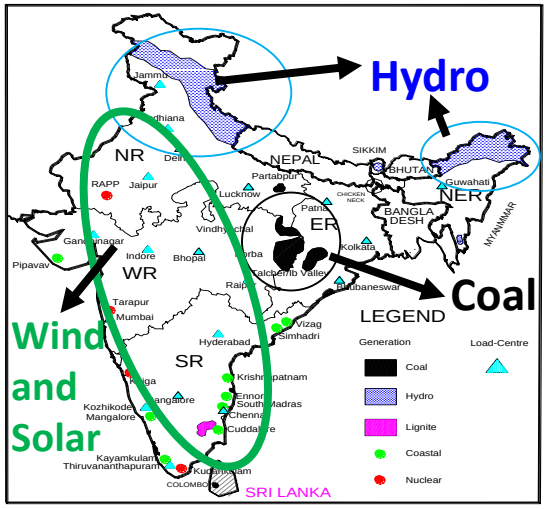
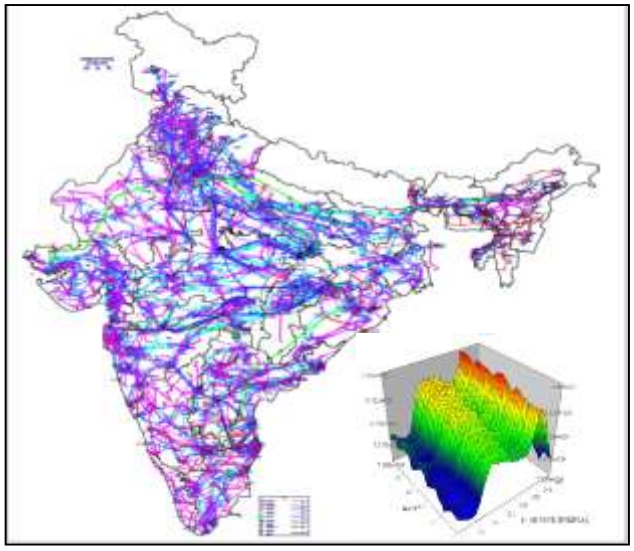
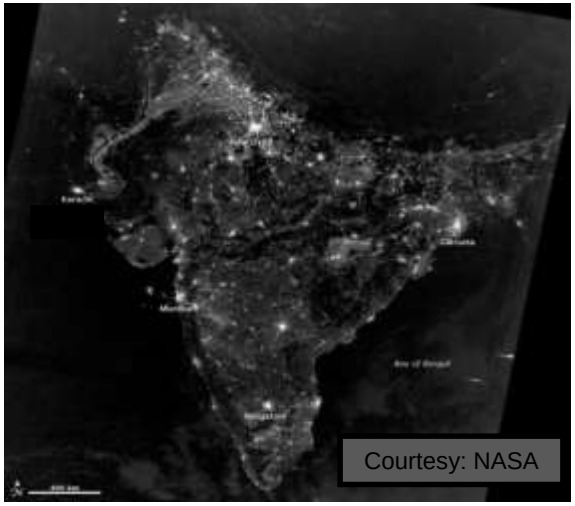
Flexibility Requirement in Indian power system

01st December 2017

Indian Grid…Large Footprint







Indian Power System

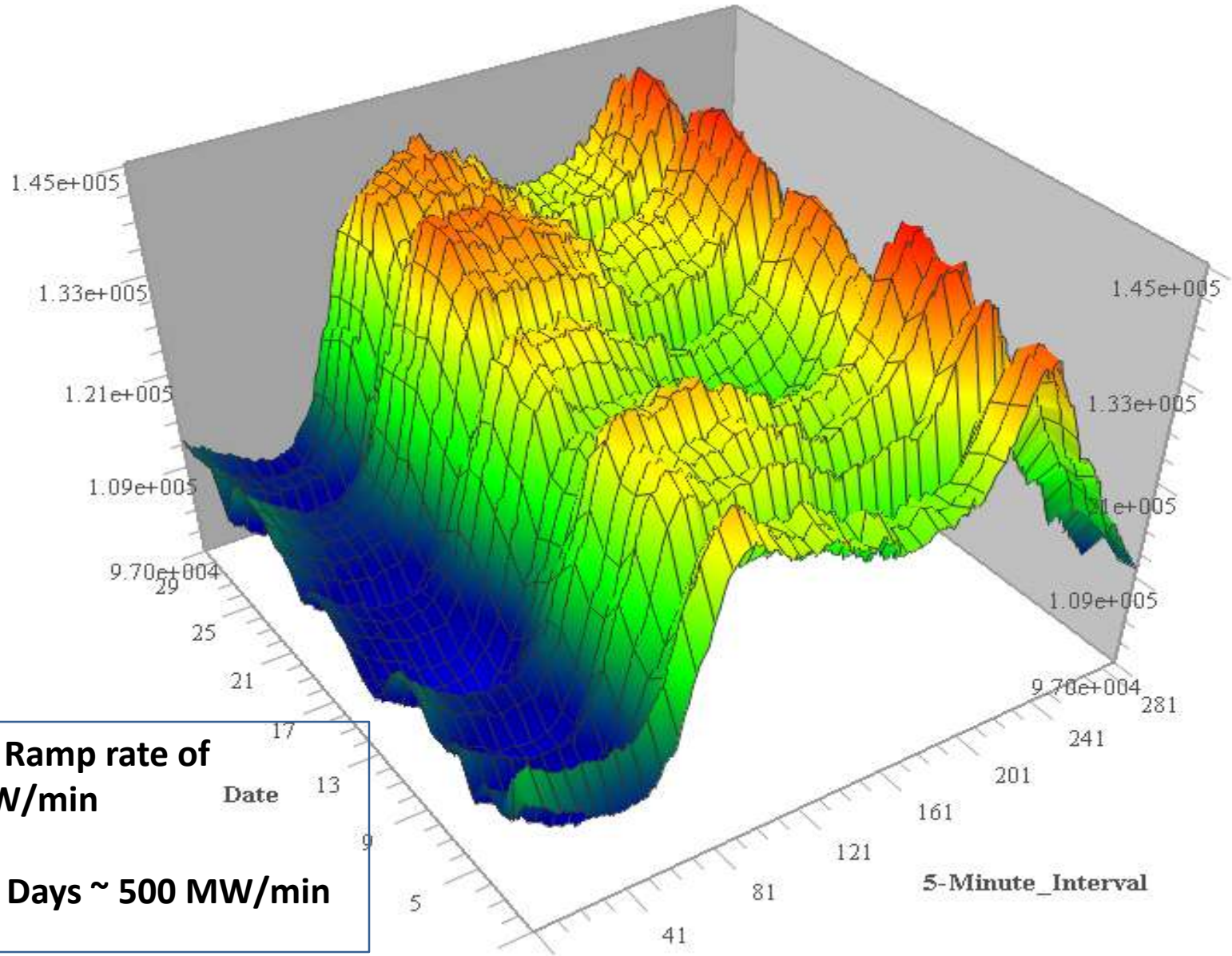
- Peak Demand ~ 160 GW
- Energy Met ~ 3.5 BUs/day
  - Hydro Gen. ~ 712 MU/day (Max.)
  - Wind Gen. ~ 310 MU/day (Max.)
- Generating Stations ~ 900 Nos.
- Generating Units ~ 2200 Nos.
- > 7000 Sub-stations,
- > 3100 transformers
- 10 Nos. HVDC Bi-pole/BtB
- > 100 nos. 765 kV lines
- > 1300 nos. 400 kV lines,
- > 3200 nos. 220 kV lines
- 26 ISTS transmission licensees

