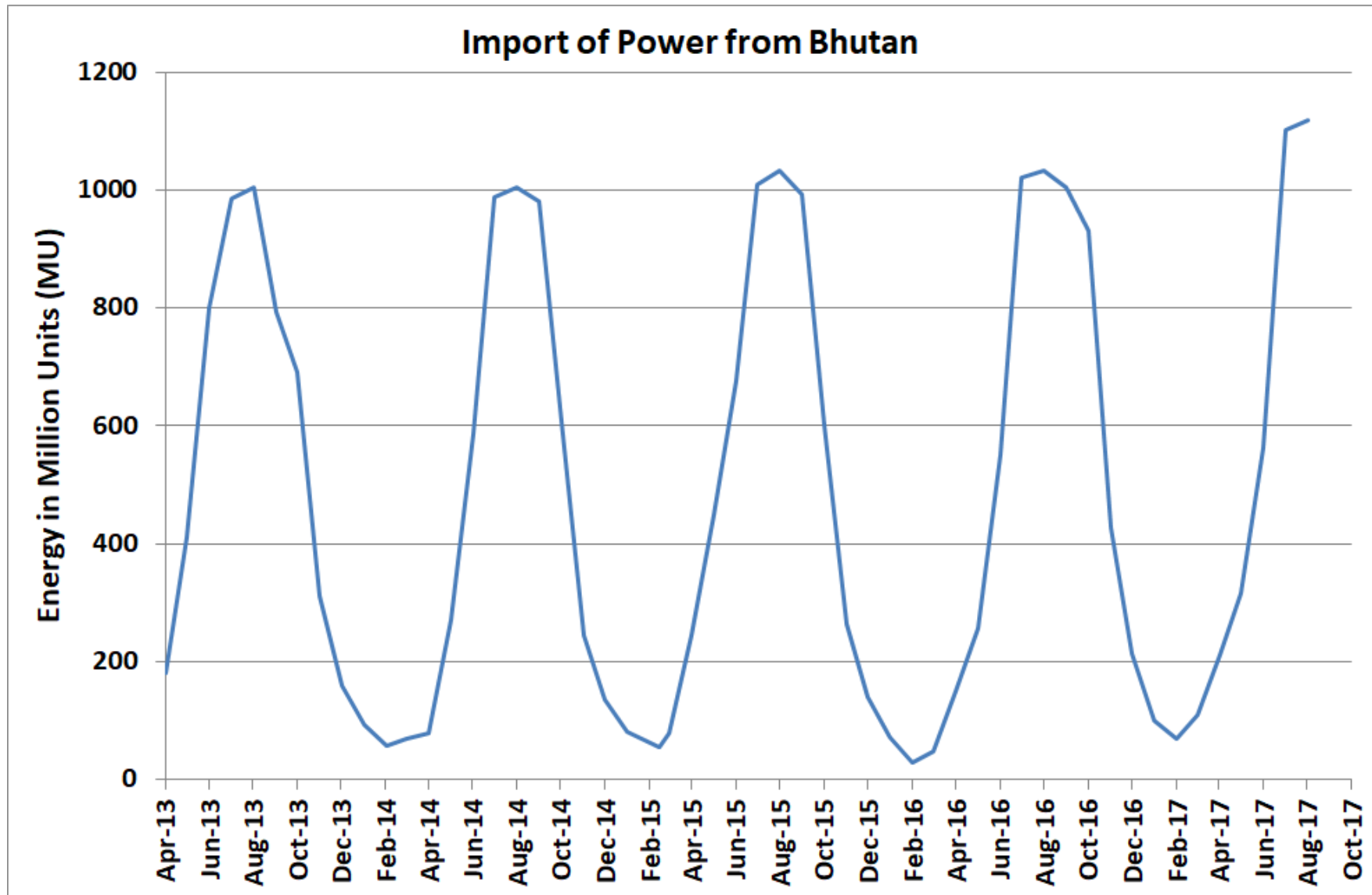
Existing Interconnections with Bhutan



**East-West Bhutan interconnection closed
(Tsirang – Jigmeling)**

- **Chukha HEP (4x84 = 336 MW)**
 - 220 kV Chukha-Birpara (2 ckts) (Bhutan-ER)
 - 220 kV Chukha-Malbase-Birpara (Bhutan-ER)
- **Kurichu HEP (4x15 = 60 MW)**
 - 132 kV Gelephu-Salakati S/c (Bhutan - NER)
 - 132 kV Rangia-Motanga (Bhutan-NER)
- **Tala HEP (6x170 MW = 1020 MW)**
 - 400 kV Tala-Binaguri (3 Ckts) (Bhutan-ER)
 - 400 kV Tala-Malbase-Binaguri (Bhutan-ER)
- **Dagachu HEP (2x63 = 126 MW)**

Import from Bhutan upto 1500 MW




Bhutan - Sample Schedule

Injection Profile of Bhutan for :: 23/07/2015

Issue Date/Time :: 23-07-2015 23:52 Hrs

Revision :: 9

Date: 

State:

Revision:

Show

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(All figures are in MW)

Block	Time	ISGS	LTA	MTOA	Bilateral	Total
1	00:00-00:15	0.00	0.00	0.00	88.18	88.18
2	00:15-00:30	0.00	0.00	0.00	88.18	88.18
3	00:30-00:45	0.00	0.00	0.00	88.18	88.18
4	00:45-01:00	0.00	0.00	0.00	88.18	88.18
5	01:00-01:15	0.00	0.00	0.00	88.18	88.18
6	01:15-01:30	0.00	0.00	0.00	88.18	88.18
7	01:30-01:45	0.00	0.00	0.00	88.18	88.18
8	01:45-02:00	0.00	0.00	0.00	88.18	88.18
9	02:00-02:15	0.00	0.00	0.00	88.18	88.18
10	02:15-02:30	0.00	0.00	0.00	88.18	88.18
11	02:30-02:45	0.00	0.00	0.00	88.18	88.18
12	02:45-03:00	0.00	0.00	0.00	88.18	88.18
13	03:00-03:15	0.00	0.00	0.00	88.18	88.18
14	03:15-03:30	0.00	0.00	0.00	88.18	88.18
15	03:30-03:45	0.00	0.00	0.00	88.18	88.18
16	03:45-04:00	0.00	0.00	0.00	88.18	88.18



Transfer Capability Declaration

National Load Despatch Centre, New Delhi Transfer Capability between India and Bangladesh for October 2017

