MINUTES OF THE TWENTY EIGHTH MEETING

OF

FORUM OF REGULATORS (FOR)

Venue : "SAMBODHI RETREAT"
BODH GAYA
(BIHAR)

Date : 03RD FEBRUARY, 2012

Shri Nitish Kumar, Hon'ble Chief Minister of Bihar and Shri Bijendra Prasad Yadav, Hon'ble Energy Minister, Government of Bihar attended the meeting of the Forum of Regulators (FOR) and interacted with the Members.

Shri U.N. Panjiar, Chairperson, Bihar Electricity Regulatory Commission (BERC) welcomed the Hon'ble Chief Minister and the Energy Minister, Government of Bihar. He conveyed deep gratitude on behalf of the Forum for sparing time out of their busy schedule to address and interact with the Electricity Regulators of the country. In his welcome address, Shri Panjiar expressed his appreciation of the proactive role being played by the State Government in furthering reforms in power sector in the State. He expressed satisfaction over the fact that there was no interference from the State Government in the functioning of the Regulatory Commission in Bihar. He stated that the State Electricity Board in Bihar would be reorganized during 2012-13. He also informed that the State

Commission has taken a number of initiatives towards restoration of financial health of the sector. The retail tariff for the Financial Year 2011-12 has been determined, provisions for fuel cost adjustment and separate tariff for uninterrupted power supply have also been made. He expressed his appreciation to the Chairperson, CERC/FOR for choosing Bodh Gaya (Bihar) as the venue for the meeting of the FOR.

Dr. Pramod Deo, Chairperson, CERC/FOR in his address highlighted the activities being carried out by the Forum of Regulators at the national level. Some of the important steps taken by the Forum towards restoration of the financial health of the distribution utilities include framing of Model Tariff Regulations which on adoption by SERCs will go a long way in addressing the problems like distribution losses, recovery of legitimate cost etc. Chairperson, CERC/FOR argued that the tendency of resource rich States (especially, States rich in coal resources) to demand share of power generation at concessional rate had the potential distorting the market development efforts and was not in the larger interest of the sectoral development.

Shri Bijendra Prasad Yadav, Hon'ble Energy Minister of Bihar in his address referred to the Shunglu Committee Report and expressed concern over the fact that the accumulated losses of the State utilities stood at Rs.75,000 crores. He highlighted the problems being faced by the State of Bihar. The State lacks new investment because of various constraints. He suggested that the electricity connections to the BPL consumers should be given on priority and tariff for such consumers should be decided based on their paying capacity.

Shri Nitish Kumar, Hon'ble Chief Minister of Bihar, in his address presented an overview of the reforms initiated by his Government as well as the issues at stake at the State level. He suggested that the State Commission should make tariff applicable prospectively. He also stressed on the need for timely issuance of the Orders by the Commission. He urged that the inefficiency of the utility should not be encouraged and at the same time any genuine losses should be allowed. He also mentioned about the initiative taken by the State Government regarding timely payment of subsidy by the State Government, purchase of power under Case-1 bidding from outside the State etc. Hon'ble Chief Minister stressed upon educating public regarding any decision taken on revision in tariff as these are the decisions of the Commission and not of the State Government. Hon'ble Chief Minister thanked Dr. Deo for having given his State the opportunity of hosting the Meeting of FOR. He felt overwhelmed by the presence of the Chairpersons of Electricity Regulatory Commission from all across the country. The Hon'ble Chief Minister wished all success to the meeting of the FOR.

Shri Nitish Kumar's speech was followed by a vote of thanks extended by Shri Rajiv Bansal, Secretary, CERC/FOR. On behalf of the BERC and FOR, he conveyed his sincere thanks to the Hon'ble Chief Minister and Energy Minister of Bihar and all the dignitaries present in the meeting.

Business Session :

The meeting was chaired by Dr. Pramod Deo, Chairperson, CERC/FOR. The list of participants is at **Annexure-I**.

Shri Rajiv Bansal, Secretary, CERC/FOR extended a warm welcome to all members of the Forum. Dr. Pramod Deo, Chairperson, CERC/FOR welcomed Shri S.P. Nanda, Chairperson, Orissa Electricity Regulatory Commission (OERC) and Shri R.N. Prasher, Chairperson, Haryana Electricity Regulatory Commission (HERC) who attended the FOR meeting for the first time after assuming charge of their office.

The FOR thereafter took agenda items for consideration.

Agenda Item No. 1: Confirmation of the Minutes of the 27th Meeting of "FOR" held on 16th December, 2011 at Hotel Babylon International, Raipur (Chhattisgarh).

Shri Rajiv Bansal, Secretary, CERC/FOR briefed the Members about the action taken on the decisions of the last meeting. After discussion, minutes of the 27th Meeting were endorsed by the Forum with the observation that the constraints faced by the State Commissions (especially, in view of the Code of Conduct restrictions during election) which could lead to delay in tariff filing/Order, should be brought to the notice of the APTEL.

Agenda Item No. 2 : Study on Assessment of Achievable Potential of New and Renewable Energy Resources in Different States during the 12th Plan Period, Determination of RPO Trajectory and its Impact on Tariff.

Shri Rajiv Bansal, Secretary, CERC/FOR briefed the Members about the three studies undertaken in the area of promotion of renewable energy, i.e., (1) Assessment of achievable potential of New and Renewable Energy resources in different States during the 12th Plan Period, determination of RPO trajectory and its impact on Tariff; (2) Preparing incentive structure for States for fulfilling Renewable Purchase Obligation (RPO) targets; and (3) Transmission infrastructure development for the likely capacity addition of RE based power plants in the States rich in RE potential during 12th Plan. He also explained that the findings of the first study will feed the other two studies. The Forum noted. On the first study, i.e., determination of RPO trajectory based on the assessment of the achievable potential of new and renewable energy resources in different State during the 12^{th} Plan Period and its impact on retail tariff, the Consultant (CRISIL) made a presentation (copy **enclosed** at **Annexure – II**). They informed that the likely RE capacity addition which have been projected in the report are based on the information received from the important stakeholders like the State Nodal Agency, STUs, and industry players etc. The study has highlighted that around 36,000 MW could be added during the 12^{th} Plan Period and NAPCC target can be achieved if adequate steps are taken to address the infrastructure barrier, policy and regulatory barrier and financing barrier. Depending on the cost/tariff of the renewable energy source, the incremental impact on Power Purchase Cost on Pan-India based is not substantial. Based on the renewable energy resource availability and impact on tariff, the study has also suggested an RPO trajectory for each State.

After discussion, the report was endorsed with the following observations :-

- An analysis of target versus achievement during the previous Plan Periods (10^{th} and 11^{th} Plans) should be made to bring the desired confidence level for the projection for the 12^{th} Plan.
- Capacity addition target should also be validated based on the written communication received from the State Power Secretaries.

- ❖ Year-wise capacity addition of various technologies and their corresponding CUF should be taken as the reference for arriving at the feasible generation availability and corresponding RPO level for each State.
- ❖ Impact of factors like import of coal and invoking of section 11 by States should also be considered while projecting the RE capacity and corresponding RPO level for States.
- ❖ Impact analysis should be further elaborated with suitable justification.

Agenda Item No. 3 : Presentations on "Smart Grid".

A presentation was made by Shri Rahul Tongia, Principal Research Scientist of Centre for Study of Science, Technology & Policy (CSTEP), Bangalore. A copy of the presentation is **enclosed** at **Annexure – III**. He apprised the Members regarding the broad aspects and drivers for the Smart Grids, status of Smart Grid in India and its cost-benefit analysis. He also highlighted the need for regulatory intervention for promotion of Smart Grid in India. It was argued that introduction of Smart Grid can lead to various benefits for consumers like reduction in load shedding, improved power quality. It can also lead to better load planning, asset optimization, freeing up of capacity during peak period, and AT&C loss reduction etc. Specific regulatory interventions required for introduction of Smart Grid include implementation of Time of Use (subsequently dynamic/Real Time) tariffs and mandating requirement for smart meters and allowing the costs, especially, the pilot costs as pass through in the ARR. The Forum appreciated the concept.

Agenda Item No. 4 : Smart Metering Solutions.

A presentation was made by the representative of M/s. A_2Z Powertech Limited regarding road map for deployment of Smart Metering Solutions. They also apprised the Members regarding the Automated Meter Reading Instruments (AMI), various options available in smart meter server architecture and benefits realized with smart metering infrastructure solution with AMI vis-a-vis conventional meters. A copy of the presentation made by them is **enclosed** at **Annexure – IV**.

The Forum appreciated the efforts of BERC for the arrangements made for the meeting.

A vote of thanks was extended by Shri Rajiv Bansal, Secretary, CERC/FOR. He conveyed his sincere thanks to all the dignitaries present in the meeting. He also thanked the staff of "FOR" Secretariat for their arduous efforts at organizing the meeting.

The meeting ended with a vote of thanks to the Chair.

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/ ANNEXURE – I /

LIST OF PARTICIPANTS ATTENDED THE TWENTY EIGHTH MEETING OF

FORUM OF REGULATORS (FOR)

HELD ON 03RD FEBRUARY, 2012

AT "SAMBODHI RETREAT" BODH GAYA, (BIHAR)

S. No.	NAME	ERC
01.	Dr. Pramod Deo Chairperson	CERC – in Chair.
02.	Shri A. Raghotham Rao Chairperson	APERC
03.	Shri Digvijai Nath Chairperson	APSERC
04.	Shri Jayanta Barkakati Chairperson	AERC
05.	Shri Umesh Narayan Panjiar Chairperson	BERC
06.	Shri Manoj Dey Chairperson	CSERC
07.	Shri P.D. Sudhakar Chairperson	DERC
08.	Dr. P.K. Mishra Chairperson	GERC
09.	Shri R.N. Prasher Chairperson	HERC
10.	Shri Subhash Chander Negi Chairperson	HPERC
11.	Shri S. Maria Desalphine Chairperson	J&KSERC
12.	Dr. V.K. Garg Chairperson	JERC for Goa & All UTs
13.	Shri Himam Bihar Singh Chairperson	JERC for Manipur & Mizoram
14.	Shri Mukhtiar Singh Chairperson	JSERC

15.	Shri V.P. Raja Chairperson	MERC
16.	Shri Anand Kumar Chairperson	MSERC
17.	Shri S.I. Longkumer Chairperson	NERC
18.	Shri S.P. Nanda Chairperson	OERC
19.	Ms. Romila Dubey Chairperson	PSERC
20.	Shri D.C. Samant Chairperson	RERC
21.	Shri T.T. Dorji Chairperson	SSERC
22.	Shri Manoranjan Karmarkar Chairperson	TERC
23.	Shri Jag Mohan Lal Chairperson	UERC
24.	Shri Prasad Ranjan Ray Chairperson	WBERC
25.	Shri Rajiv Bansal Secretary	CERC/FOR
26.	Shri Sushanta K. Chatterjee Deputy Chief (RA)	CERC
27.	Ms. Neerja Verma Assistant Secretary	FOR

Assessment of RPO trajectory for the states during the 12th Plan Period

Study for Forum of Regulators

Presentation to Forum of Regulators

Presentation by :
CRISIL Risk & Infrastructure Solutions Limited

3rd February, 2012

Content

- Scope of work
- Approach and Methodology
- Key Messages
- 12th Plan Targets and Comparison with CRIS Assessment
- Technology wise Likely capacity addition and constraints
- Nationwide Scenario

Scope of Work & Our Approach

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Scope of work

Scope of Work

Scope	Activity	Details
Validation of achievable potential for various RE sources in different states	Field Visit/ data collection	• Formation of clusters on the basis of RE potential and visit the sample sites • Interaction with the developers , industry players, State Renewable Agencies
Validation of likely RE-capacity additions during the 12th Plan period	Corroboration	• Corroborated from MNRE, C-WET, Biomass Resource Atlas, Solar Radiation data, SERCs etc. • Confidential Developers Business Plan
Determination of optimum as well as achievable RPO trajectory for various States	Stakeholder Consultation	• Interaction with MNRE, Regulators, Banks/FIs, IREDA, State Nodal Agencies, Utilities, Manufacturers and their Associations
Thorough assessment of impact of RPO on PPC	Impact Analysis	• Impact on PPC

Objective is to suggest the RPO trajectory for the states keeping in view the achievable potential of New and Renewable Energy Resources in different states during the 12th Plan Period and its impact on tariff

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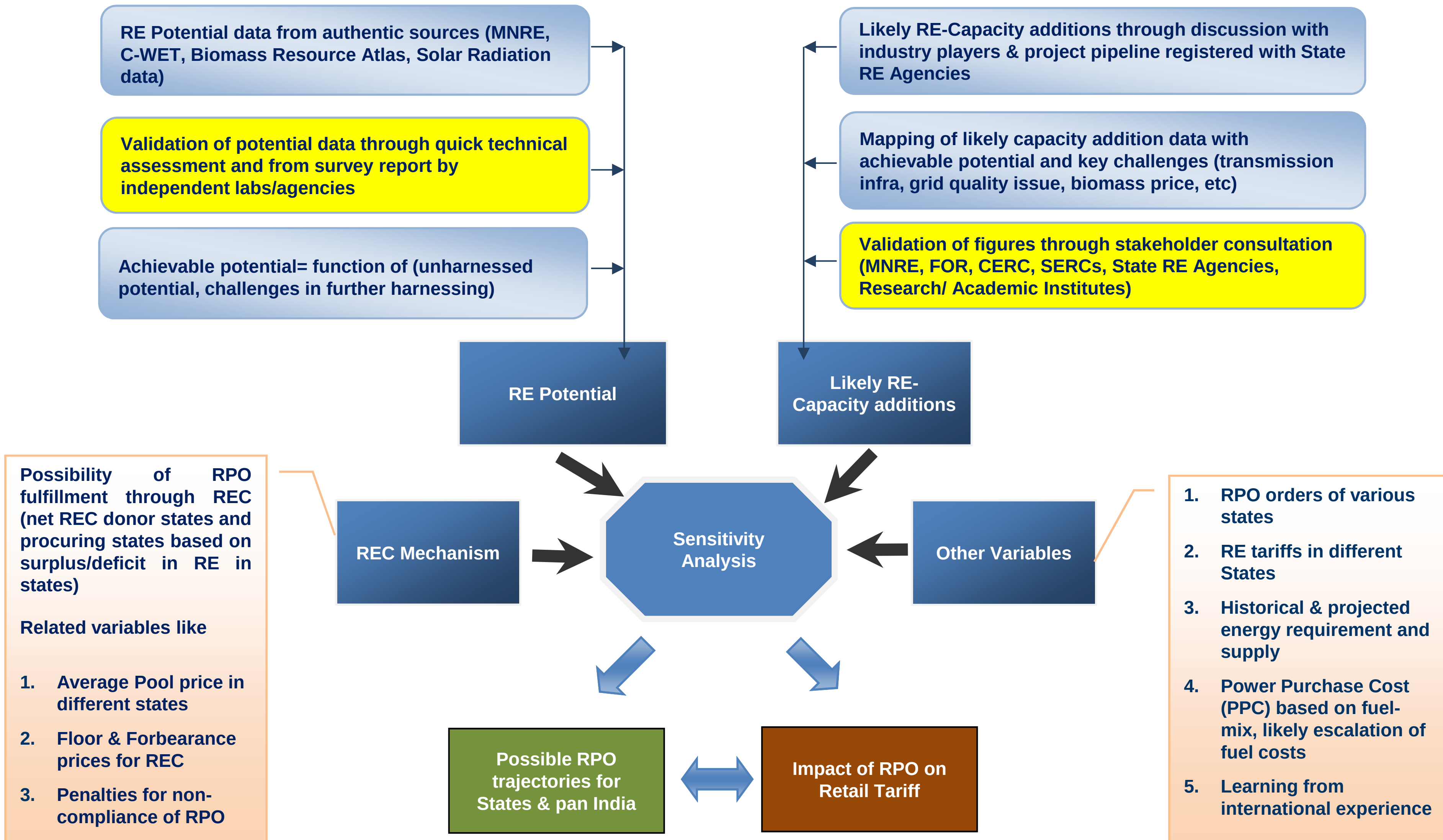
Our Approach- Four Key Sources for estimating likely RE supply



-SNA, STU, SERC and Micro level details from the confidential Business Plan of the Manufacturer
- SERC orders for RE tariffs, existing RPO levels, PPC cost and trend

Key Messages

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Key Messages

- **39600 MW (grid-connected) could be added during the 12th plan based on the micro-level data provided by the SNA, STU and developers business plan**
- **NAPCC target could be achieved during the 12th plan, if the adequate steps are taken to address the following issues:**
  - Infrastructure Barriers:
    - Transmission and power evacuation infrastructure and grid management
    - Land approvals (Single window clearance), specially for solar
  - Policy and Regulatory Barriers:
    - long term perspective on RPO, RE Tariffs (and inter-state difference in tariffs)
    - Sale of RE power through open access and inter-state sale
  - Incoherent Resource Assessment
  - Financing Barriers
- **States will have surplus and deficit RE vis-à-vis installed capacity installed in the state – REC mechanism and Inter-State Sale of RE power**
- **Depending on the cost/tariff of RE, incremental impact on Power Purchase Cost (PPC) on Pan-India basis could be negative**

NAPCC, 12th plan target and Proposed RPO trajectory

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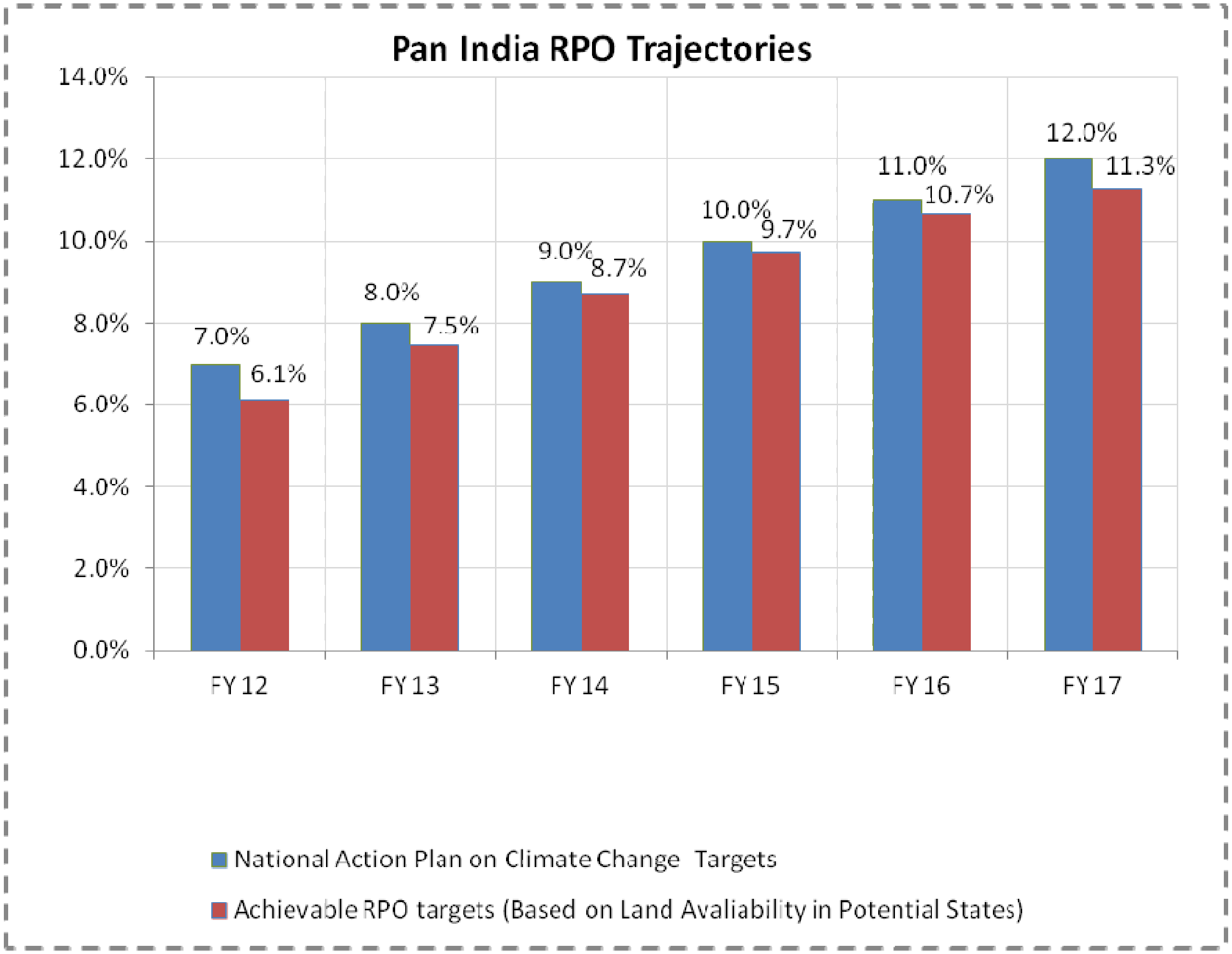
Nation wide Scenario (12th Plan Period)