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 %

International Interconnections

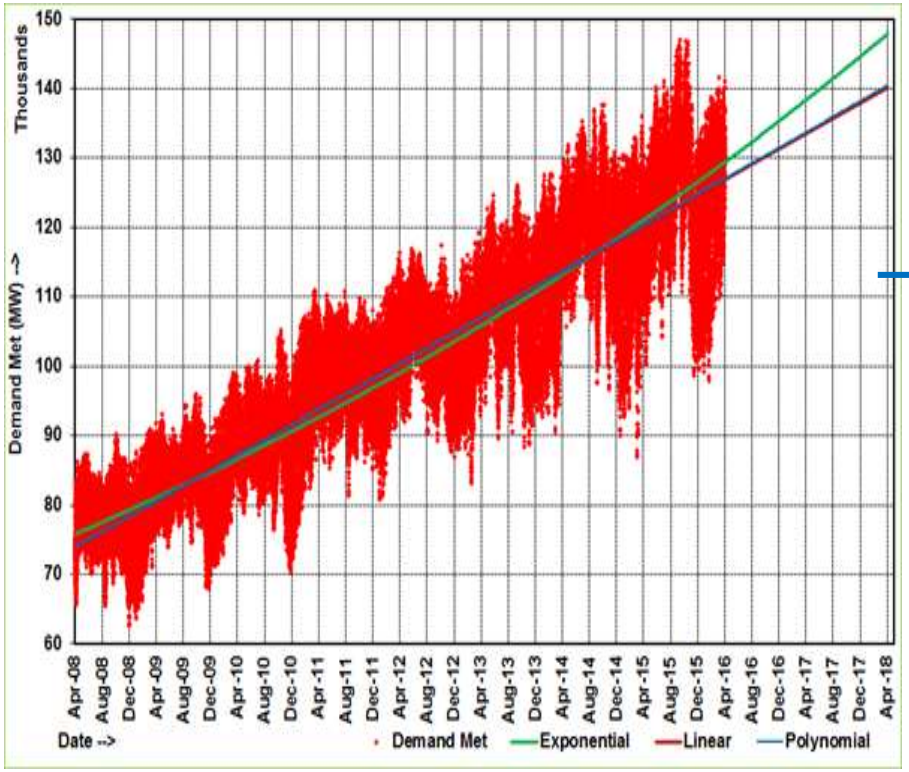
Typical All India Load Pattern



Typical Ramp rate of 250 MW/min

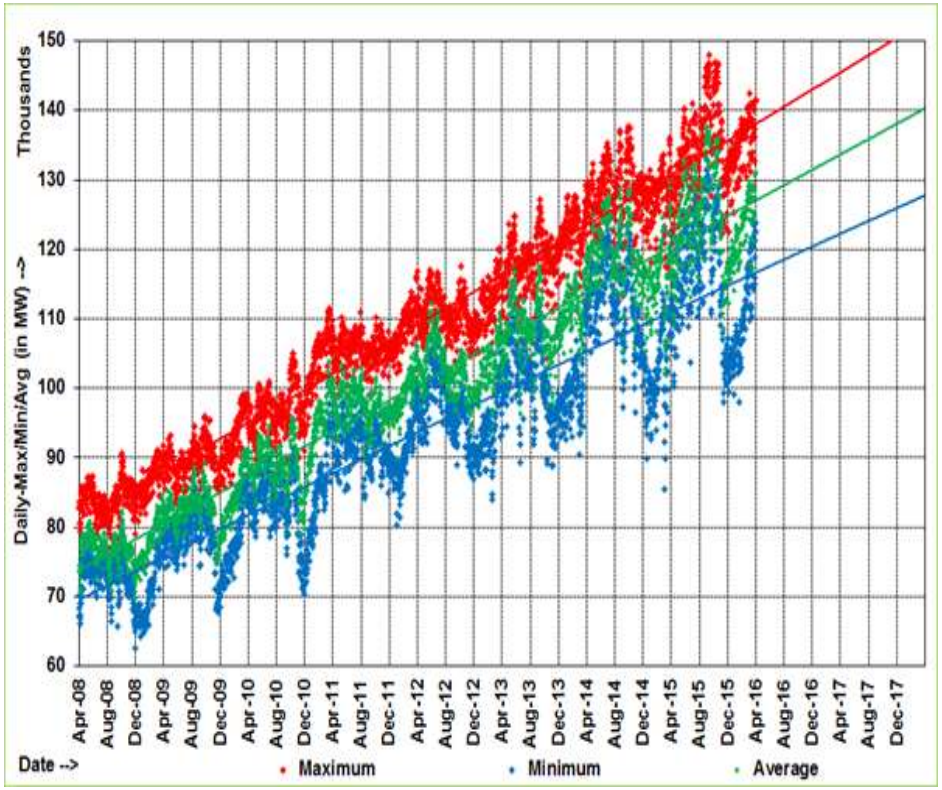
Special Days ~ 500 MW/min

Increasing trend of demand met

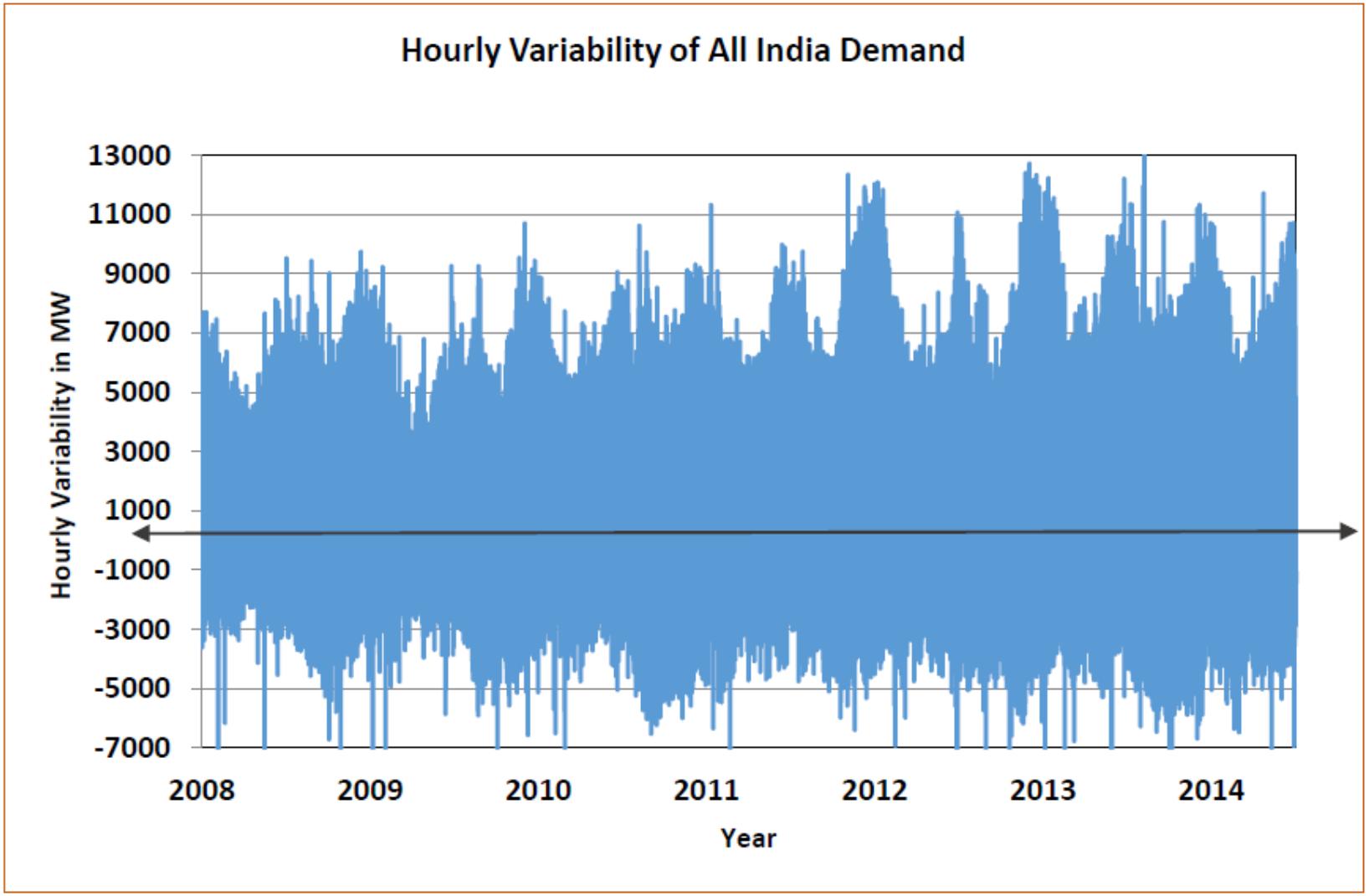


- **Hourly demand met pattern**

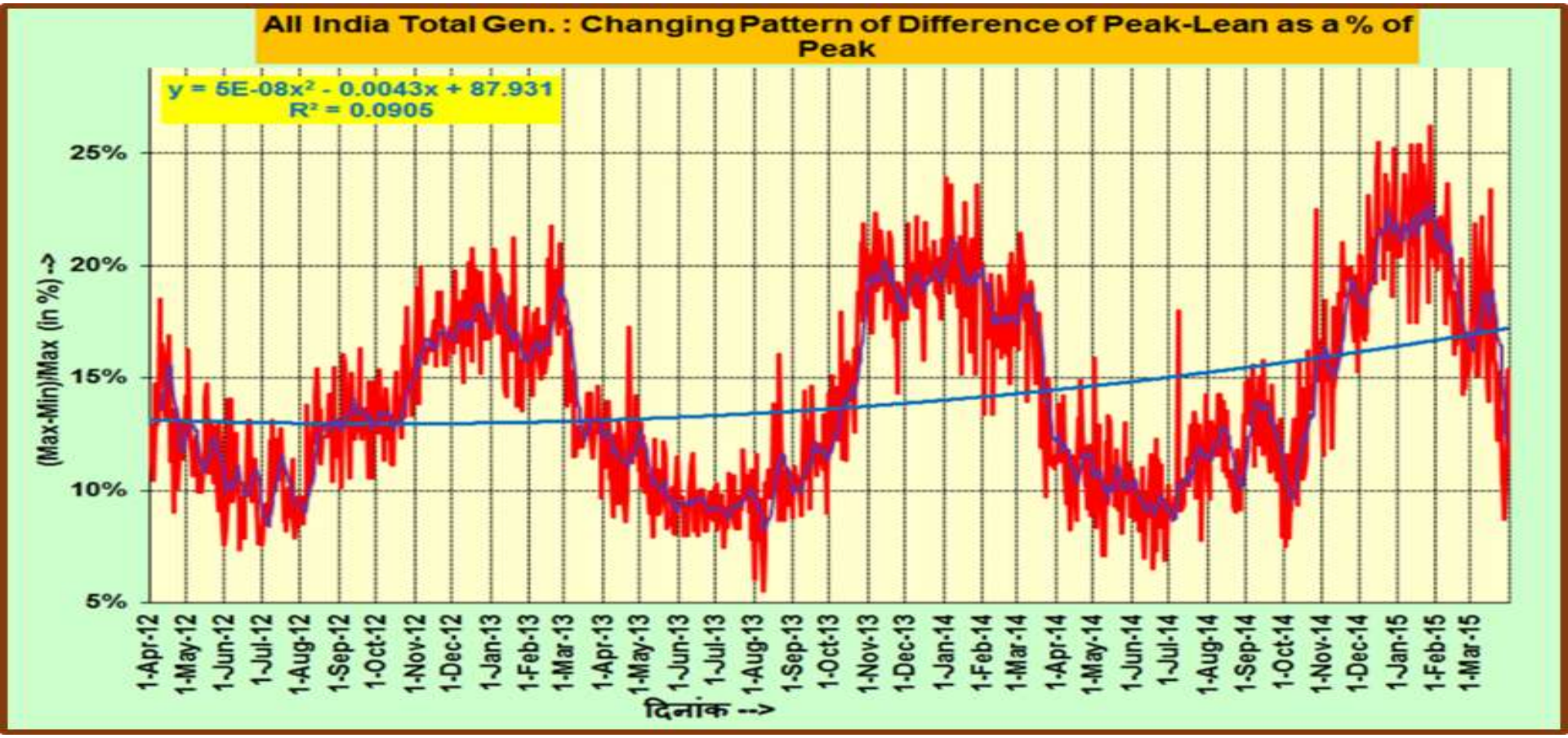
- **Maximum, Minimum and Average Demand met pattern.**



