

Smart Grid In India

Amit Narayan, Ph.D.,
Stanford University

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Smart Grid – Areas of Interest

New Technologies

Generation

- Solar, Wind, Fuel-Cells etc.
- Distributed Generation

Storage

- Utility Scale Storage
- Distributed Storage

Customer Participation

- Smart-Meters / Smart-Appliances
- Residential Solar
- Electric Vehicles (PHEVs, BEVs)

Market Dynamics

Wholesale Markets

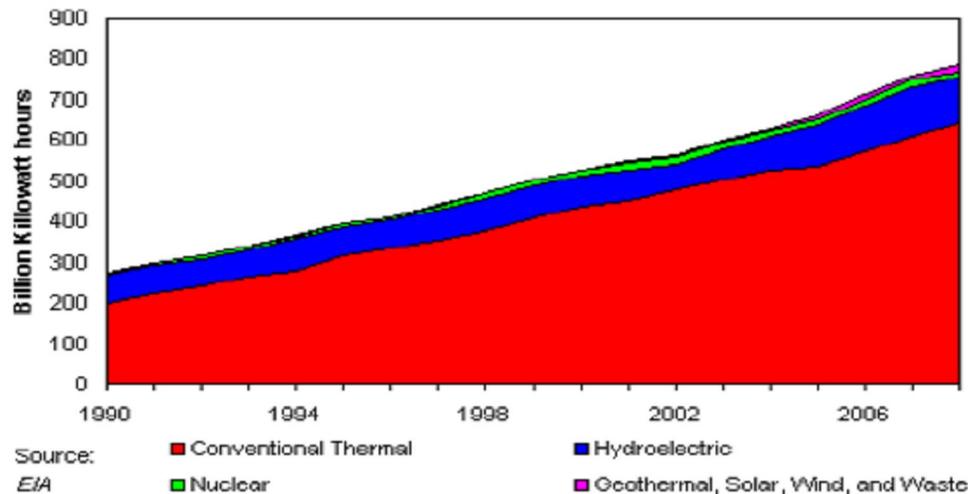
- Day-ahead and hour-ahead markets
- IPPs and LSEs

Retail Markets

- Demand Response
- New Rate Structures
 - TOU, RTP, CPP, CPP-R...
- Retail Competition

Generation in India – Strong Growth in Generation Capacity, Strong Emphasis on Renewable Sources

Electricity Generation by Type, India
1990-2008



Capacity:

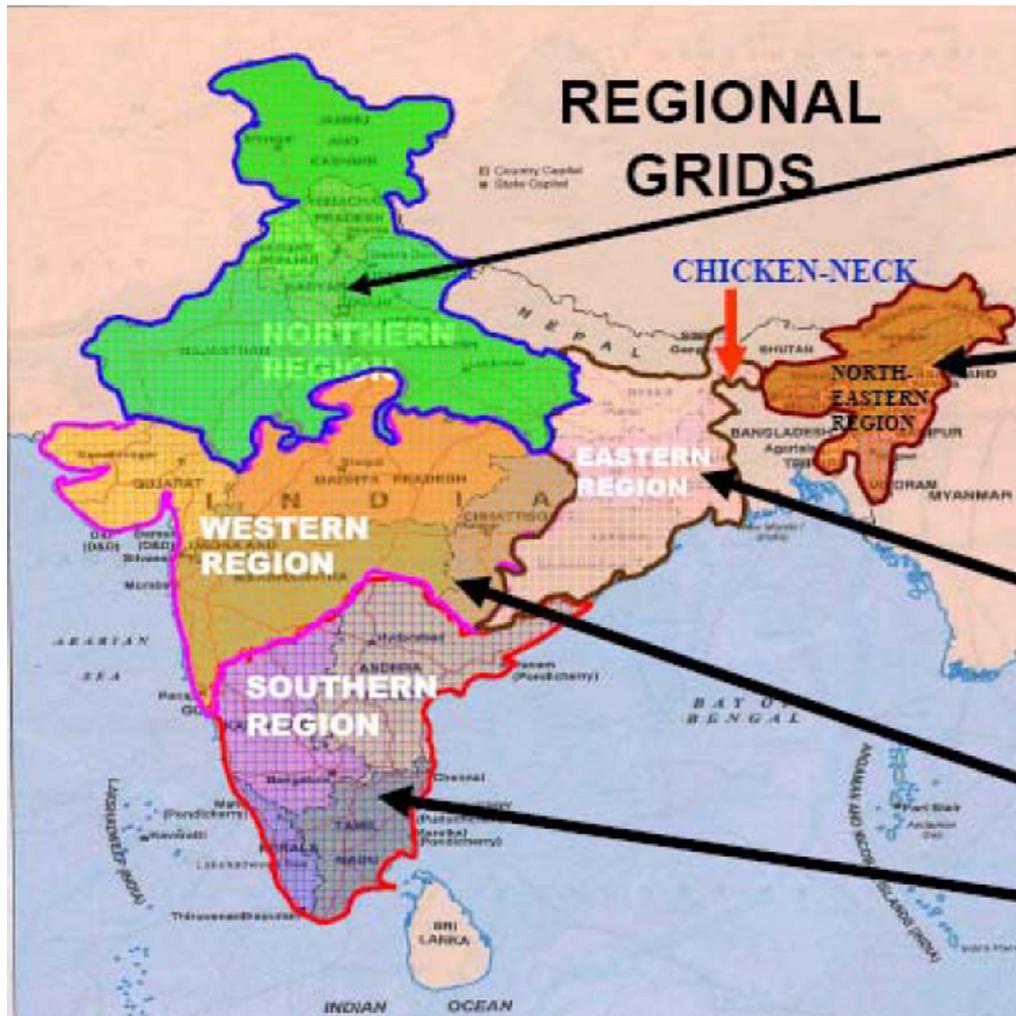
- Approx. 150 GW now (US: ~1000GW)
- >100% growth/decade until 2030
 - 950 GW by 2030

Generation Mix:

- Thermal – 64%
- Hydro – 22%
- Renewable (mainly wind) – ~10%
- Nuclear – 3%

- Ministry of Renewable Energy; National Action Plan on Climate
- 18 states have Renewable Portfolio Standards; 9 states have feed-in tariffs
- **Wind** – India has the world's 3rd largest wind provider; largest in Asia (**Suzlon**)
- **Solar** – 20 GW by 2020; National Solar Mission
- **Nuclear** – 30 GW of nuclear by 2020; Collaboration with France, Russia, US
- **Gujarat, Maharashtra, Rajasthan, Tamil Nadu** pushing forward with renewables

Transmission Infrastructure In India



Northern Grid –

- Run-of-the-river hydro (snow fed)
- Highly weather sensitive load
- Net Deficit region

North-Eastern Grid –

- High hydro potential – micro Hydro
- Very low loads
- Electricity evacuation is a problem