Issue Date: 28/6/2017

Issue Time: 1300 hrs

Revision No. 0

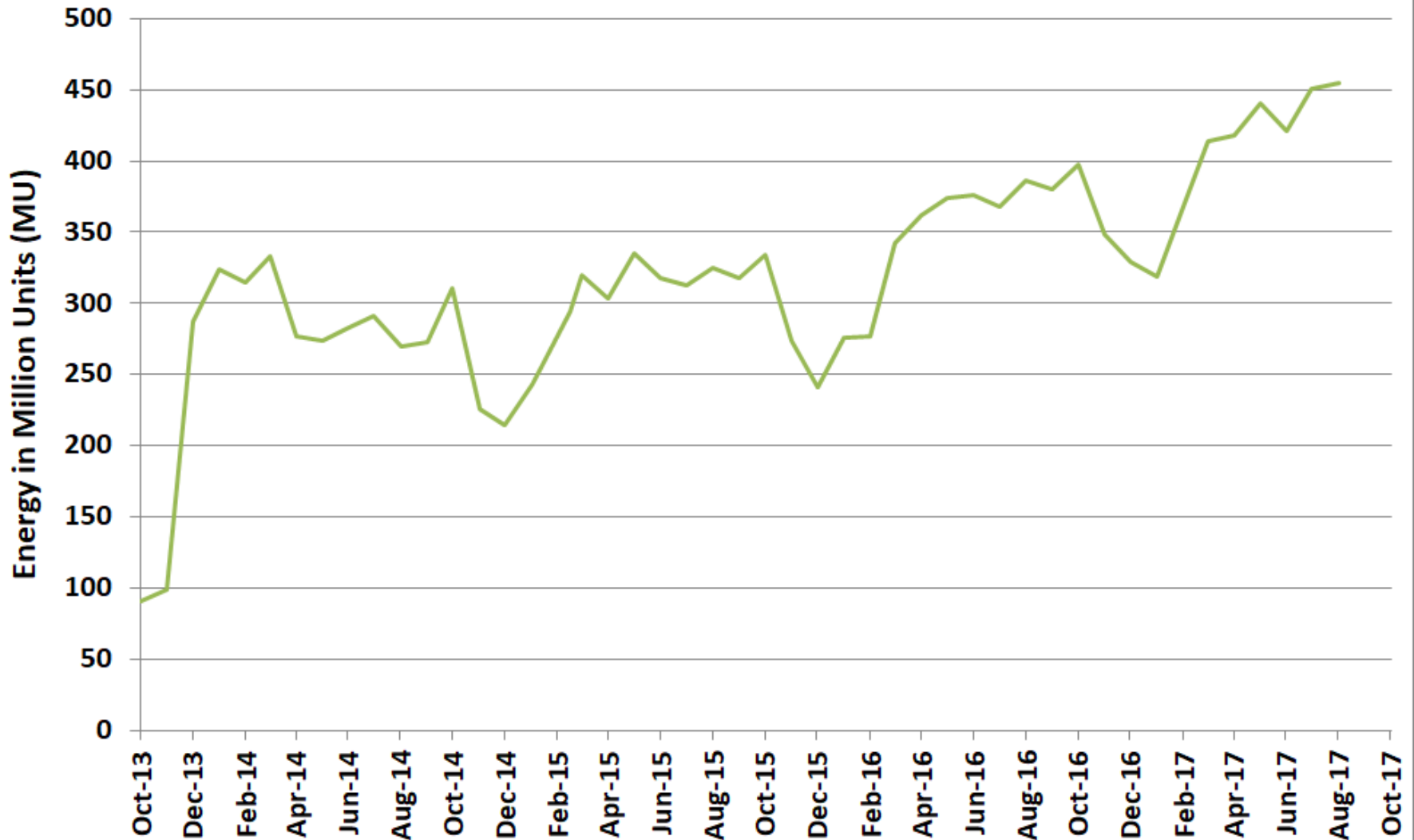
Date	Time Period in IST (hrs)	TTC from India to Bangladesh from Indian Side*	Reliability Margin	Available Transfer Capability (ATC)	Long Term Access (LTA)/ Medium Term Open Access (MTOA) #	Margin Available for Short Term Open Access (STOA)	Changes in TTC w.r.t. Last Revision	Limiting constraint	Comments
1st October 17 to 31st October 17	0000-0630	500	0	500	250	250		No constraints from Indian Side	
	0630-2330	500		500	250	250			
	2330-2400	500		500	250	250			

- For transfer of power through Bheramara HVDC only; Radial load of Bangladesh being met through Surjamani Nagar-Comilla is treated as Intra State flow of Tripura.
- There is no limitation on the flow on HVDC Bheramera from the Indian side during normal conditions.
- In case of operation of SPS, Transfer Capability will be revised accordingly.
- Transfer Capability between India and Bangladesh has been evaluated ignoring the constraints from Bangladesh side

Export to Bangladesh upto 650 MW



Export of Power to Bangladesh





Bangladesh - Sample Schedule

Drawal Schedule of Bangladesh for :: 11/01/2016

Issue Date/Time :: 11-01-2016 19:23 Hrs

Revision :: 6

Date:



State:

Revision:

Show

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(All figures are in MW)

Block	Time	ISGS	LTA	MTOA	Bilateral	Total
73	18:00-18:15	222.93	0.00	245.90	0.00	468.82
74	18:15-18:30	223.52	0.00	245.90	0.00	469.42
75	18:30-18:45	224.13	0.00	245.90	0.00	470.02
76	18:45-19:00	224.13	0.00	245.90	0.00	470.02
77	19:00-19:15	224.13	0.00	245.90	0.00	470.02
78	19:15-19:30	224.99	0.00	245.90	0.00	470.89
79	19:30-19:45	225.82	0.00	245.90	0.00	471.72
80	19:45-20:00	225.82	0.00	245.90	0.00	471.72
81	20:00-20:15	225.82	0.00	245.90	0.00	471.72
82	20:15-20:30	225.82	0.00	245.90	0.00	471.72
83	20:30-20:45	225.98	0.00	245.90	0.00	471.87
84	20:45-21:00	225.98	0.00	245.90	0.00	471.87
85	21:00-21:15	225.98	0.00	245.90	0.00	471.87
86	21:15-21:30	225.98	0.00	245.90	0.00	471.87
87	21:30-21:45	225.98	0.00	245.90	0.00	471.87
88	21:45-22:00	225.98	0.00	245.90	0.00	471.87
89	22:00-22:15	226.60	0.00	245.90	0.00	472.50
90	22:15-22:30	226.60	0.00	245.90	0.00	472.50
91	22:30-22:45	226.60	0.00	245.90	0.00	472.50
92	22:45-23:00	226.60	0.00	245.90	0.00	472.50
93	23:00-23:15	226.60	0.00	245.90	0.00	472.50

