

# **INTEGRATION OF POWER SYSTEMS: TECHINICAL CHALLENGES.**

By

**A.Velayutham  
Ex –Member,(MERC)  
India**

Delivered at

**Paro, Bhutan on 22/08/2013**

# INTEGRATION OF POWER SYSTEMS

- Introduction
- System Interconnection
- Transmission planning/design
- Distributed Energy Resources/integration
- Operational Philosophy
- Commercial mechanism /Power Market
- Cross Border Energy Trade
- Regulatory aspects
- Way forward action plan

# ELEMENTS OF POWER SYSTEM

- **LOAD**
- **GENERATION**
- **TRANSMISSION**

## WHAT IS

- **ISOLATED SYSTEM**
- **INTER-CONNECTED SYSTEM**
- **INFINITE GRID**

RELIABLE QUALITY(50Hz) GREEN POWER

# POWER SECTOR PRIORITIES

- Reliable and Quality Power to all
- Green House Gas Emission Control
- Human Development Index
- Per Capita Energy Consumption
- Energy Security –without air heating
- Affordable Cost to serve End User
- Meeting more load at the cost of frequency –can we?
- Power available but not scheduled
- Fuel supply guarantee –missing links

# Generators

- Thermal
  - Coal, Gas, oil
- Renewable Energy Sources
  - Hydro, Small Hydro, Pumped storage
  - Wind, Solar
  - Storage devices
- Nuclear

RELIABLE QUALITY(50Hz) GREEN POWER

# LOAD

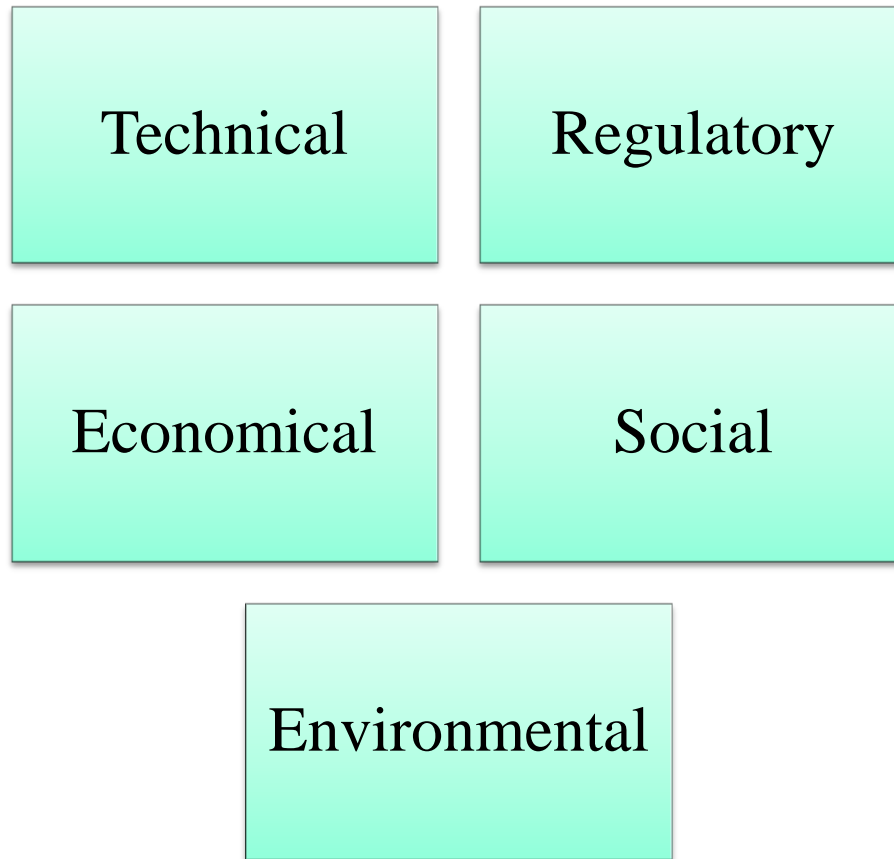
- Domestic
- Commercial
- Agricultural
- Industry
- Educational Institutions/Hospitals
- Railways/Airport

# Inter connected systems

Transmission System Operators  
(TSO) of Control Areas to ensure

- Optimal utilization of assets
- Security of the system
- development of market mechanism
- adequacy of generating resources
- transparent operating guide lines reduce the cost of electricity to developing economies.

