WIND POWER FORECASTING
AND
POWER DISPATCH INTEGRATION
IN
INDIAN CONTEXT

P.R.RAGHURAM

Presentation Plan

- Southern Region Power system Overview
- Review of Wind Power Generation in SR
- Issues to be addressed for better system operation
- **The way Indian Power system operates vis-a-vis in a developed country**
- **Real time operational issues**
- **Market issues**
- **Conclusion**

SR STATES – POWER SYSTEM STATISTICS

KARNATAKA

INSTALLED CAPACITY – 6122 MW

MAX DEMAND MET – 5445 MW

DAILY CONSUMPTION MAX – 112 MU

DAILY CONSUMPTION AVG – 90 MU

CONSUMER PROFILE –

INDS -26%, DOM-19%, COMM-7%, IRRI-39% & OTHERS-9%

ANDHRA PRADESH

INSTALLED CAPACITY – 8487 MW

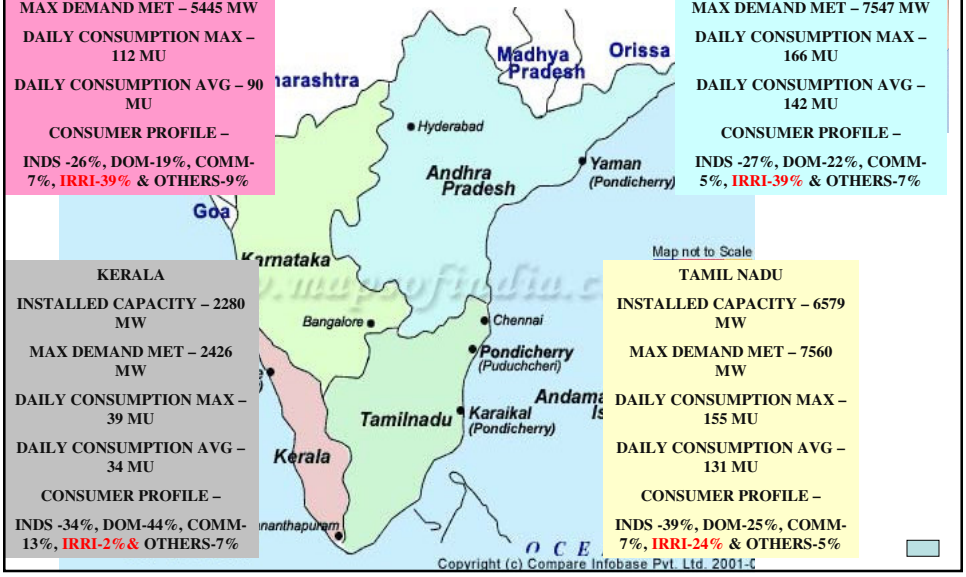
MAX DEMAND MET – 7547 MW

DAILY CONSUMPTION MAX – 166 MU

DAILY CONSUMPTION AVG – 142 MU

CONSUMER PROFILE –

INDS -27%, DOM-22%, COMM-5%, IRRI-39% & OTHERS-7%



KERALA

INSTALLED CAPACITY – 2280 MW

MAX DEMAND MET – 2426 MW

DAILY CONSUMPTION MAX – 39 MU

DAILY CONSUMPTION AVG – 34 MU

CONSUMER PROFILE –

INDS -34%, DOM-44%, COMM-13%, IRRI-2% & OTHERS-7%

TAMIL NADU

INSTALLED CAPACITY – 6579 MW

MAX DEMAND MET – 7560 MW

DAILY CONSUMPTION MAX – 155 MU

DAILY CONSUMPTION AVG – 131 MU

CONSUMER PROFILE –

INDS -39%, DOM-25%, COMM-7%, IRRI-24% & OTHERS-5%

SR STATES – GEOGRAPHY

KARNATAKA

POPULATION :- 5.3 CRORES

AREA :- 192 ('000 SQ KM)