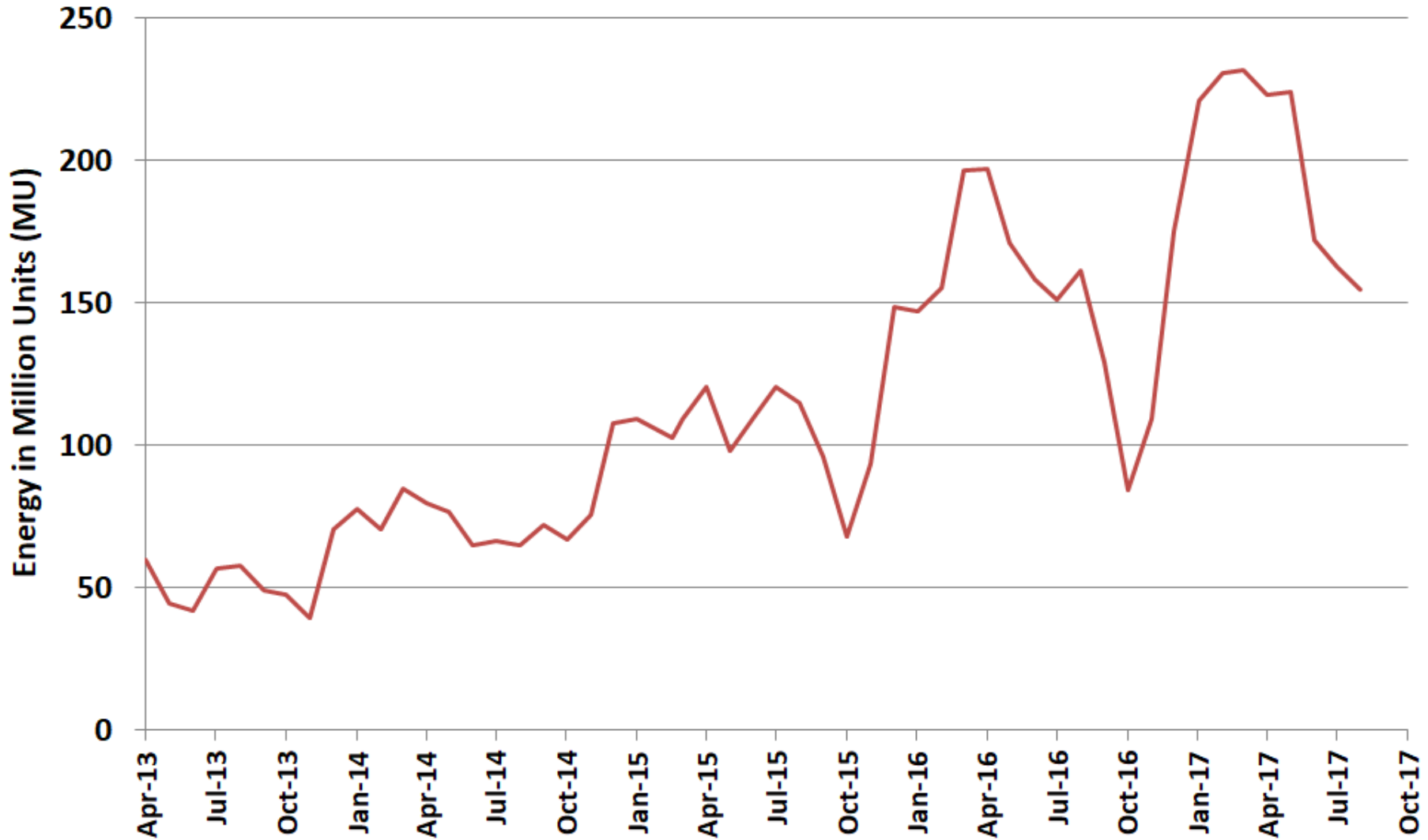


This map was produced by the Map Design Unit of the World Bank. The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of the World Bank Group, any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries.