Hourly Variability of Demand

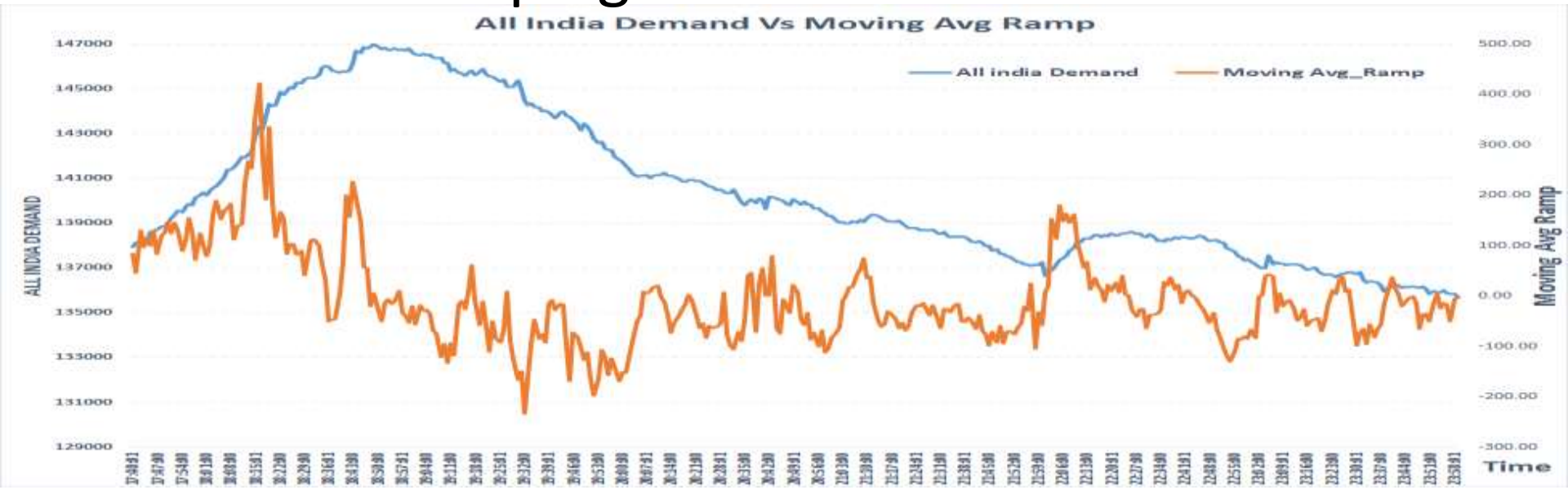


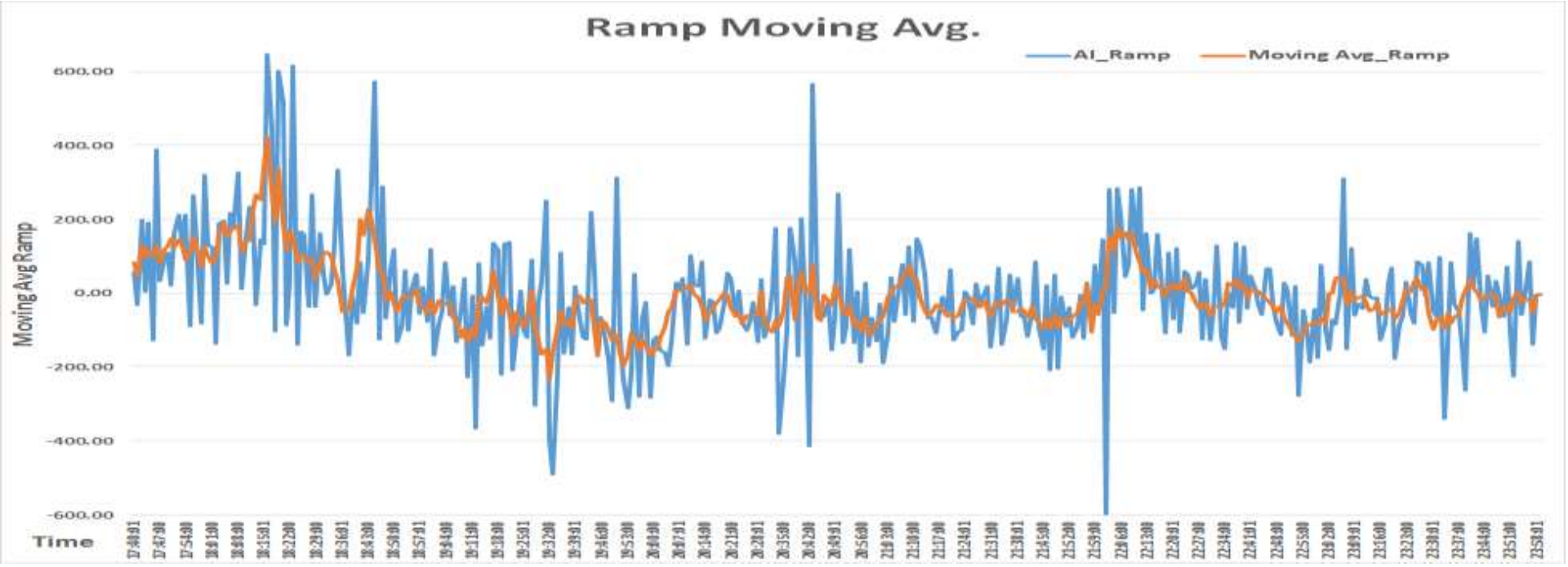
Increasing Flexibility Requirement



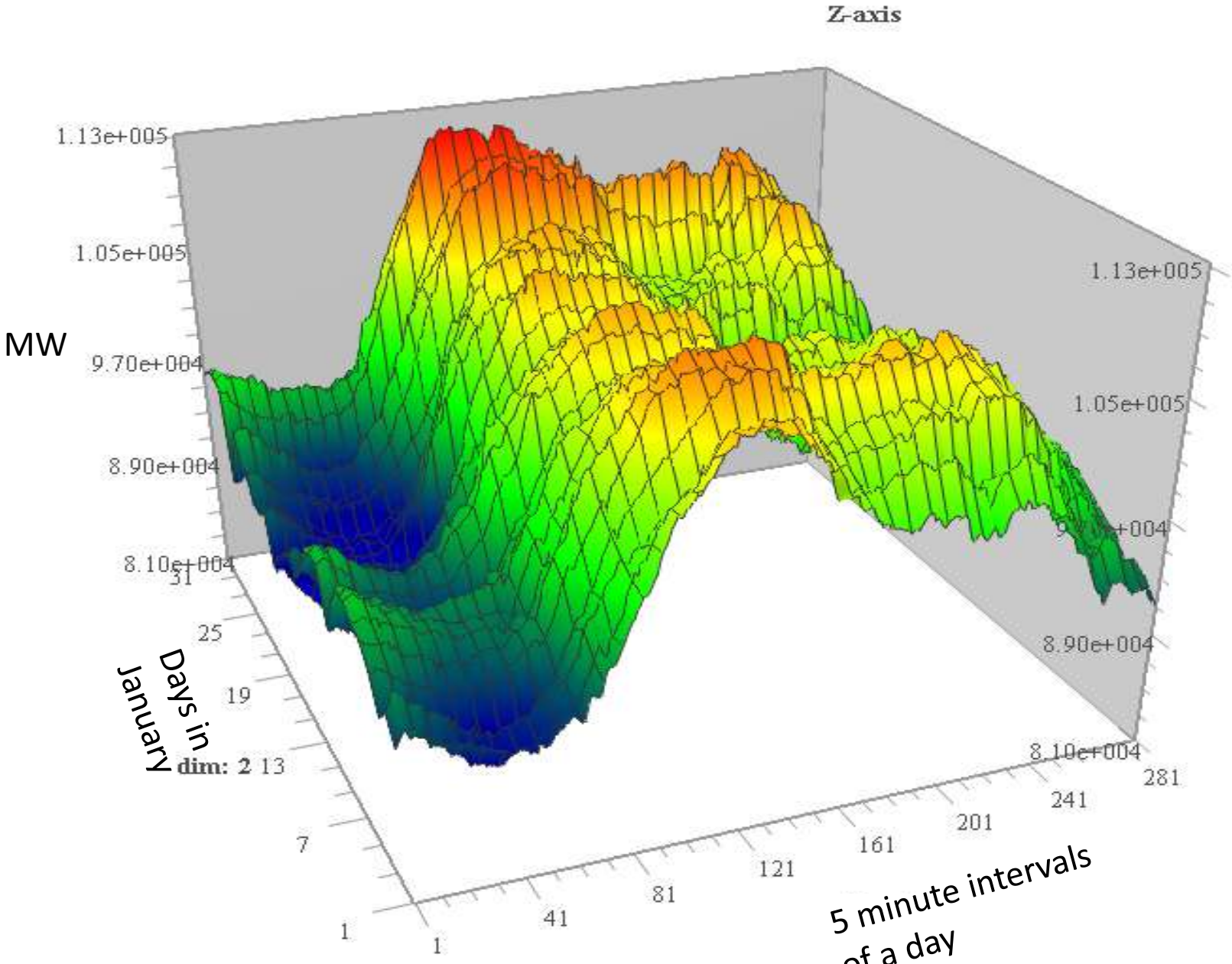
- Peak demand increasing year after year
- Difference between daily peak and lean is showing an increasing trend
- Growth during peak hours is much more than lean hours
- Need for more flexible generation to counter this gap