NO OF CONSUMERS :- 105 LAKHS

PER CAPITA CONS. :- 642 UNITS

MAIN AGRICULTURE CROP :- COFFEE & RAGI

CLIMATIC CONDITION :- HOT AND HOT & HUMID

ANDHRA PRADESH

POPULATION :- 7.6 CRORES

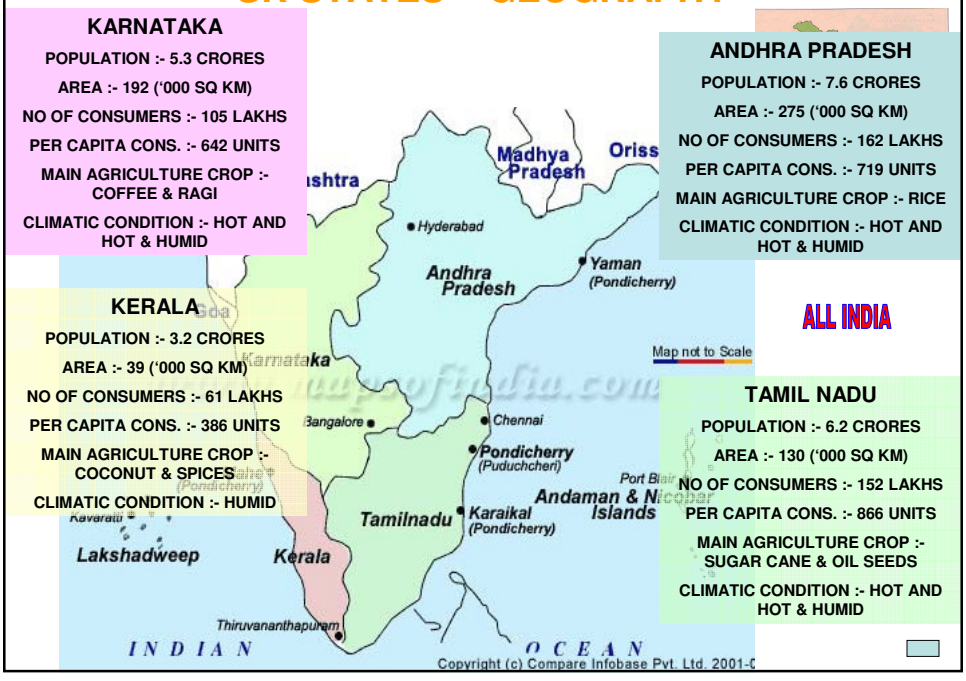
AREA :- 275 ('000 SQ KM)

NO OF CONSUMERS :- 162 LAKHS

PER CAPITA CONS. :- 719 UNITS

MAIN AGRICULTURE CROP :- RICE

CLIMATIC CONDITION :- HOT AND HOT & HUMID



KERALA

POPULATION :- 3.2 CRORES

AREA :- 39 ('000 SQ KM)

NO OF CONSUMERS :- 61 LAKHS

PER CAPITA CONS. :- 386 UNITS

MAIN AGRICULTURE CROP :- COCONUT & SPICES

CLIMATIC CONDITION :- HUMID

ALL INDIA

TAMIL NADU

POPULATION :- 6.2 CRORES

AREA :- 130 ('000 SQ KM)