Export to Nepal upto 350 MW



Export of Power to Nepal



Nepal - Sample Schedule



State Drawal Schedule of NEPAL for :: 11/01/2016

Issue Date/Time :: 11/01/2016 23:05 Hrs

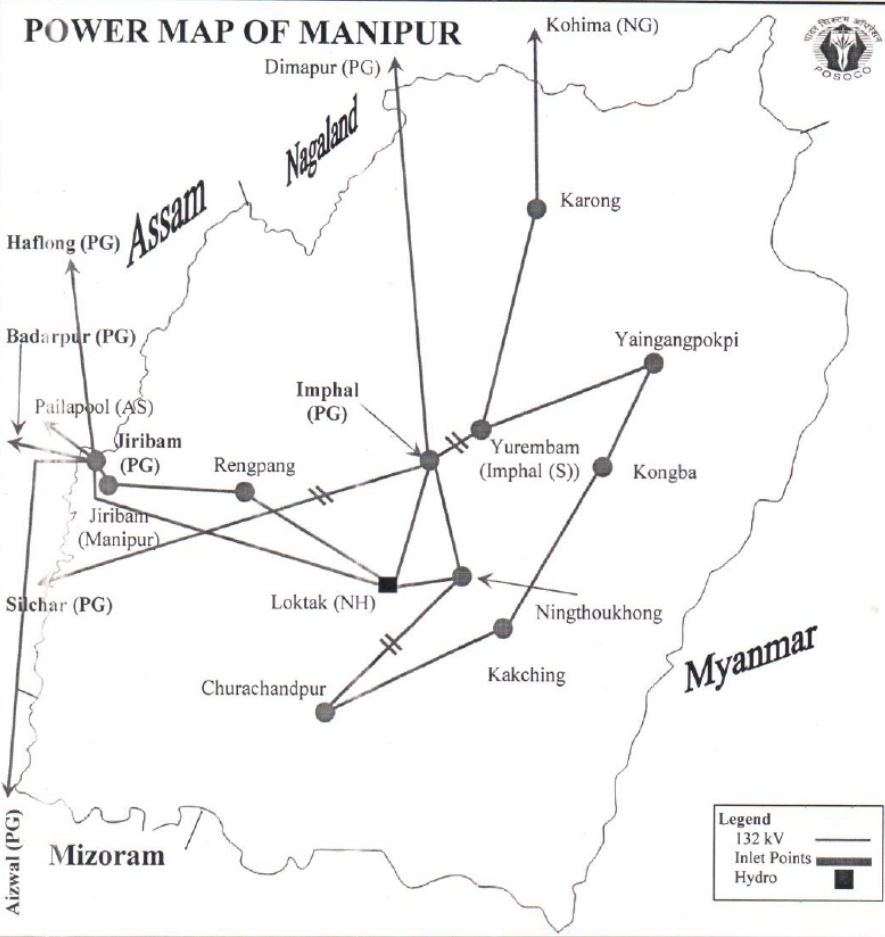
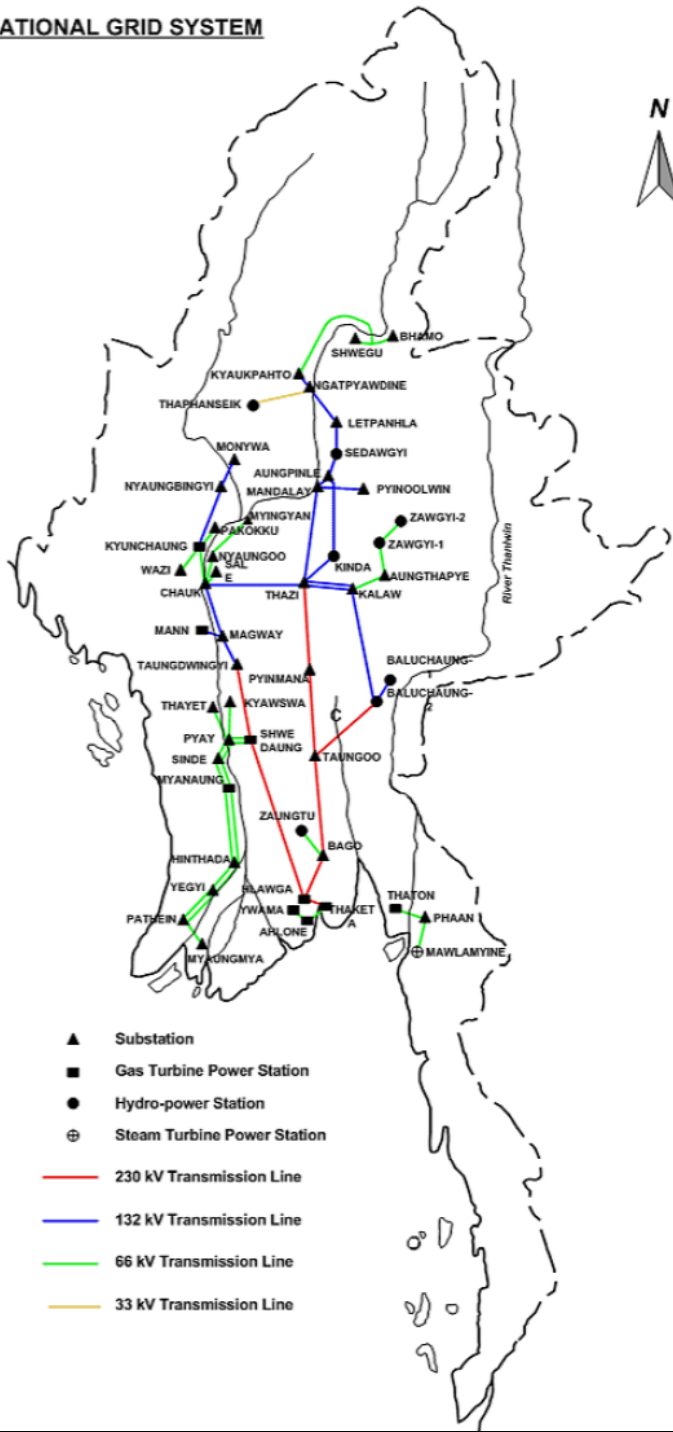
Revision :: 51

Date: State: Revision:

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Block	Time	ISGS	LTA	MTOA	Shared	Bilateral	IEX	PXIL	Total
76	18:45-19:00	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
77	19:00-19:15	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
78	19:15-19:30	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
79	19:30-19:45	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
80	19:45-20:00	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
81	20:00-20:15	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
82	20:15-20:30	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
83	20:30-20:45	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
84	20:45-21:00	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
85	21:00-21:15	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
86	21:15-21:30	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
87	21:30-21:45	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
88	21:45-22:00	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
89	22:00-22:15	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
90	22:15-22:30	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
91	22:30-22:45	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
92	22:45-23:00	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
93	23:00-23:15	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
94	23:15-23:30	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
95	23:30-23:45	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
96	23:45-24:00	6.56	0.00	0.00	0.00	26.96	0.00	0.00	33.52
MWHR		146.20	0.00	0.00	0.00	647.04	0.00	0.00	793.24

