Smart Grid Initiatives in EHV Transmission in Indian Power Sector

पावरग्रिड

Presentation by

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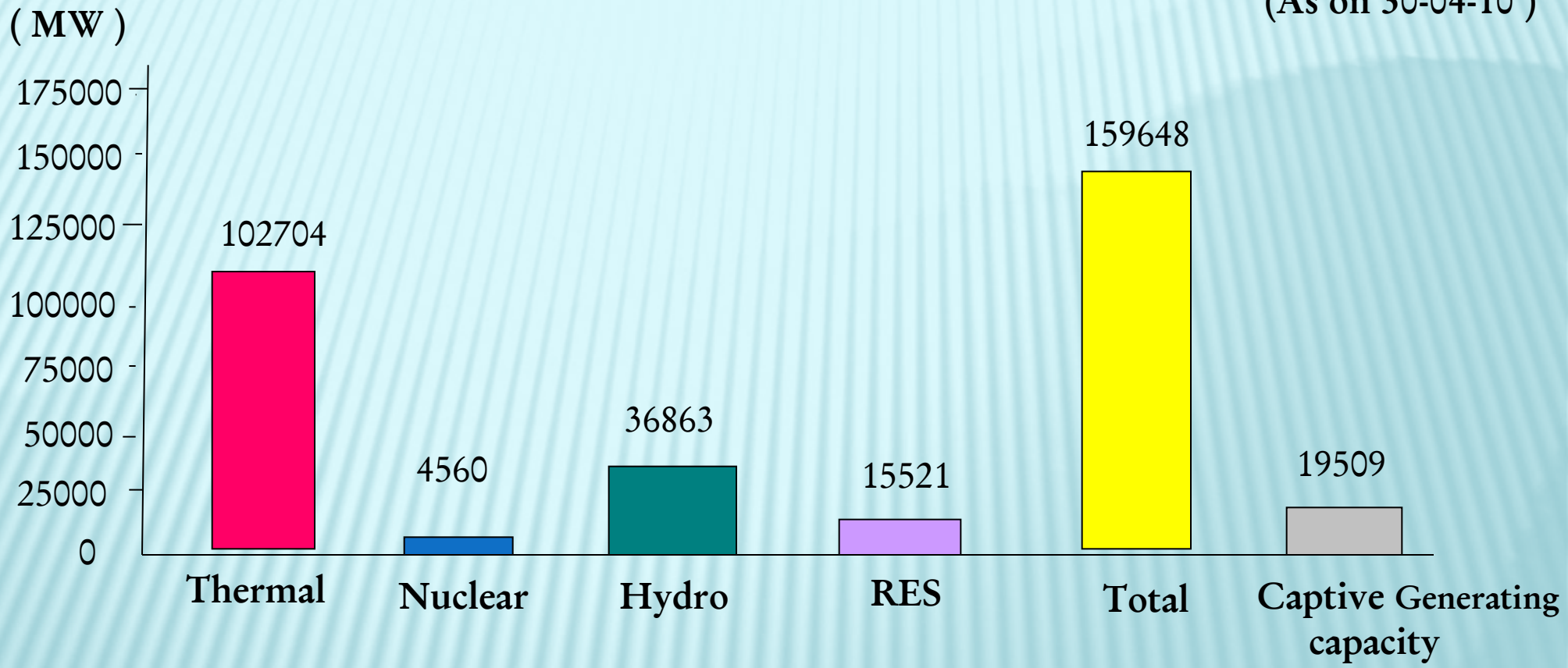
Presentation Flow

- EHV Transmission in Indian Power Sector
- Challenges in Grid Operation
- Synchrophasor & Smart Grid in Transmission
- Road Map for synchrophasor technology

EHV Transmission in Indian Power Sector

Indian Power System -Generating Installed Capacity

(Source: www.cea.nic.in)
(As on 30-04-10)

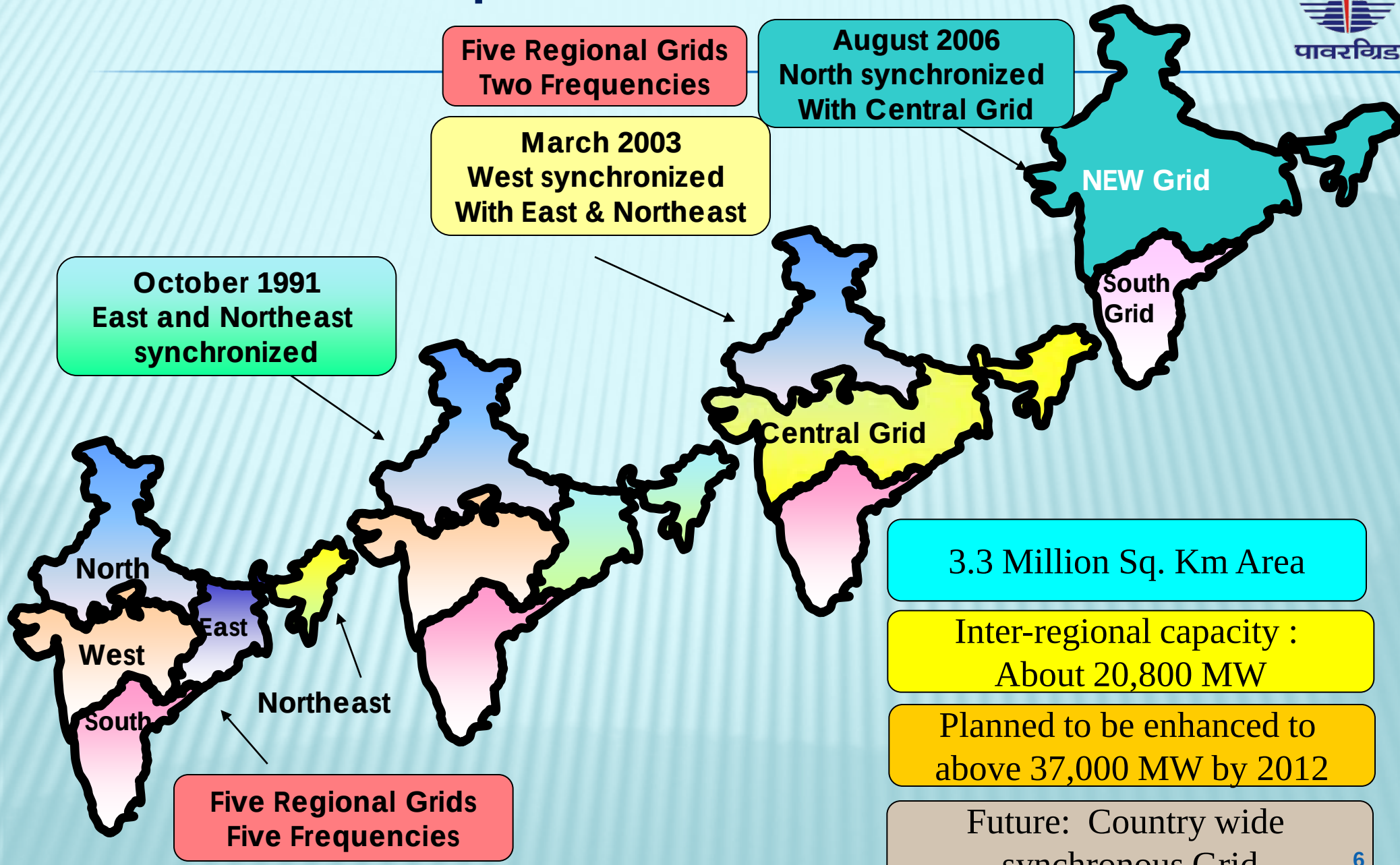


RES -Renewable Energy Sources includes Small Hydro Project (SHP-2604.92 MW), Biomass Gas (BG)& Biomass Power (BP)-2167.73MW, Solar-101.01MW and Wind Energy-10647.45MW