NO OF CONSUMERS :- 152 LAKHS

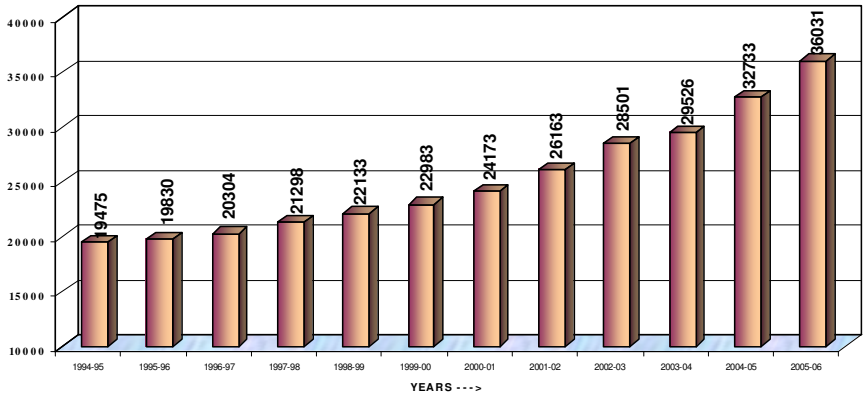
PER CAPITA CONS. :- 866 UNITS

MAIN AGRICULTURE CROP :- SUGAR CANE & OIL SEEDS

CLIMATIC CONDITION :- HOT AND HOT & HUMID

GROWTH OF INSTALLED CAPACITY OF SR

IN MW



Average Growth ~ 5 %

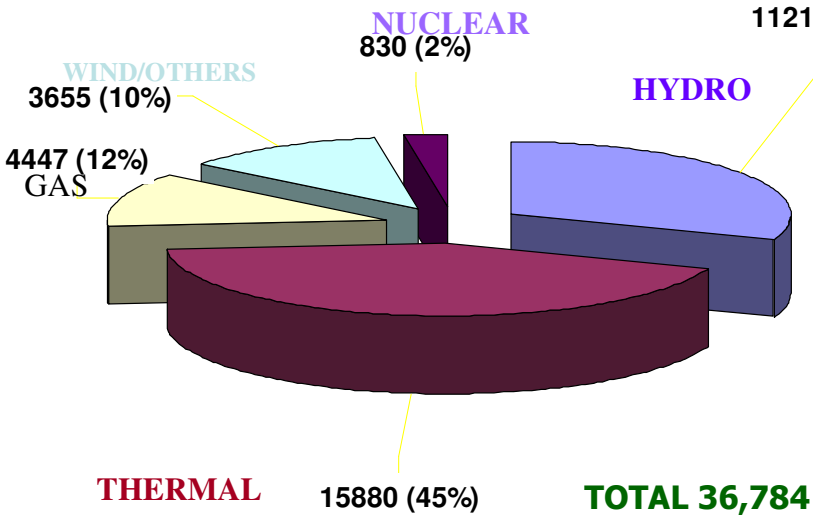
INSTALLED CAPACITY IN SR

SUMMARY OF INSTALLED CAPACITY(MW)

AS ON 01.06.2006

AGENCY	HYDRO	THERMAL	GAS/DIESEL	WIND/OTHERS	NUCLEAR	TOTAL
ANDHRA PRADESH	3586.36	2962.5	272	2	---	6822.86
KARNATAKA	3389.25	1470	127.8	4.55	---	4991.6
KERALA	1835.1	---	234.6	2.025	---	2071.725
TAMILNADU	2137.35	2970	422.88	19.355	---	5549.585
PONDICHERRY	---	---	32.5	---	---	32.5
CENTRAL SECTOR	---	8090	359.58	---	880	9329.58
IPP	278.13	387.01	3012.26	4308.865	---	7986.265
TOTAL	11226 (31%)	15880 (43%)	4462 (12%)	4337 (12%)	880 (2%)	36784 (100%)

SOURCE-WISE INSTALLED CAPACITY OF SR

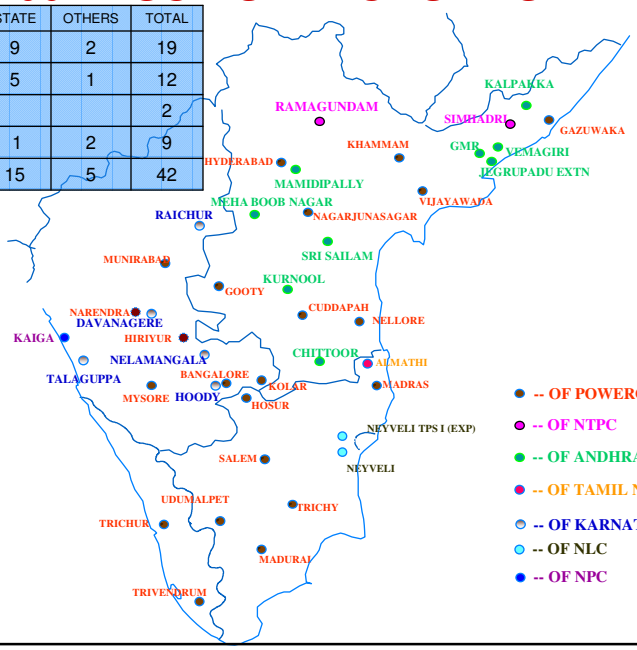


TOTAL 36,784 MW

All Figures In MW

400KV SUB-STATIONS IN SR

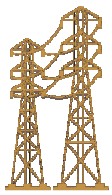
	POWERGRID	STATE	OTHERS	TOTAL
AP	8	9	2	19
KAR	6	5	1	12
KER	2			2
TN	6	1	2	9
TOTAL	22	15	5	42