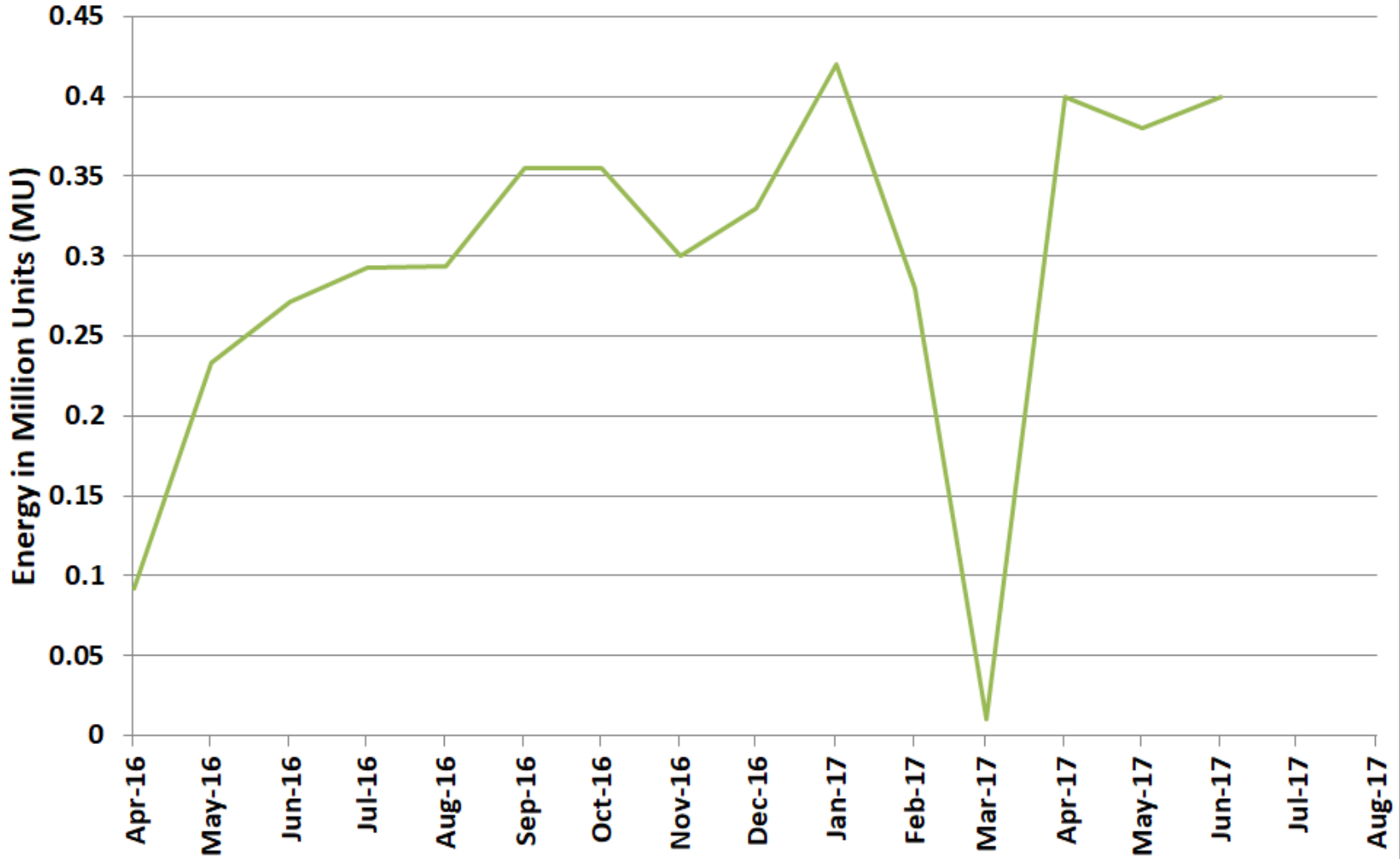
NATIONAL GRID SYSTEM



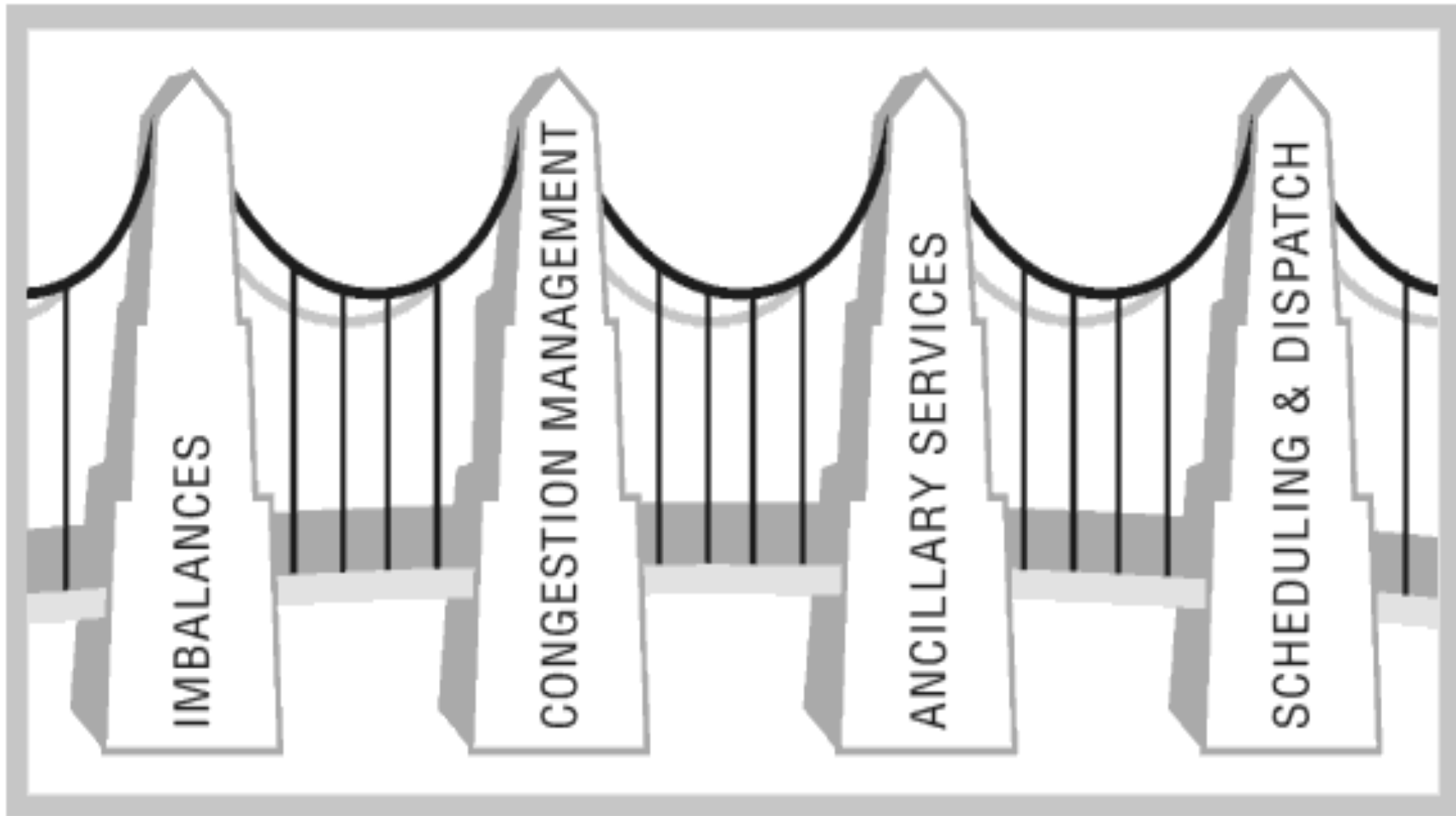
Export to Myanmar upto 3 MW



Export of Power to Myanmar



Pillars of Market Design

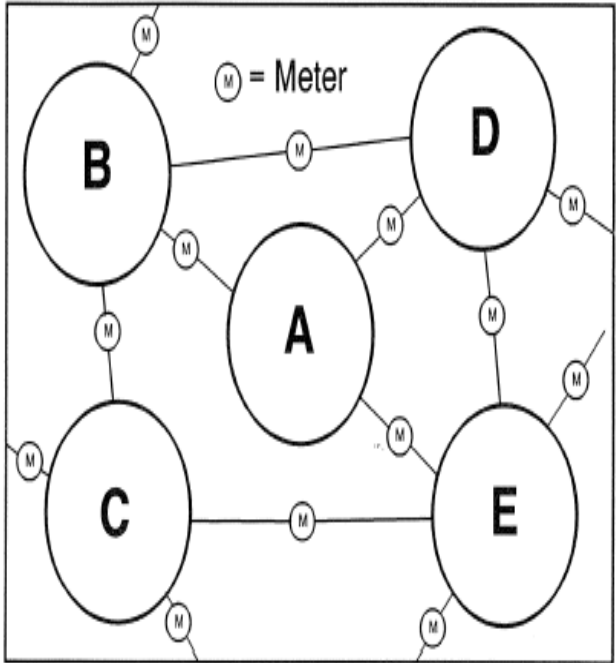
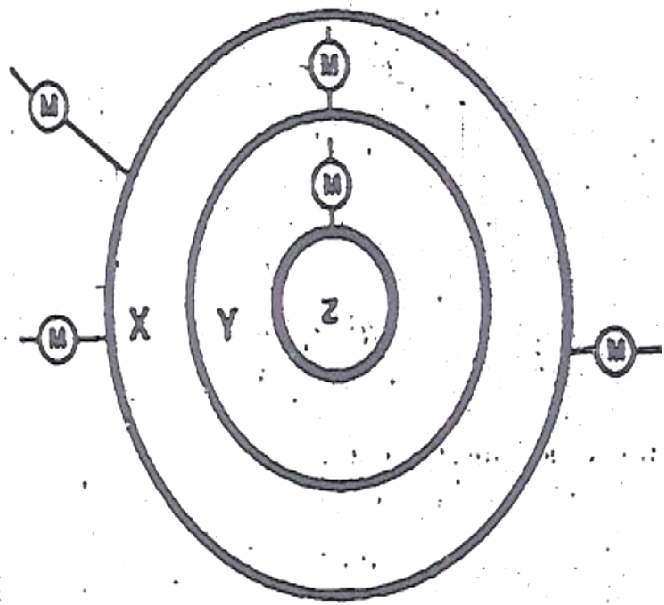