# INTERCONNECTION ISSUES



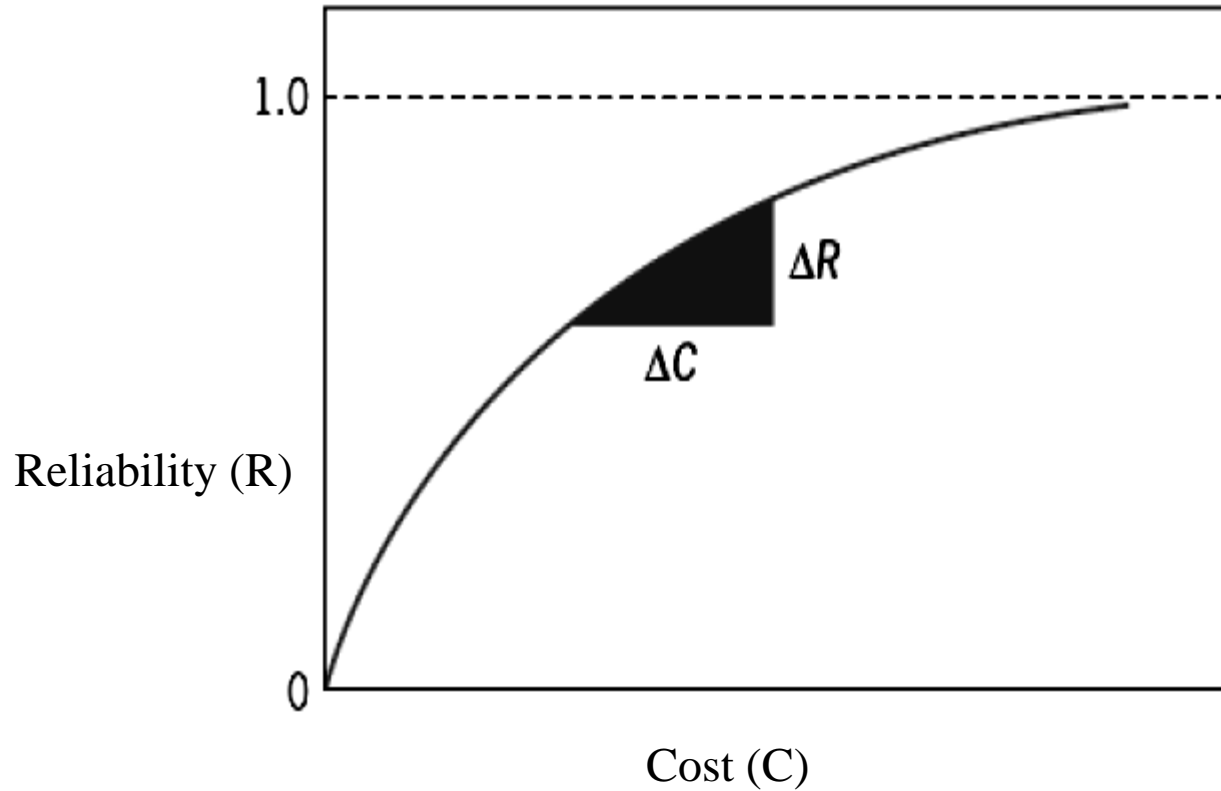
RELIABLE QUALITY(50Hz) GREEN POWER



# Transmission Investments

- Power transfer limitation attributable to investment restriction
- Weak Investment policy leads to grid disturbance
- Market constraints due to congestion
- Interconnection network reliability investments
- Generator deliverability investments
- Portion of Transmission equity by State/Union
- Private participation/Joint venture
- Green fund/viability gap funding/venture capital funding

# Transmission Reliability -Cost



RELIABLE QUALITY(50Hz) GREEN POWER

# Planning Criteria

- LOLP < one day in ten years, used in generation planning. (Why not one day in five years, or one day in twenty years)
- Availability, Auxiliary Power Consumption, Unit Heat Rate, Plant Load Factor
- The n-1 criterion, used in transmission planning. (Why not n-0 or n-2? What constitutes a single contingency? )

# TRANSMISSION SECTOR CHALLENGES/MEASURES

- *Right Of Way (ROW)*
- *Up gradation based on need*
- *Improved Tower/Conductor Design*
- *Regulation of line loading*
- *Voltage(Node) profile control*
- *Higher Surge Impedance Loading*
- *Condition based monitoring/preventive maintenance/hot line maintenance*

# TRANSMISSION SECTOR CHALLENGES/MEASURES (Contnd...)

- *HVDC with control /measures to assist system during normal/emergency operation*
- *FACT Devices(TCSC,SVC,SATCOM,UPFC... )*
- *Wide Area Measurement System*
- *Phasor Measuring units*
- *Phasor data concentrator*
- *Smart Grid/ Special Protection Schemes*
- *Advanced Communication System*