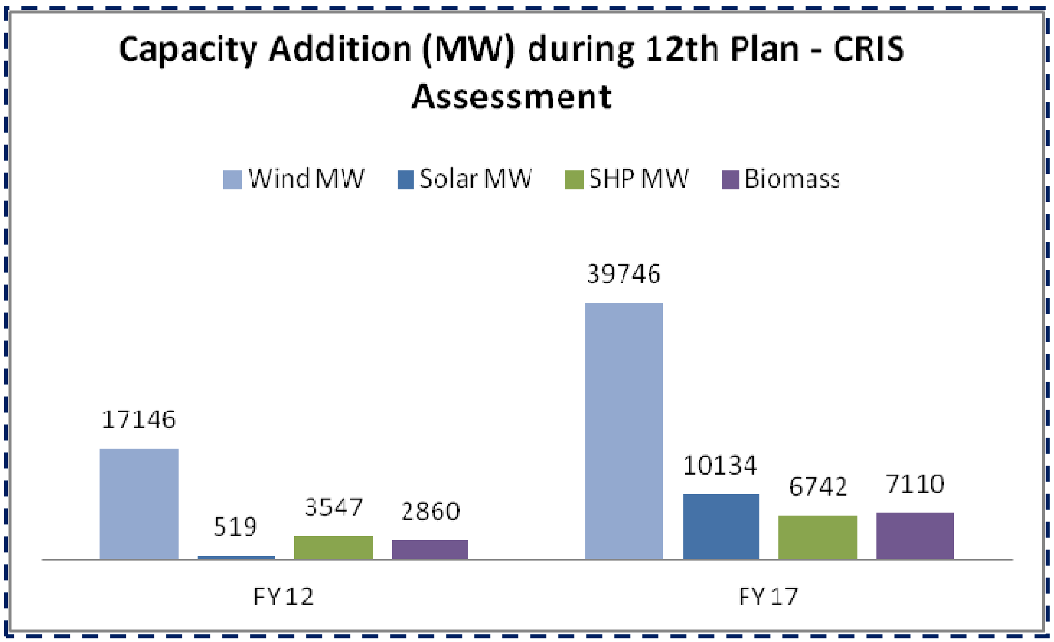
Targets for 12th Plan - MNRE

Resource	2012-13	2013-14	2014-15	2015-16	2016-17	Cumulative 12th Plan Addition
Wind	2500	2750	3000	3250	3500	15000
Biomass Power	350	625	825	950	1300	4050
Waste to energy	40	60	100	100	200	500
Solar	1000	1000	2000	2500	3500	10000
Small Hydro	350	400	400	450	500	2100
Tidal Power	0.5	1.00	1.50	2.00	2.00	7
Geothermal	0.5	1.00	1.50	2.00	2.00	7
Total	**4241**	**4837**	**6328**	**7254**	**9004**	**31664**

Resource	MNRE – 12th Plan	CRIS Study
Wind Power	15000	22600
Solar Power	10000	9615
Small Hydro Power	2100	3195
Biomass Power	4050	4250
Total RE	**31150**	**39660**

CRIS Assessment

RE Technology	Installed till FY 2011	Estimated till FY 2012	Estimated till FY 2017	12th Plan Capacity Addition (MW)
Wind Power	14157	17335	39746	22600
Solar Power	38	420	10134	9615
Small Hydro Power	3043	3547	6742	3195
Biomass Power	2737	2860	7110	4250
Total RE	**19974**	**24162**	**63731**	**39660**



Technology wise Likely capacity addition and constraints

Wind Resource Assessment & Likely Capacity Addition

Reassessment of Wind Potential in India

- **It is concluded that wind potential is far higher than the historical estimate**

WPI I & II Assessment (J Hossain)	Change in Assumption for WP III (J Hossain)
Only a part of barren land was used	Forest land, Grazing land, Cultivated & Agricultural land have been used
WTG of 55- 250 KW rating	WTG of 1500 – 2000 KW being installed
Hub height of 20 -30 m	Hub height of 80 -90 m
Rotor Diameter 20 – 30 m	Rotor Diameter 80 – 90 m
Max rotor efficiency around 40%	Max rotor efficiency around 50%
Individual wind farm of maximum 10 - 15 MW capacity	Individual wind farm of maximum 30 -700 MW capacity
Only existing transmission line to be used	New transmission lines required being set up
Only existing substations in rural areas are used to evacuate power	Large new & dedicated substations have been set up to evacuate power
10 – 15 % penetration	In line with international practices
Limited experience of wind farm capacity of 100 MW capacity	Enhanced experience of wind farm capacity of upto 1000 MW

MNRE is conducting a study on wind resource assessment

Wind Achievable Potential Assessment

State	MNRE Figures			RPO Study Assessment (Achievable till 2020)	
	Potential (MW)	Installed Capacity (MW)	Gap (MW)	Incremental (MW)	Re – powering (MW)
Andhra Pradesh	8968	198.20	8769.8	7000 – 8000	
Chhattisgarh	-	-	-	500	
Gujarat	10645	2269.43	8375.57	6000 – 7000	
Jharkhand	-	-	-	500	
Karnataka	11531	1727.65	9803.35	5000	1000
Kerala	1171	35.10	1135.9	-	
Madhya Pradesh	1019	275.90	743.1	3000 – 3500	
Maharashtra	4584	2345.80	2238.2	6000 – 7000	
Orissa	255	-	255	500	
Rajasthan	4858	1620.10	3237.9	4000 – 5000	
Tamil Nadu	5530	6084.20		7,000 – 8,000	1500
West Bengal	-	4.30			
Total	**48561**	**14560.68**		**39000 – 43000**	**2500**

- Assuming land/site restriction constraint of Land/Site Availability only
- Utilizing the Class III turbines
- If any further support can be provided targets can be achieved by 2017

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Gujarat – Likely Capacity Addition through wind

Gujarat - Likely Capacity Addition

MNRE Figures			RPO Study Assessment (Achievable till 2020)
Potential (MW)	Installed Capacity (MW)	Gap (MW)	Incremental (MW)
10645	2269.43	8375.57	6000 – 7000

	Year Wise Capacity Addition MW				
FY12 (E)	FY 13	FY 14	FY 15	FY 16	FY 17
503	500	500	500	500	500

•Minimum capacity addition of 2500 MW during the 12th plan period

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GUJARAT (CTU – Data)

(A) Future- Potential Capacity (MW)

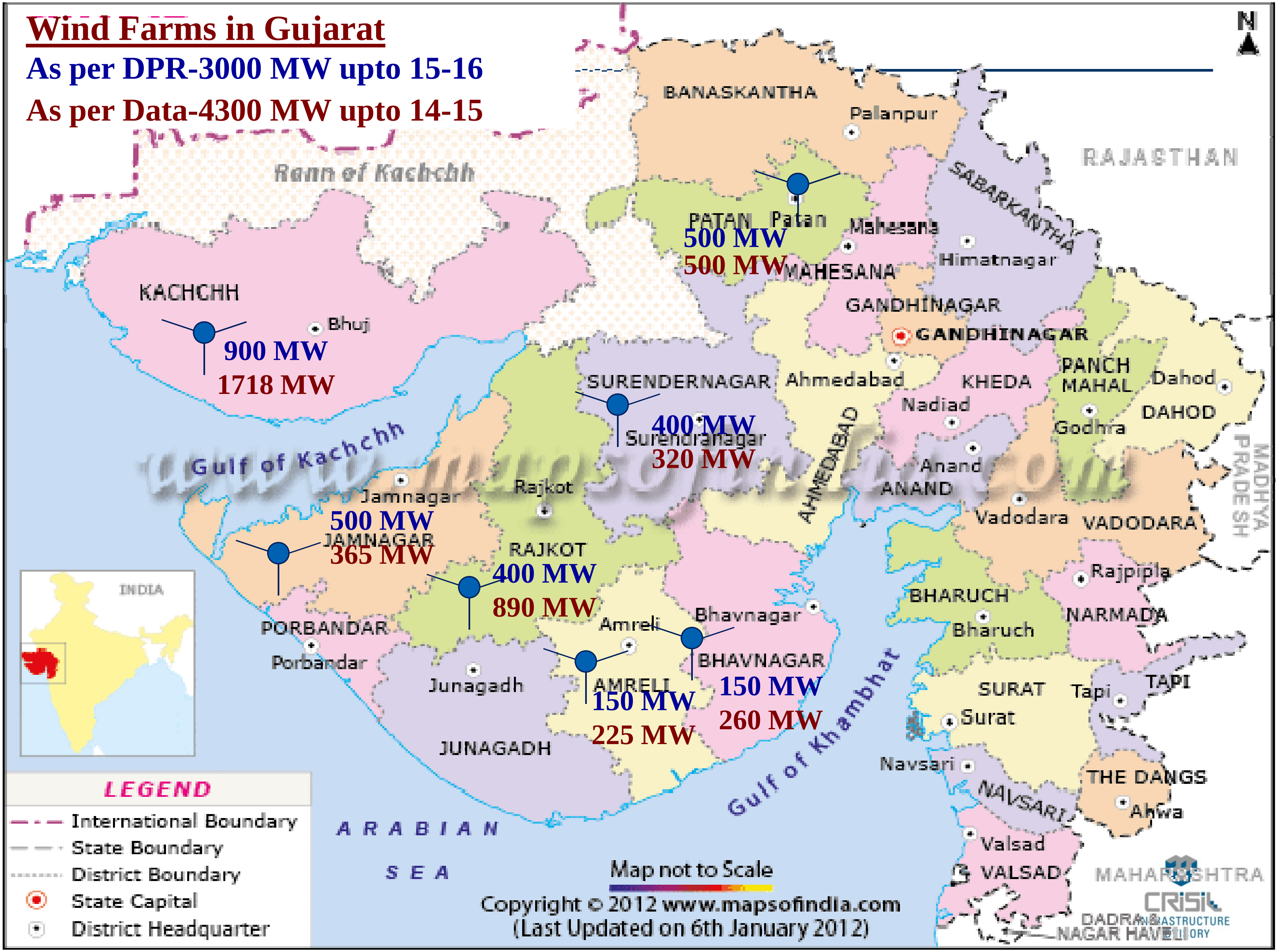
Wind	4918
Solar PV	853.5
Solar Thermal	45
Small Hydro	5
Biomass/Waste to Energy	100

(B) RES Capacity Addition Programme in 12th Plan

	2012-13	2013-14	2014-15	2015-16	2016-17
Type					
Wind	600	600	600	600	600
Solar PV	853.5	300	300	300	300
Solar Thermal	45				
Small Hydro	0				
Biomass/Waste to Energy	20	20	20	20	20

As per the Applications processed (Based on which studies are to carried out)

	2012-13	2013-14	2014-15	2015-16	2016-17
Type					
Wind	2633	300	1150		
Solar PV	890.5				
Solar Thermal					
Small Hydro					
Biomass/Waste to Energy					


Wind Farms in Gujarat
As per DPR-3000 MW upto 15-16
As per Data-4300 MW upto 14-15
KACHCHH
Bhuj
900 MW
1718 MW
PATAN
Patan
500 MW
500 MW
SURENDERNAGAR
Surendranagar
400 MW
320 MW
Jamnagar
JAMNAGAR
500 MW
365 MW
RAJKOT
Rajkot
400 MW
890 MW
AMRELI
Amreli
150 MW
225 MW
BHAVNAGAR
Bhavnagar
150 MW
260 MW
BANASKANTHA
Palanpur
RAJASTHAN
Rann of Kachchh
SABARKANTHA
Mahesana
MAHESANA
Himatnagar
GANDHINAGAR
GANDHINAGAR
Ahmedabad
AHMEDABAD
KHEDA
Nadiad
PANCH MAHAL
Godhra
Dahod
DAHOD
MADHYA PRADESH
Anand
ANAND
Vadodara
VADODARA
Gulf of Kachchh
PORBANDAR
Porbandar
Junagadh
JUNAGADH
Rajpipla
NARMADA
BHARUCH
Bharuch
SURAT
Surat
Tapi
TAPI
Gulf of Khambhat
Navsari
NAVSARI
THE DANGS
Ahwa
Valsad
VALSAD
MAHARASHTRA
DADRA & NAGAR HAVELI
ARABIAN SEA
INDIA
LEGEND
International Boundary
State Boundary
District Boundary
State Capital
District Headquarter
Map not to Scale
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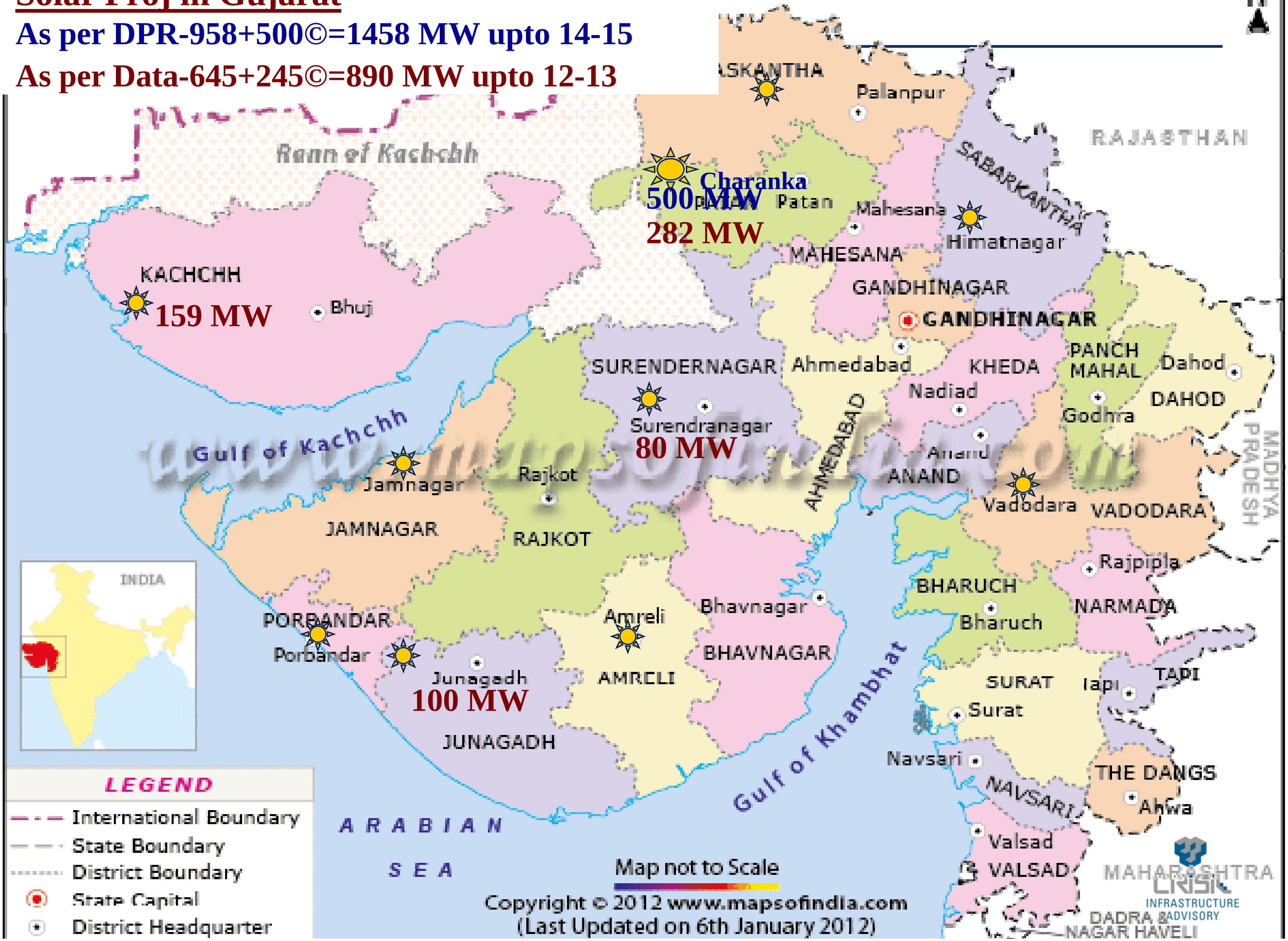
Solar Proj in Gujarat

As per DPR-958+500©=1458 MW upto 14-15

As per Data-645+245©=890 MW upto 12-13



Gujarat - Wind Pockets CRIS Assessment

Kachch – 750 MW

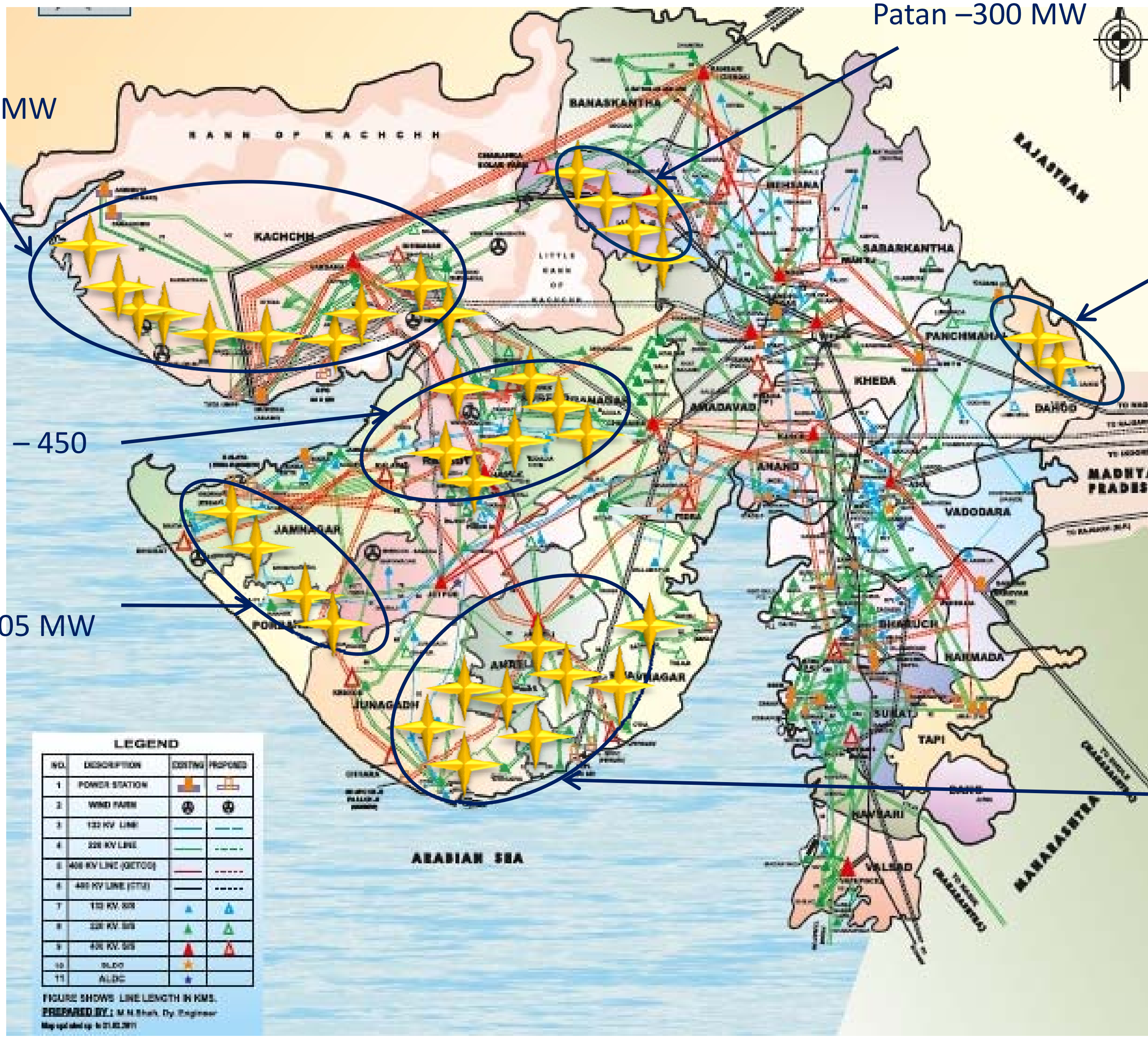
Patan –300 MW

Dahod – 100 MW

Rajkot & Surendranagar – 450 MW

Jamnagar & Porbandar – 305 MW

Amreli, Bhavnagar & Junagarh – 500 MW



•Minimum capacity addition of 2500 MW

Tamil Nadu – Likely Capacity Addition through wind

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Tamil Nadu - Likely Capacity Addition