TRANSMISSION NETWORK

- National Grid interconnecting all the five(5) regional grids of 159,648 MW capacity geographically spread over about 3.3 million sq. kms
- Transmission Grid Comprises
  - 765kV/400kV Lines - About 78,000 ckt. km
  - 220/132kV Lines – About 115,000 ckt. km
  - HVDC Bipoles/Back - to –back - 10 nos.
  - FSC – 23 nos.; TCSC – 6 nos.
- Inter regional capacity – About 20,800 MW

Development of National Grid



3.3 Million Sq. Km Area

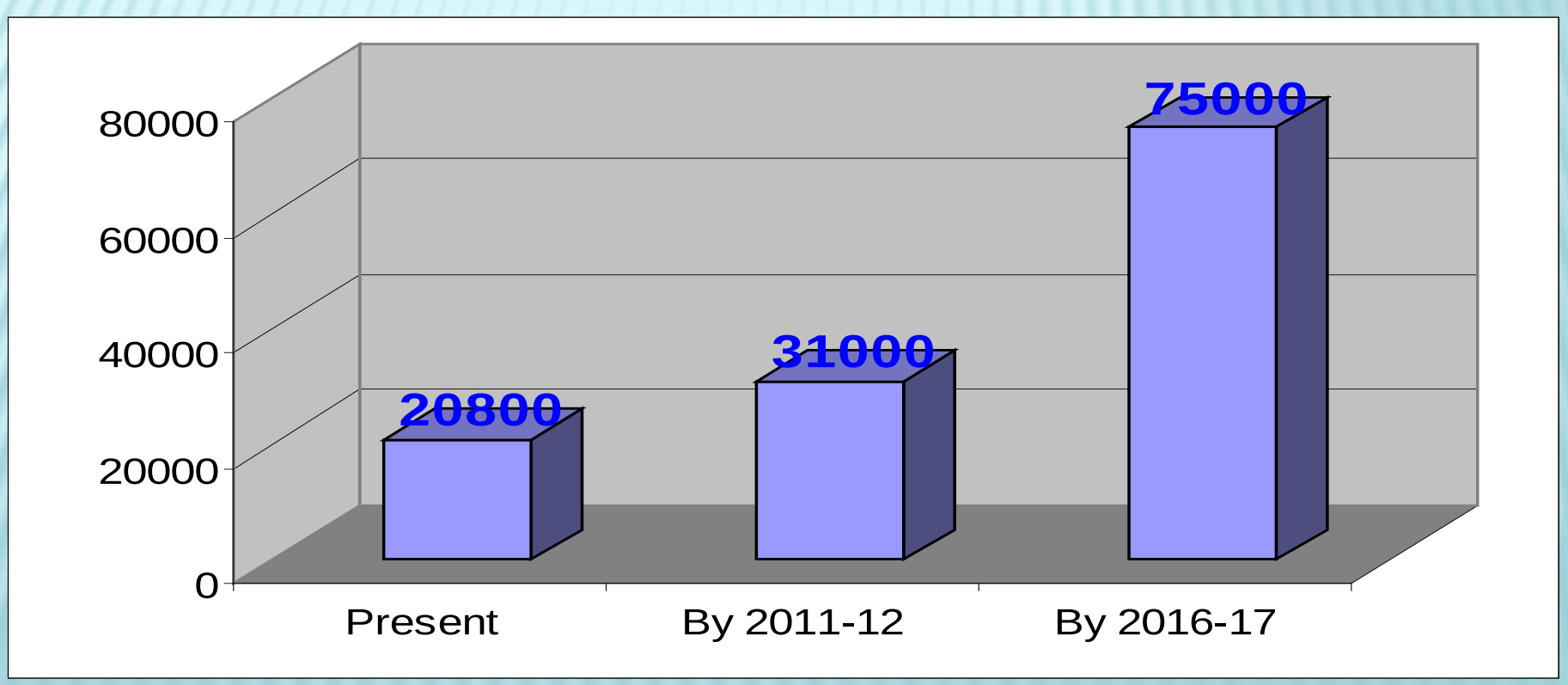
Inter-regional capacity :
About 20,800 MW