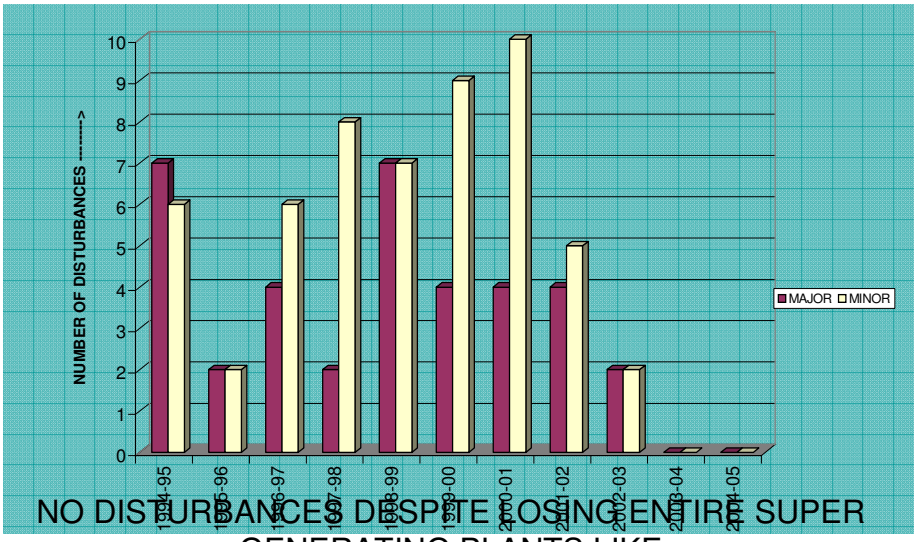
TRANSMISSION IN SOUTHERN INDIA

VOLTAGE LEVEL	AP	KAR	KER	TN	CGS	TOTAL
400 KV	2042	1614			9850	**13506**
220/230 KV	10050	7590	2650	6270	366	**26926**
132/110 KV	12360	6060	3720	10220		**32360**
TOTAL	**24452**	**15264**	**6370**	**16490**	**10216**	**71404**

ABOUT 2800 CKM OF 400 KV LINES ADDED IN THE PAST 2 YEARS



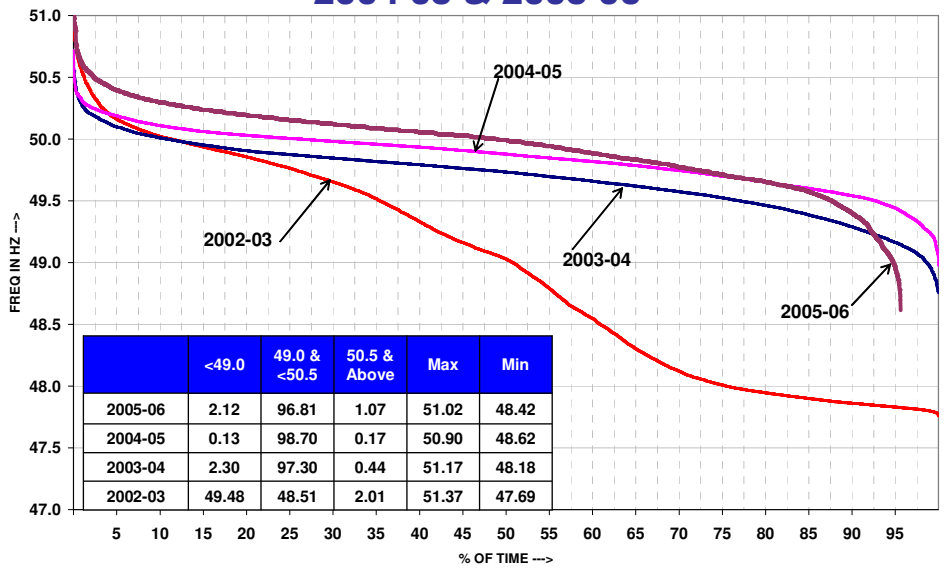
MAJOR AND MINOR DISTURBANCES SINCE 1994



NO DISTURBANCES DESPITE LOSING ENTIRE SUPER GENERATING PLANTS LIKE

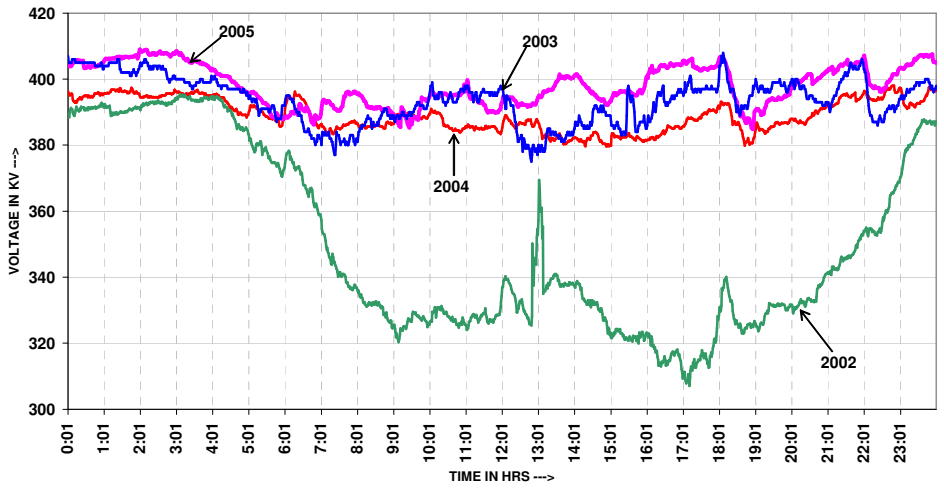
RAMAGUNDAM,VIJAYAWADA,KOTHAGUDEM, NORTH CHENNAI, SHARAVATHY ,NAGJHARI ETC