MNRE Figures			RPO Study Assessment (Achievable till 2020)	
Potential (MW)	Installed Capacity (MW)	Gap (MW)	Incremental (MW)	Re – powering (MW)
5530	6084.20	NA	7,000 – 8,000	1500

	Year Wise Capacity Addition MW				
FY12 (E)	FY 13	FY 14	FY 15	FY 16	FY 17
1200-1400	1000	1000	1000	1000	1000

•Capacity addition of 5000 MW in 12th plan

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TAMIL NADU (CTU Data)

(A) Future- Potential Capacity (MW)

Wind	10500
Solar PV	50
Solar Thermal	-
Small Hydro	-
Biomass/Waste to Energy	-
Total	**10550**

(B) RES Capacity Addition Programme in 12th Plan

	2012-13	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Type					
Wind	1000	1000	1000	1000	1000
Solar PV	15	10	10	10	5
Solar Thermal	-				
Small Hydro	-	-	-	-	-
Biomass/Waste to Energy	-	-	-	-	-
Total	**1015**	**1010**	**1010**	**1010**	**1005**

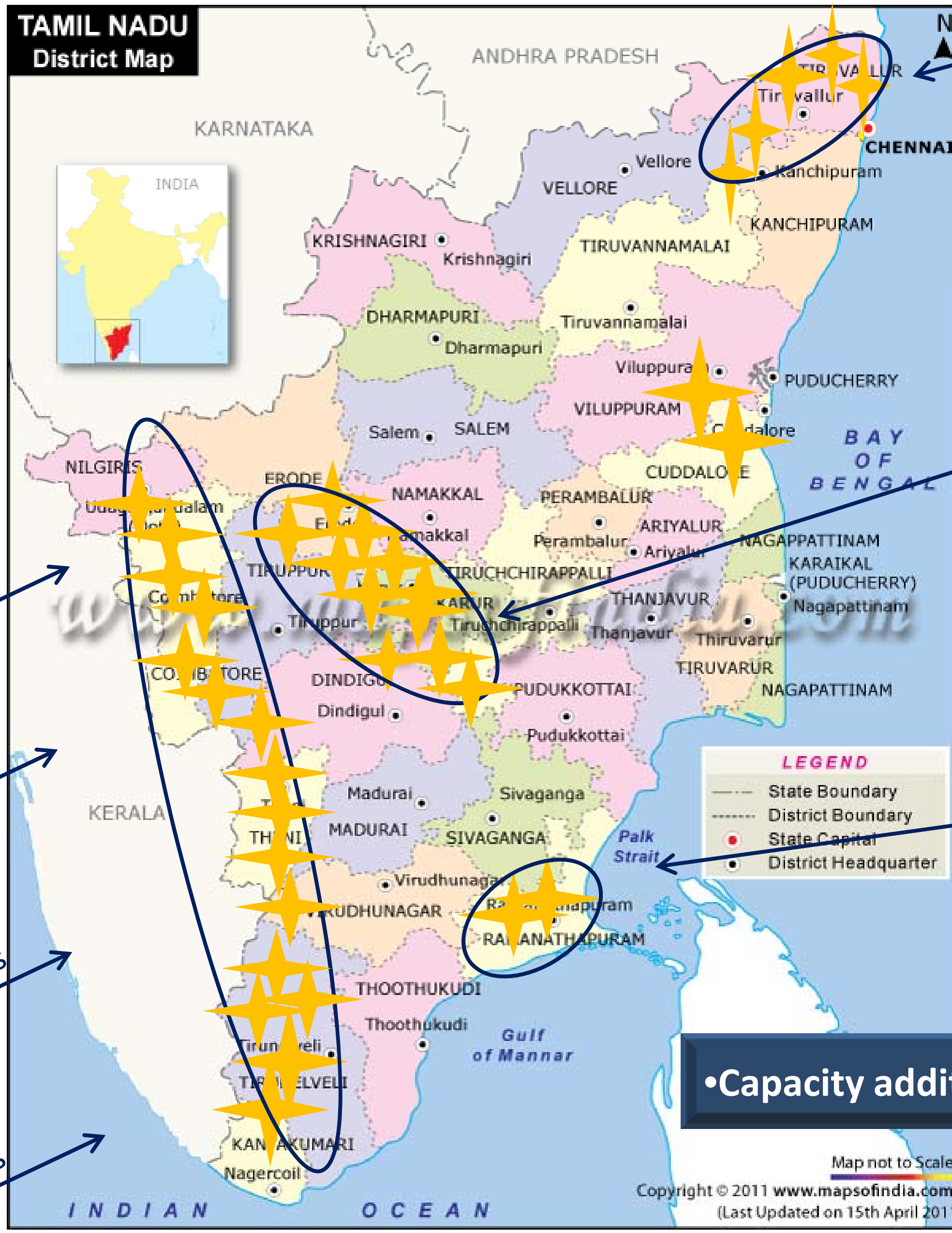
Total Capacity Addition : **5050 MW**

Wind Project

As per DPR- Wind–5400MW

As per data-Wind -5000 MW upto 16-17

Tamil Nadu - Wind Pockets CRIS Assessment



Tiruvallur – 300 MW

Central Tamil Nadu Likely to develop around 2014 – 2500 - 3000 MW

Ramnathpuram – 200 MW

Palgaut Pass

Theni Pass

Shemkottai Pass

Tirunelvi Pass

Incremental Capacity of 1500 MW

•Capacity addition of 5000 MW in 12th plan

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Rajasthan – Likely Capacity Addition through wind

Rajasthan - Likely Capacity Addition

MNRE Figures			RPO Study Assessment (Achievable till 2020)
Potential (MW)	Installed Capacity (MW)	Gap (MW)	Incremental (MW)
4858	1620.10	3237.9	4000 – 5000

	Year Wise Capacity Addition MW				
FY12 (E)	FY 13	FY 14	FY 15	FY 16	FY 17
650	739	739	686	634	581

•3400 MW likely to be added during the 12th plan

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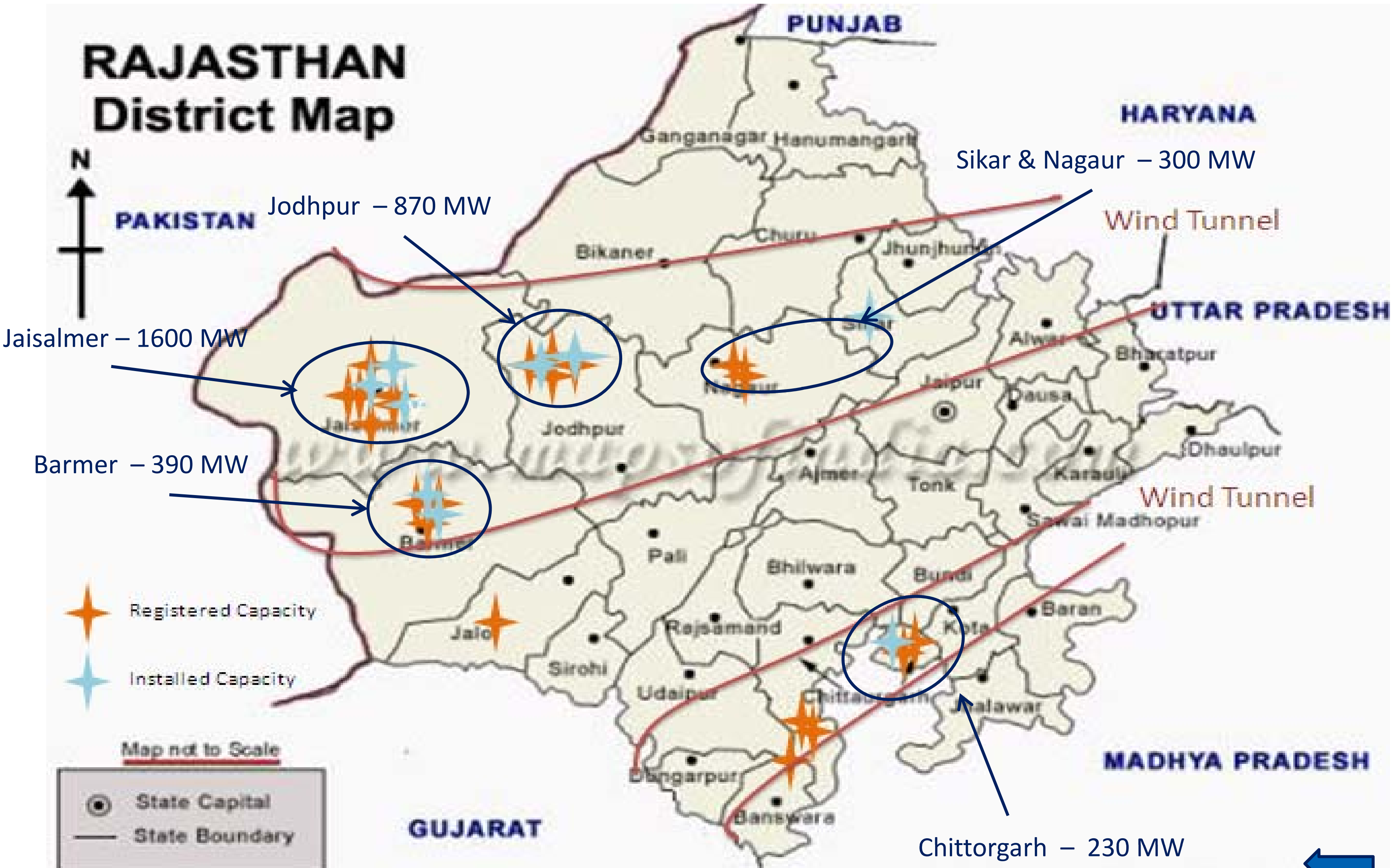
Rajasthan - Wind Pockets CRIS Assessment



- 16000 MW of registered capacity for wind projects, out of which land allotted for 5000 MW
- 3400 MW likely to be added during the 12th plan

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Rajasthan (CTU Data)

(A) Future- Potential Capacity (MW)

Wind	2215
Solar PV	1950
Solar Thermal	1730
Small Hydro	
Biomass/Waste to Energy	160

(B) RES Capacity Addition Programme in 12th Plan

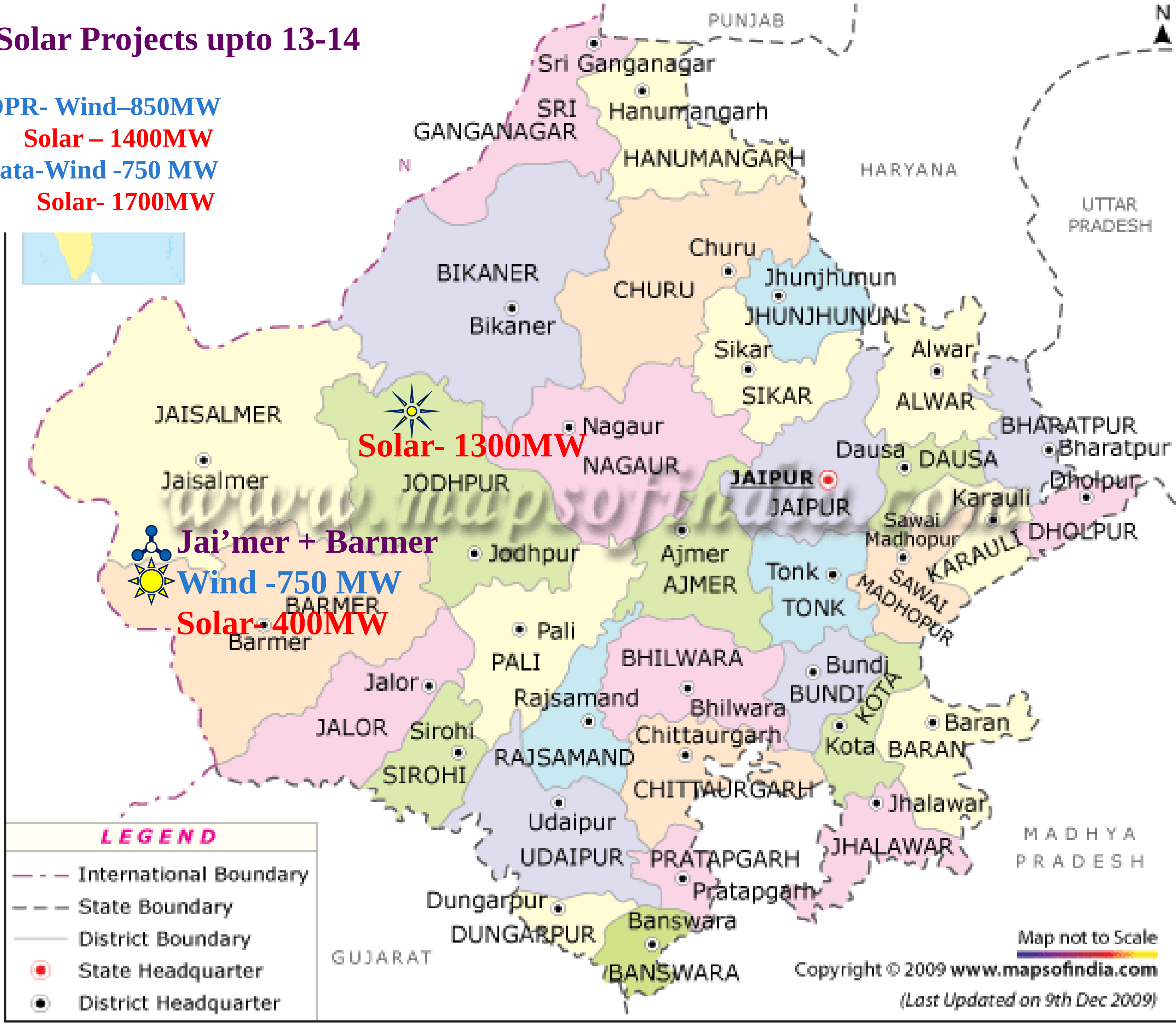
	2012-13	2013-14	2014-15	2015-16	2016-17
Type					
Wind	425	425	425	440	500
Solar PV	450	600	500	400	-
Solar Thermal	30	400	500	500	300
Small Hydro	-	-	-	-	-
Biomass/Waste to Energy	25	25	30	40	40

As per the Applications processed (Based on which studies are to be carried out)

	2012-13	2013-14	2014-15	2015-16	2016-17
Type					
Wind		713			
Solar PV		1700			
Solar Thermal					
Small Hydro					
Biomass/Waste to Energy					

Wind/Solar Projects upto 13-14

As per DPR- Wind–850MW
Solar – 1400MW
As per data-Wind -750 MW
Solar- 1700MW



Karnataka – Likely Capacity Addition through wind

Karnataka - Likely Capacity Addition

MNRE Figures			RPO Study Assessment (Achievable till 2020)	
Potential (MW)	Installed Capacity (MW)	Gap (MW)	Incremental (MW)	Re – powering (MW)
11531	1727.65	9803.35	5000	1000

	Year Wise Capacity Addition MW				
FY12 (E)	FY 13	FY 14	FY 15	FY 16	FY 17
650	620	600	700	780	523

•Capacity addition of 3200 MW during the 12th plan

CRISIL INFRASTRUCTURE ADVISORY

Karnataka (CTU Data)

(A) **Future- Potential Capacity (MW)**

Wind	11433
Solar PV	200
Solar Thermal	
Small Hydro	250
Biomass/Waste to Energy	140
Total	**12023**

(B) **RES Capacity Addition Programme in 12th Plan**

	2012-13	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Type					
Wind	530	599	-	-	-
Solar PV	40	40	40	40	-
Solar Thermal					
Small Hydro	150	100	-		-
Biomass/Waste to Energy	70	70	-	-	-
Total	**790**	**809**	**40**	**40**	-

Total Capacity Addition : **1679 MW**

INFRASTRUCTURE ADVISORY


KARNATAKA
Districts
WIND FARMS - 1538MW up to 13-14
750MW
240MW
108MW
340MW
KADUR 100MW
MAHARASHTRA
Bidar
BIDAR
Gulbarga
GULBARGA
Bijapur
BIJAPUR
Bagalkot
BAGALKOT
BELGAUM
Belgaum
Raichur
RAICHUR
Dharwar
DHARWAR
Gadag
GADAG
KOPPAL
Koppal
Bellary
BELLARY
GOA
ANDHRA PRADESH
HAVERI
Haveri
Karwar
UTTAR KANNAD
DAVANGERE
Davangere
Chitradurga
CHITRADURGA
SHIMOGA
Shimoga
Udupi
UDUPI
CHIKMAGALUR
Chikmagalur
TUMKUR
Tumkur
KOLAR
Kolar
BANGALORE
BANGALORE (URBAN)
BANGALORE (RURAL)
Hassan
HASSAN
ARABIAN SEA
Mangalore
DAKSHIN KANNAD
MANDYA
Mandya
Madikeri
KODAGU
Mysore
MYSORE
TAMIL NADU
CHAMRAJNAGAR
Chamrajnagar
KERALA
LEGEND
State Boundary
District Boundary
State Capital
District Headquarter
Map not to Scale
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Karnataka - Wind Pockets CRIS Assessment

Pockets	Estimated Capacity
Bagalkote	111
Belgaum	527
Bellary	230
Bijapur	197
Chikmangalur	200
Chitradurga	210
Davanagere	443
Gadag	119
Hassan	35
Haveri	446
Kolar	33
Kopal	494
Mysore	8.25
Raichur	96
Shimoga	76
Total	**3223**

- Capacity addition of 3200 MW

Andhra Pradesh – Likely Capacity Addition through wind

Andhra Pradesh (CTU Data)

(A) Future- Potential Capacity (MW)