Planned to be enhanced to
above 37,000 MW by 2012

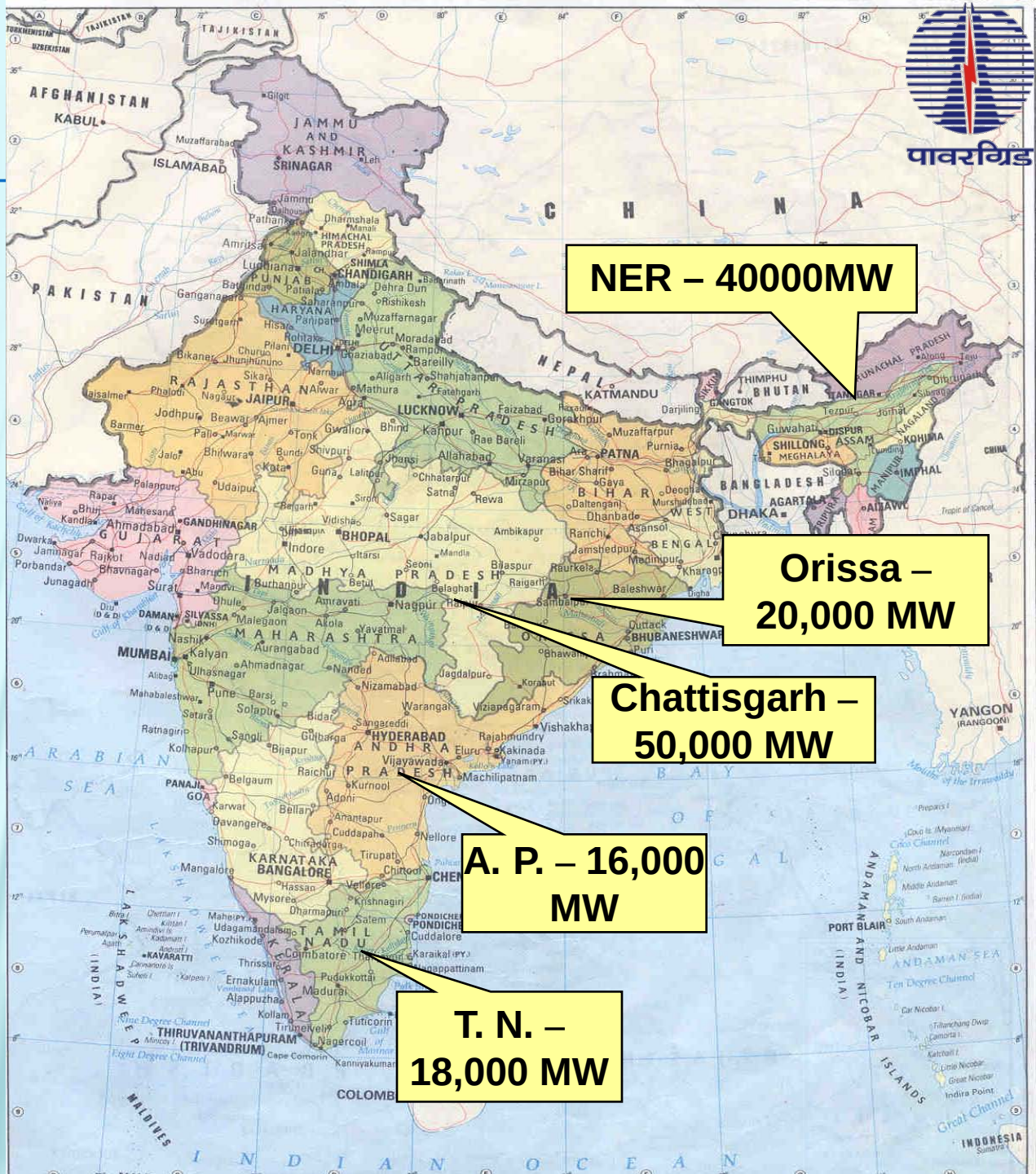
Future: Country wide
synchronous Grid

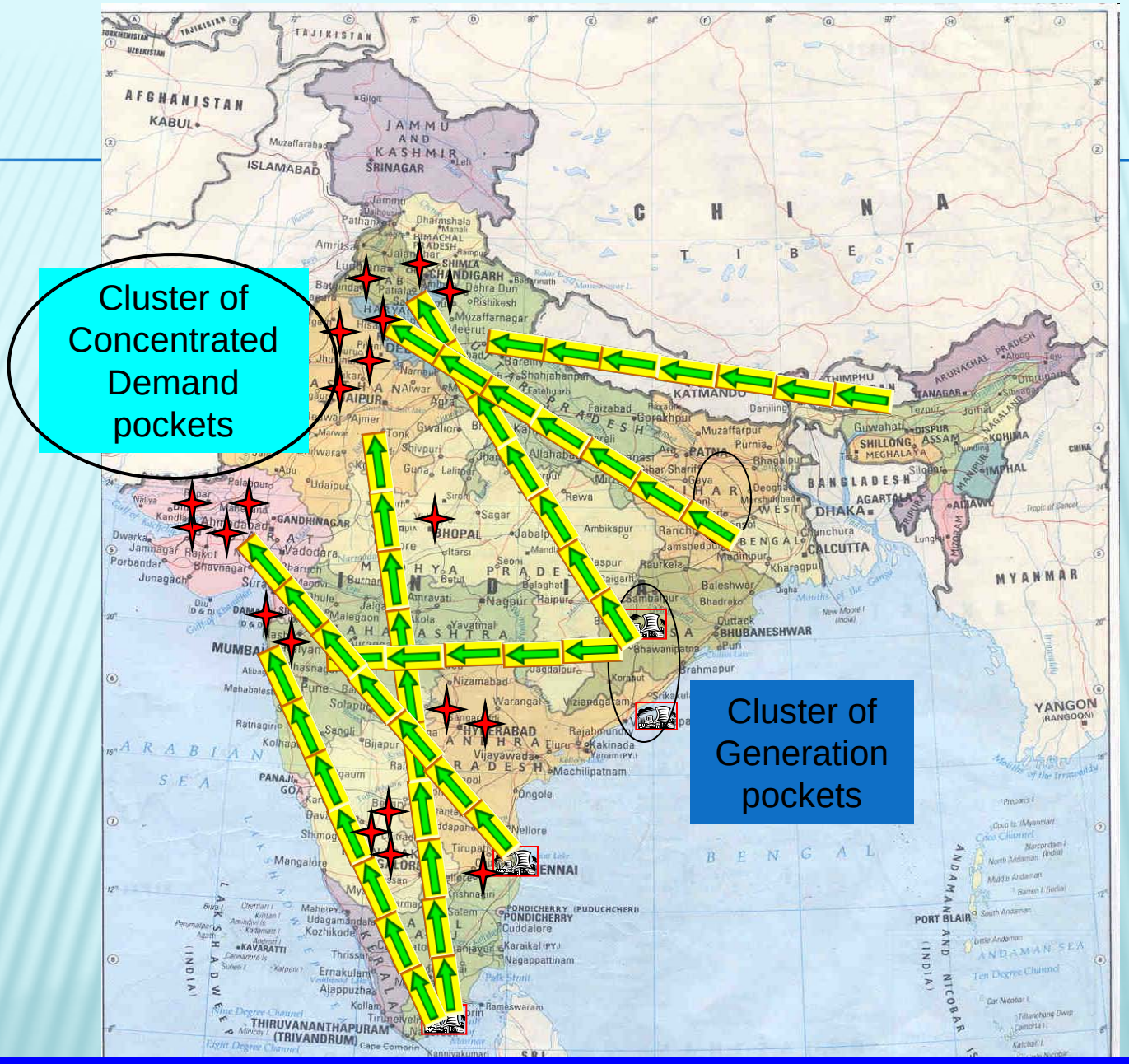
STRENGTHENING OF NATIONAL GRID

- Development of National Grid on continual basis with sufficient inter-regional power transfer capacity
- Planned to enhance the capacity progressively to about 75000 MVA by 2017.



UPCOMING GENERATIONS IN INDIA





Bulk Power transfer over long distance through Strong National Electricity Grid necessary

POWERGRID Transmission System Capacity Addition

- 11th Plan Target - 2012 –
  - Budget Rs 55,000 crs
  - 44,000 ckm lines is to be added
- Targets achieved till now
  - Spent Rs. 25237 crs
  - Added 17000 ckm lines
- Future target in next 2 years
  - Spend Rs. 29763c Crs
  - To add 27000 ckm including HVDC, 765 kv etc.