Eastern Grid –

- High coal reserves – base load plants
- Low loads
- Net excess capacity

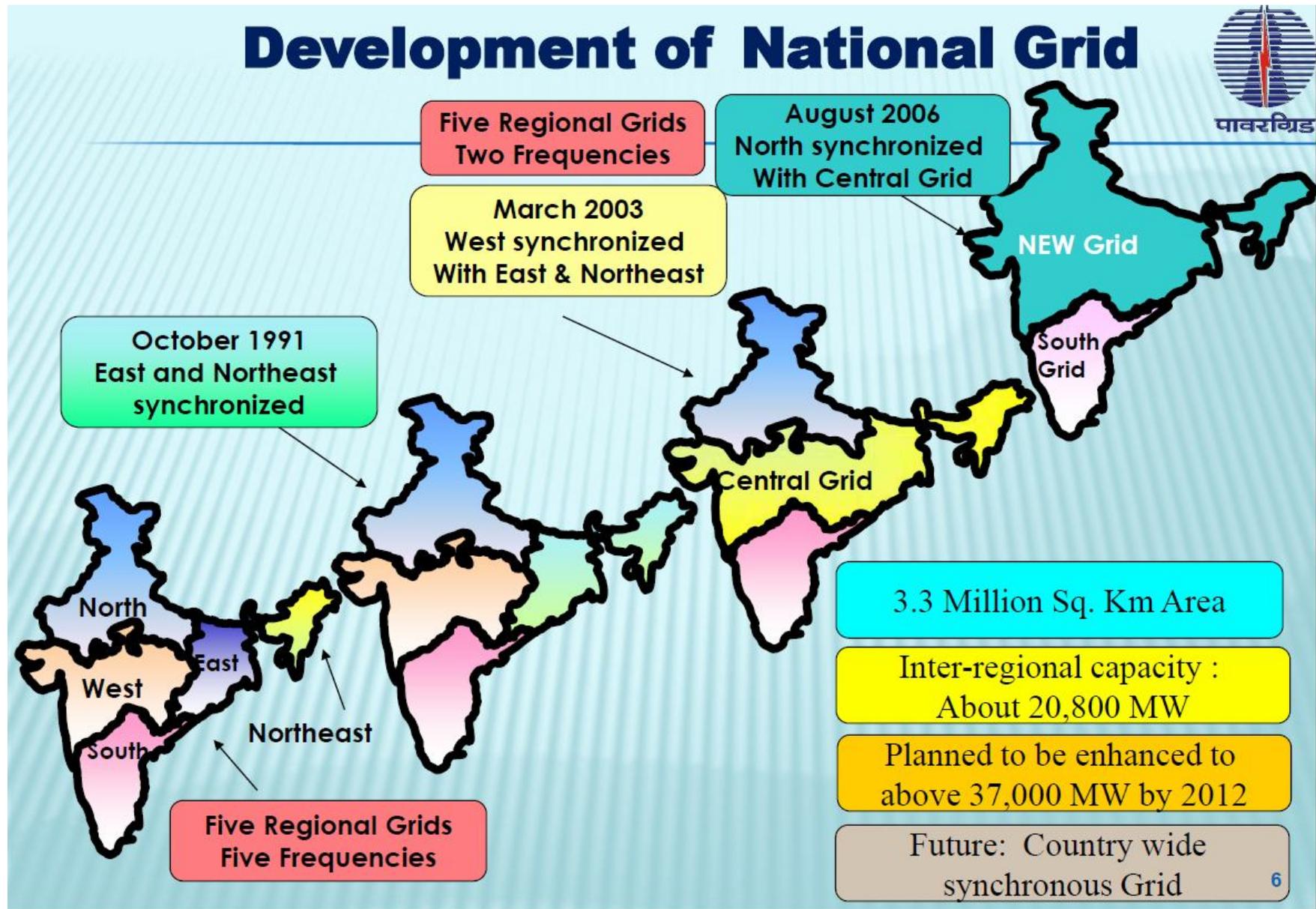
Western Grid –

- High load – industrial + agriculture
- High interest in solar / wind

Southern Grid –

- Hydro (rain dependent)
- High load (40% agriculture)

Transmission Infrastructure In India



Smart Grid for Transmission Network

- **Power Grid Corp** – operation of the national grid
 - Growing at 40% CAGR;
- Aggressive deployment of **Phasor Measurement Units (PMUs)**
 - Northern – already installed 4 PMUs, 20 more in progress
 - Western – 25 PMUs
 - Eastern – 70-80 PMUs
- Functioning wholesale electricity trading markets on commodity exchanges
 - Low volumes, ~5% of electricity traded on exchanges
- Lot of research activity related to PMUs in universities
 - Optimal placement of PMUs
 - Dynamic State Estimation
 - Control schemes, Software for data visualization, ...