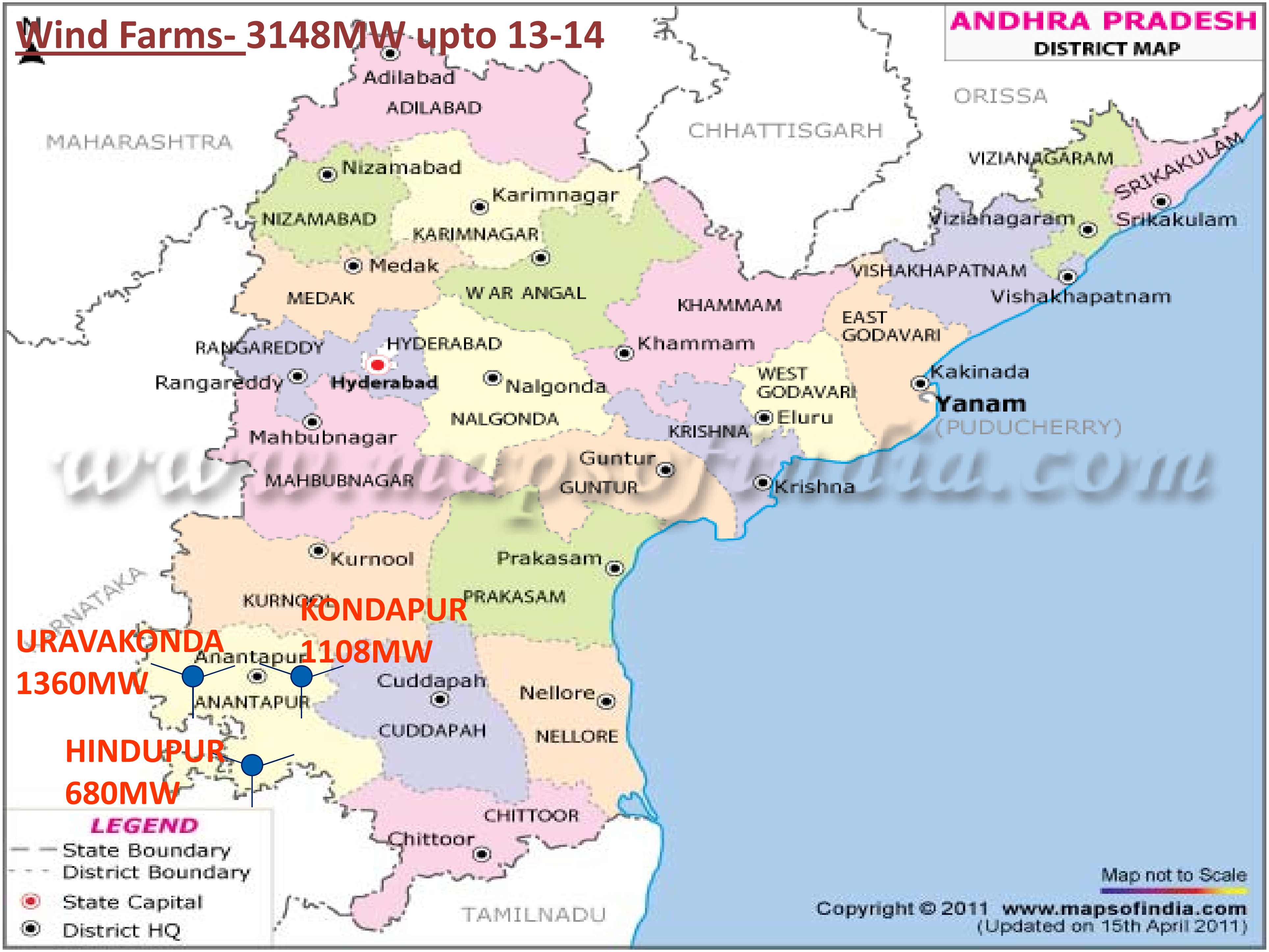
Wind	3149.25
Solar PV	25.5
Solar Thermal	57
Small Hydro	0
Biomass/Waste to Energy	27
Total	**3258.75**

(B) RES Capacity Addition Programme in 12th Plan

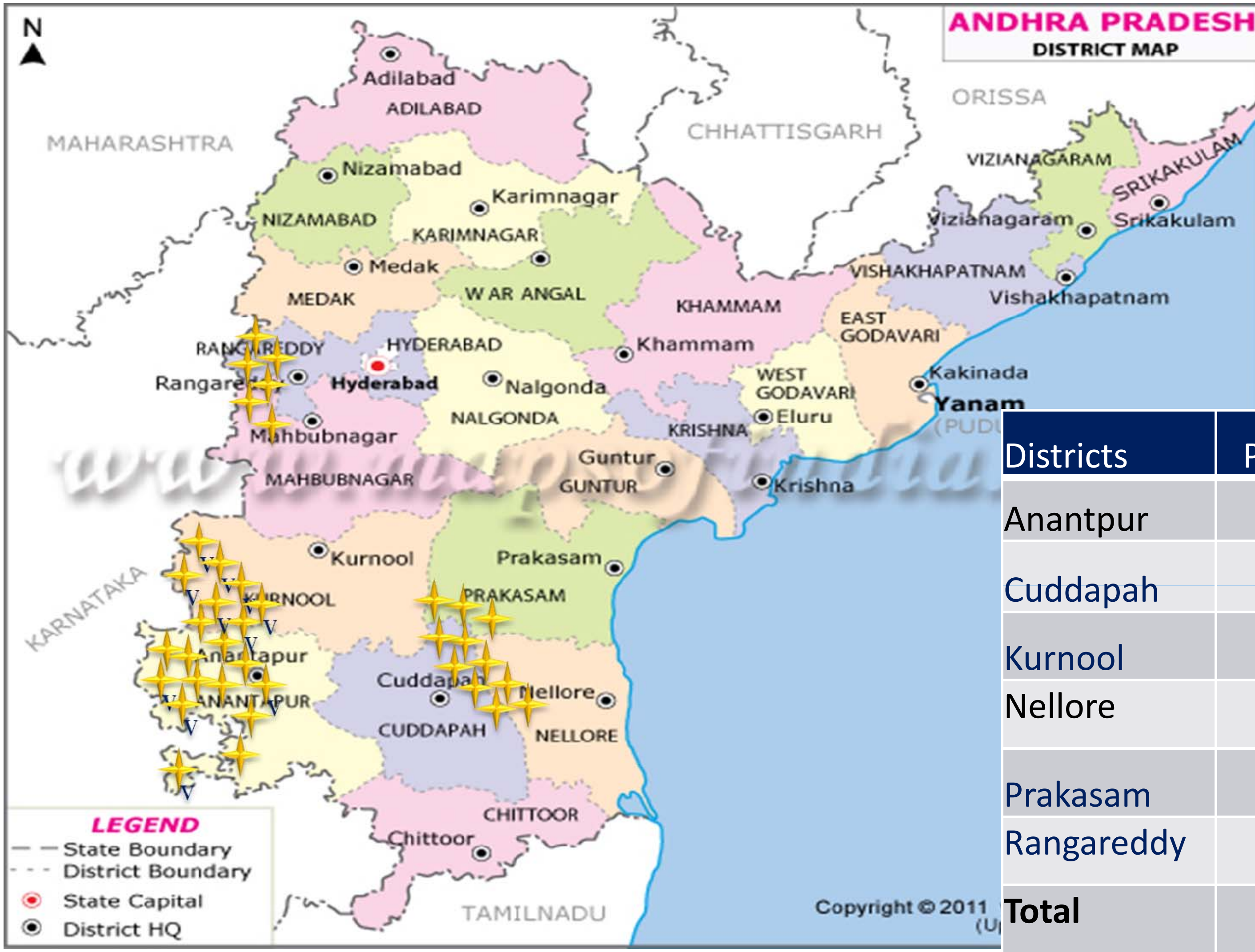
	2012-13	2013-14	2014-15	2015-16	2016-17
Type					
Wind	1503.2	1435.3			
Solar PV	25.5				
Solar Thermal	57				
Small Hydro	0				
Biomass/Waste to Energy	27				
Total	**1612.7**	**1435.3**			

Total Capacity Addition : **3048 MW**

Wind Farms- 3148MW upto 13-14



Andhra Pradesh Wind Pockets – CRIS Assessment



Districts	Proposed Capacity (MW)
Anantpur	3558
Cuddapah	768.5
Kurnool	423.35
Nellore	179.10
Prakasam	224.45
Rangareddy	100
Total	**5047.6**

Proposed capacity addition of 5000 MW

CRISIL INFRASTRUCTURE ADVISORY

Andhra Pradesh - Likely Capacity Addition

MNRE Figures			RPO Study Assessment (Achievable till 2020)
Potential (MW)	Installed Capacity (MW)	Gap (MW)	Incremental (MW)
8968	198.20	8769.8	7000 – 8000

	Year Wise Capacity Addition MW				
FY 12 (E)	FY 13	FY 14	FY 15	FY 16	FY 17
210.75	1503.20	1435.30	256.60	1202.2	650.3

Maharashtra – Likely Capacity Addition through wind

MAHARASHTRA (CTU Data)

(A) Future- Potential Capacity (MW)

Wind	5439 MW
Solar PV	49 MW/sq km
Solar Thermal	35 MW/sq km
Small Hydro	732 MW
Biomass	781 MW
Bagasse	1250 MW

(B) RES Capacity Addition Programme in 12th Plan

Type	2012-13	2013-14	2014-15	2015-16	2016-17	Total (MW)
Wind (in MW)	300	300	300	300	300	**1500**
Solar PV(in MW) Solar Thermal (in MW)	125	100	100	100	100	**525**
Small Hydro (in MW)	10	10	10	10	10	**50**
Bagasse Co-generation (in MW)	50	50	50	50	50	**250**
Biomass (in MW)	30	30	30	30	30	**150**
Waste to energy (in MW)	3	3	3	3	3	**15**
Total (in MW)	*518*	*493*	*493*	*493*	*493*	**2490**

As per the Applications processed (Based on which studies are to carried out)

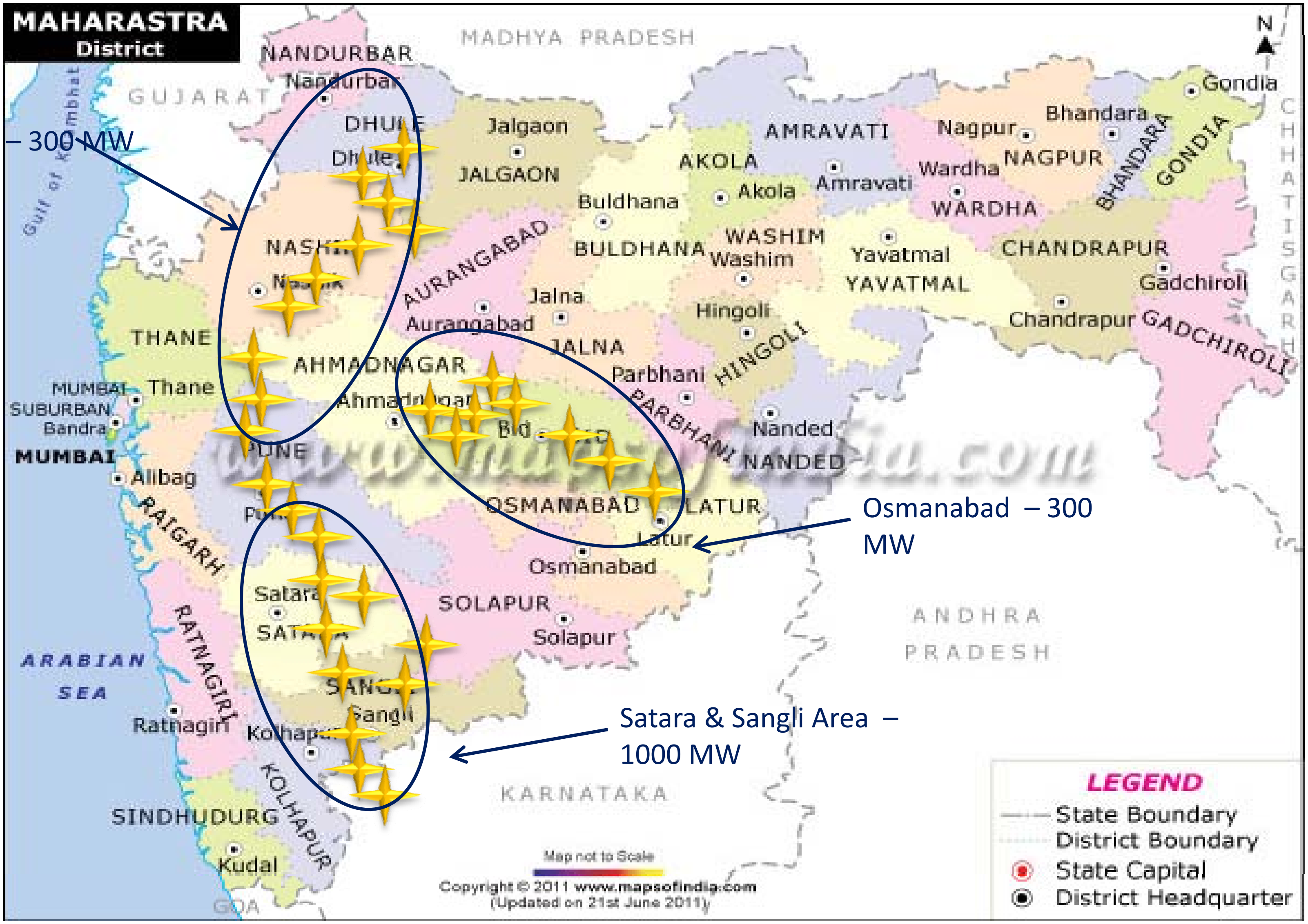
	2012-13	2013-14	2014-15	2015-16	2016-17
Type					
Wind	1002	1220	2782.5	670	
Solar PV	200				
Solar Thermal					
Small Hydro		2			
Biomass/Bagasse/Waste to Energy	314.21				

CRISIL INFRASTRUCTURE ADVISORY

Wind Farms in Maharashtra

As per Data-4300 MW upto 15-16

Maharashtra Wind Pockets – CRIS Assessment



CRISIL INFRASTRUCTURE ADVISORY

Overall Likely Capacity Addition Through Wind

Wind - Likely Capacity Addition

States	Source	FY 12 (E)	Year Wise Capacity Addition MW				
			FY 13	FY 14	FY 15	FY 16	FY 17
Tamil Nadu	TNEB Estimate	1200 - 1400	1000	1000	1000	1000	1000
Karnataka	KREDL Estimate	530	620	600	700	780	523
Andhra Pradesh	Corroborated Estimate	210.75	1503	1435	256.6	1202.2	650.3
Maharashtra	MEDA Estimate	300	300	300	300	300	300
Gujarat	GEDA Estimate	503	500	500	500	500	500
Rajasthan	Corroborated Estimate	654	739	739	686	634	581
Madhya Pradesh	Corroborated Estimate	150	150	150	150	150	150
Orissa	Corroborated Estimate		50	100	100	100	50
Chhattisgarh	Corroborated Estimate		50	100	100	100	50
Jharkhand	Corroborated Estimate		50	100	100	100	50
Total		**3545**	**4963**	**5024**	**3893**	**4866**	**3854**

•Corroborated estimate based on developer BP, STU and SNA

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Small Hydro Likely Capacity Addition

CRISIL INFRASTRUCTURE ADVISORY

HIMACHAL PRADESH (Collected by CTU as well as CRIS)

- Future Potential (SHP) : 1916.98 MW
- Year-wise capacity addition program:

FY 13	FY 14	FY 15	FY 16	FY 17	Total
105.45	219.65	165.15	307.45	198.02	1916.98

- Basin wise capacity addition program: 3607.32 MW
  - Beas Basin: 1475.09 MW
  - Ravi Basin: 507.20 MW
  - Satluj Basin: 767.70 MW
  - Yamuna Basin: 843.33 MW
  - Chenab Basin: 14.00 MW

CRISIL INFRASTRUCTURE ADVISORY

Karnataka (Collected by CTU as well as CRIS)

Year-wise capacity addition program:

FY 13	FY 14	FY 15	FY 16	FY 17	Total
161.2	108.5	152.8	150.8	145.3	718.6

CRISIL INFRASTRUCTURE ADVISORY

Small Hydro - Likely Capacity Addition by CRIS

State	FY 12 (E)	CRIS Assessment					
		12th Plan (MW)	FY 13	FY 14	FY 15	FY 16	FY 17
Andaman & Nicobar	0	0.0	0.0	0.0	0.0	0.0	0
Andhra Pradesh	15	73.4	15.8	15.8	19.2	19.2	3.4
Arunachal Pradesh	0	47.7	11.9	11.9	11.9	11.9	0.0
Assam	0	21.3	3.8	3.8	5.9	5.9	2.1
Bihar	4.7	24.1	6.0	6.0	6.0	6.0	0.0
Chhattisgarh	1.2	291.0	37.1	37.1	84.7	84.7	47.6
Goa	0	0.0	0.0	0.0	0.0	0.0	0.0
Gujarat	0	0.0	0.0	0.0	0.0	0.0	0.0
Haryana	3.4	3.4	0.9	0.9	0.9	0.9	0.0
Himachal Pradesh	107.55	995.72	105.45	219.65	165.15	307.45	198.02
Jammu & Kashmir	3	28.5	2.2	2.2	8.8	8.8	6.5
Jharkhand	0	34.9	8.7	8.7	8.7	8.7	0.0
Karnataka	176.5	718.6	161.2	108.5	152.8	150.8	145.3
Kerala	0	71.0	16.4	16.4	18.2	18.2	1.8
Madhya Pradesh	0	36.4	1.2	1.2	11.7	11.7	10.5
Maharashtra	4.9	197.7	22.8	22.8	58.3	58.3	35.5
Manipur	0	2.8	0.7	0.7	0.7	0.7	0.0
Meghalaya	0	1.7	0.4	0.4	0.4	0.4	0.0
Mizoram	0	0.5	0.1	0.1	0.1	0.1	0.0
Nagaland	0	4.2	1.1	1.1	1.1	1.1	0.0
Orrisa	20	136.7	0.9	0.9	45.3	45.3	44.4
Punjab	15	30.6	5.3	5.3	8.4	8.4	3.2
Rajasthan	0	0.0	0.0	0.0	0.0	0.0	0.0
Sikkim	0	0.2	0.1	0.1	0.1	0.1	0.0
Tamil Nadu	0	20.5	5.1	5.1	5.1	5.1	0.0
Tripura	0	0.0	0.0	0.0	0.0	0.0	0.0
Uttar Pradesh	0	0.0	0.0	0.0	0.0	0.0	0.0
Uttarakhand	22	341.2	57.4	57.4	94.6	94.6	37.2
West Bengal	10	112.8	21.1	21.1	30.6	30.6	9.5
Total	**383.25**	**3195**	**485**	**547**	**738**	**879**	**545**

CRISIL INFRASTRUCTURE ADVISORY

Solar & Likely Capacity Addition

CRISIL INFRASTRUCTURE ADVISORY

Solar - Likely Capacity Addition

States	Remarks	FY 12 (E)	Year Wise Capacity Addition MW				
			FY 13	FY 14	FY 15	FY 16	FY 17
Andhra Pradesh		94.5	15	0	120	100	50
Gujarat	GEDA Estimate		209	331	331	441	560
	Corroborated Estimate	250	300	400	400	500	550
Karnataka	KREDL Estimate	40	40	40	40	40	40
Maharashtra	MEDA Estimate	9	100	125	125	75	75
Orissa		5	10	10	20	20	20
Rajasthan	Corroborated Estimate	100	500	500	700	700	1000
Tamil Nadu	Based on TEDA Estimates	20	100	500	700	700	1000
Total		**518.5**	**1065**	**1575**	**2105**	**2135**	**2735**

CRISIL INFRASTRUCTURE ADVISORY

Biomass Potential & Likely Capacity Addition

Biomass Potential

- **As per Biomass Atlas of India**
  - Estimated biomass power potential is 18601 MW
  - Estimated wasteland power potential is 6239 MW
- **It is possible to generate about 5,000-6,000 MW power from raising dedicated plantations on about 2 million hectare forest and non-forest degraded lands.**
- **It is also highlighted that a comprehensive mapping of biomass resource estimation needs to be carried out in order to estimate the realistic assessment of achievable biomass power potential. We understand the MNRE has already initiated various studies and therefore has taken up the launch of Bioenergy Mission in the 12th plan period.**

Biomass Potential

State	Agro Potential (MWe)	Forest & Wasteland Potential (MWe)
Andhra Pradesh	738.3	
Arunachal Pradesh	9.3	
Assam	278.7	
Bihar	645.9	
Chhattisgarh	245.6	
Goa	26.1	
Gujarat	1226.1	1155.2
Haryana	1375.1	39.5
Himachal Pradesh	142.2	
Jammu & Kashmir	42.7	
Jharkhand	107	
Karnataka	1222.1	
Kerala	864.4	
Madhya Pradesh	1386.2	2060.6
Maharashtra	1969.7	1741.7
Manipur	15.3	
Meghalaya	11.4	
Mizoram	1.16	
Nagaland	10.2	
Orissa	432.8	
Punjab	3177.6	36.8
Rajasthan	1121.9	262.3
Sikkim	2.44	
Tamil Nadu	1163.9	429.4
Tripura	2.96	
Uttar Pradesh	1764.9	514.1
Uttaranchal	88.3	
West Bengal	529.2	
Sub- Total	18601.5	6239.6
Total	24841.1	