Challenges in Grid Operation

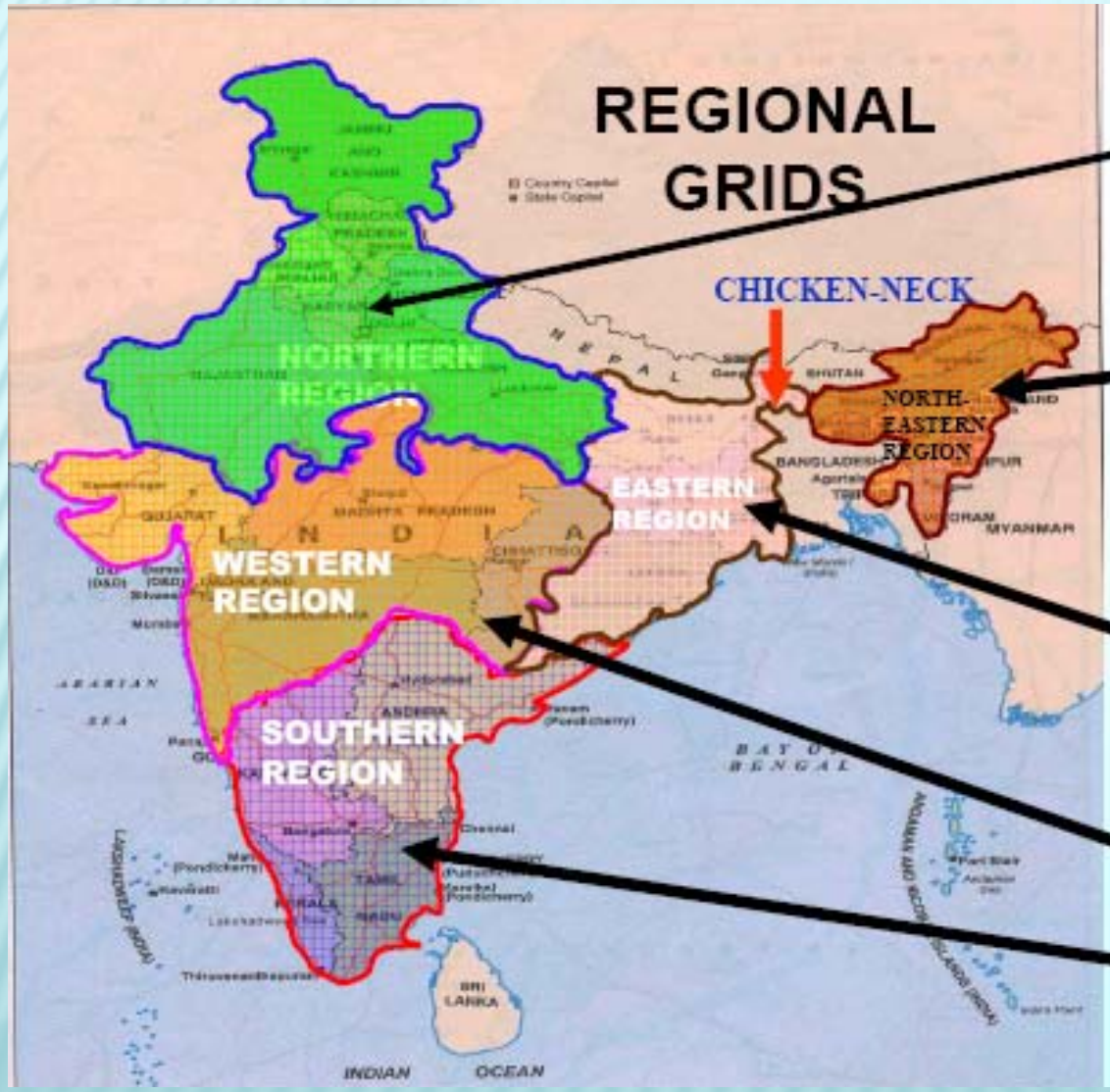
POWER FLOW PATTERN

1. **Variation in generation**
   - **High hydro in monsoon and summer**
   - **In winter only during peak hours**
   - **Power flow variations due to commercial/operational reasons**

2. **Variation in load demand**
   - **Daily basis (peak and off-peak)**
   - **Seasonal variations**

Due to above, each transmission corridor has varied power flow pattern ranging from high to low loading, results into wide variation in voltages

PECULIARITIES OF REGIONAL GRIDS IN INDIA



Deficit Region

Snow fed - run-of -the -river hydro

Highly weather sensitive load

Adverse weather conditions: Fog & Dust Storm

Very low load

High hydro potential

Evacuation problems

Low load

High coal reserves

Pit head base load plants

Industrial load and agricultural load

High load (40% agricultural load)

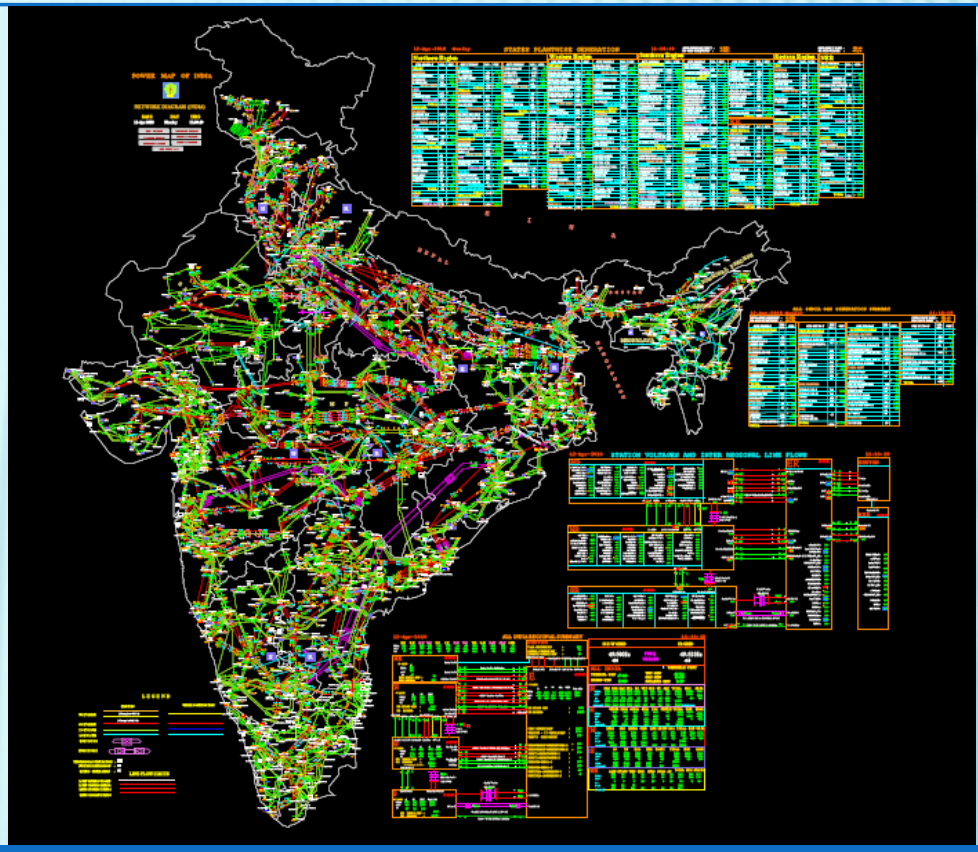
Monsoon dependent hydro

ISSUES & CHALLENGES IN TRANSMISSION DEVELOPMENT

- Hybrid Transmission System for maintaining critical parameters
- Increase in MW flow per metre of ROW
- Controlling high Short Circuit Levels
- Non-discriminatory Open Access
  - Market driven exchanges may influence pattern of power flow
  - Periodic review and strengthening
- *Necessitates optimal utilization of existing transmission infrastructure by enhancing transmission capacity using emerging technologies at marginal investment*

ISSUES & CHALLENGES IN SYSTEM OPERATION

- Static view of system
- Latency and Time skew in Data
- Integration of upcoming Wind and Solar Generations.
- Integration of upcoming IPPs and MPPs
- Integration of Dispersed Generation



Necessitates installation of Intelligent Electronic Devices, Phasor measurement units (PMU) and Wide area Monitoring systems (WAMS) to enhance system operation capabilities and visualization of Unified National Grid.