Ramping in All India Demand

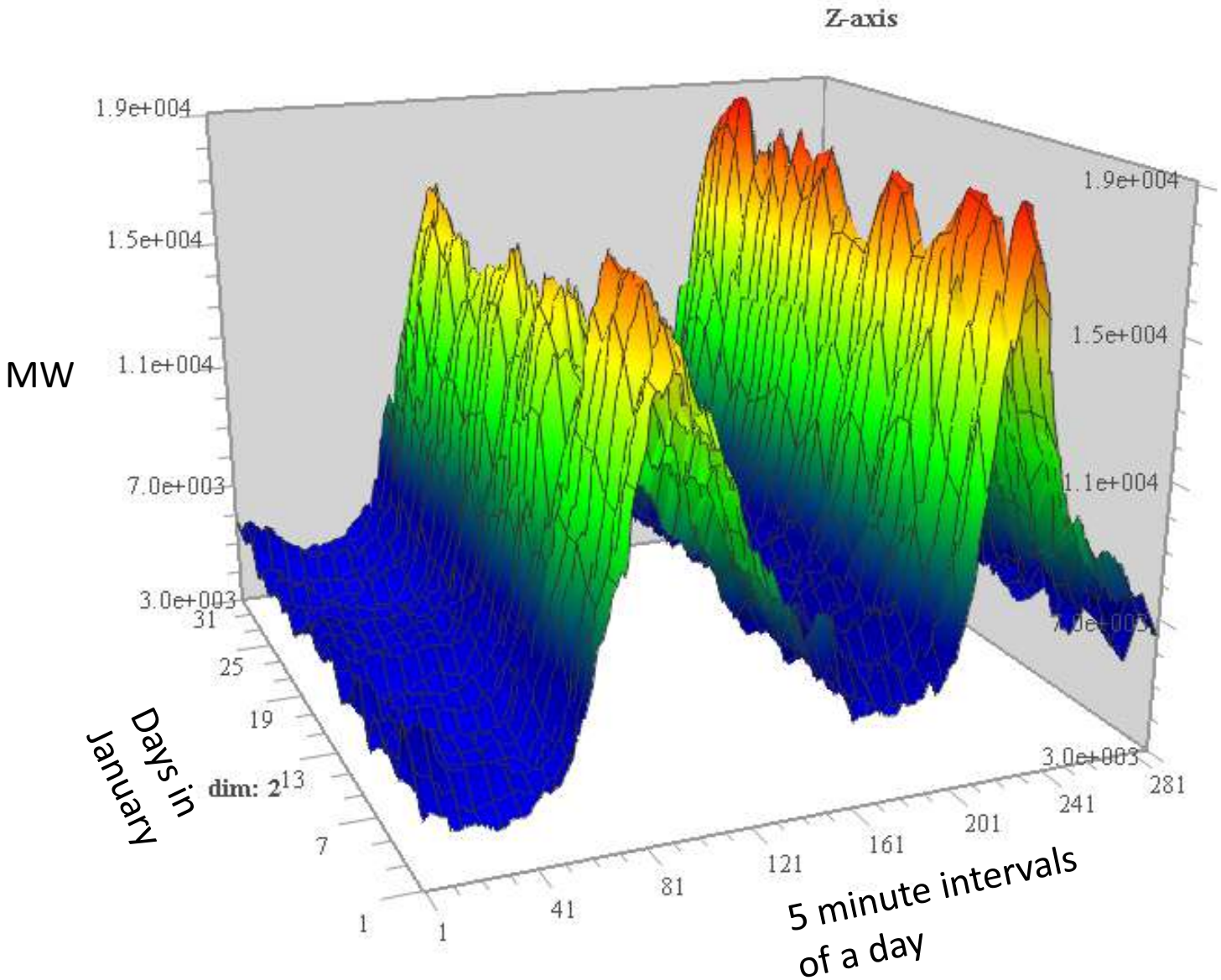




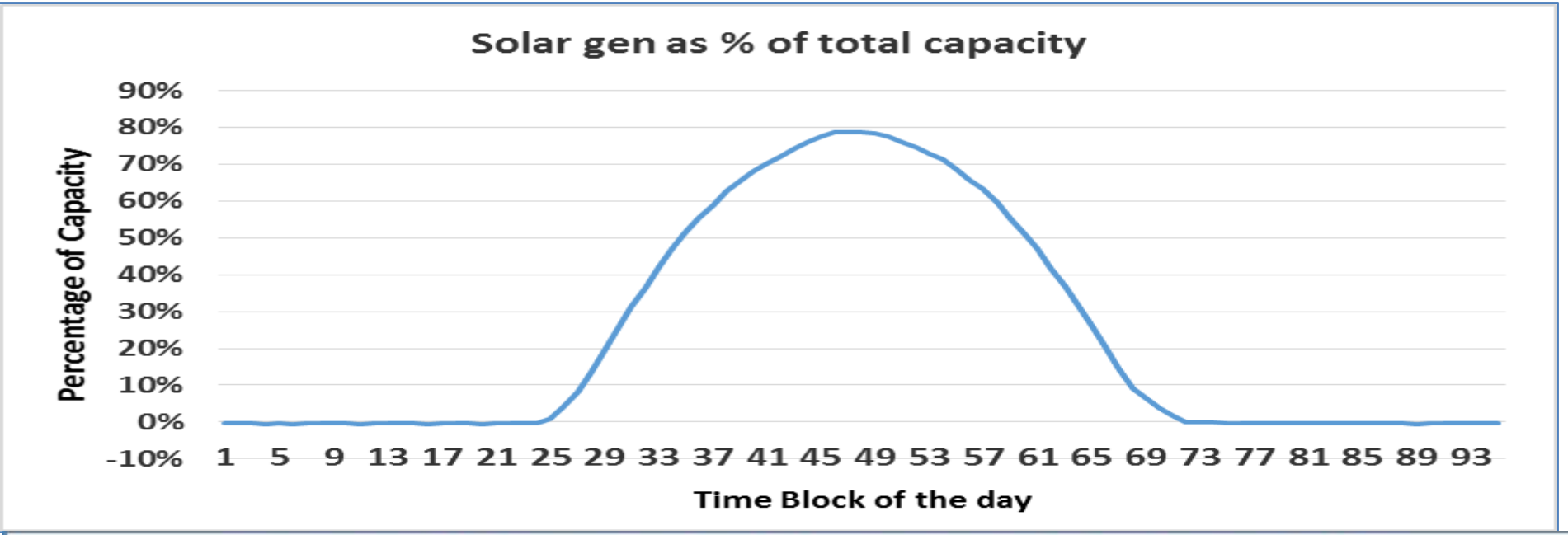
All India Thermal Generation

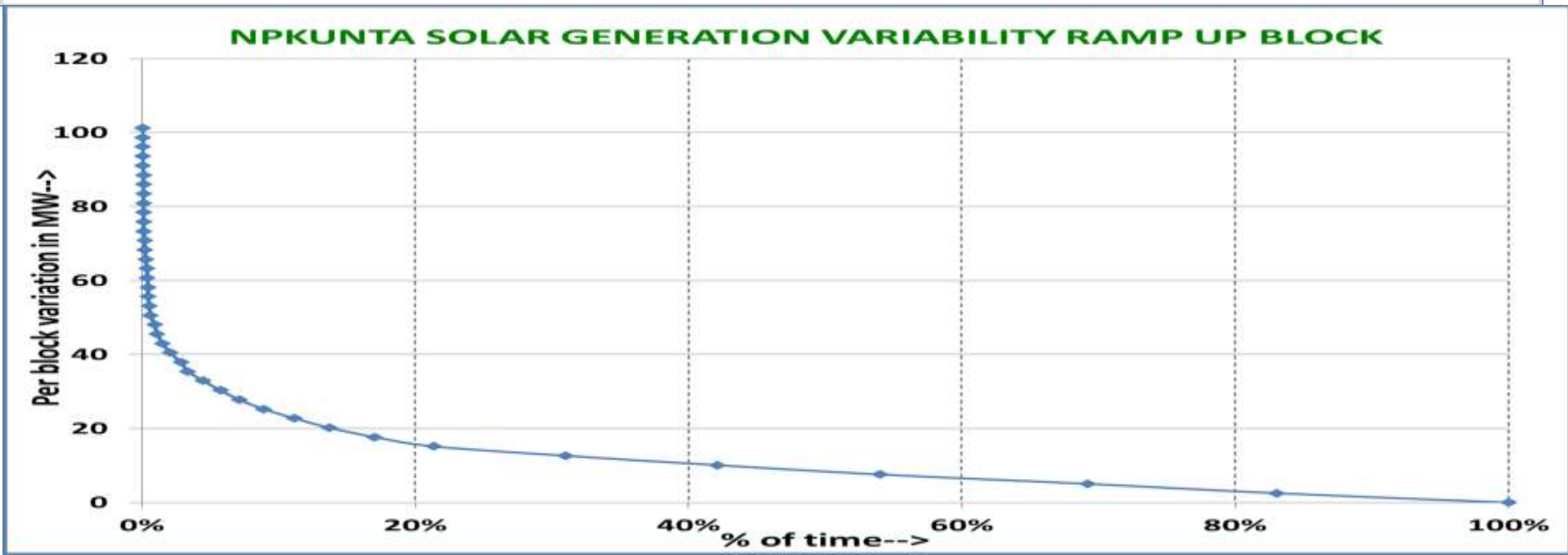


All India Hydro Generation

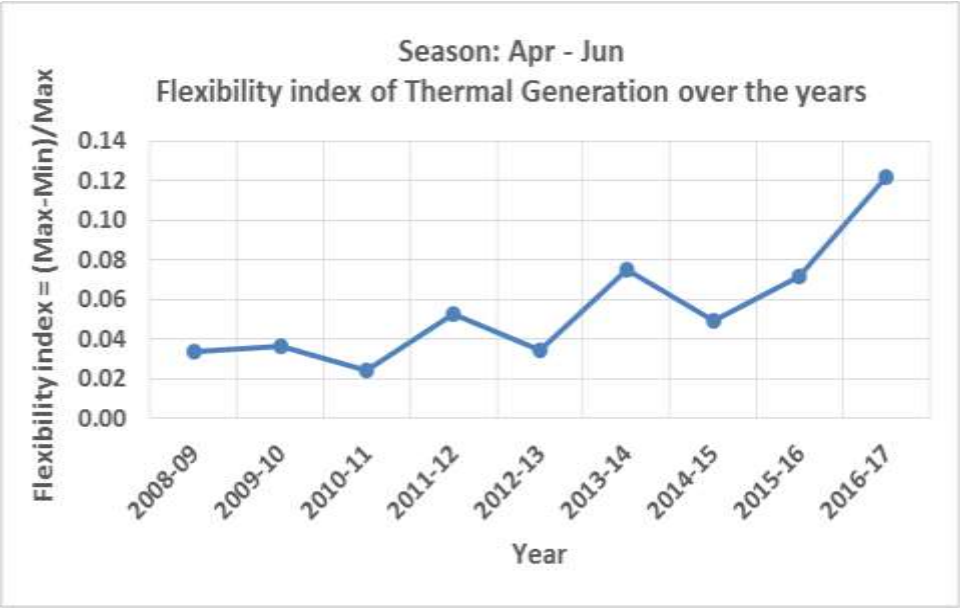