FREQUENCY DURATION CURVE 2002-03, 2003-04, 2004-05 & 2005-06



	<49.0	49.0 & <50.5	50.5 & Above	Max	Min
2005-06	2.12	96.81	1.07	51.02	48.42
2004-05	0.13	98.70	0.17	50.90	48.62
2003-04	2.30	97.30	0.44	51.17	48.18
2002-03	49.48	48.51	2.01	51.37	47.69

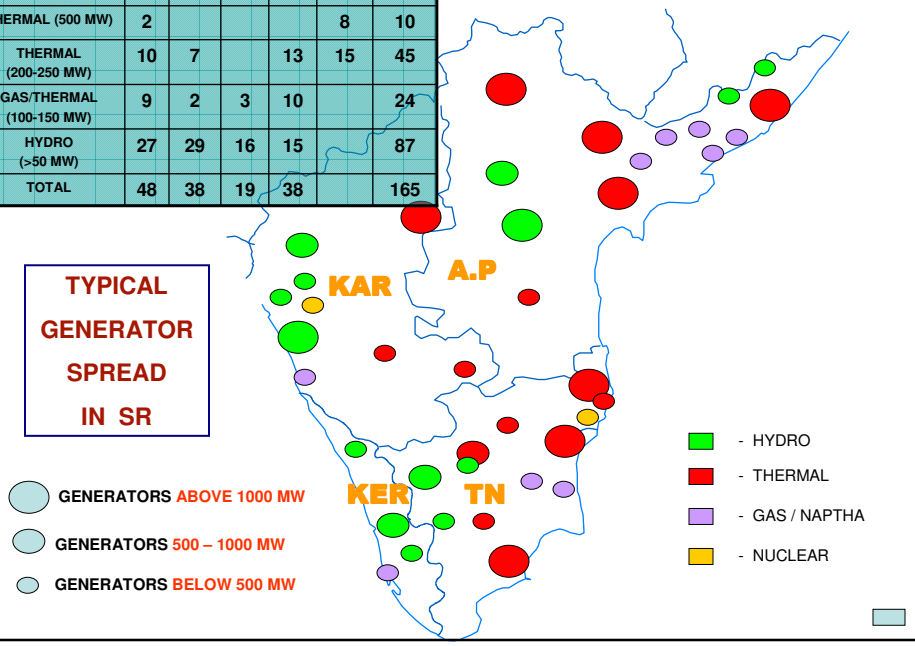
COMPARISION OF BANGALORE VOLTAGE ON TYPICAL DAYS IN LAST FOUR YEARS



GENERATING UNITS IN SOUTHERN REGION

UNIT CAPACITY	AP	KAR	KER	TN	CGS	TOTAL
THERMAL (500 MW)	2				8	10
THERMAL (200-250 MW)	10	7		13	15	45
GAS/THERMAL (100-150 MW)	9	2	3	10		24
HYDRO (>50 MW)	27	29	16	15		87
TOTAL	48	38	19	38		165