Sally Hunt – ' Making Competition Work in Electricity'

Control Areas and Coordinated Structure



Nested Control Areas



Control Area Metering

~ 100 Control Areas in India

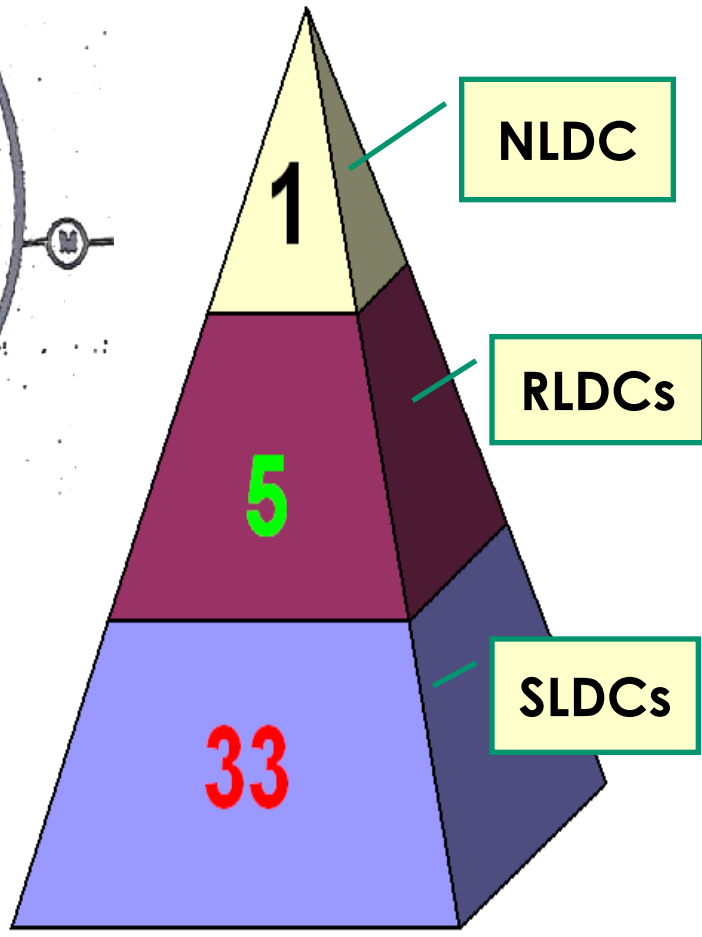
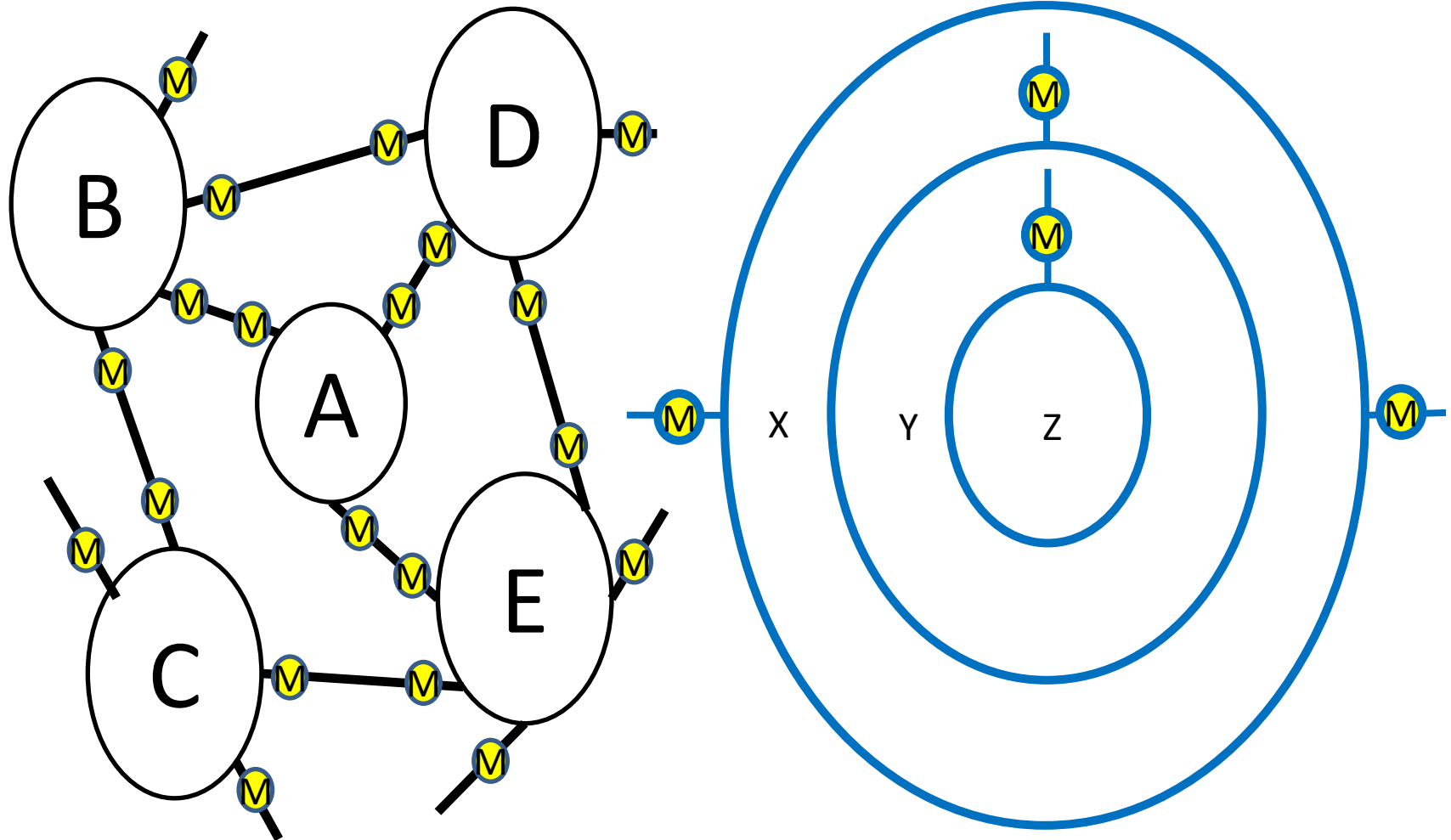