# New Technologies in Transmission

- Gas Insulated Transmission Lines
- Application of EHV class power cables
- Application of submarine cables
- Expert/Intelligent system to analyze data
- Real time Power System Simulator

# **POWER SYSTEM PARAMETERS**

**FREQUENCY**

**VOLTAGE**

# **POWER SYSTEM OPERATION**

## **OBJECTIVE**

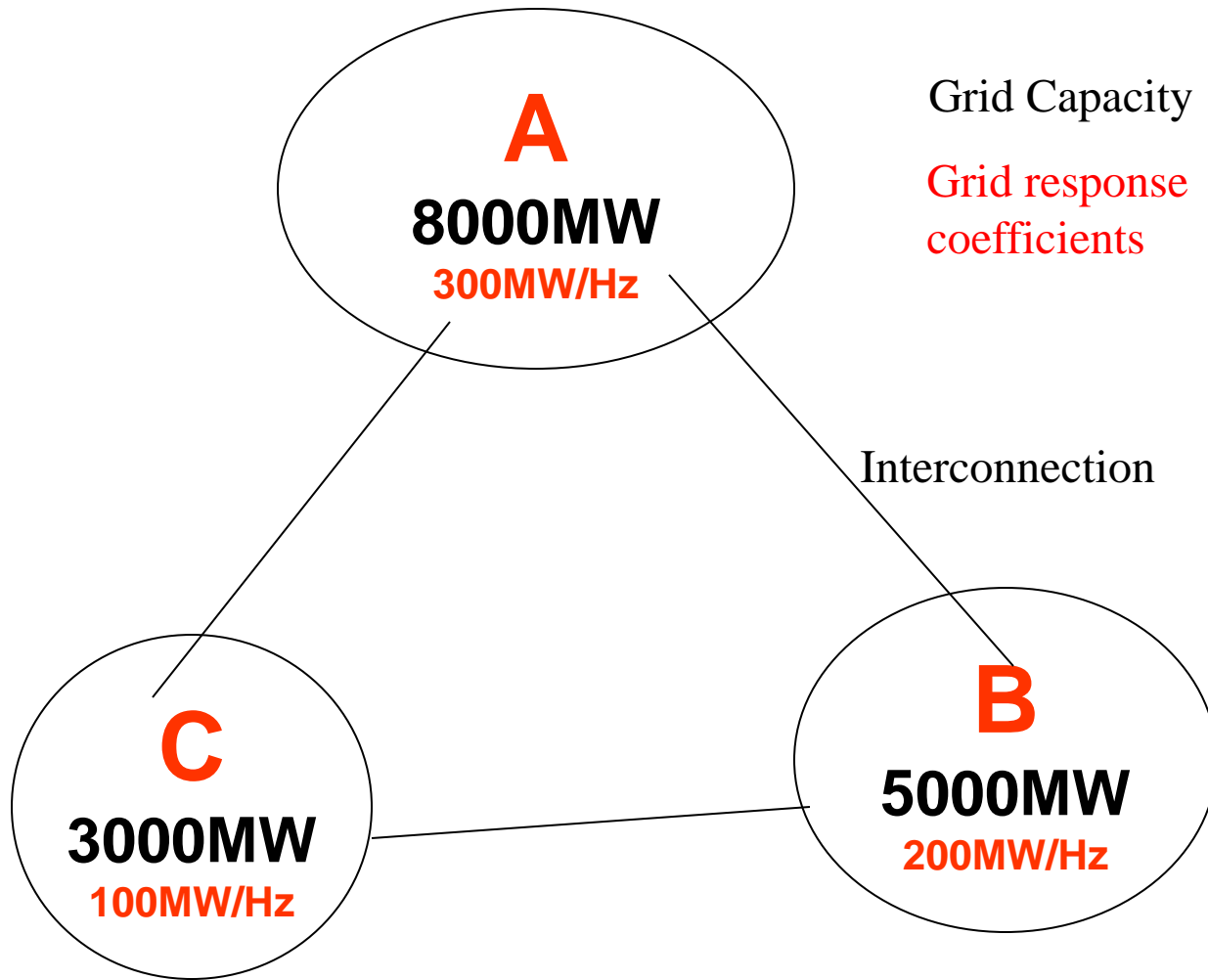
**1. OPERATE THE SYSTEM BY MAINTAINING SYSTEM PARAMETERS WITH IN LIMITS**