MNRE - Bioenergy Mission

Bio energy Mission	Overall Target 2017				
	IPP	Tail End	Off Grid	Co gen	Total
Agro Residue	2100	550	150	325	3125
Plantation	800	150	75	100	1125
Total	2900	700	225	425	4250

State Wise Pipeline		Proportionate Capacity Addition (MW) 12th Plan Period
Bihar	17%	579
Karnataka	15%	511
Andhra Pradesh	13%	443
Gujarat	10%	341
Madhya Pradesh	10%	341
Punjab	9%	307
Rajasthan	9%	307
Haryana	6%	204
Maharashtra	5%	170
Chhattisgarh	4%	136
Tamil Nadu	2%	68

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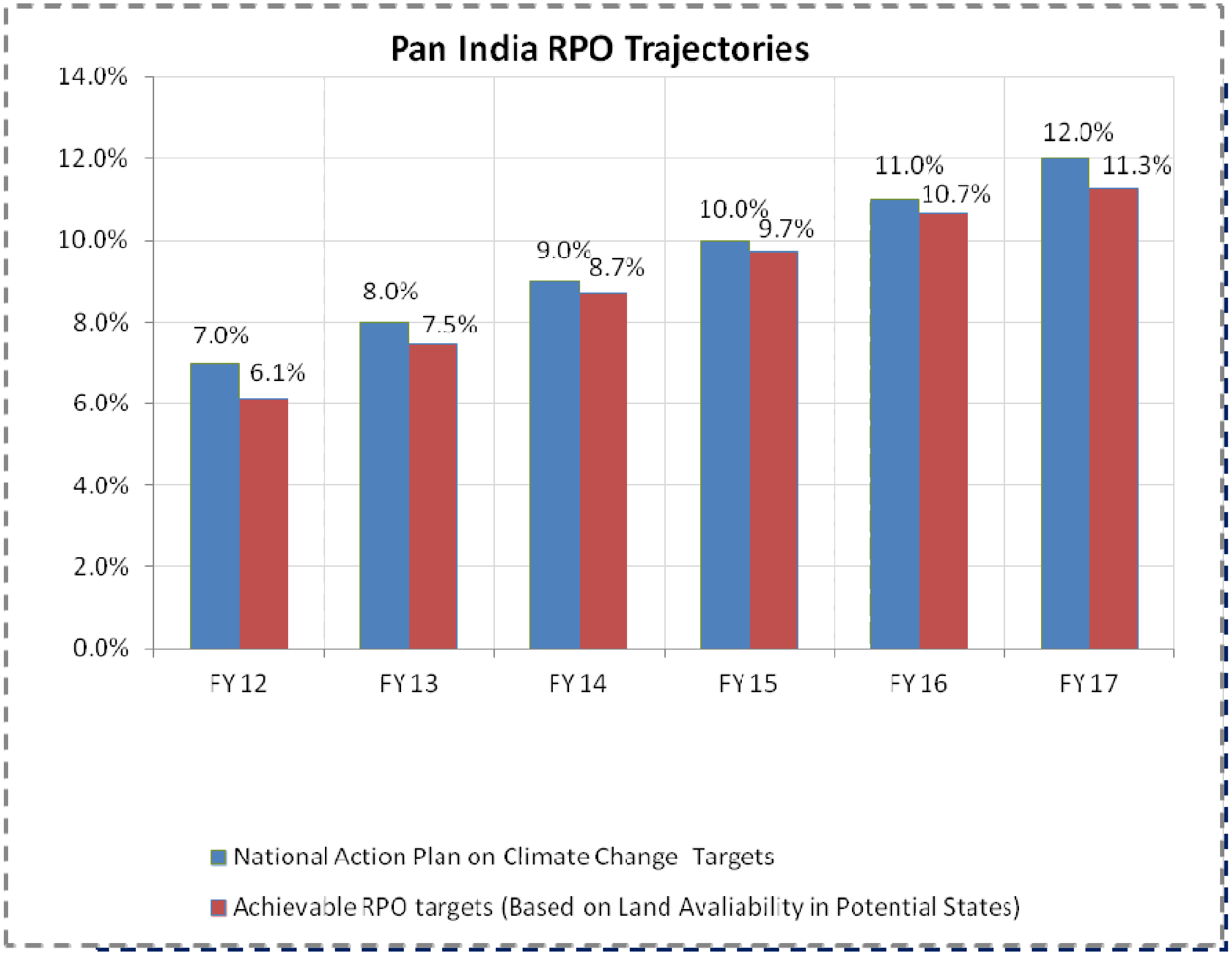
Biomass Likely Capacity Addition (Contd.)

State	CRIS Assessment					
	12th Plan (MW)	FY 13	FY 14	FY 15	FY 16	FY 17
Andhra Pradesh	553	110.50	110.50	110.50	110.50	110.50
Bihar	723	144.50	144.50	144.50	144.50	144.50
Chhattisgarh	170	34.00	34.00	34.00	34.00	34.00
Gujarat	425	85.00	85.00	85.00	85.00	85.00
Haryana	255	51.0	51.0	51.0	51.0	51.0
Karnataka	638	127.50	127.50	127.50	127.50	127.50
Madhya Pradesh	425	85	85	85	85	85
Maharashtra	213	42.5	42.5	42.5	42.5	42.5
Punjab	383	76.5	76.5	76.5	76.5	76.5
Rajasthan	383	76.5	76.5	76.5	76.5	76.5
Tamil Nadu	85	17	17	17	17	17
Total	**4250**	**850**	**850**	**850**	**850**	**850**

Nation Wide Scenario

Nation wide Scenario (12th Plan Period)



CRISIL INFRASTRUCTURE ADVISORY

CRIS Assessment

	FY 13	FY 14	FY 15	FY 16	FY 17
RPO % (inclusive of Solar RPO as well)	7.46%	8.7%	9.7%	10.7%	11.3%
Solar RPO %	0.26%	0.49%	0.75%	0.98%	1.24%
Wind Installed (MW)	22109	27133	31026	35892	39746
Solar Installed (MW)	1584	3159	5264	7399	10134
SHP Installed (MW)	4032	4579	5318	6196	6742
Biomass Installed (MW)	3710	4560	5410	6260	7110
Total RE Installed (MW)	31434	39431	47017	55747	63731
Wind Installed YOY (MW)	4963	5024	3893	4866	3854
Solar Installed YOY (MW)	1065	1575	2105	2135	2735
SHP Installed YOY (MW)	485	547	739	879	545
Biomass Installed YOY (MW)	850	850	850	850	850
Total RE Installed YOY (MW)	7363	7996	7586	8730	7984

CRISIL INFRASTRUCTURE ADVISORY

Impact on Power Purchase Cost

Item	FY 13	FY 14	FY 15	FY 16	FY 17
Total Energy (MUs)	1053341	1138023	1222705	1324812	1435707
RE energy (MUs)	70907	88329	107965	131988	163266
RPO %	**6.7%**	**7.8%**	**8.8%**	**10.0%**	**11.4%**
Increase in RPO	1.1%	1.0%	1.1%	1.1%	1.4%
Impact of inclusion of RE (p/unit)	9.2	11.1	12.6	13.8	14.8
Incremental impact (p/unit)	**1.8**	**1.8**	**1.5**	**1.2**	**1.0**
Time Value of Impact of inclusion of RE (p/unit)*	8.5	9.3	9.6	9.6	9.5
Incremental impact, considering time value (p/unit)	**1.0**	**0.0**	**0.4**	**0.0**	**-0.2**
** Discount rate= 9.35%*					

CRISIL INFRASTRUCTURE ADVISORY

Statewise RPO targets

State	RPO %						
	FY12	FY13	FY14	FY15	FY16	FY17	Max
Tamil Nadu*	14.0%	14.2%	14.4%	14.6%	14.8%	15.0%	-0.5
Karnataka	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	-0.7
Himachal Pradesh	10.01%	11.0% (10.25%)	12.0% (10.25%)	13.0%(10.25%)	14.0%(11.25%)	15.0%(12.25%)	0.4
Gujarat	6.0%	7.2%(7.0%)	8.4%	9.6%	10.8%	13.0%	1.3
Rajasthan	6.0%	7.2% (7.1%)	8.4%	9.6%	10.8%	13.0%	1.0
Maharashtra	7.0%	8.0%	9.0%	10.0%(9.0%)	11.0%(9.0%)	13.0%	1.5
Andhra Pradesh	5.0%	6.0%(5.0%)	7.5%(5.0%)	9.0%(5.0%)	11.0%(5.0%)	13.0%(5.0%)	0.7
Kerala	3.3%	4.5%(3.6%)	5.5%(3.9%)	6.5%(4.2%)	7.5%(4.5%)	9.0%(4.8%)	3.2
Uttar Pradesh	5.0%	6.0%	6.6%	7.4%	8.2%	9.0%	1.0
Chhattisgarh	5.25%	6.0%(5.75%)	6.8%	7.5%	8.3%	9.0%	3.1
Punjab	2.4%	3.7%(2.9%)	5.0%(3.5%)	6.4%(4.0%)	7.7%	9.0%	2.4
Uttrakhand	4.5%	5.8%(5.05%)	6.6%	7.4%	8.2%	9.0%	1.6
Madhya Pradesh	2.5%	4.0%	5.5%	7.0%	8.0%	9.0%	3.2
West Bengal	3.0%	4.0%	5.0%	6.0%	7.5%(7.0%)	9.0%(8.0%)	2.8
Haryana	1.5%	3.0%(2.0%)	4.5%(3.0%)	6.0%	7.5%	9.0%	1.9
Orissa	5.0%	6.2%(5.5%)	6.9%(6.0%)	7.6%(6.5%)	8.3%(7.0%)	9.0%	3.4
Delhi	2.0%	3.4%	4.8%	6.2%	7.6%	9.0%	3.0
Bihar	2.5%	4.0%	5.0%	6.0%	7.5%	9.0%	3.5
Jharkhand	3.0%	4.0%	5.0%	6.0%	7.5%	9.0%	3.6
Jammu &Kashmir	3.0%	5.0%	5.0%	6.0%	7.5%	9.0%	3.5
Assam	2.8%	4.2%	5.6%	7.0%	8.0%	9.0%	2.4
Others	2.0%	3.0%	4.0%	5.5%	7.0%	9.0%	3.3

Resource Rich States (Tamil Nadu to Andhra Pradesh)

Resource Deficient States (Kerala to Others)

* Includes RPO for Captives as well

Statewise RPO targets are inclusive of Solar targets
Solar RPO is assumed as per the National Solar Mission targets

CRISIL INFRASTRUCTURE ADVISORY

Annexure

- Andhra Pradesh
- Tamil Nadu
- Karnataka
- Gujarat
- Rajasthan
- Delhi
- Himachal Pradesh

CRISIL INFRASTRUCTURE ADVISORY

CRISIL Risk and Infrastructure Solutions Limited

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Annexure 1 - Andhra Pradesh

CALCULATION DETAILS

Item	Unit	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	
Total Energy Requirement	MUs	89,032	97,649	106,266	114,884	125,350	136,770	
PPC without RE	Rs./Unit	2.50	2.59	2.68	2.77	2.87	2.97	3.52%
Cost of power purchase, without RE	Rs. Crores	22,258	25,271	28,469	31,861	35,987	40,647	
RPO Level	%	5.0%	6.0%	7.5%	9.0%	11.0%	13.0%	
RPO Level- Solar (inclusive in overall RPO)	%	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	84,580	91,790	98,296	104,544	111,562	118,990	
Renewable Energy Purchase	MUs	4,452	5,859	7,970	10,340	13,789	17,780	
- Non Solar	MUs	4,229	5,371	7,173	9,191	12,222	15,729	
- Solar	MUs	222.6	488.2	797.0	1,148.8	1,566.9	2,051.6	
RE (NonSolar) Tariff	Rs./Unit	3.55	3.61	3.71	3.79	3.86	3.94	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	21,145	23,755	26,334	28,993	32,028	35,363	
Renewable Energy Purchase Costs	Rs. Crores	1,732	2,429	3,416	4,525	6,079	7,869	
Total Power Purchase Costs	Rs. Crores	22,877	26,184	29,750	33,518	38,108	43,233	
Per unit Cost of power	Rs./Unit	2.57	2.68	2.80	2.92	3.04	3.16	
Difference in Power Purchase Cost	Rs./Unit	0.070	0.093	0.121	0.144	0.169	0.189	

CRISIL INFRASTRUCTURE ADVISORY

Annexure 1 - Andhra Pradesh (Contd.)

Impact Analysis

Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
	Increase in RPO Level:		1.0%	1.5%	1.5%	2.0%	2.0%
RPO Level	%	5.0%	6.0%	7.5%	9.0%	11.0%	13.0%
Difference in PPC due to inclusion of RE	Paisa/ unit	7.0	9.3	12.1	14.4	16.9	18.9
Incremental impact on PPC	Paisa/ unit		2.4	2.7	2.4	2.5	2.0

Annexure 2 - Maharashtra

CALCULATION DETAILS								
Item	Unit	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	
Total Energy Requirement	MUs	125,661	133,974	142,287	150,601	160,166	170,339	
PPC without RE	Rs./Unit	2.62	2.75	2.88	3.03	3.17	3.33	4.92%
Cost of power purchase, without RE	Rs. Crores	32,923	36,828	41,038	45,572	50,852	56,742	
RPO Level	%	7.0%	8.0%	9.0%	10.0%	11.0%	13.0%	
RPO Level- Solar (inclusive in overall RPO)	%	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	116,865	123,256	129,482	135,541	142,548	148,195	
Renewable Energy Purchase	MUs	8,796	10,718	12,806	15,060	17,618	22,144	
- Non Solar	MUs	8,482	10,048	11,739	13,554	15,616	19,589	
- Solar	MUs	314.2	669.9	1,067.2	1,506.0	2,002.1	2,555.1	
RE (NonSolar) Tariff	Rs./Unit	3.04	3.10	4.80	4.80	4.80	5.04	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	30,619	33,882	37,344	41,015	45,258	49,366	
Renewable Energy Purchase Costs	Rs. Crores	2,905	3,771	4,992	6,293	7,738	10,206	
Total Power Purchase Costs	Rs. Crores	33,524	37,653	42,336	47,309	52,996	59,572	
Per unit Cost of power	Rs./Unit	2.67	2.81	2.98	3.14	3.31	3.50	
Difference in Power Purchase Cost	Rs./Unit	0.048	0.062	0.091	0.115	0.134	0.166	

Annexure 2 - Maharashtra (Contd.)

Impact Analysis

Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
	Increase in RPO Level:		1.0%	1.0%	1.0%	1.0%	2.0%
RPO Level	%	7.00%	8.00%	9.00%	10.00%	11.00%	13.00%
Difference in PPC due to inclusion of RE	Paisa/ unit	4.8	6.2	9.1	11.5	13.4	16.6
Incremental impact on PPC	Paisa/ unit		1.4	3.0	2.4	1.9	3.2

Annexure 3 - Tamil Nadu

CALCULATION DETAILS								
Item	Unit	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	
Total Energy Requirement	MUs	87,222	96,729	106,235	115,742	126,999	139,350	
PPC without RE	Rs./Unit	3.38	3.55	3.72	3.90	4.10	4.30	4.92%
Cost of power purchase, without RE	Rs. Crores	29,481	34,303	39,528	45,184	52,017	59,885	
RPO Level	%	14.0%	14.2%	14.4%	14.6%	14.8%	15.0%	
RPO Level- Solar (inclusive in overall RPO)	%	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	75,011	82,993	90,937	98,843	108,203	118,448	
Renewable Energy Purchase	MUs	12,211	13,735	15,298	16,898	18,796	20,903	
- Non Solar	MUs	11,993	13,252	14,501	15,741	17,208	18,812	
- Solar	MUs	218.1	483.6	796.8	1,157.4	1,587.5	2,090.3	
RE (NonSolar) Tariff	Rs./Unit	3.75	3.76	3.77	3.79	3.81	3.82	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	25,354	29,432	33,836	38,587	44,319	50,902	
Renewable Energy Purchase Costs	Rs. Crores	4,721	5,479	6,273	7,096	8,050	9,086	
Total Power Purchase Costs	Rs. Crores	30,075	34,911	40,109	45,683	52,368	59,988	
Per unit Cost of power	Rs./Unit	3.45	3.61	3.78	3.95	4.12	4.30	
Difference in Power Purchase Cost	Rs./Unit	0.068	0.063	0.055	0.043	0.028	0.007	

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Annexure 3 - Tamil Nadu (Contd.)

Impact Analysis

Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
	Increase in RPO Level:		0.2%	0.2%	0.2%	0.2%	0.2%
RPO Level	%	**14.0%**	**14.2%**	**14.4%**	**14.6%**	**14.8%**	**15.0%**
Difference in PPC due to inclusion of RE	Paisa/ unit	6.8	6.3	5.5	4.3	2.8	0.7
Incremental impact on PPC	Paisa/ unit		-0.5	-0.8	-1.2	-1.6	-2.0

Annexure 4 - Karnataka

CALCULATION DETAILS

Item	Unit	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	
Total Energy Requirement	MUs	53,540	58,831	64,122	69,414	75,425	81,957	
PPC without RE	Rs./Unit	2.66	2.84	3.02	3.22	3.43	3.66	6.59%
Cost of power purchase, without RE	Rs. Crores	14,242	16,680	19,377	22,358	25,894	29,989	
RPO Level	%	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	
RPO Level- Solar (inclusive in overall RPO)	%	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	48,186	52,360	56,428	60,390	64,865	69,663	
Renewable Energy Purchase	MUs	5,354	6,471	7,695	9,024	10,559	12,294	
- Non Solar	MUs	5,220	6,177	7,214	8,330	9,617	11,064	
- Solar	MUs	133.9	294.2	480.9	694.1	942.8	1,229.4	
RE (NonSolar) Tariff	Rs./Unit	3.60	3.98	4.12	4.12	4.20	4.20	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	12,817	14,845	17,052	19,451	22,269	25,491	
Renewable Energy Purchase Costs	Rs. Crores	2,017	2,569	3,189	3,858	4,627	5,476	
Total Power Purchase Costs	Rs. Crores	14,834	17,414	20,241	23,309	26,895	30,967	
Per unit Cost of power	Rs./Unit	2.77	2.96	3.16	3.36	3.57	3.78	
Difference in Power Purchase Cost	Rs./Unit	0.111	0.125	0.135	0.137	0.133	0.119	

Annexure 4 - Karnataka (Contd.)

Impact Analysis

Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
RPO Level	Increase in RPO Level:		1.0%	1.0%	1.0%	1.0%	1.0%
	%	**10.0%**	**11.0%**	**12.0%**	**13.0%**	**14.0%**	**15.0%**
Difference in PPC due to inclusion of RE	Paisa/ unit	11.1	12.5	13.5	13.7	13.3	11.9
Incremental impact on PPC	Paisa/ unit		1.4	1.0	0.2	-0.4	-1.4

Annexure 5 - Gujarat

CALCULATION DETAILS

Item	Unit	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	
Total Energy Requirement	MUs	85,445	92,173	98,900	105,628	113,799	122,603	
PPC without RE	Rs./Unit	2.98	3.11	3.25	3.39	3.54	3.70	4.43%
Cost of power purchase, without RE	Rs. Crores	25,463	28,685	32,143	35,851	40,337	45,384	
RPO Level	%	6.0%	7.2%	8.4%	9.6%	10.8%	13.0%	
RPO Level- Solar (inclusive in overall RPO)	%	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	80,318	85,536	90,593	95,488	101,509	106,665	
Renewable Energy Purchase	MUs	5,127	6,636	8,308	10,140	12,290	15,938	
- Non Solar	MUs	4,913	6,176	7,566	9,084	10,868	14,099	
- Solar	MUs	213.6	460.9	741.8	1,056.3	1,422.5	1,839.0	
RE (NonSolar) Tariff	Rs./Unit	3.56	3.91	3.91	3.91	3.91	3.91	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	23,935	26,620	29,443	32,410	35,981	39,484	
Renewable Energy Purchase Costs	Rs. Crores	1,970	2,728	3,562	4,464	5,498	7,112	
Total Power Purchase Costs	Rs. Crores	25,905	29,348	33,005	36,873	41,478	46,596	
Per unit Cost of power	Rs./Unit	3.03	3.18	3.34	3.49	3.64	3.80	
Difference in Power Purchase Cost	Rs./Unit	0.052	0.072	0.087	0.097	0.100	0.099	

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Annexure 5 - Gujarat (Contd.)