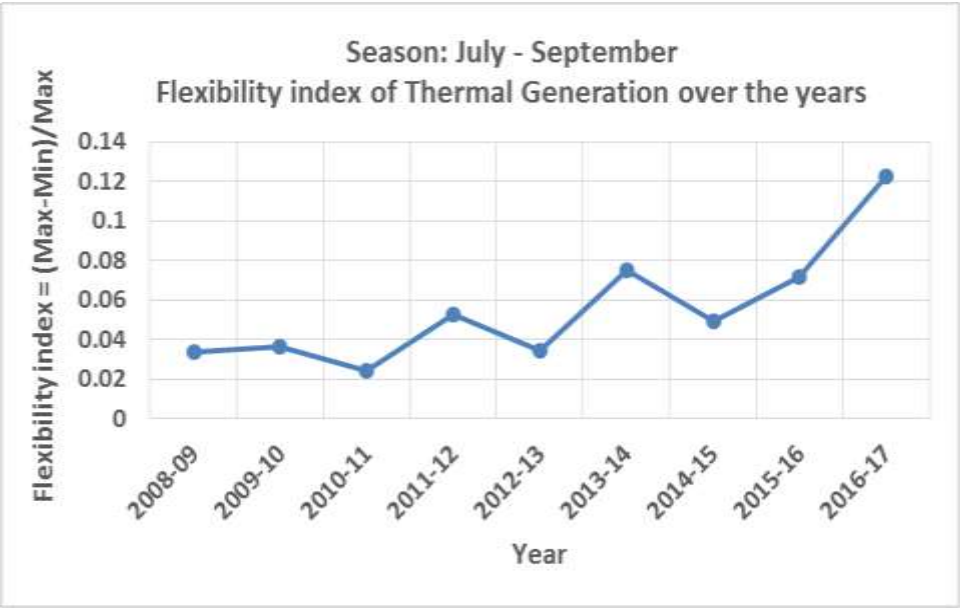
Solar Generation

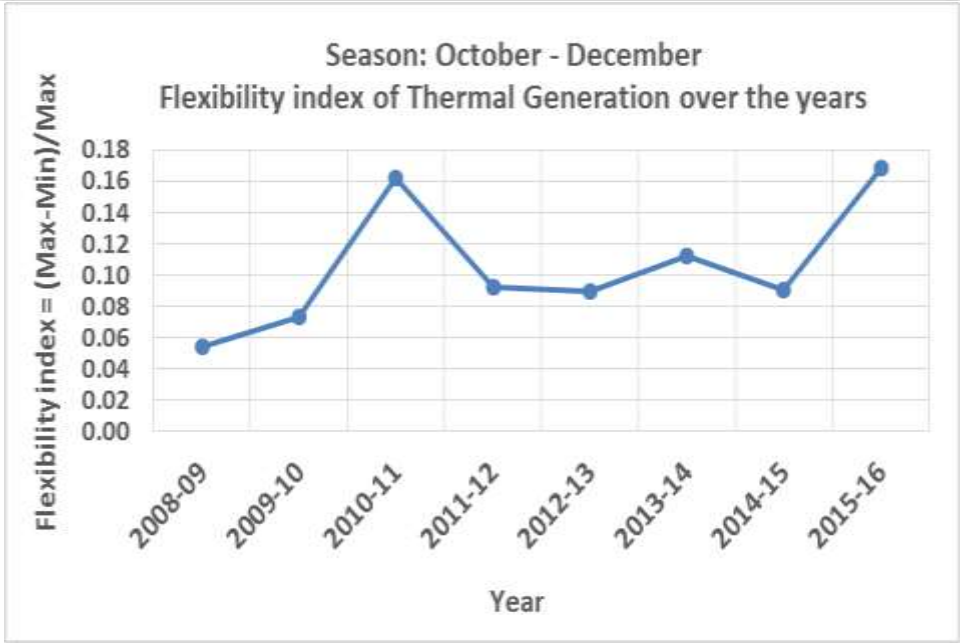


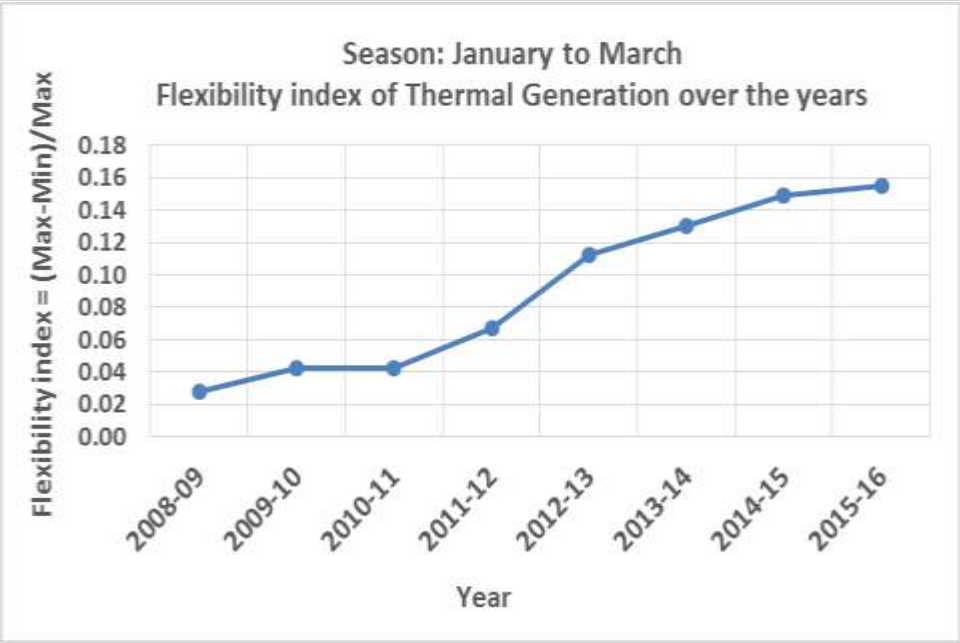


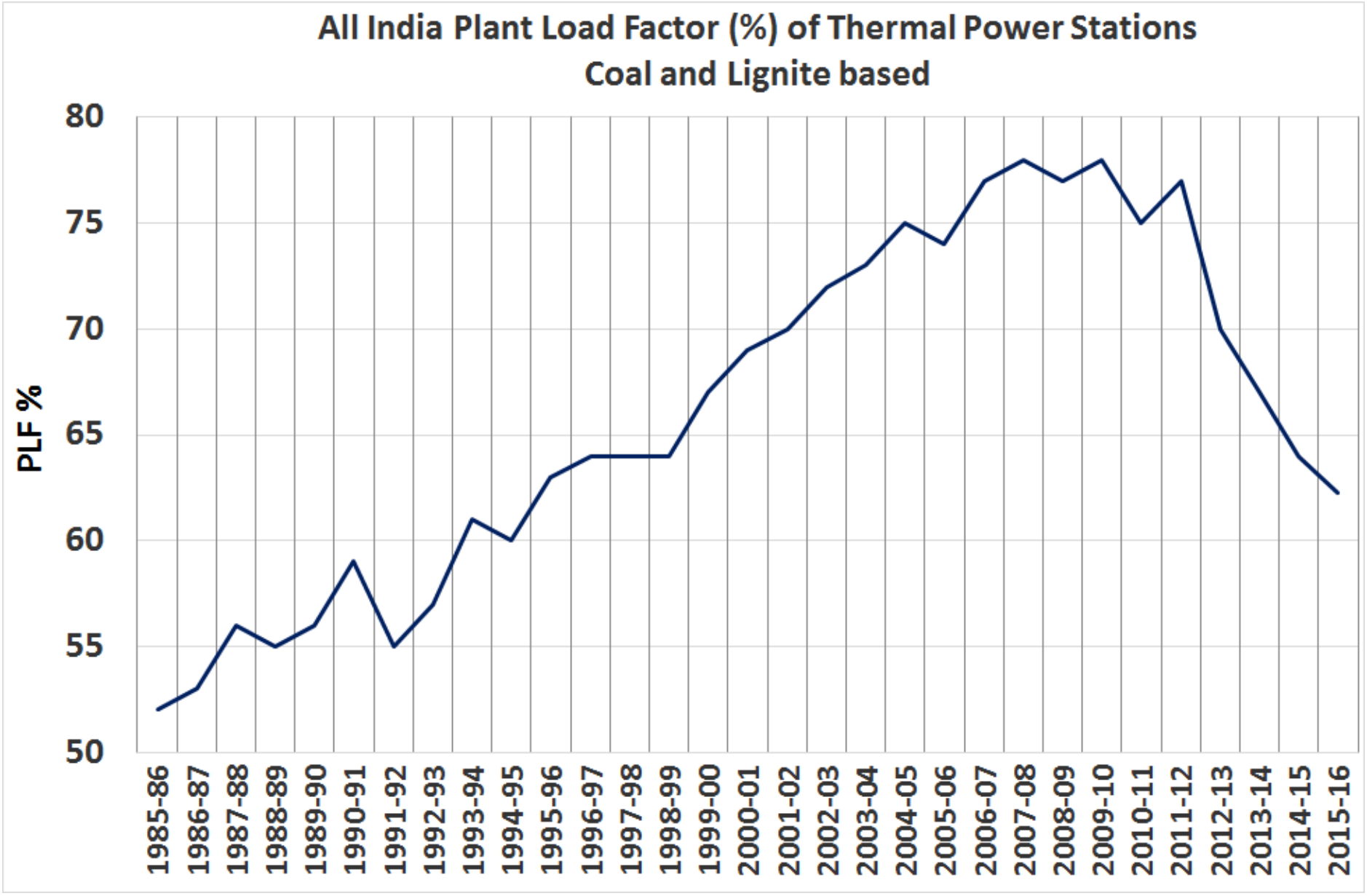
Flexibility index = ((Max-Min)/Max) over the years










All India Plant Load Factor (%) of Thermal Power Stations
Coal and Lignite based
PLF %
80
75
70
65
60
55
50
1985-86
1986-87
1987-88
1988-89
1989-90
1990-91
1991-92
1992-93
1993-94
1994-95
1995-96
1996-97
1997-98
1998-99
1999-00
2000-01
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16