FUTURE ROAD MAP

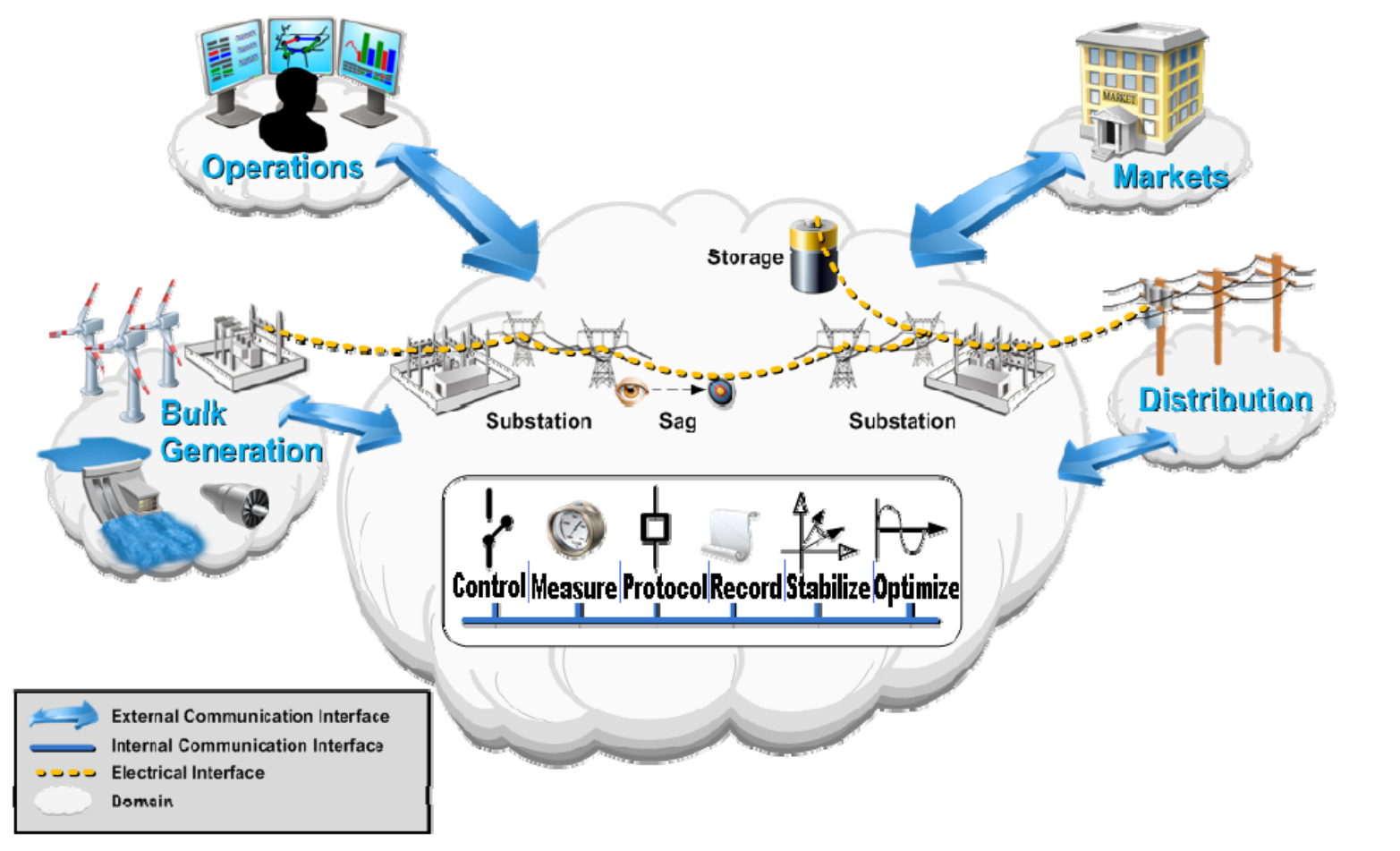
- 1200kV UHVAC test station is under development
- Supergrid comprises hybrid transmission system of 765kV/1200kV AC and ±800kV, 6000MW HVDC system
- Supergrid supported by high capacity 400kV AC & ±500kV HVDC system
- Technology integration to address reactive power management and high short circuit level
- Control features to regulate power flow and maintain system parameters
- Smart Grid with Wide Area Monitoring (WAMs), adaptive islanding

Synchrophasor & Smart Grid in Transmission

SMART GRID IN POWER SECTORS

- Transmission
- Distribution
- System Operations

SMART GRID IN TRANSMISSION



Source: Report on Smart Grid Interoperability Standards Roadmap(NIST)

Need for Synchrophasor Technology

1. Visualisation of Dynamic Behaviour
2. Stability Aspects
3. Operate the System at its Limits
4. Protections backup & adaptive
5. Adaptive islanding
6. State Determination
7. Empower System Operators

Need of PMUs/WAMs for Large Indian Grid

- Large Geographical Area Coverage (3.3 Million Square Kms)
- Interregional Capacity
  - From present 20800 MW to 37000MW by 2017
- Large Fiber Optic Network on EHV Transmission
- Increasing Stress on Transmission Grids
  - Interconnected Grid
  - Open Access
  - Inter-Regional Power Trading
  - Need for carrying more Megawatts per meter of ROW
- Integration of Renewable (Wind/ Solar etc.)
- Lack of tools for monitoring Dynamic behavior
  - Existing tools are not adequate
  - Monitor & then “Estimate” the steady state
  - Heavy dependence on Dispatcher’s knowledge

Opportunities Provided by WAMS

- On-line or real time monitoring and state estimation
  - State estimator results obtained very fast
  - Provides an opportunity to peep into electromechanical system dynamics in real time
  - Upgrade from local control to wide area controller e.g., for PSS & damping controllers etc
  - Improve performance of the apparatus protection schemes
  - Improve performance of the system protection schemes
- Accurate measurement of transmission system data in real time

WAM applications

- **Protection**
  - Power Swing blocking
  - Improved back up protection
  - Current Differential protection
- **Continuous Closed Loop Control**
  - e.g., PSS using global signals

WAM applications

Emergency Control (System Protection Schemes)

- Controlled System Separation
- Triggering of load shedding based on NON-LOCAL signals. Better df/dt relaying.
- Triggering other schemes (generator shedding, dynamic brake, governor)etc.

Some may require accurate loss of synchronism prediction

SPS: How can WAMS help ?

- **Angular instability :**
  - Predict out of step in real time -> trigger control actions like gen/load tripping or dynamic brake to prevent loss of synchronism.

  OR

  - Allow graceful system separation and do intelligent load/gen tripping to stabilize frequency and voltage in island

  Former is preferable - no resynchronization of systems required
  BUT how does one

  a) Predict out of step in real time

  b) Determine quantum of control actions

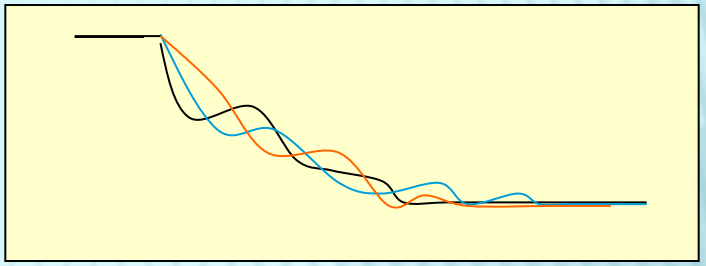
  For controlled system separation :

  Adaptive choice of separation points conceivable

NON-LOCAL measurements may help

SPS: How can WAMS help ?

- **Frequency stability :**



Present day problems:

- Local frequency contaminated due to swings (1 -2 Hz). df/dt should not trigger on swings but on “common” motion of generator speeds.

- Setting of df/dt relay should reflect actual power deficiency. Need to know total inertia (will need to know whether islanded or not, which generators in island)

Conclusion : NON LOCAL signals will help!!

WAMS for Transmission Protection Systems

- Current Differential Protection can be implemented with ease:
  - Most accurate
  - Provides crisp zone of protection
  - Free of non-idealities like tripping on power swings, non-tripping on voltage or current inversion, etc.
  - Can be applied to series compensated lines
- Current Differential Scheme can be used to suitably block Zone-3 trips

WAM based Z3 Blocking

- As Line BC is quite long in comparison to AB, Zone-3 on AB at A can trip on power swing
- If Current Differential Protection was implemented on line BC, it could be used to block Zone-3 of relay AB if no fault is detected by it on BC
- Since Z2 and Z3 timer setting are of the order of 15-30 cycles and 90 cycles respectively, communication delays will not be very critical
- Blocking scheme will not impair but only improve the performance of the system

A Transmission System with a short line terminating into a long line

WAM Applications

- **Islanding Detection**
- **Loss of Synchronism detection**
- **Average line temperature can be estimated** from true line impedance: thermal overloading if it exists

- **Power System Restoration**

  Better picture – better confidence level – better decisions.

  More remote actions

Road Map for Synchrophasor & Smart Grid

ROAD MAP SMART GRID

- Awareness & learning Smart Grid Technology

➢ POWERGRID has conducted two Workshops during Aug'09 & Jan'10 wherein representatives from Electricity Boards, Regional Power Committees, Power Ministry, IITs(Indian Institute of Technology) and Industry have participated

➢ The faculty for the workshop were Prof A.G. Phadke, Professor emeritus from Virginia Tech. USA and

Mr. Ken Martin, EPG Group, USA along with Indian Experts

Road Map for Smart Grid

Collaboration with Leading Experts of the World

POWERGRID has decided to form a panel of experts including international experts for advising & guiding in Smart Grid technology implementation.