**2. OPTIMAL OPERATION**

**3. IN CASE OF SYSTEM DISTURBANCE EARLY RESTORATION**

## **SCOPE**

**FUNCTIONS AS PER GRID CODE**



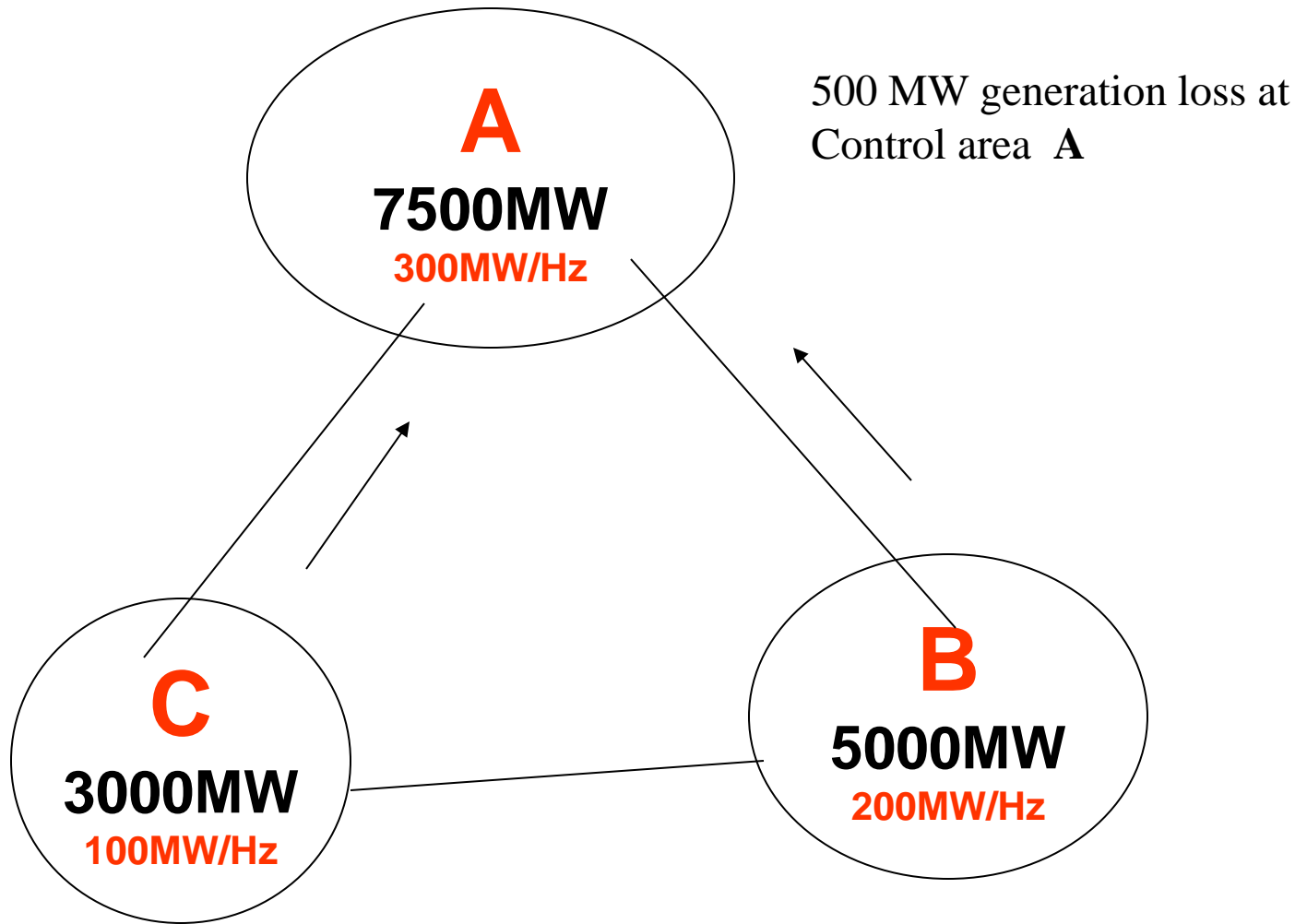
Grid Capacity

Grid response coefficients

Interconnection

Control Area A,B,C





# GRID OPERATION CHALLENGES

- Frequency control –Spinning reserve/AGC/Ancillary service support
- 50 Hz –frequency for Power Quality, no deviation
- 50 Hz enable Free Governor Mode Operation, in turn strengthens security
- Voltage at node impact security
- Day ahead demand assessment/generation identification at 50 Hz by Distribution Companies, Scheduling at 50 Hz.
- Inadvertent flow and methodology for correction
- Wind/Solar Power must run

# RES – BALANCING ACT

- Wind and solar power output is variable
- Grid needs support to address variability
- Wind/ Solar power potential
- Hydro power potential
- Pumped storage potential
- Fuel cells/compressed Air Energy Storage
- PEV/ Solar power back up
- Wind/ Solar power forecast is a must.