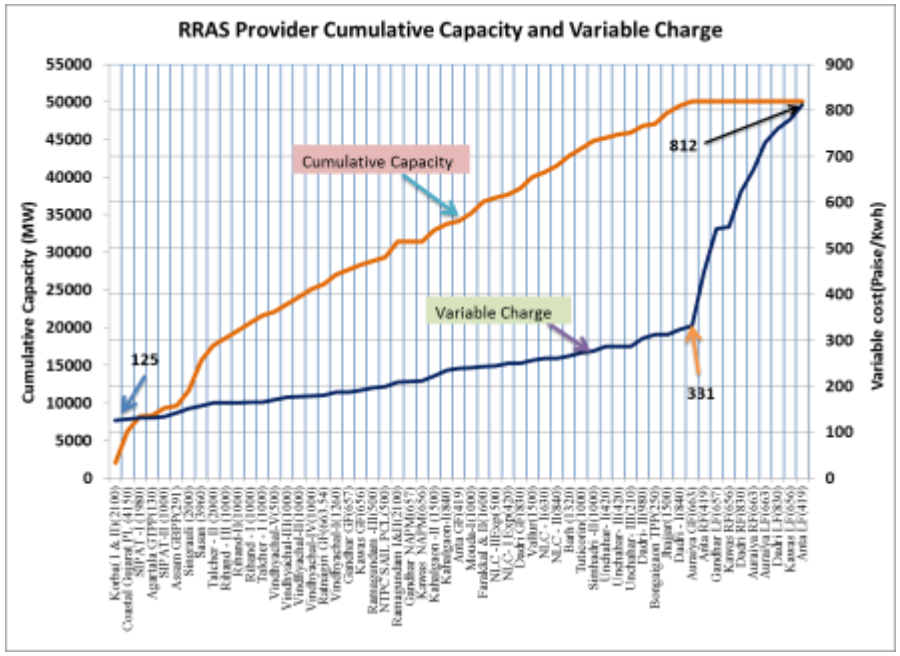
Ancillary Services

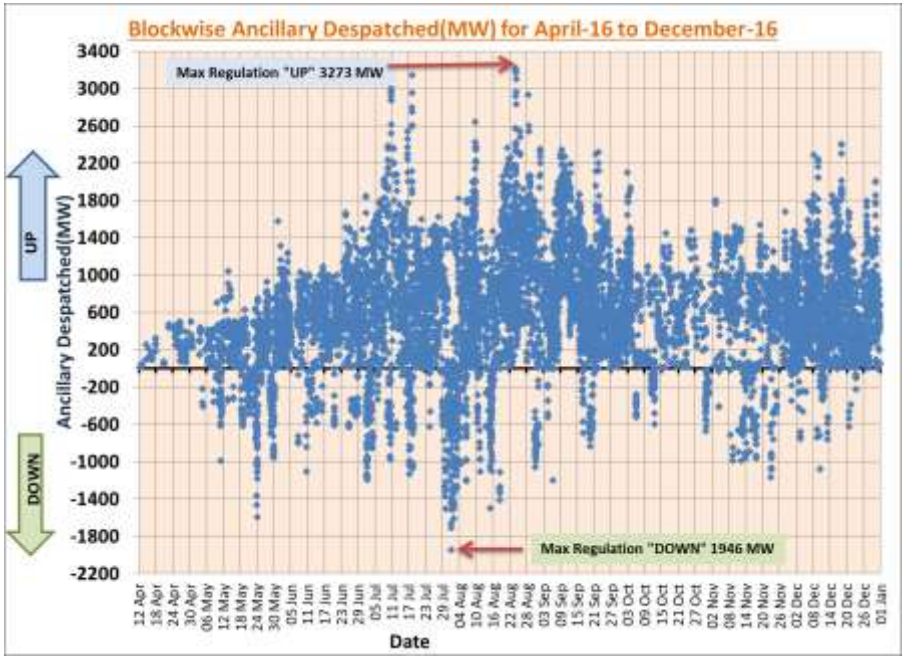
RRAS Providers:
48 Nos.

Capacity under RRAS:
51 GW

Maximum 'Up' Regulation :
3746 MW

Maximum 'Down' Regulation :
1946 MW





Lowest Variable Charge
~ Rs. 1.25 / Unit
(CGPL– WR)

Highest Variable Charge
~ Rs. 8.12 / Unit
(Anta LF– NR)

RRAS Despatch :
48 Time-blocks / day
(Avg.)

Energy Despatched:
Up – 6 **MU / day**
Down – 1 **MU / day**

Avg. Daily Number of RRAS Instructions :
06 to 07 Nos.

Energy Despatched:
Up – 6 MU / day
(0.2% of Energy met)

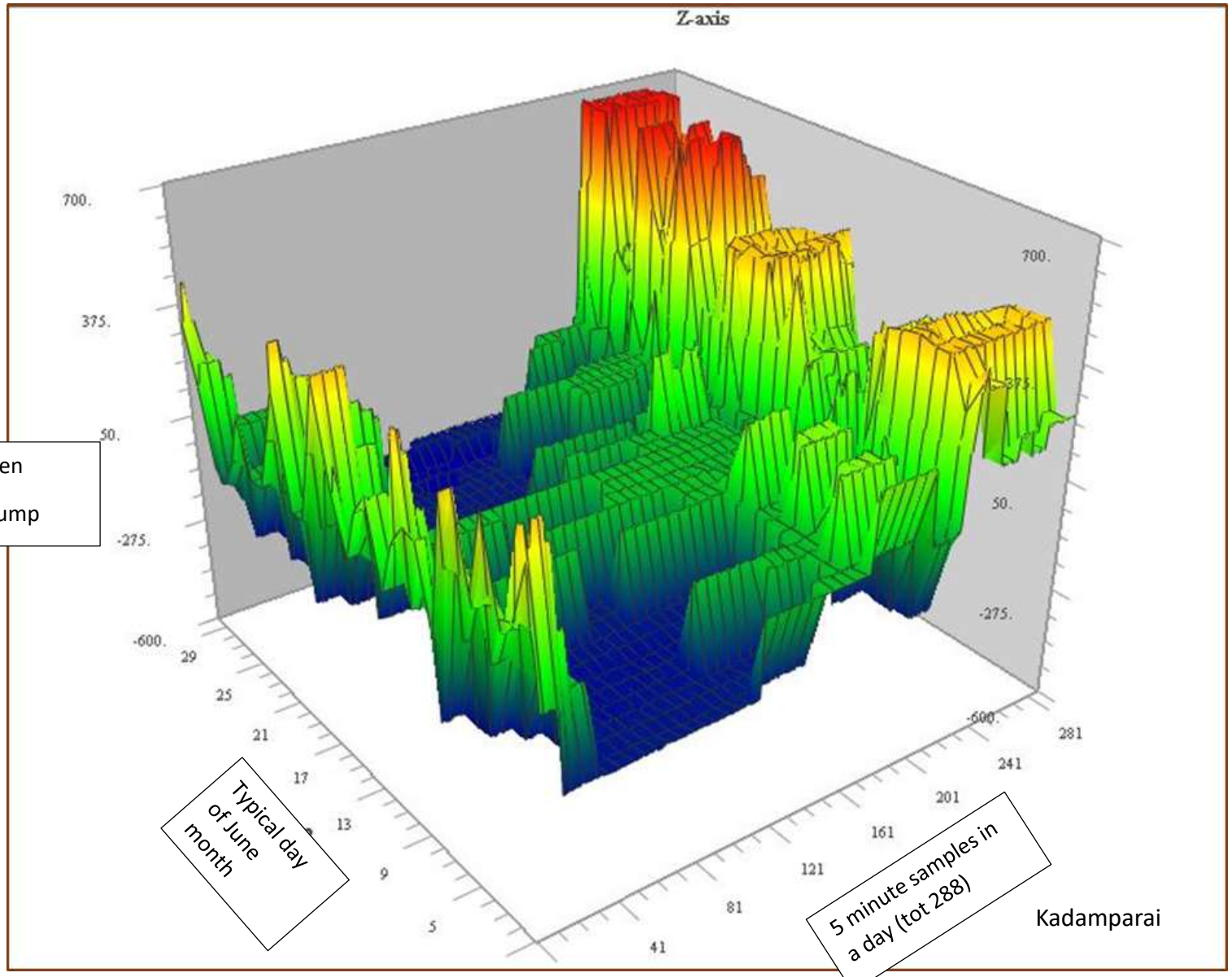
Energy Despatched:
Down – 1 MU / day
(0.03% of Energy met)

Pumped Storage Plants in India

S. No.	Name of Project / State	Installed Capacity		Pumping Mode Operation	Reasons for not working in Pumping mode
		No. of units x MW	Total (MW)		
1	Kadana St. I&II Gujarat	2x60+2x60	240	Not working	Due to vibration problem
2	Nagarjuna Sagar Andhra Pradesh	7x100.80	705.60	Not working	Tail pool dam under construction
3	Kadamparai Tamil Nadu	4x100	400	Working	-
4	Panchet Hill - DVC	1x40	40	Not working	Tail pool dam not constructed
5	Bhira Maharashtra	1x150	150	Working	-
6	Srisailam LBPH Andhra Pradsesh	6x150	900	Working	-
7	Sardar Sarovar Gujarat	6x200	1200	Not working	Tail pool dam not constructed
8	Purlia PSS West Bengal	4x225	900	Working	-
9	Ghatgar Maharashtra	2x125	250	Working	-
		Total	**4785.60**		

Source: " Large scale integration of Renewable Energy Sources-Way forward" Report by CEA