Impact Analysis

Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
	Increase in RPO Level:		1.2%	1.2%	1.2%	1.2%	2.2%
RPO Level	%	**6.0%**	**7.2%**	**8.4%**	**9.6%**	**10.8%**	**13.0%**
Difference in PPC due to inclusion of RE	Paisa/ unit	5.2	7.2	8.7	9.7	10.0	9.9
Incremental impact on PPC	Paisa/ unit		2.0	1.5	1.0	0.4	-0.1

Annexure 6 - Rajasthan

CALCULATION DETAILS								
Item	Unit	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	
Total Energy Requirement	MUs	48,916	52,686	56,456	60,227	64,669	69,438	
PPC without RE	Rs./Unit	2.60	2.76	2.92	3.10	3.28	3.48	6.00%
Cost of power purchase, without RE	Rs. Crores	12,718	14,520	16,493	18,650	21,227	24,160	
RPO Level	%	6.0%	7.2%	8.4%	9.6%	10.8%	13.0%	
RPO Level- Solar (inclusive in overall RPO)	%	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	45,981	48,893	51,714	54,445	57,684	60,411	
Renewable Energy Purchase	MUs	2,935	3,793	4,742	5,782	6,984	9,027	
- Non Solar	MUs	2,813	3,530	4,319	5,179	6,176	7,985	
- Solar	MUs	122.3	263.4	423.4	602.3	808.4	1,041.6	
RE (NonSolar) Tariff	Rs./Unit	4.68	4.69	4.71	4.73	4.75	4.78	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	11,955	13,475	15,108	16,860	18,935	21,019	
Renewable Energy Purchase Costs	Rs. Crores	1,442	1,930	2,467	3,049	3,712	4,772	
Total Power Purchase Costs	Rs. Crores	13,397	15,405	17,574	19,909	22,646	25,792	
Per unit Cost of power	Rs./Unit	2.74	2.92	3.11	3.31	3.50	3.71	
Difference in Power Purchase Cost	Rs./Unit	0.139	0.168	0.191	0.209	0.219	0.235	

Annexure 7 - Rajasthan (Contd.)

Impact Analysis

Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
	Increase in RPO Level:		1.2%	1.2%	1.2%	1.2%	2.2%
RPO Level	%	**6.00%**	**7.20%**	**8.40%**	**9.60%**	**10.80%**	**13.0%**
Difference in PPC due to inclusion of RE	Paisa/ unit	13.9	16.8	19.1	20.9	21.9	23.5
Incremental impact on PPC	Paisa/ unit		2.9	2.4	1.7	1.0	1.5

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Annexure 8 - Delhi

CALCULATION DETAILS								
Item	Unit	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	
Total Energy Requirement	MUs	36,293	39,587	42,881	46,174	49,988	54,116	
PPC without RE	Rs./Unit	2.62	2.79	2.97	3.16	3.37	3.59	6.48%
Cost of power purchase, without RE	Rs. Crores	9,509	11,044	12,737	14,604	16,834	19,405	
RPO Level	%	2.0%	3.4%	4.8%	6.2%	7.6%	9.0%	
RPO Level- Solar (inclusive in overall RPO)	%	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	35,567	38,241	40,822	43,312	46,189	49,246	
Renewable Energy Purchase	MUs	726	1,346	2,058	2,863	3,799	4,870	
- Non Solar	MUs	635	1,148	1,737	2,401	3,174	4,059	
- Solar	MUs	90.7	197.9	321.6	461.7	624.8	811.7	
RE (NonSolar) Tariff	Rs./Unit	4.53	4.66	4.80	4.94	5.09	5.25	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	9,319	10,668	12,126	13,698	15,555	17,658	
Renewable Energy Purchase Costs	Rs. Crores	382	736	1,146	1,611	2,154	2,776	
Total Power Purchase Costs	Rs. Crores	9,701	11,404	13,272	15,310	17,709	20,434	
Per unit Cost of power	Rs./Unit	2.67	2.88	3.10	3.32	3.54	3.78	
Difference in Power Purchase Cost	Rs./Unit	0.053	0.091	0.125	0.153	0.175	0.190	

Annexure 8 - Delhi (Contd.)

Impact Analysis

Item`	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
	Increase in RPO Level:		1.4%	1.4%	1.4%	1.4%	1.4%
RPO Level	%	2.0%	3.4%	4.8%	6.2%	7.6%	9.0%
Difference in PPC due to inclusion of RE	Paisa/ unit	5.3	9.1	12.5	15.3	17.5	19.0
Incremental impact on PPC	Paisa/ unit		3.8	3.4	2.8	2.2	1.5

Annexure 9 - Himachal Pradesh

CALCULATION DETAILS

Item	Unit	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	
Total Energy Requirement	MUs	9,504	10,230	10,957	11,683	12,539	13,457	
PPC without RE	Rs./Unit	2.34	2.48	2.62	2.77	2.93	3.10	5.80%
Cost of power purchase, without RE	Rs. Crores	2,224	2,533	2,870	3,238	3,677	4,175	
RPO Level	%	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	
RPO Level- Solar (inclusive in overall RPO)	%	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	8,553	9,105	9,642	10,164	10,783	11,438	
Renewable Energy Purchase	MUs	951	1,125	1,315	1,519	1,755	2,018	
- Non Solar	MUs	928	1,074	1,233	1,402	1,599	1,817	
- Solar	MUs	23.8	51.2	82.2	116.8	156.7	201.8	
RE (NonSolar) Tariff	Rs./Unit	2.95	2.95	2.95	2.95	2.95	2.95	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	2,001	2,254	2,526	2,817	3,162	3,549	
Renewable Energy Purchase Costs	Rs. Crores	298	371	450	534	628	730	
Total Power Purchase Costs	Rs. Crores	2,300	2,625	2,975	3,351	3,790	4,279	
Per unit Cost of power	Rs./Unit	2.42	2.57	2.72	2.87	3.02	3.18	
Difference in Power Purchase Cost	Rs./Unit	0.080	0.090	0.096	0.096	0.090	0.077	

Annexure 9 - Himachal Pradesh (Contd.)

Impact Analysis

Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
	Increase in RPO Level:		1.0%	1.0%	1.0%	1.0%	1.0%
RPO Level	%	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%
Difference in PPC due to inclusion of RE	Paisa/ unit	8.0	9.0	9.6	9.6	9.0	7.7
Incremental impact on PPC	Paisa/ unit		1.1	0.6	0.0	-0.6	-1.3

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[illegible]

03 Feb, 2012

28th FOR Meeting at Bodhagaya, Bihar

Rahul Tongia, Ph.D.

Principal Research Scientist, CSTEP

Technical Advisor, Smart Grid Task Force, Govt. of India

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Topics for Discussion

- Overview of Smart Grids
- Indian Status
- Drivers and business case
- Cost-benefit Analysis
- Pilot projects
- Regulatory Questions and needs

CSTEP/Personal Background

- Leading not-for-profit research institution
  - Interdisciplinary
  - Founded by Dr. V. S. Arunachalam
- Am Professor at Carnegie Mellon University (on leave)
  - Was on Tech. Advisory Board at leading US utility Smart Grid project
- We have been active in SG in India, e.g.,
  - Min. of Power IT Task Force Report Update (2008)
  - Key advisors to SG Task Force, SG Forum
  - Work *bottom-up* with a number of utilities
    - Roadmaps, IT planning, CBA, etc.

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No single Definition of Smart Grids

- "A **smart grid** delivers electricity from suppliers to consumers using digital technology to save energy, reduce cost and increase reliability."

-- Wikipedia

*(More formal definitions are **far** more complex)*

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Stylized Definition of Smart Grids

- A Smart Grid is a Transformation of the power system based on harnessing digital communications and control
- Utilities will be able to:
  - Know what power is going where, and when
  - Charge "appropriately" for it
  - Control the use of (if not flow) of power

- Although **Advanced Metering Infrastructure (AMI)** is considered to be the **basic building block** for a **Smart Grid,** the Smart Grid is not just **AMI!**
  - The **Smart Grid** is a much broader set of technologies and solutions

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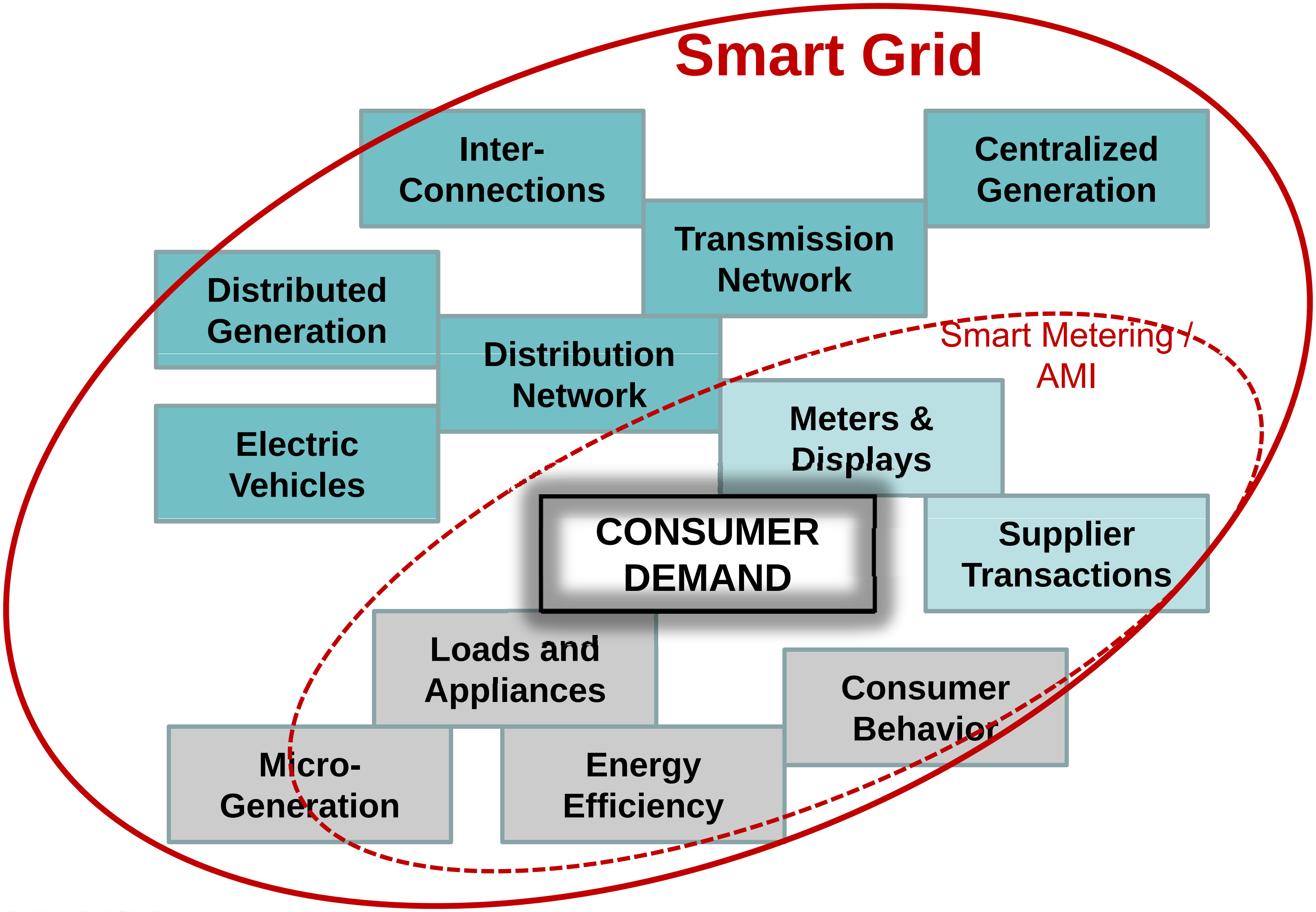
Smart Grid
Inter-Connections
Centralized Generation
Transmission Network
Distributed Generation
Distribution Network
Smart Metering / AMI
Electric Vehicles
Meters & Displays
CONSUMER DEMAND
Supplier Transactions
Loads and Appliances
Consumer Behavior
Micro-Generation
Energy Efficiency

Broad Aspects and Drivers for Smart Grids

- Generation
  - Distributed
  - Renewable
- Transmission
  - Improve transfer capacity
  - Reliability (avoid blackouts)
- Distribution
  - {Includes consumption}
  - Area of most effort
  - One aspect is “smart metering”
  - Others include Demand Response aka Load Control
    - Dynamic instead of mere DSM

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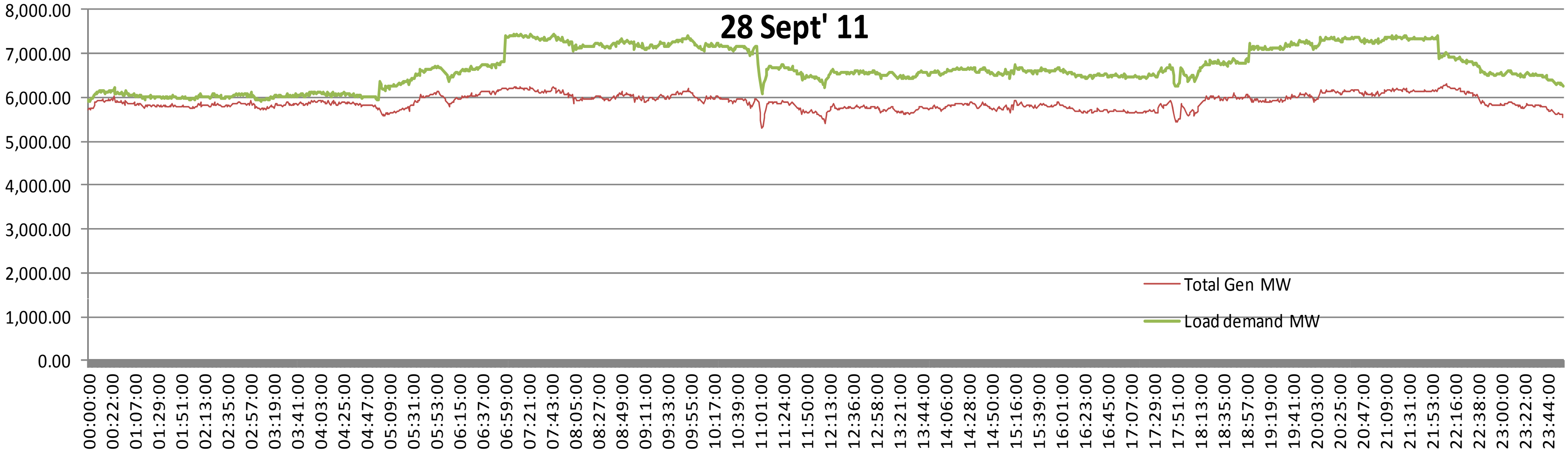
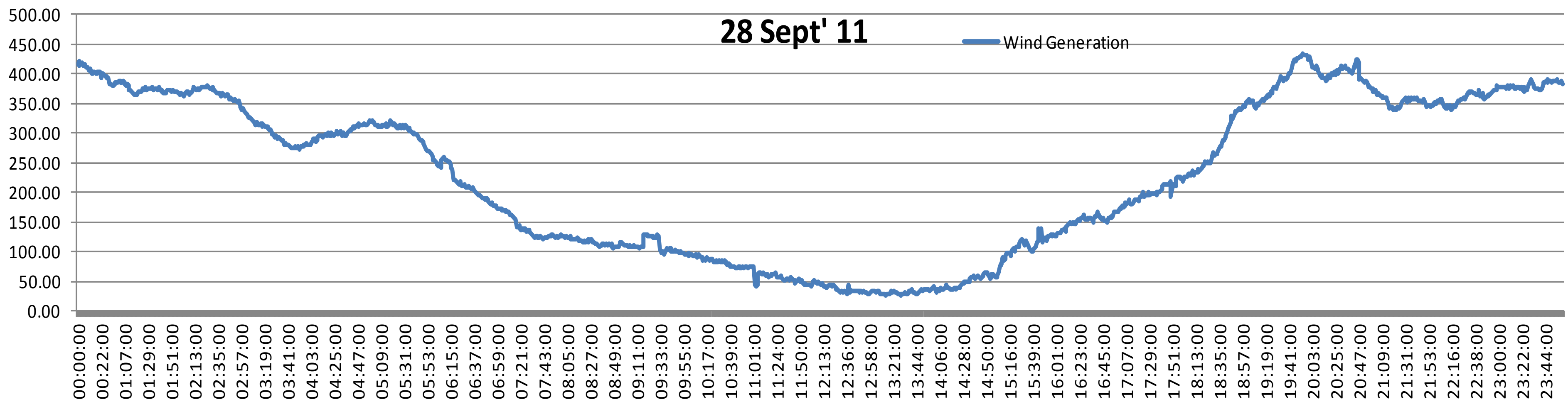
Variation of Wind Power Generation with Load Demand - Karnataka





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Source: KPTCL

Drivers for Smart Grids

- **US and Other Developed Countries**
  - Meter reading
  - Grid modernization
  - Robustness
  - Saving $$
    - Deregulation exposed a lot of costs
      - Some consumers saw 20-40% increase in tariffs
    - Needs Time of Use (ToU) if not Real Time Pricing (RTP)

- **Indian (Developing Country)**
  - Power system has challenges
    - Loses Rs. 1+/kWh on average
    - Supply << Demand
      - 20+% shortfall
  - Growth is a big need
  - Theft is a major concern
    - Large segment of load is unmetered (agriculture)
  - Reforms ongoing
    - May allow new operating models

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Future (or even Subtle) Drivers

- US and Others
  - Carbon and green
  - Bi-directional power
    - (Plug in) Hybrid vehicles
  - New services
    - Home automation
    - Home monitoring
    - Green Power
- India
  - Remove the "human element" in operations
  - The peak is NOT industrial
  - Smart peak management
    - No more load shedding
    - Even in emergencies can allow smart control
  - LEAPFROG

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What Smart Grids really mean

- *Cost Implications**

↑ ?	1. More choices
	▪ Includes renewables
↑ ↑	2. Better quality and service
↑ ↑	3. Greater resiliency / robustness
↓ ↓	4. Increased efficiency and asset utilization

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Why we NEED Smart Grids

- Cost of supply is only increasing
- Ancillary Services (non-kWh markets/contracts) are lacking in India
- Availability of supply is limited
  - Load shedding is expensive to consumers
- Peak demand is growing faster than baseload
  - Any proposed "peak tariff" for supply may end up (perhaps) Rs. 7-8/unit [TBD]
  - Blending 20% such "peak" power with other power would raise average costs by maybe 50%!

Fundamental Qs for the Regulator

- Is a Smart Grid worthwhile?
  - Cost Benefit Analysis
- Who should pay for it?
  - High capital costs
- What changes are needed in pricing models?
  - Variable if not Dynamic pricing
  - Need to reflect the peak *marginal* cost of power
    - BULK supply, not just retail
- To what extent must the solutions be deployed? Can the utility optimize based only on
  - Geography
  - Consumer, etc.? [80:20 rule]

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Indian Examples of Functionalities

- Loss reduction
  - Requires precise and full metering
  - 15 minute or 30 minute or even hourly readings can help give visibility for operations
- Ending load shedding
  - Only two options
    - Buy more (peak) power
    - Reduce Demand
    - (Third "Option" is to load shed!)