Panel of Experts

Dr. Arun G. Phadke, Professor, Emeritus, Virginia tech, USA shall be Chairman of the Panel

Road Map for Smart Grid

- Pilot Project in Northern Region already commissioned
- Pilot Project in Western Region is under finalization
- WAMS project in Eastern Region is under approval
- The above projects involve around 70-80 PMUs
- Expert Panel for guidance

NORTHERN REGION PILOT PROJECT

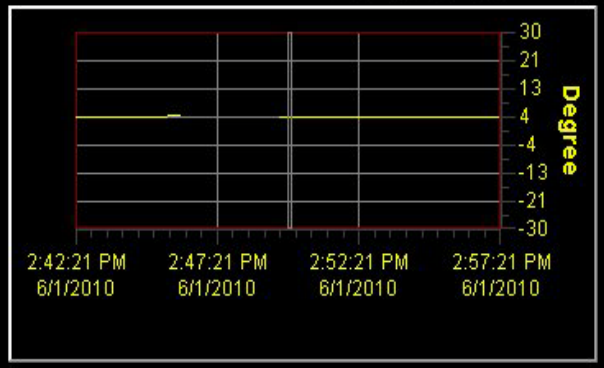
- Phasor Measurement Units at 4 Locations
  - Vidhyachal- Thermal Generation Pooling Station
  - Kanpur- Transmission Pooling Station
  - Moga- Hydro Pooling Station
  - Dadri- Generating plant close to Load Center
- PDC at NRLDC
- Visualization application software for situational awareness.
- Data archiving for post mortem analysis
- Project already Commissioned in April'2010 and PMU Data available at NRLDC

NR Pilot Project Features

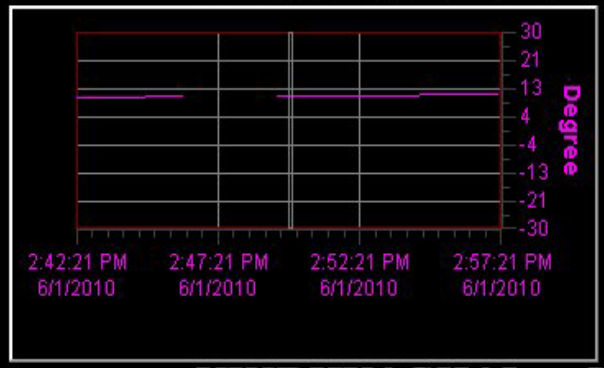
- Installed Capacity for NR – 35620 MW
- No. of PMU – 4 at present but system has capability to integrate 20 PMUs
- Conforming To IEEE C37.118 Standard.
- Sampling rate: 25 Samples/second
- Application are for Monitoring & archiving data
- Commercially available off the shelf product

Angle Difference

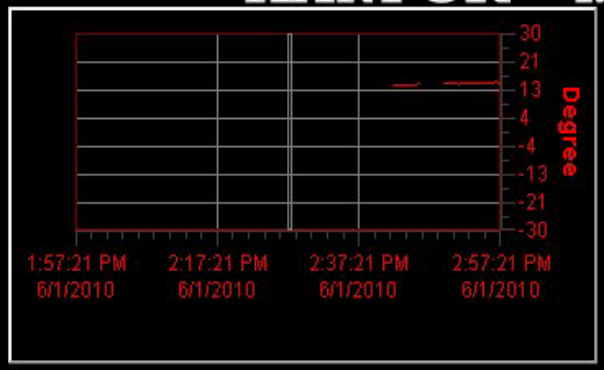
DADRI - MOGA



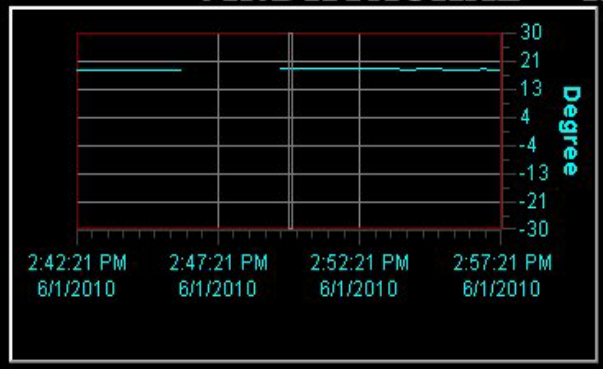
KANPUR - DADRI



KANPUR - MOGA



VINDHYACHAL - KANPUR



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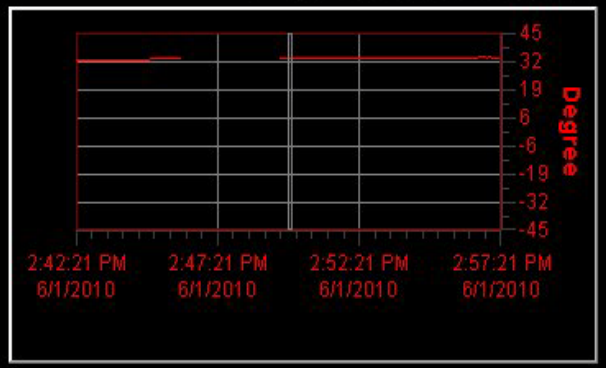
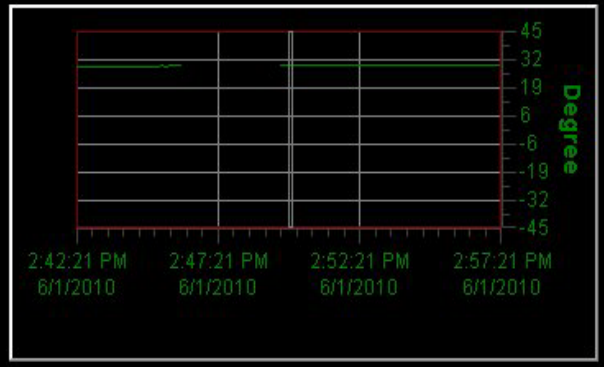