Distribution Infrastructure In India

- 80% of villages are 'electrified', yet...
 - 45% of the population doesn't have access to electricity
 - ~400 Million people without electricity (US population ~300 Million)
 - For other 55%, power-cuts and rationing are a norm
- Aggregate Technical and Commercial (AT&C) losses are very high
 - >30% on average, >50% in many states
 - High electricity 'theft'; poor policing / enforcement due to political reasons
- Subsidies to agricultural sector
 - Free or very low-cost power which is often un-metered;
 - Hard to separate free power from 'theft'

Distribution Infrastructure In India

- ~60 Electricity Distribution companies in India
 - Generally state-owned monopolies
 - Generally loss making entities (average loss 11% of sales / year mainly due to high AT&C losses and poor revenue collection)
- Reform of the distribution sector identified as a key need by the government -
 - APDRP, R-APDRP – Reducing AT&C losses a key focus
 - Open-Access for the distribution network to foster competition
 - Laws against theft - better enforcement, better communication
 - Privatization & Franchising of distribution network
 - Demand Side Management – especially in agricultural sector
 - Rationalization of tariffs and removal of cross-subsidies

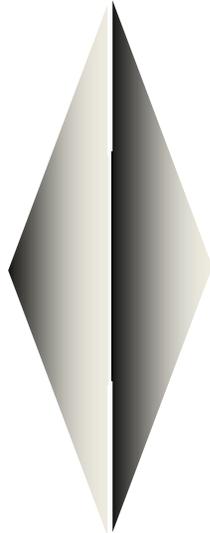
High Penetration of Distributed Energy Resources

- Many customer segments taking things in their own hands -
 - Industrial centers, Software Export Zones (SEZs) have their own captive generation
 - Large residential complexes usually have near-100% power back-up through captive generation
 - Small residential customers have a high penetration of distributed energy resources -
 - Diesel-generators
 - Battery-Inverter packs – peak-load shifting and load management
- No active government policy to encourage distributed generation and storage (except renewable), yet a high-level of customer adoption
 - Feed-in tariffs, micro-grid creation, tax-incentives...

One Smart-Meter for Every House?

- Smart Metering coming to India -
 - Driven by the need for reducing AT&C losses
 - Measurement the first step towards improvement
 - Some companies are already active – Echelon, GE, Landy+Gyr
- Can we build & deploy a smart-meter for \$10-\$20 ?
 - US Typical smart-meter deployment cost is around \$200-\$250 / meter
 - e.g. Baltimore installing 2 Million smart meters @ \$450 Million
 - Bill-of-Material is \$50-100; rest is labor and back-office software
 - We can build a laptop for \$10 (One Laptop Per Child program)!
 - Custom SoC, open-source software, low-installation cost

Water-Power Nexus in India



- High ground water usage for irrigation and household consumption
 - Significant energy consumption in pumping ground water
 - Poor power quality and unreliable power supply leads to inefficient use of ground water & electricity
 - Subsidies to agricultural sector leads to poor / unreliable supply
- Opportunity to break the vicious cycle by –
 - Demand Side Management
 - Distributed Renewable Integration
 - Higher efficiency equipment

On-going Smart Grid Activities in India -

- APDRP, R-APDRP initiative for distribution reform (AT&C focus)
- DRUM India – Distribution Reform Upgrade, Management
 - Four pilot sites (North Delhi, Bangalore, Gujarat, Maharashtra)
 - Smart Grid Vision for India
- Smart Grid Task Force – Headed by Sam Pitroda
- BESCOM project – Bangalore – Integration of renewable and distributed energy resources into the grid
- KEPCO project in Kerala India - \$10 Billion initiative for Smart-Grid
- L&T and Telvent project – Maharashtra – Distribution Management System roll-out
- Housing –
 - Rabisashi Abasan Housing project – Kolkata (2008). First instance of net-metering in India from roof-top Solar
 - SA Habitat and Valence Energy – Hyderabad (2009) . Distributed generation via roof-top solar for 40% in a micro-grid

Conclusion

- Lot of excitement around Smart Grid in India
- Power Infrastructure recognized as a key bottleneck in India's growth
- Favorable government policies / investments
 - Rural electrification, renewable generation, distribution reforms
- Implementation requires education and marketing of benefits to consumers and implementers
 - Strong leadership team coming together
- Opportunity to customize US / western solutions for Indian conditions
 - Cost / feature trade-off;