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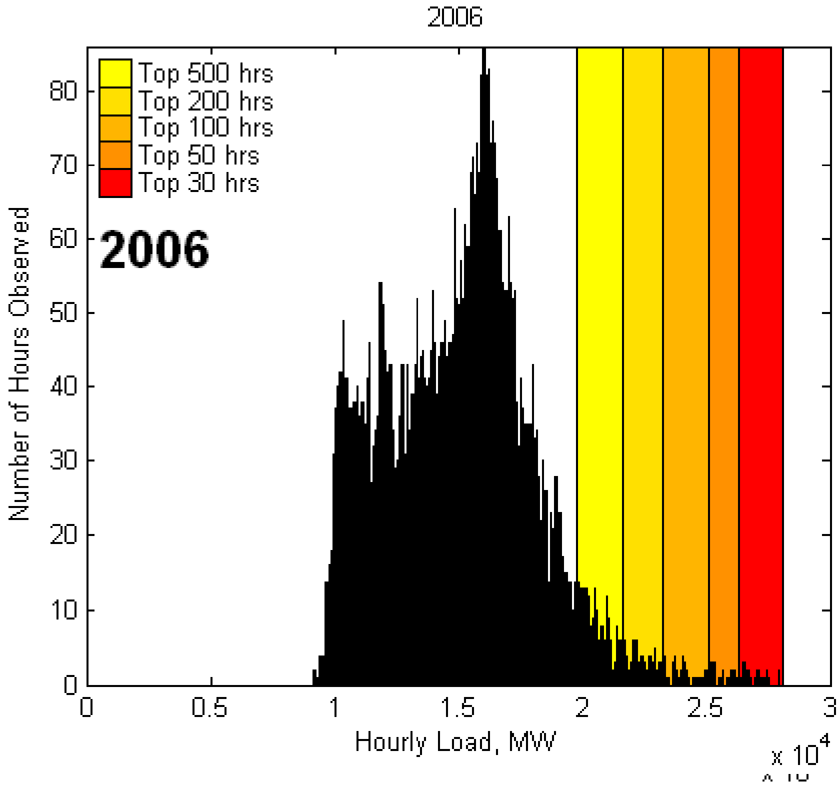
Drivers for Smart Grids

- Rhetorical Q: if developed nations don't have high AT&C losses, and no load shedding, why do they need a smart grid?
- A smart grid is about more than the above
  - Labor costs are an issue in the West
  - Renewables and electric vehicles are high on the agenda in the west, esp. Europe
- The regulator may not mandate smart grids
  - May only require smart meters
  - May also require ToU tariffs or renewable integration
    - This de facto requires some level of a smart grid
- Many nations have put in Smart Grid/Smart Meter mandates (legislation), e.g., EISA (2007) in USA
  - India does not yet have any legislative / policy support for smart grids

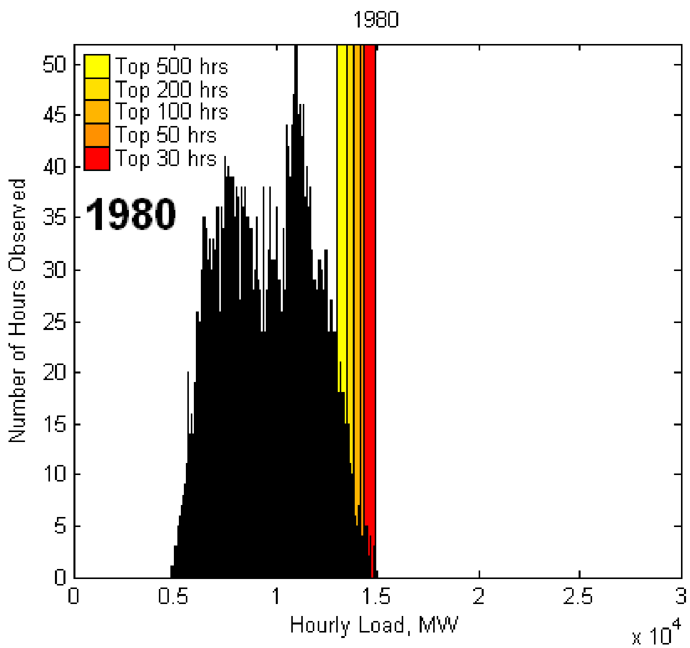
Peak is growing faster than average

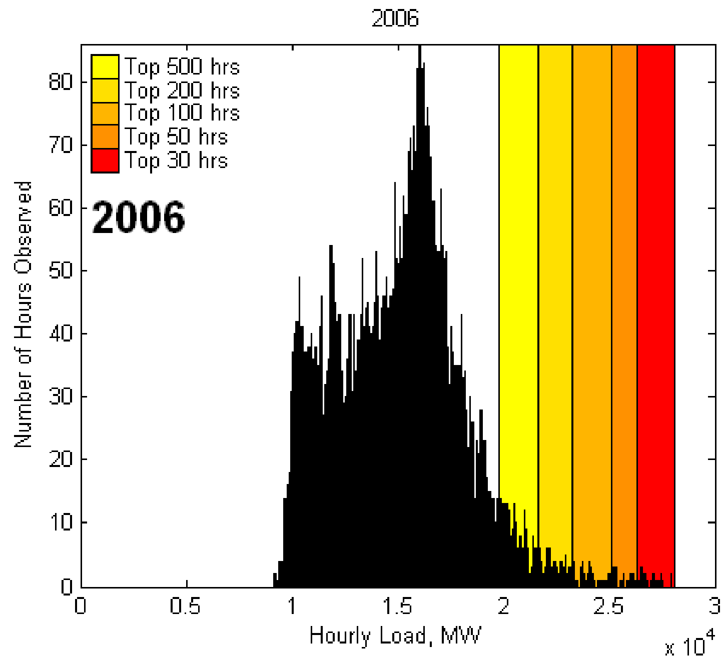
(Independent System Operator-New England [ISO-NE] Example)



[Source: Kathleen Spees, CMU/CSTEP]

Peak Load in ISO-NE Change Between 1980 and 2006





[Source: Kathleen Spees, CMU/CSTEP]

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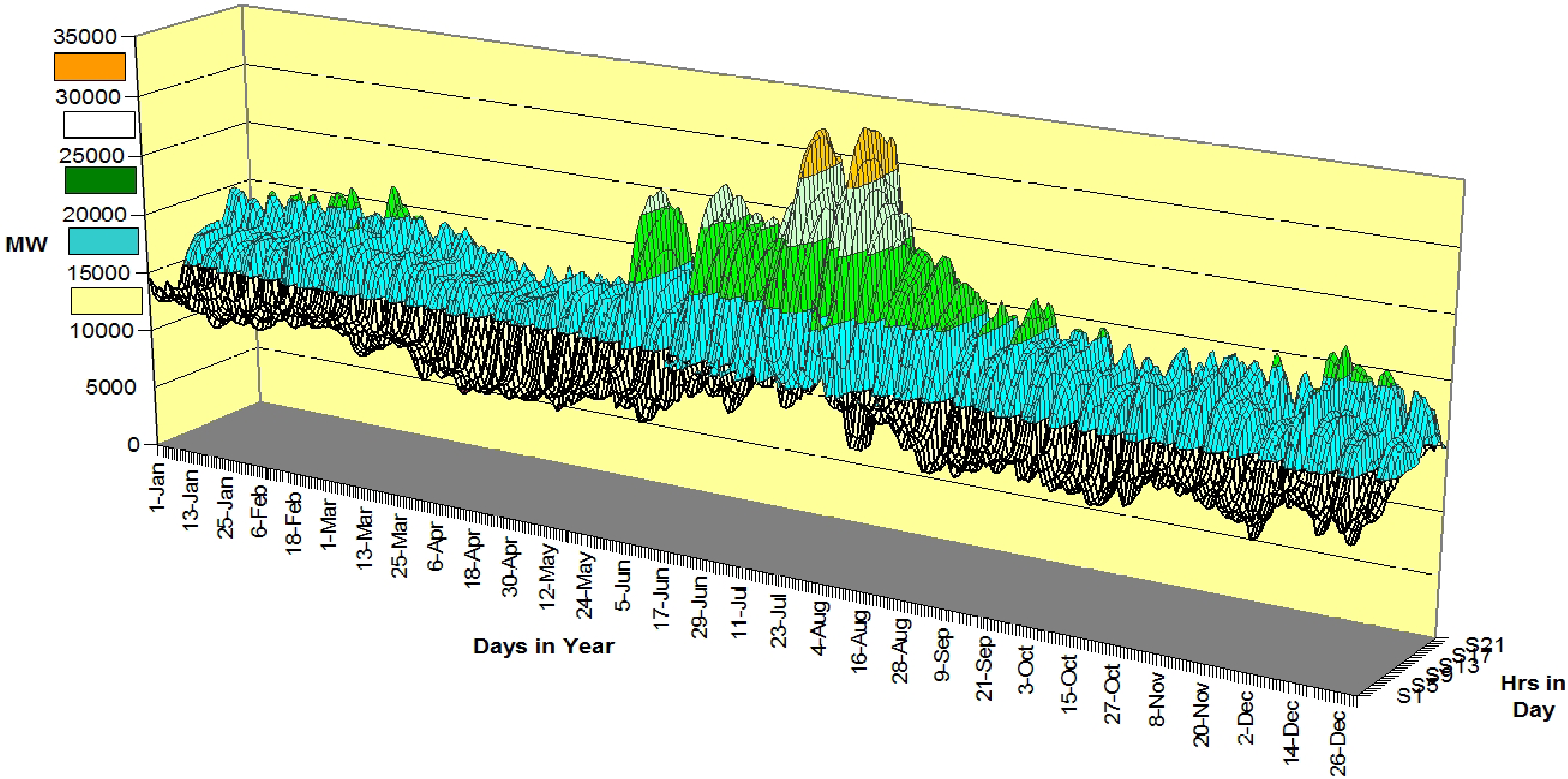
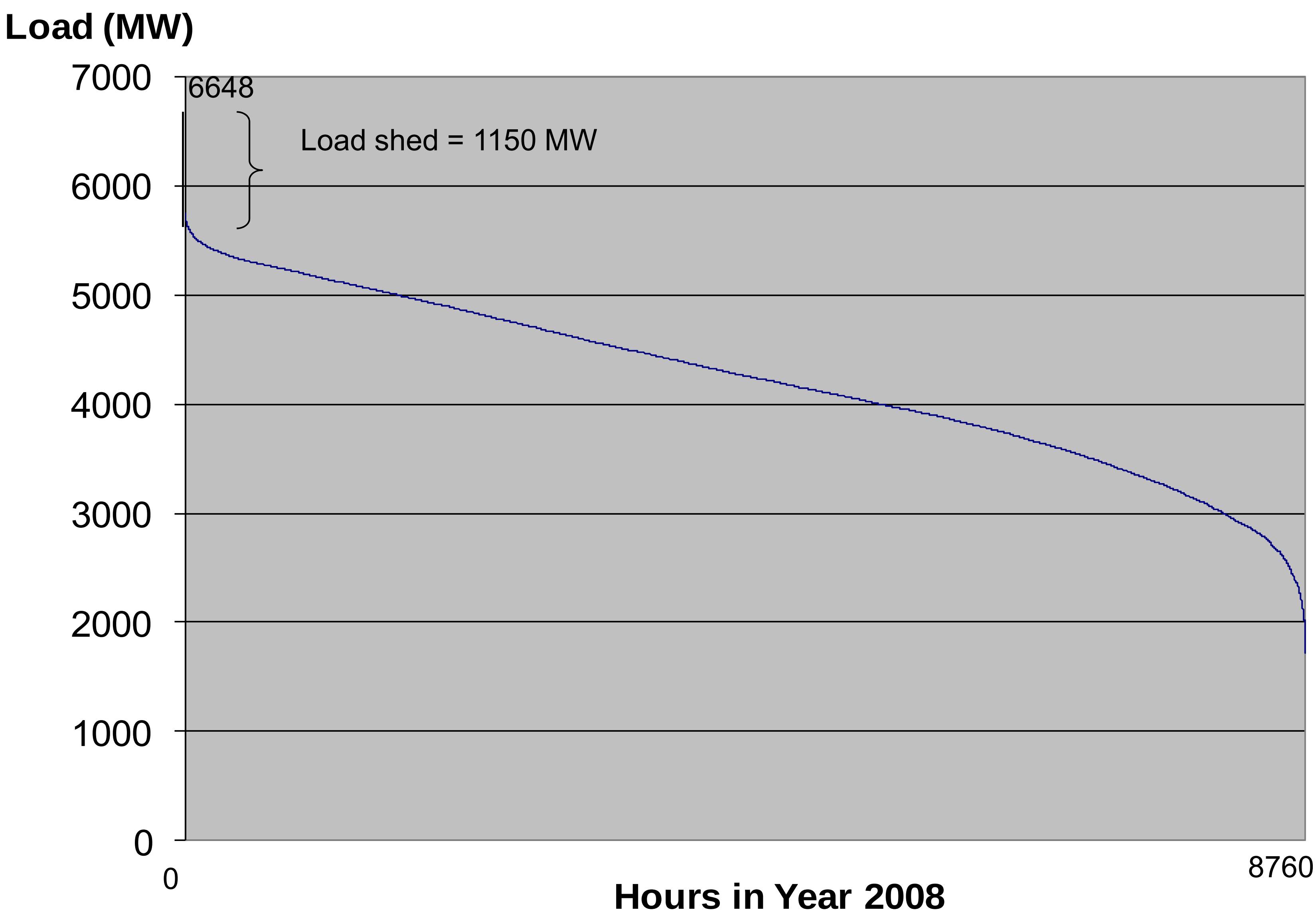
Variability in Demand (NY)



Source: Walawalkar et.al 2007

Load Duration Curve - Karnataka



What is the Value of one kWh AVOIDED?

- It could be from rooftop PV or smart grid or anything…
- Today's system for both CONSUMERS and UTILITY are based on average cost accounting
  - Ignoring cross-subsidies even
- What we want is the marginal cost
  - "Costly power" = UI, Power Exchange, IPPs, Diesel, etc.
- The answer depends on when, where, etc.

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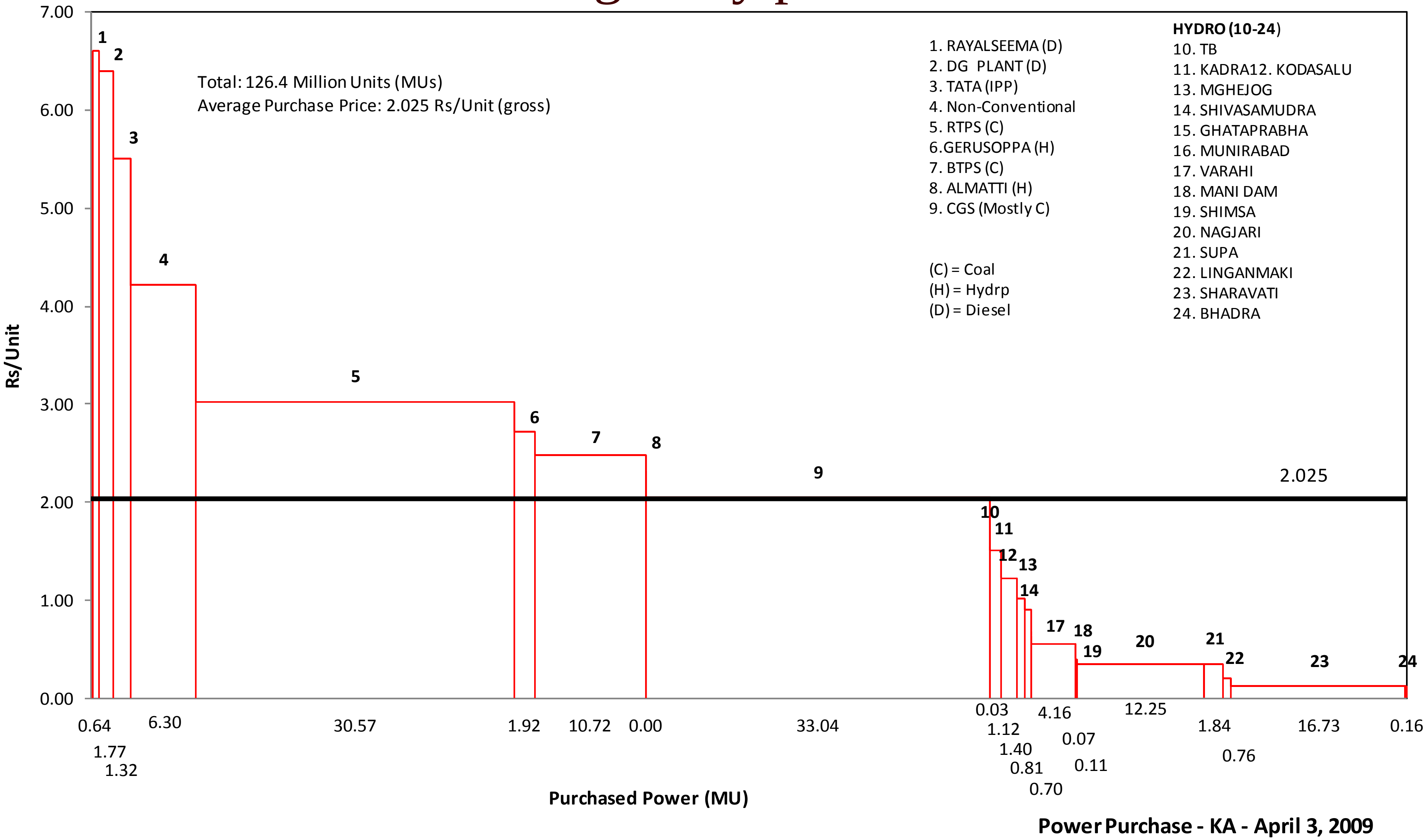
KN single day purchases



Buying Peaking Power

- Peak power is always more expensive than the average
  - Plants operate at only 500 or 1000 hours per year
  - Ignores 15% target spinning reserves, today articulated as 5% by GoI
- Blending such peak power today is what the West does
  - Raises the costs for ALL users for ALL kWh
  - KN example – Raises purchase cost for utilities by Rs. 1/kWh!
- Alternative – peaking tariff – let those who contribute to the peak pay for it
  - Requires appropriate metering

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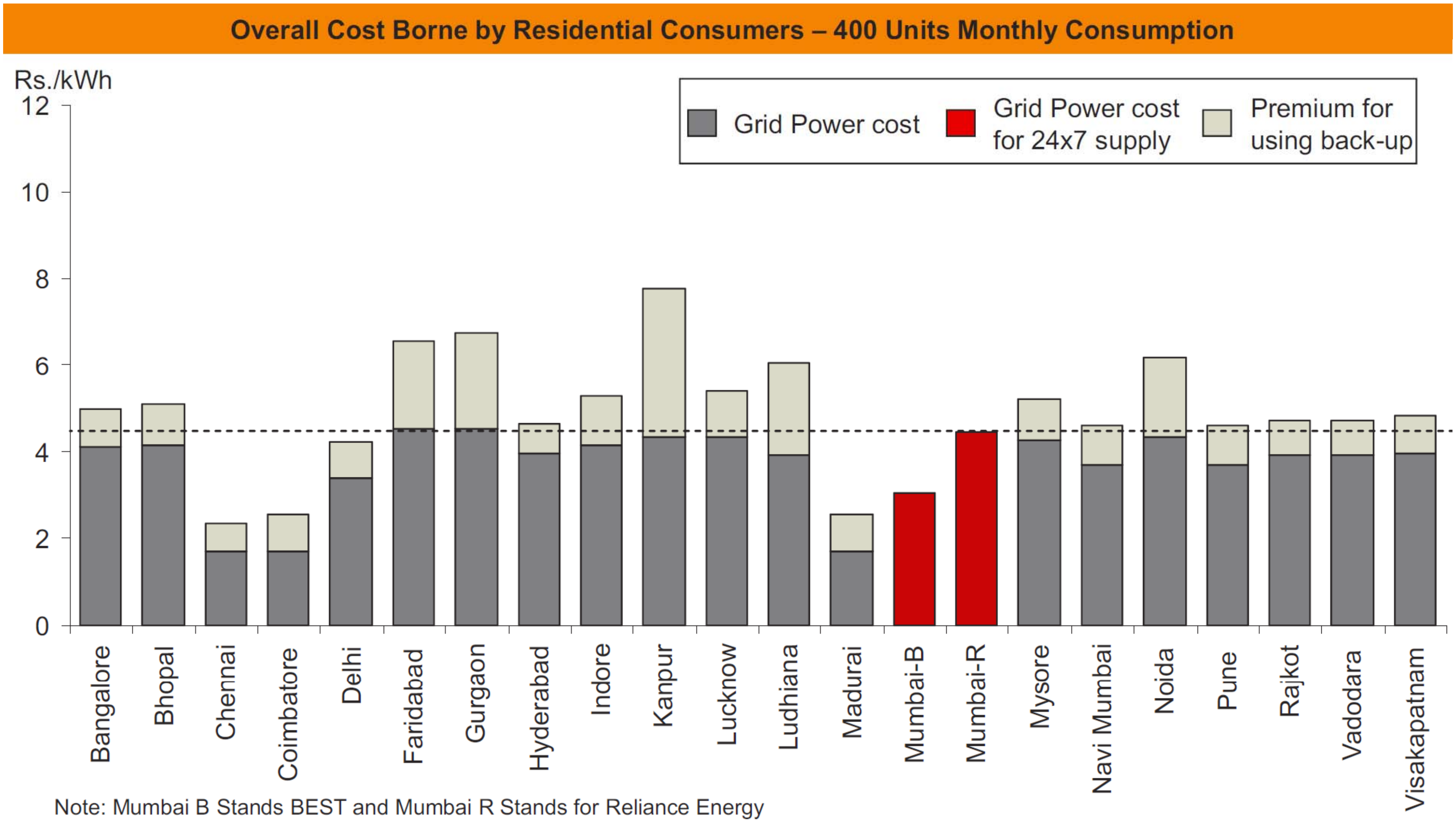

Note: Mumbai B Stands BEST and Mumbai R Stands for Reliance Energy

Source: Wartsila Report (2009): Real Cost of Power

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A Smart Grid needs Smart Tariffs

- Short run: Pilot
- Long run: full-scale deployment
- Limited off-take for ToU (voluntary, bulk consumers)
  - Differential appears too low to be attractive
- Tariff Options
  - Time of Use/Time of Day
    - Seasonal adjustments
  - Real-time
    - Likely to be complex
  - Can allow selected RTP signaling like critical peak pricing (CPP) – rare conditions
- Can a utility undertake tariff innovations in a selected area or for selected consumers?