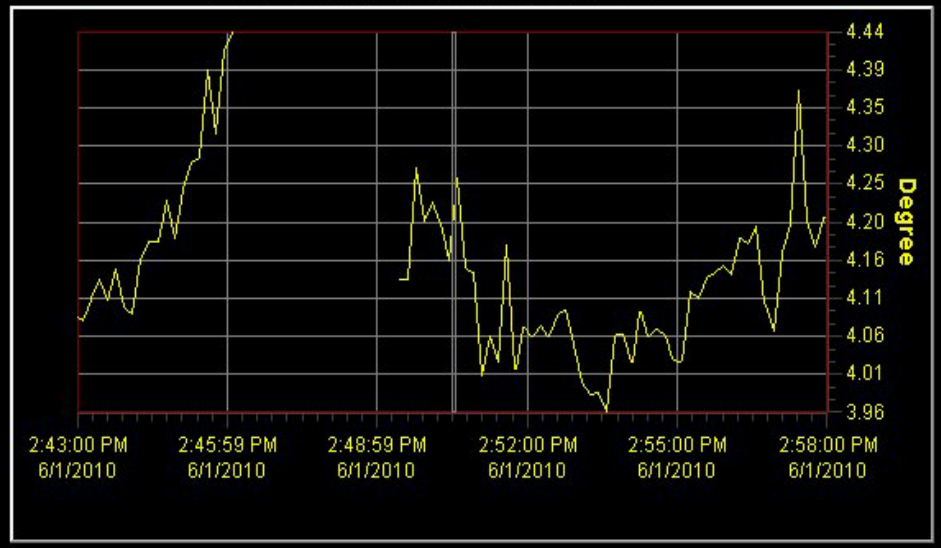
VINDHYACHAL - DADRI



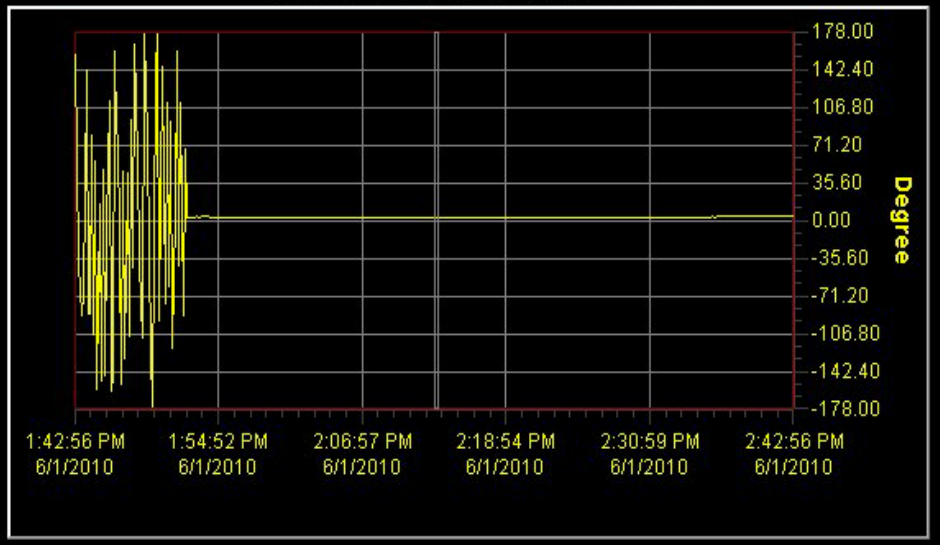
SYSTEM OVERVIEW | DATA | ALARM | R TREND | H TREND | PARAMETER | ANGLE DIFF. | Histroical Ang DIFF . | Hist df/dt | Hist Freq Varitn

DADRI - MOGA

HISTORICAL 15 MIN TREND



HISTORICAL 1HOUR TREND



HISTORICAL 1DAY TREND

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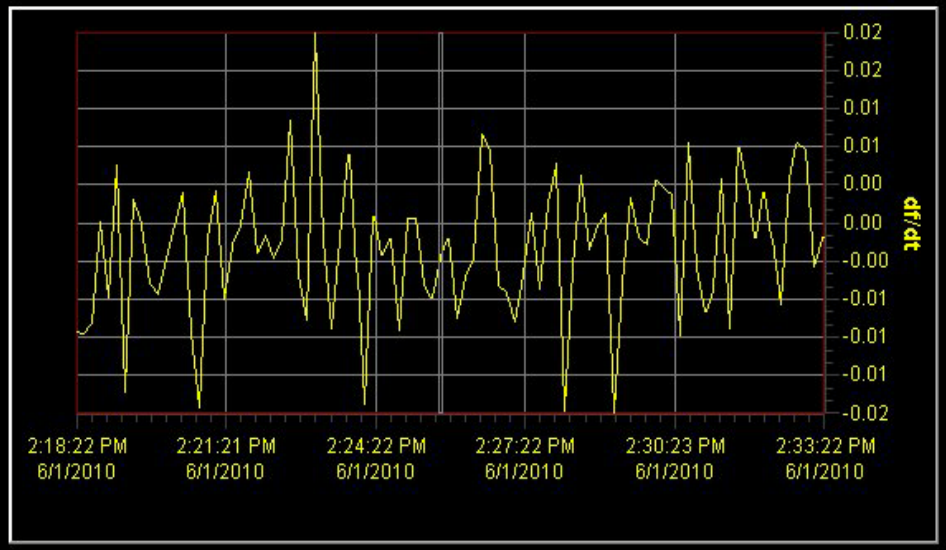
HISTORICAL 15 MIN TREND



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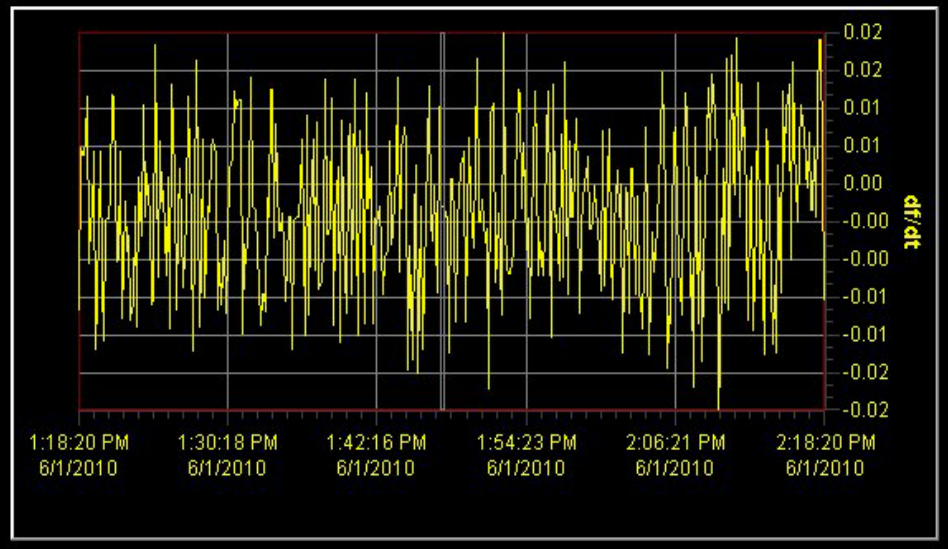

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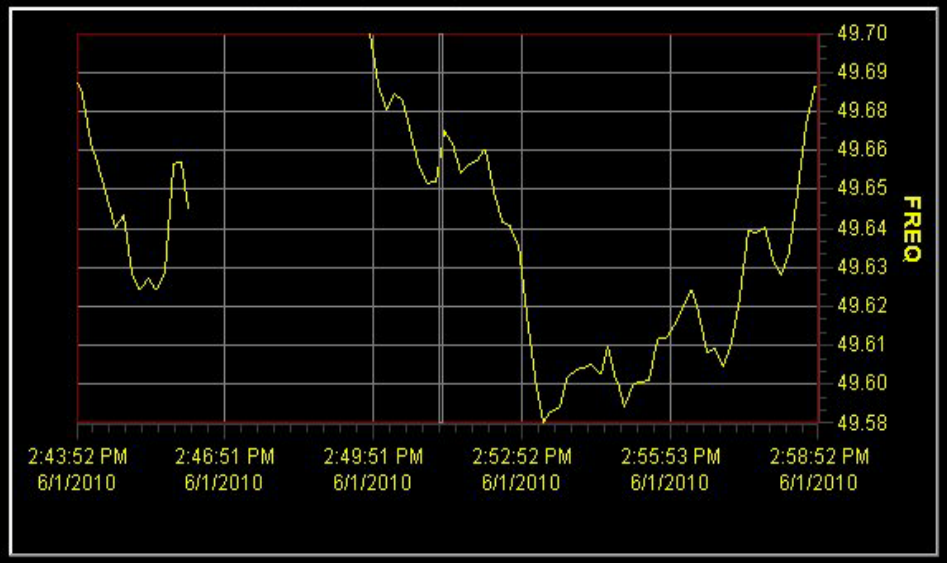