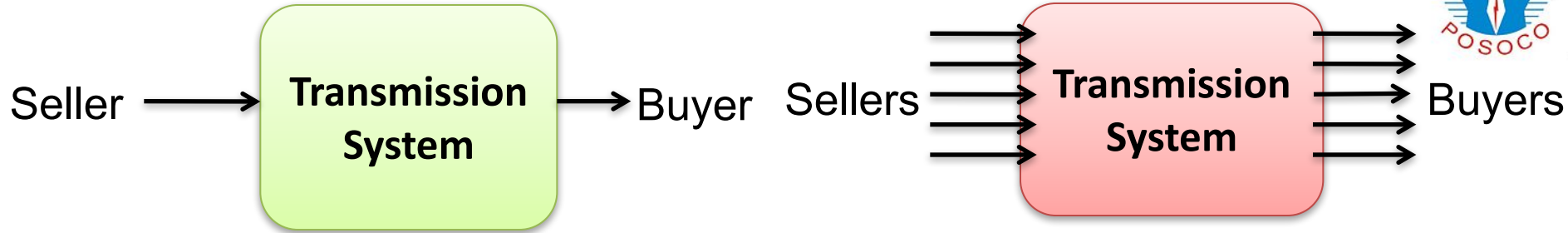
Figure 2 – Control area metering

Granularity of Control Area



Source : "Control Area Trends: Principles and response", Larry R. Day

Settling Electricity Transactions



- **A Simple transaction**

- One buyer – one seller, single part settlement

- **Increasing Complexity**

- Multiple sellers to one buyer
- Multiple sellers multiple buyers
- Multiple trades at different rates

- **Solution: Schedule Transactions**

- Multi part settlement (fixed, variable, deviations)
- Settle the scheduled quantum as deemed delivered
 - Fixed charges based on availability
 - Variable charges as per schedule
- Settle imbalances/deviations from schedule separately

**More than 5000
Interface Meters !**

**More than 100
Control Areas !**

**More than 3000
Market Participant !**

Need for Deviation Settlement Mechanism !

Settlement of Charges and losses for any transaction

- **Charges settled directly between buyer and seller**
 - Capacity charges as per availability
 - Energy charges as per schedule
- **Charges settled through System Operator**
 - Charges for imbalance/deviations
 - Transmission charges
 - For inter-state transmission – POC charges for injection and withdrawal
 - For intra-state transmission – As specified by respective SERC
 - Operating Charges
 - Application Fees
- **Transmission Losses**
 - POC losses for inter-state system – Injection and Withdrawal PoC Losses (additional losses are applicable - intra-state system)
 - To be paid in kind

Energy Accounting

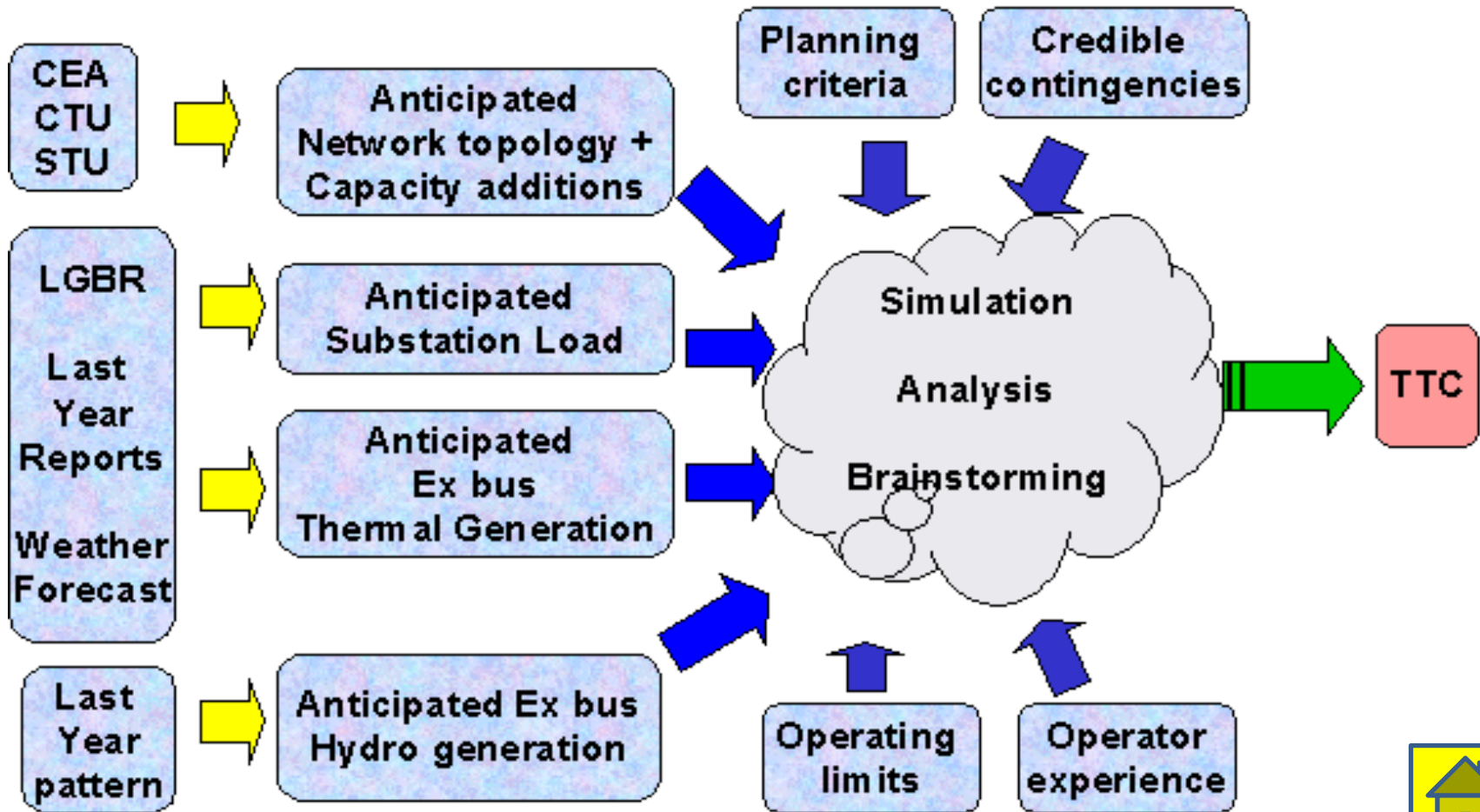
- Regional Power Committees (RPCs) prepare the following accounts as per Regulations:
 - Weekly Deviation Settlement account
 - Weekly Reactive Energy Charge account
 - Monthly Regional Energy Account
 - Monthly Regional Transmission Account
 - Monthly Regional Transmission Deviation Account