TYPICAL GENERATOR SPREAD IN SR



GENERATORS ABOVE 1000 MW

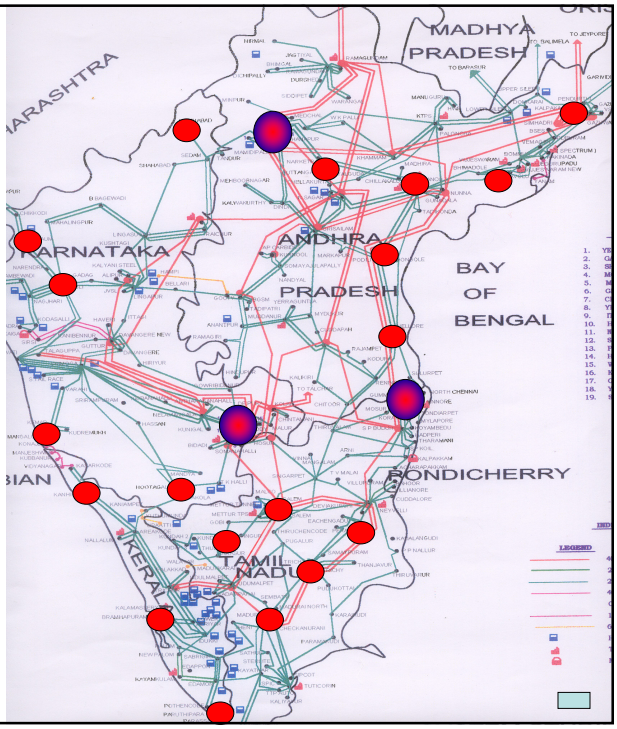
GENERATORS 500 – 1000 MW

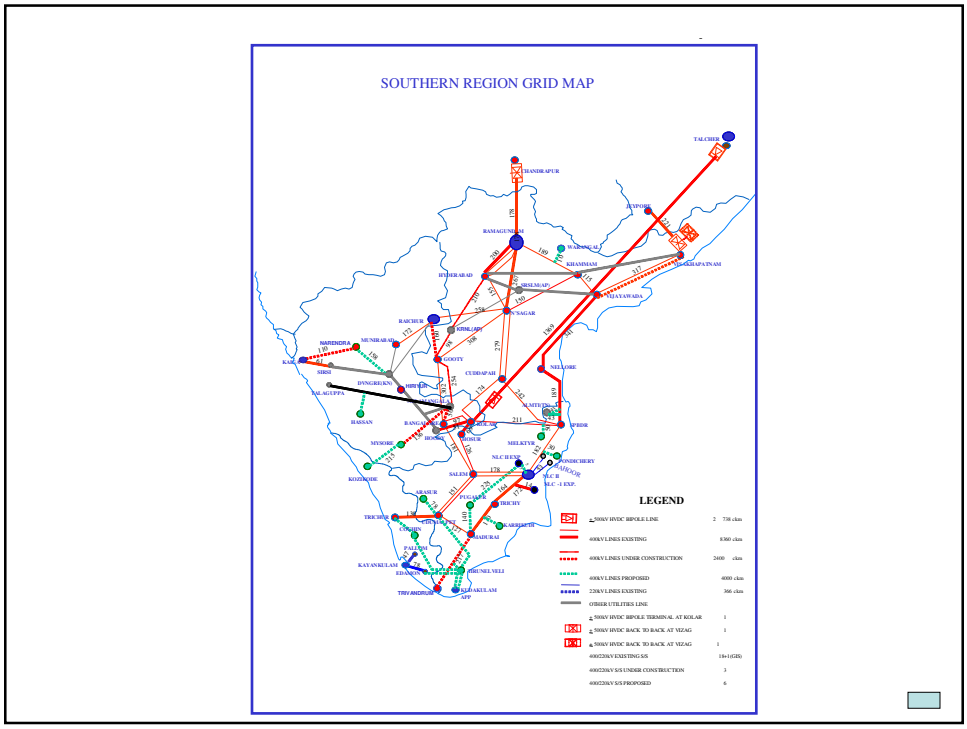
GENERATORS BELOW 500 MW

TYPICAL LOAD SPREAD IN SR

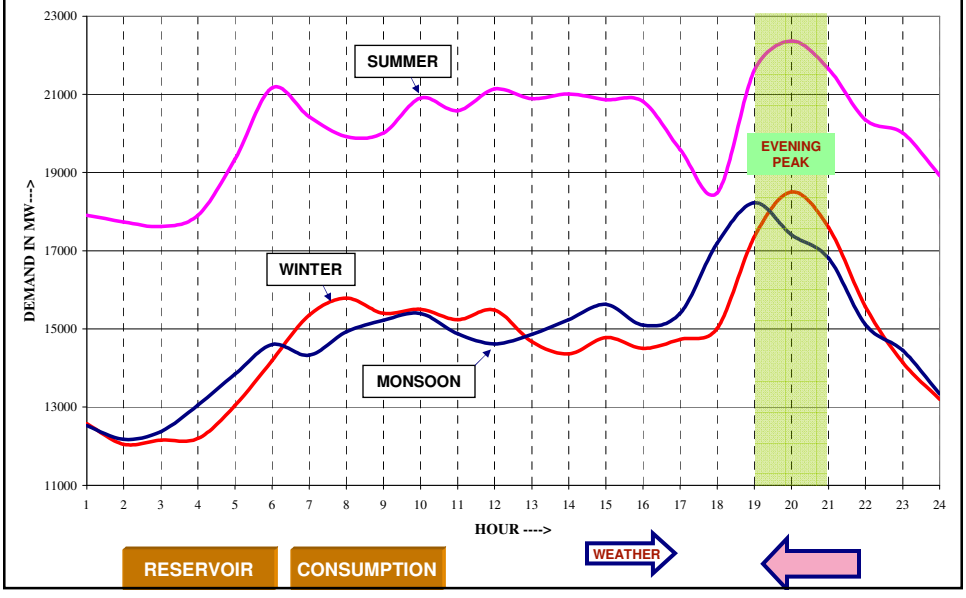
LOAD 500-1500 MW

LOAD 200-500 MW





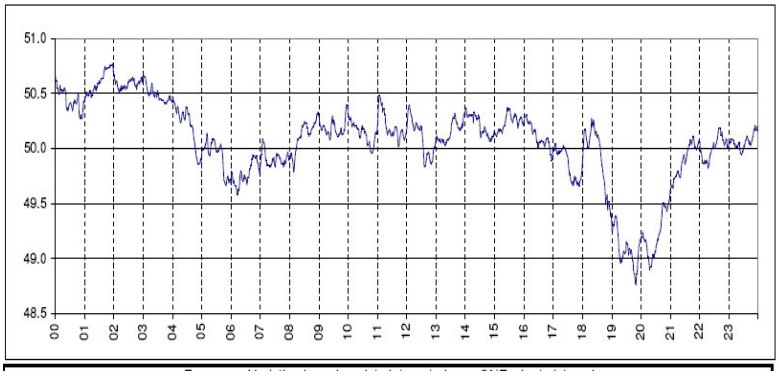
TYPICAL LOAD CURVE OF SR



- Typical day wind generation trend curve
- Daily Maximum,Minimum and Avg wind generation for six month
- Wind generation plot for the month of July
- Wind generation plot for the month of May
- A typical day frequency plot

POWER GRID CORPORATION OF INDIA LTD.
SOUTHERN REGIONAL LOAD DESPATCH CENTRE

FREQUENCY ANALYSIS FOR 27-07-05 Wednesday



Issues to be addressed for smooth integration of wind power with the grid and better system operation

1. Real time system operation Issues
   - Issues like Reserve capability,
   - accurate short term forecasting of wind
2. Market issues
   - Participation of Wind Generator in Trade
   - Imbalance Settlement system
3. Connection issues
   - Impact of wind generation on system stability