# Congestion/Shortage Management

- Seasonal trading is done by the distribution utilities to meet their seasonal demand or sell their seasonal surplus. Short term trading on day-ahead basis is required for balancing the demand with supply. Short term trading is also required for meeting contingency requirement. Normally, there should be regular pattern of short term trading which may vary depending on uncertain factors like weather.
- Load Shedding/protocol/stand by arrangements

# South Asian System Operation

- In order to ensure optimal management of the electricity transmission network and to allow trading and supplying electricity across borders in the Countries, South Asian Network of TSOs may be established.

# CROSS BORDER ENERGY TRANSFER CODE

- Increased cooperation and coordination among transmission system operators is required to create network codes for providing and managing effective and transparent access to the transmission networks across borders, and to ensure coordinated and sufficiently forward-looking planning and sound technical evolution of the transmission system in the Nation, including the creation of interconnection capacities, with due regard to the environment.

# NETWORK CODE

- Network codes for cross-border issues.
- Network code for Country level/regional/state level
- Compatibility of codes to ensure development of efficient and competitive market.
- Member countries may ensure their regional/state level structure and their long/medium term system development plan.

# Transmission System Tariff Methodology

- Postage Stamp(PS)
- Contract Path(CP)
- MW-Mile
- Marginal-Participation(MP)
- Average Participation(AP)
- MP –AP Hybrid



# TRANSMISSION PRICING

- *Aggregate of Annual Revenue Requirement of all licensees, as approved by the Commission, shall form “Pooled Cost” ( “Total Transmission System Cost – TTSC) of the intra-State transmission system, to be recovered from the Transmission System Users*
- *The ‘Base Transmission Capacity Rights’ for ‘capacity utilisation’ shall be denominated in terms of ‘kW’. The TTSC shall be shared amongst the TSUs based on the ‘contribution to co-incident peak demand’ (CPD)/Non-Co-incident peak demand by each TSU.*
- *‘Base Transmission Tariff’ for each financial year shall be derived as ‘TTSC’ of intra-State transmission system divided by ‘Base Transmission Capacity Rights’ and denominated in terms of “Rs/kW/month” or “Rs/MW/day”*

# TRANSMISSION TARIFF CONTD...

- Postage Stamp Method of recovery is most suitable for design of transmission tariff , the size of postage stamp should be the same for the entire pool/control area and denominated in terms of Rs/MW/month or Rs/kW/day.
- There shall be charges for drawal/injection of reactive energy linked to nominal voltage

# BALANCING AND SETTLEMENT CODE

- Generator(Seller) is to receive charge for the energy produced  
–Fixed/capacity/variable energy charge
- Distribution Licensee(Procurer) has to pay for the energy drawn.
- Balancing and settlement Code may identify the quantum of payment(payable/Receivable) by the various stake holders.
- Payment towards transmission loss/ transmission cost/TSO charge may also have to be settled by concerned based on purchase agreement
- Deviation from Schedule settlement methodology
- Energy Meters at interface points to record injection/drawl

# Power Market

- Well-functioning internal market in electricity should, provide producers with the appropriate incentives for investing in new power generation, including in electricity from renewable energy sources, also provide consumers with adequate measures to promote the more efficient use of energy for which a secure supply of energy is a precondition.
- Trader/Trading Licence/Power Exchange

# REGULATORY ASPECTS

- Specifying standards for connectivity – generator/transmission/distribution interface
- Specifying standards for construction/operation/maintenance of Transmission lines
- Network/grid code to address technical and commercial rules, encompassing all the Utilities connected to/or using the transmission system ,facilitation of optimal operation,Ancillary Services, Power market development and Renewable Energy development

# REGULATORY ASPECTS

(Contnd...)

- To specify guide lines for the non –discriminate access of transmission lines by any user
- To specify term and condition for Trading/transmission licensees
- Guide lines to develop power market/ formulation of power exchanges

# Way Forward Action Plan

- Identifying issue related to advance transmission system interconnection for cross border electricity trade
- Formulating a road map to establish South Asian electricity market
- Preparation of Regulatory guide lines/Regulations towards connectivity, Network Code, Tariff, Balancing and settlement code etc.

**Join & Contribute to  
resolve the issues of  
South Asian Power  
System**

**THANK YOU ALL**