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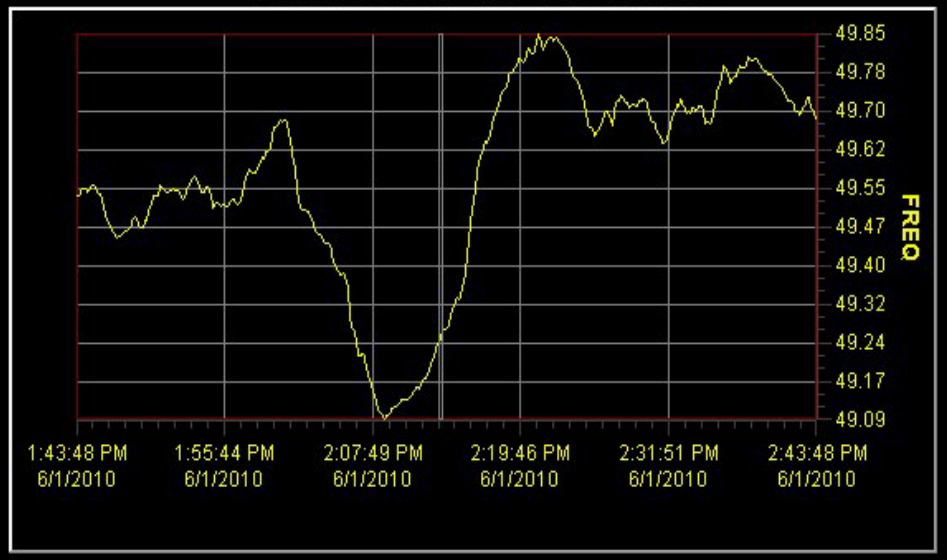

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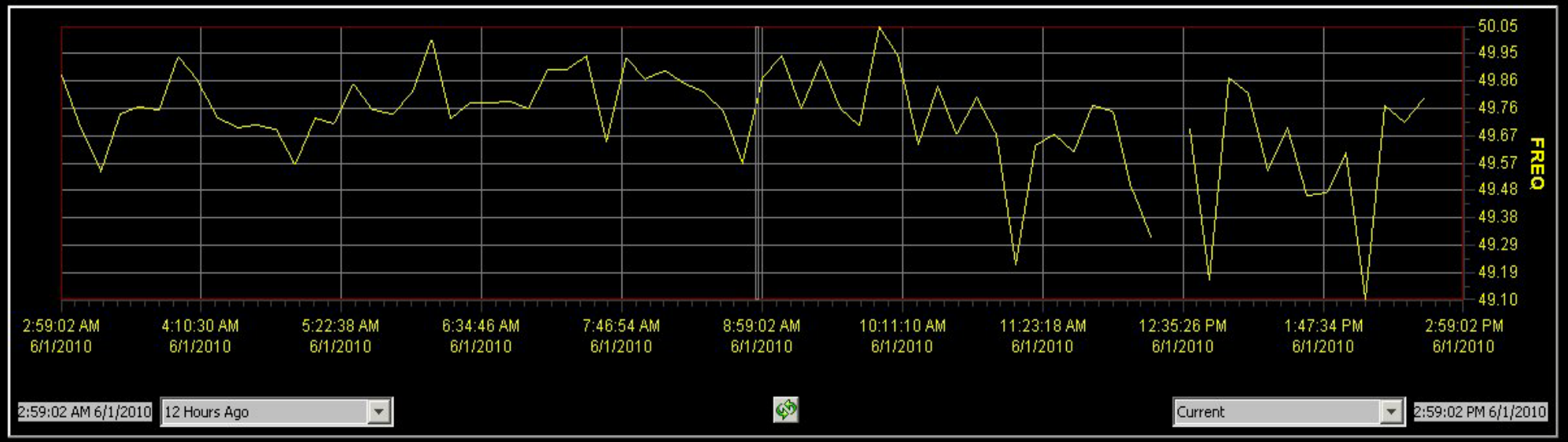


WESTERN REGION WAMS PROJECT

- Installation of PMUs at around 25 Locations in Western Region Grid with data acquisition at Western Regional Load Dispatch Center (WRLDC)
- Development of software for Optimal placement of PMUs
- Dynamic State estimator/Monitor
- Development of Supervised Zone-3 Blocking functionality
- Emergency control schemes for mitigating system instabilities

Road Map for Smart Grid

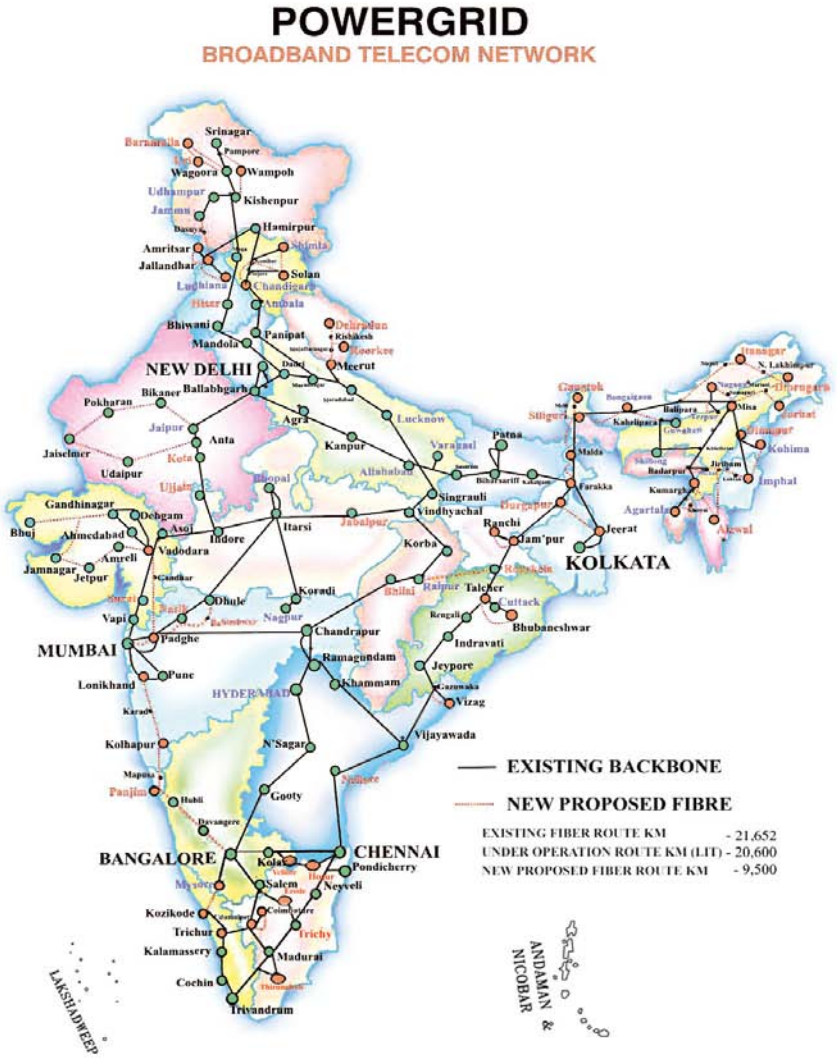
- Train manpower across Indian Power Sector to build capabilities
- Have a Strong Communication Network of Fibre optic which is available for Power system operation and also for Telecom business
- National Road Map involve implementation of around 600-700 PMUs

Communication Network

OPGW

-20,000 Km at Present
-15,000 Km is to be added

-By 2015 the OPGW shall be 35,000 Km (can be utilized for Power system Control & Telecom Business wing “POWERTEL”



Road Map for Smart Grid

- Set up “Smart Grid Centre” to accelerate standards harmonization and development/ adoption of smart grid technologies for Indian Power Sector
- Smart Building with Green & Energy efficient Technolgy(~ 7500 Sq.m. Area Approx.)
- Development of Testing facilities for Smaller equipments
- Take up Pilot Projects in Distribution Sector

Future plannning

- POWERGRID is planning implementation of Syncrophasor technology in big way.
- POWERGRID shall take advice & guidance from Expert Panel.
- Suggestions from the Experts at NASPI Forum are Welcome

Thank you for your kind attention please

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