4. Grid infrastructure issues
   - congestion management
5. Contribution of wind power to ancillary service
6. Institutional issues

Real time system operation Issues

- Difference between our grid & developed country grid
- Managing Load Generation Balance during normal System operation
- Managing Load generation Balance during High Wind power integration

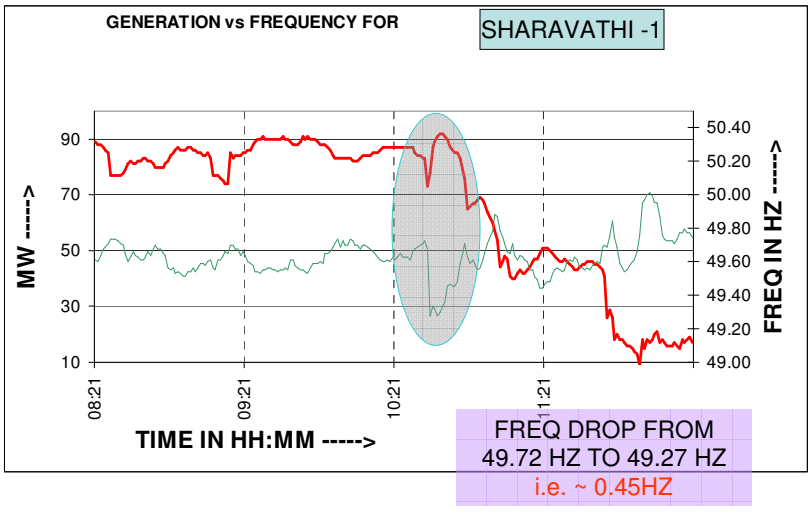
Difference between our grid & developed country grid

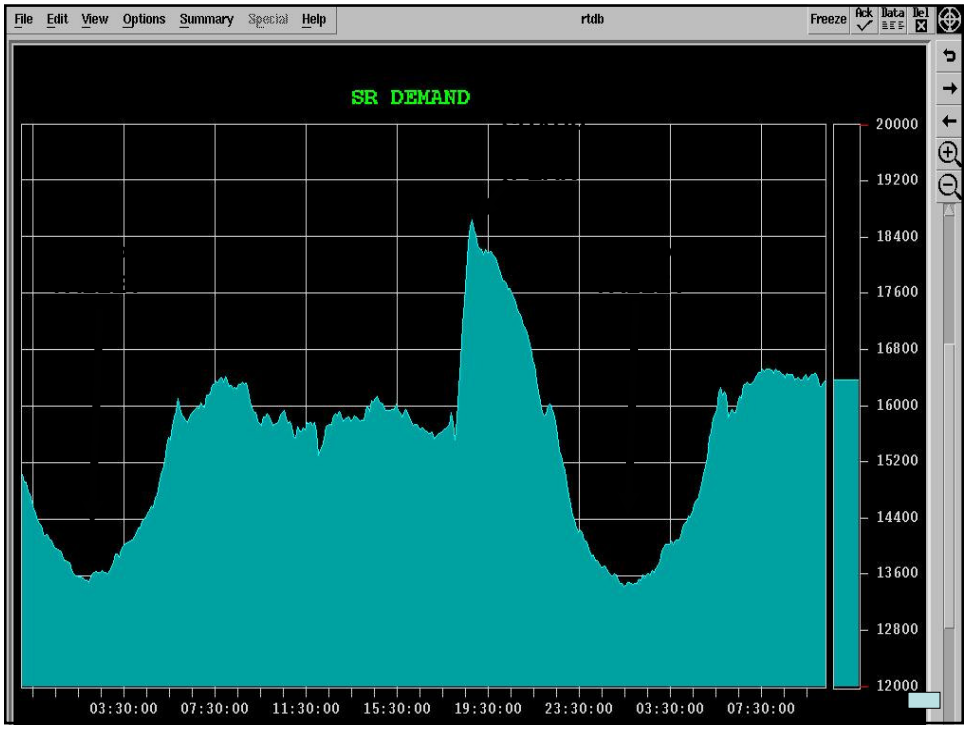
- Our grid is both Energy and Capacity deficit power system
- Our grid does not have spinning reserve or secondary /tertiary reserve
- We work on sliding frequency between 49Hz and 50.5 Hz
- Spot market is yet to be fully developed
- We do not have ancillary service such as
  - Market for energy imbalance
  - Load following service
- Following service is not considered for payments
  - Black Start
  - Reactive energy generation /absorption by generator
- We have a scientific settlement system in ABT which is a local solution for the above mentioned local problems