Pumped Storage



Provisions Regarding Ramping

- **Provisions in the Indian Electricity Grid Code (IEGC):**
  - Operating Code (Section 5.2):
    - System Security Aspects - Ramping of
      - All thermal units greater than 200 MW.
      - All Hydro units greater than 10 MW
    - Sudden change in generation / load by the utilities of more than 100 MW without prior intimation to and consent of the RLDC.
  - Scheduling and Despatch Code (Section 6.4)
    - Generators to declare rate of ramping up / ramping down in a 15 minute block.
    - Acceptable ramping rate – 200 MW/Hour (in NER 50 MW/Hour)
- **CEA Standard Technical Features of Super-Critical Units**
  - Ramp rate: + 3% per minute (above 30% loading)
  - Technical minimum load of super critical units – 40%
  - Two shift operation mandated

Technical minimum

- **CERC grid code fourth amendment regulations 2016**
  - Technical Minimum - 55%
  - Implementation is notified by CERC
- **Beneficiaries (DISCOMs) are directed to compensate for the Heat rate degradation**

S. No.	Unit loading as a percentage % of installed capacity of the unit	Increase in SHR for supercritical units (%)	Increase in SHR for sub – critical units (%)
1	85-100	Nil	Nil
2	75-84.99	1.25	2.25
3	65 -74.99	2	4
4	55-64.99	3	6

Increasing granularity of Despatch Interval

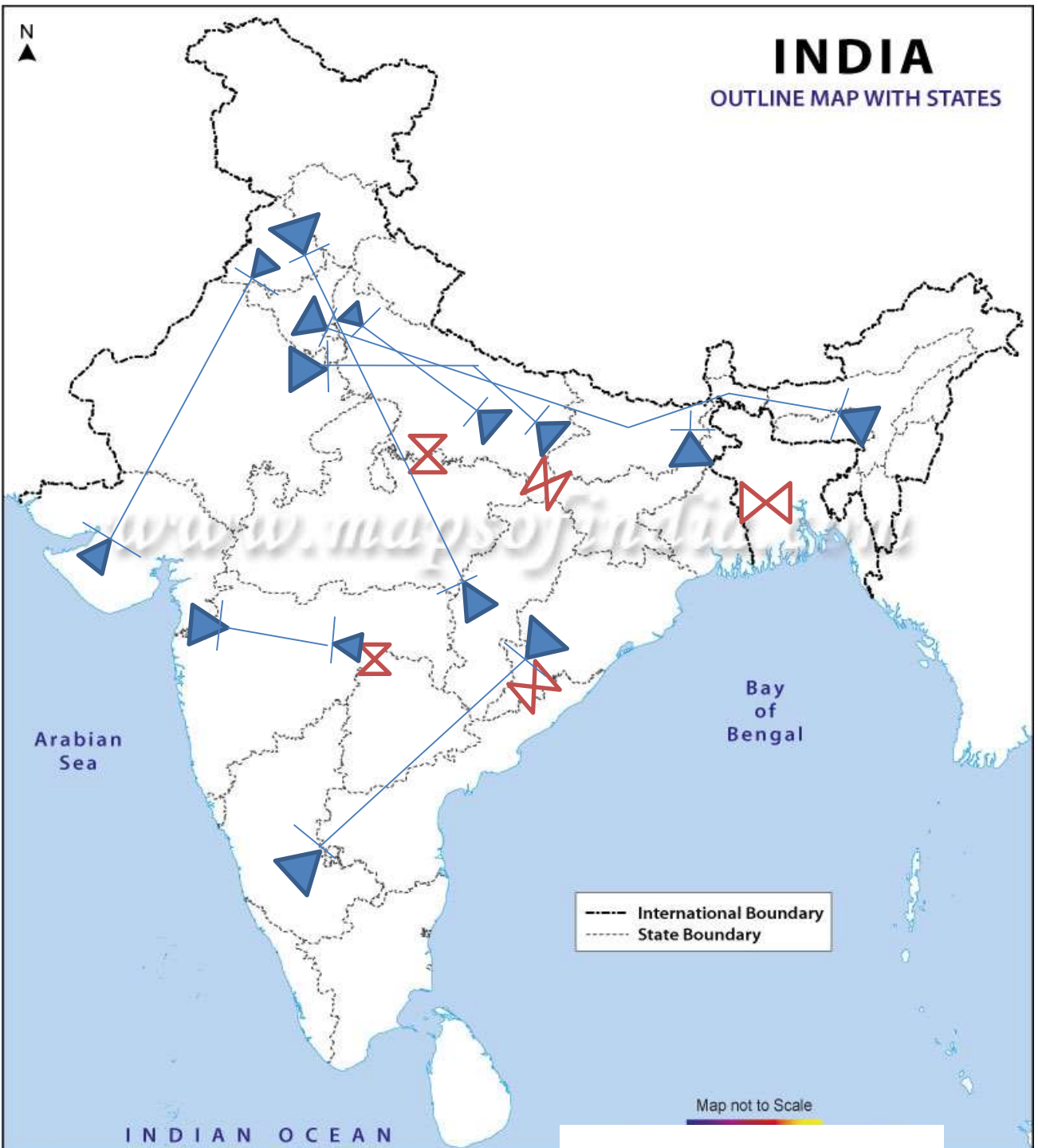
- 5-minutes scheduling:
  - Reduced the steep ramps
  - Eliminates sharp discreet changes
  - Reduced frequency fluctuations
  - Facilitates better load management
  - Facilitates integration of renewables

Flexible Generation

- **Hydro**
  - Plan and implement more pumped storage
  - Operational norms to incentivize flexibility

- **Thermal**
  - Grid Code clauses on flexibility (ramp rate, minimum)
  - Incentives for flexible generation
  - Two-shift operation of thermal plants
  - Primary, Secondary and Tertiary Controls

- **Renewables**
  - Low Voltage Ride Through (LVRT)
  - Draft CEA standards notified



Flexible Transmission

- **HVDCs in India**
  - **4 back to back HVDCs**
  - **6 bipole HVDC links**
  - **1 MTDC**
  - **1 more planned**

- **CEA Transmission Planning Criterion (Section 18)**
  - More than 2000 MW over long distance more than 700 km.
  - Corridors of AC lines carrying heavy power flows (total more than 5000 MW)

Signs of Inflexibility

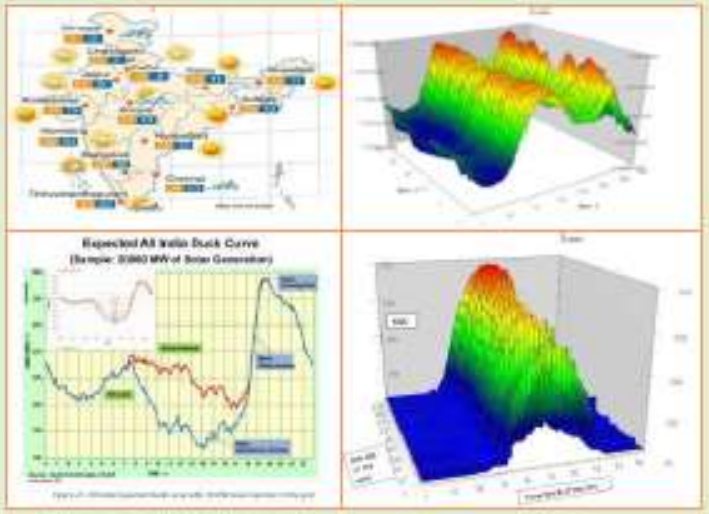
- Difficulty in balancing demand and supply
  - Frequency excursions
- Renewable curtailment
  - Inability to balance
- Area Balance Violations (Deviations)
- Electricity Markets
  - Price volatility

Source: Cochran, J. et al. (2012), "Flexibility in 21st Century Power Systems, A 21st Century Power Partnership Report". Golden, CO: National Renewable Energy Laboratory.
http://www.nrel.gov/docs/fy14osti/61721.pdf

Way Forward

- **Power systems are already flexible, designed to accommodate variable and uncertain load.**
  - New actors RE, distributed generation, storage etc. to be accommodated
- **Need for 'Flexible' Systems**
  - **Flexible Generation**
  - **Flexible Transmission** – FACTs, HVDC
  - **Flexible Distribution** – Price responsive demand
  - **Flexible Markets -**
    - More Frequent market operation, Ancillary services, Demand response
- **Policy / Regulatory Framework for Flexibility**
  - Measuring Flexibility
  - Metrics for performance
  - Incentivizing and paying for flexibility
  - Policy support to anticipate flexibility needs and support system flexibility
  - Flexibility considerations can be integrated into the design of procurement policies

Flexibility Requirement in Indian Power System



Power System Operation Corporation Limited

New Delhi

January 2016

https://posoco.in/download/flexibility_requirement_in_indian_power_system/?wpdmdl=711

Thank You