Scheduling and Despatch – Need for Nodal Agency

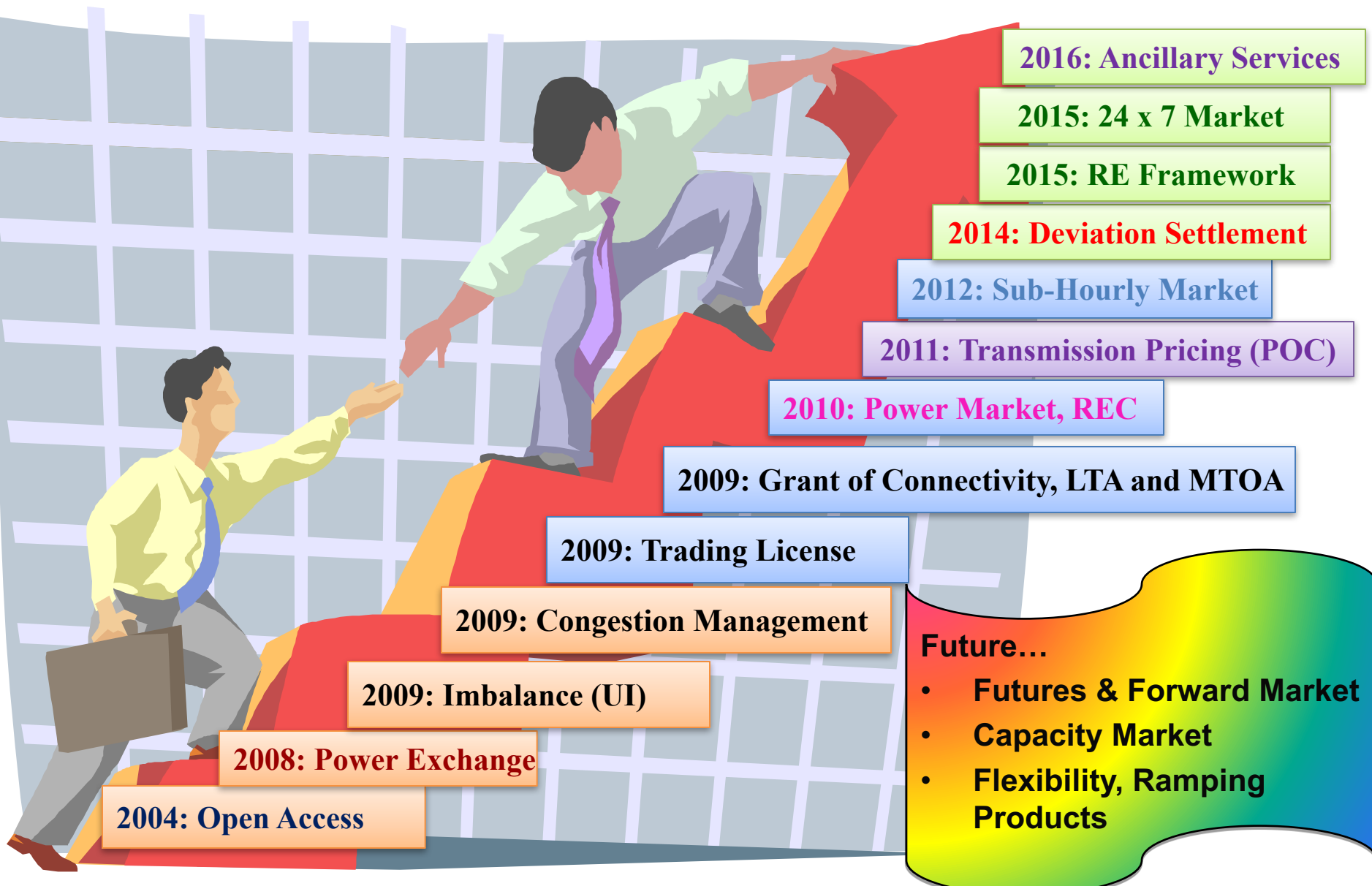


- Power transfer between countries
- Need for Nodal Agency
 - Settle transactions and deviations in Indian Pool
 - Back to back arrangement with buying entities in participant country
 - Coordinate day-to-day scheduling with Load Despatch Centre in India and participant country
 - Transactions feasible
 - Long term Access/ Medium Term Open Access
 - Schedule to the LDCs on Day ahead basis
 - Revision allowed
 - Short Term Open Access
 - Bilateral transactions - Revision as per Open Access regulations
- Net schedule – datum for exchange of power through the link
- Deviations settled as per CERC Deviation Settlement Regulations

TTC assessment block diagram



Evolution of Electricity Market in India





Key Success Factors for Robust Electricity Market

Robust Transmission System

Control Area Demarcation & Boundary Metering

Streamlined Scheduling and Settlement Mechanism

Assessment of Transfer Capability

Congestion Management

Imbalance Handling Mechanism

Methodology for Transmission Charge Sharing

Treatment of Transmission Losses

Transparent and Non-discriminatory Implementation

Compliance Monitoring and Regulatory Oversight

Dispute Redressal Mechanism



Cross Border Operational Coordination

- System Security Aspects
- Operational & Outage planning
- Transfer Capability Assessment
- Scheduling and Despatch
- Operating instructions
- Congestion management
- Protection
- Recovery Procedures
- Event information
- Formation of coordination groups

Way Forward



- **Scheduling of Transactions (multi buyer – multi seller)**
- **Coordination at all levels**
 - **Planners, Regulators and Grid Operators**
- **Harmonization of scheduling and despatch procedures**
- **Metering, Accounting and Deviations Settlement Mechanism**
- **Congestion Management**
- **Application of (transmission & system operation) charges and losses**
- **Payment Security & Dispute Resolution Mechanism**

Decades back, Dr. R .Buckminster Fuller proposed interconnecting regional power system into a single, continuous world-wide electric energy grid as a number one solution to solve many of the world's pressing problems.

Fuller also saw power grid as the way to reduce human suffering, preserve environment besides creating economical power systems.