Managing Load Generation Balance during normal System operation

- Load generation imbalance occur due to
  - Generators tripping
  - Transmission line outages
  - Tools available to system operator to overcome this
    - Using available reserve
    - Free governor mode of operation of generator
    - Special System protection scheme
    - Automatic under frequency load relief operation
- Load generation imbalance will also occur due to continuous variation in demand and lot of tools are available to predict the same in advance and take corrective action

FREE GOVERNOR MODE OF OPERATION Typical graph





Managing Load generation Balance during High Wind power integration

- Un predictable variation in Power output its effect on
  - Predominantly Hydro system
  - Predominantly Thermal system
  - Pump storage system
  - Solution
    - Accurate tool for short term prediction wind power output
- Sharp Ramp up and Ramp downs
  - Solution –Proper management of Wind generator clusters

Market Issues

- Open access issues
- Scheduling wind power
- Payment for Imbalance
- Wind generation cost to match UI rate curve

Conclusion

- Following are required to be developed
  - Accurate tool to match Indian requirement for Short term forecasting of wind power output
  - Managing wind generators clusters to reduce the effect of sudden ramp ups and downs
  - Wind generator outputs to modulate with frequency
  - Telemetering of wind generator outputs to Load despatch centers

Questions?

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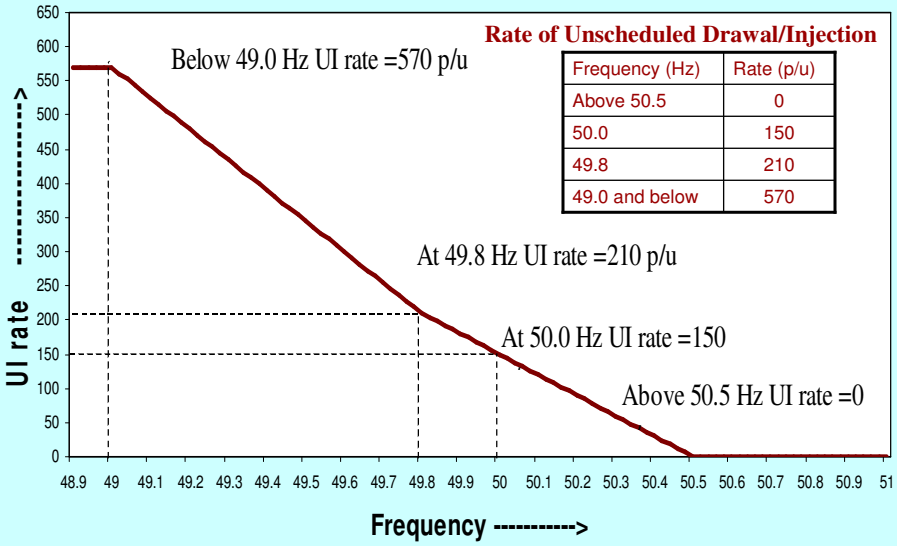
UI RATE


Rate of Unscheduled Drawal/Injection
Frequency (Hz) | Rate (p/u)
Above 50.5 | 0
50.0 | 150
49.8 | 210
49.0 and below | 570
Below 49.0 Hz UI rate =570 p/u
At 49.8 Hz UI rate =210 p/u
At 50.0 Hz UI rate =150
Above 50.5 Hz UI rate =0
UI rate ---------->
650 600 550 500 450 400 350 300 250 200 150 100 50 0
48.9 49 49.1 49.2 49.3 49.4 49.5 49.6 49.7 49.8 49.9 50 50.1 50.2 50.3 50.4 50.5 50.6 50.7 50.8 50.9 51
Frequency ---------->