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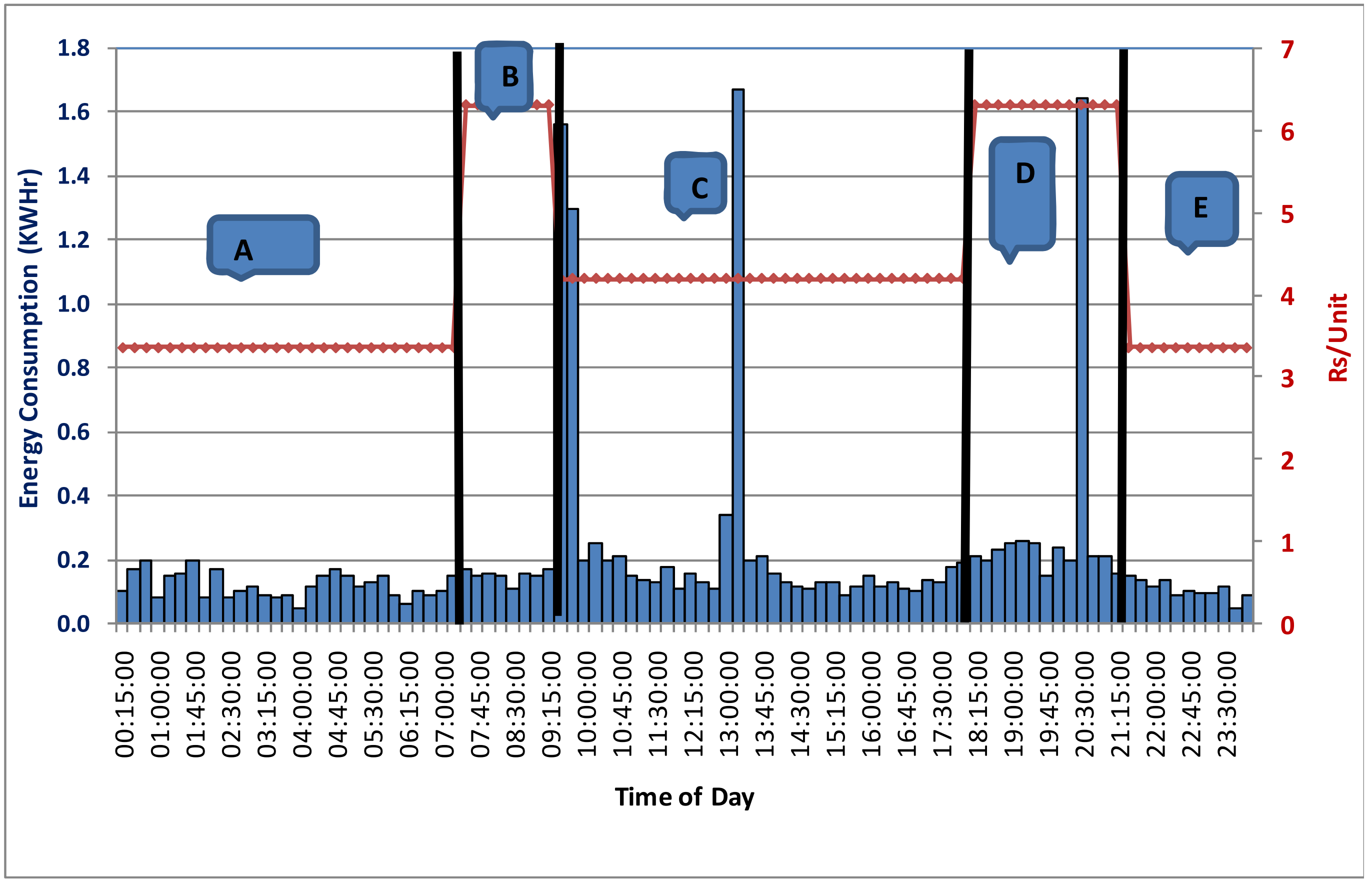
Example for ToU tariff calculations

- Need load profile of appropriate granularity
- Need grid conditions to determine *system* peak and off-peak times
- Base assumptions
  - Utility should be revenue neutral
- Will show this for one consumer example
- In theory, do this for all consumers per category, and then come up with a tariff plan
  - Too computationally challenging (and requires data = infrastructure needed)
  - Can statistically sample a few hundred users

One Methodology for determining differential tariff

- The Total Energy consumed can be recorded in 15 minute intervals (say) over the 24 hour period using digital energy meter and can be represented as follows:



- Based on the ToU Tariff structure, the 24 hour period can be divided into 5 intervals (as - A, B, C, D & E), which are, respectively, early morning off-peak, morning-peak, daytime, evening-peak, night off-peak.
- A and E could be chosen as identical if desired, and B and D could also be priced at the same level. The total cost of energy in one day, with ToU pricing, is given by the following equation:

$$T_A*E_A+T_B*E_B+T_C*E_C+T_D*E_D+T_E*E_E=\textit{Total Cost with ToU Tariff} \quad \ldots\ldots(1)$$

Where, To = normal (Flat) tariff,

TA = TE =To*x is the off peak Tariff, with x < 1

TB = TD =To*y is the Peak Tariff, with y > 1

Tc = is the Normal/Shoulder Tariff, and could be set equal to 'To' if desired

EA to EE are the energy consumed in A to E intervals, respectively

- In order to ensure consumer interest, there should not be any profit to the utility as such and the following equation is to be satisfied (at a aggregate utility level):

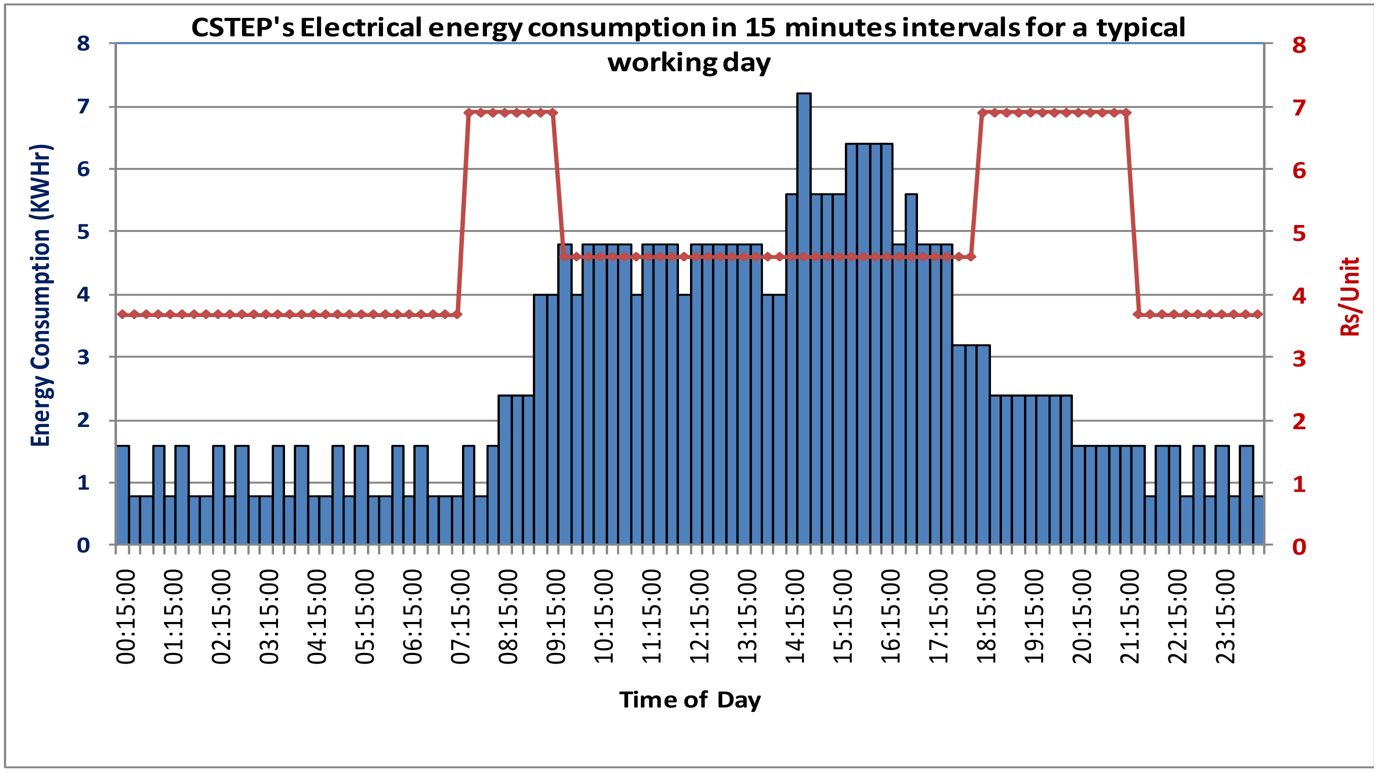
$$\sum_{i=1}^{n}\{\text{Total Price with Flat Tariff} - \text{Total Price with Differential Tariff}\} = 0; \quad \ldots\ldots(2)$$

Where, n = number of consumers

- Once the timings for different blocks- A,B,C,D & E are defined from system load duration curve (Regional or ESCOM level), one can select a value of Peak Tariff multiplying factor (x) and the corresponding value of Off-Peak multiplying factor(y) can be obtained using equation (2) which will make net profit to utility as zero.
- In theory, one could do the calculation and have x & y values for each consumer, but that is complicated.
- Therefore, a consumer group (Industrial, commercial or residential) can be considered and based on the total load of the group, differential tariff can be designed
- The value of the proposed methodology is that it gives multiplying factors and thus is valid for each and every consumer within the group regardless of their energy consumption slab. However, there will be some losers and some winners among consumers based on their Peak and Off-Peak coincidence.
- The peak multiplier "x" can be chosen as to be reasonable, e.g., 2x of today's tariff.
- *One additional constraint that can be added is that the off-peak consumption can have a floor such that it will not go below the marginal cost to the utility (except for consumers with already subsidized tariffs based on their low consumption).*

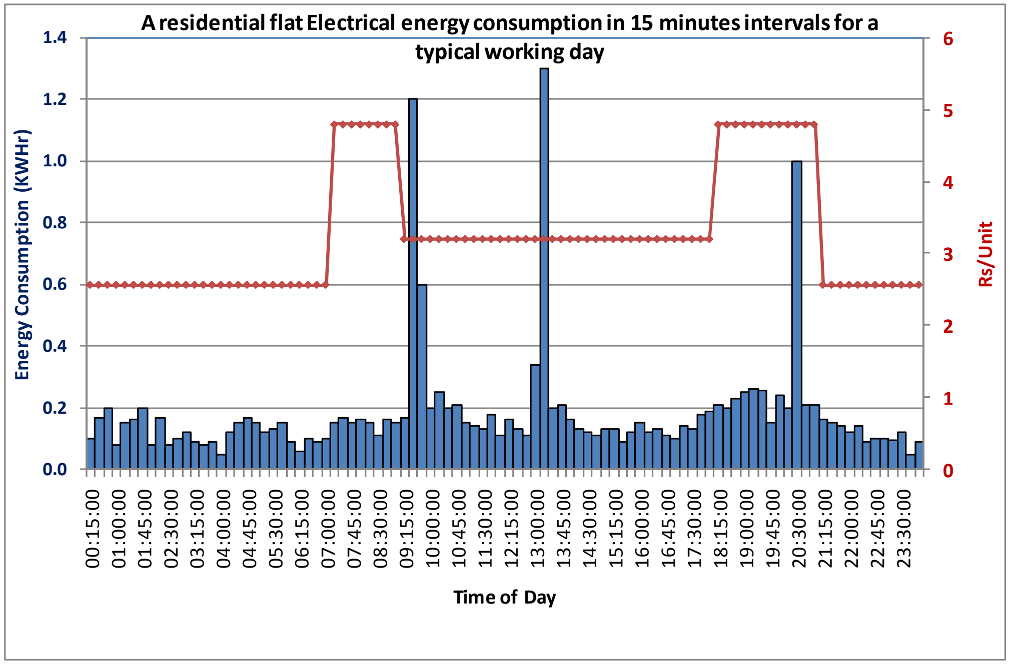
Case Example:

- The following graph shows the actual energy consumption at CSTEP's office, measured at 15 minute intervals, on 7 Oct'10 which is a working day. Also the assumed differential tariff structure is shown on the secondary axis.



ToU Example (Cont.)

- Assuming, peak tariff is 150% of base tariff (i.e. x=1.5) for the time interval 7AM to 9AM and 6PM to 9PM and off-peak tariff is 80% of the base tariff (y=0.8) between 9 PM to 7 AM, it is observed that the total cost of energy consumed for the day is ***increased by 4.47%.***
- However, if "x" is chosen as 1.5, we get y= 0.54 from equation(2) in order to get net profit/loss as zero. But we suggest leaving peak vs. off-peak mostly fixed, i.e., determined by the grid overall.
- Similarly, for a residential flat energy consumption in 15 minute interval is shown in figure bellow:



With the similar differential tariff structure as discussed in previous case, there is an ***increase in total cost to the consumer by 7.79%.***

However, it can be worked out by taking all consumer of same category (tariff-wise) to make net profit to utility as zero, using the proposed methodology.

Hard Regulatory/Policy Questions

- Business case
  - If it made sense, wouldn't utilities already do it?
  - The "numbers" depend on many unknowns (Time horizons, Consumer responsiveness, Future tariffs and costs, Discount rates, etc.)
- Incentives to participate
  - Utility
    - If they are on a costs-plus regulated world, why do they care?
    - Global experience has been capital-centric
  - Consumer
    - Unless I am paid to modify my behaviour, why should I change?
  - ToU or even real time pricing
    - Need much more than voluntary, small differentials

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Regulatory/Policy Qs (cont.)

- There are many other challenges in policy, e.g.,
  - Transfer of social welfare – even if just a few people participate, EVERYONE can benefit
  - There will be some winners and some losers – now what?
  - How much should the schemes be mandatory vs. voluntary; opt-in vs. opt-out?
- Privacy and Security
  - At the very least, the utility will know if a consumer is home or not

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Role of the Regulator

- Balance the needs of suppliers with consumers
- Assumption: Utility is to make a regulated (stipulated) return at best, assuming performance targets (e.g., AT&C improvements)
  - Any increase in tariffs (peak) must be balanced with a commensurate decrease (off-peak)
  - QUESTION: WHAT ABOUT TRANSACTION COSTS?
- There are two types of tariffs – wholesale (utility buys) and retail (consumer pays)
  - It is very problematic to allow one to be market while the other is purely regulated (e.g., California crisis)
  - Must have a plan in place for both
- Suggestion: make both dynamic, reflective of the dynamic cost at the margin (by time of day)
- Does the regulator want to cap consumer liabilities?
  - E.g., cap on peak rates (not allowing market full pass through)

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Beware Parmenides Fallacy: i.e., *Comparing the Future to the Present, and not Alternative Futures*

- Today's and Smart Grid future are not easily comparable
  - Latter may have no (feeder level) load shedding
  - A 15 minute automated reading cannot be compared to today's monthly manual (often out-sourced) reading
    - Clearly, saving the Rs. 1-3/month for the meter reader is not sufficient to justify a Smart Grid/AMI
    - BUT, AMI enables many new functionalities, such as
      - Load profiling
      - Energy audits / loss reduction
      - Power purchase planning
      - Outage detection, etc.

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Business Model Issues

- Smart Grids are Capital Expenditure (capex) heavy
  - Benefits accrue over time
- Utility has 2 main choices (esp. given most are cash-strapped)
  - Treat capex into the rate base for RoR calculations
    - Raises tariffs on paper
    - Reduces rise in future tariffs due to monetization of benefits
  - Undertake outside funding
    - Loan – has debt servicing implications
    - Grant (from state or central govt.)
      - Limited in availability, and unlikely beyond a pilot
    - Public-private partnerships (PPP)
      - What's in it for a private player?
        - Sharing benefits (ala ESCO model)
- ESCO (and other) models
  - Require very strong calculations of baselines and metrics (targets)
    - Baselines must be over 1 year long due to annual growth and seasonal variations (forget if it is an election year!)
  - Irony – the worse the present condition, the easier it is to justify a Smart Grid (e.g., loss reduction)
    - But one has to be honest in what is due to a Smart Grid vs. improved operations

Rethinking Quality

- Today, consumers face load-shedding and numerous momentary interruptions
  - NOT captured in *declared* KPIs like SAIDI, CAIFI, etc.
  - Recommend adding MAIFI
  - Recommend adding scheduled and un-scheduled load shedding data, and making this public
- Smart Grid can quickly end feeder-level load-shedding!
  - Load limiting control switch integrated into meters (remote controllable connect/disconnect)
  - Quality impacts consumers
    - They needed diesel and backups
    - Pumpset burnouts
    - Can one split the benefits between utility and consumer? E.g.,
      - "Normal" tariff is, say, Rs. 5/unit, and diesel costs Rs. 15/unit
      - Above a minimum assured supply, during shortage periods only, charge a premium for unrestricted supply on a voluntary basis, e.g., Rs. 10/unit (or enough to cover the utility costs)

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Costs and Benefits are Hard to Calculate

- Investor (utility) Return on Investment is somewhat easier than societal impacts
  - Selected difficulties
    - Long timespans
    - Uncertainty of participation and effectiveness
    - Cost allocation for Smart Grid vs. Grid Upgrade
- Societal Cost-benefit is needed
  - E.g., Improved power quality helps the consumer
    - No need for diesel generator/inverter backups
- Rigour is more than academic
  - Confounding factors include annual load growth, seasonal variations, "unusual" events, etc.

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What do we need for a CBA?

- Cost Benefit Analysis needs ALL costs (monetary, non-monetary, etc.) to ALL stakeholders across the life of the project
- How do we convert implicit or value-laden impacts (e.g., time)?
  - Assumptions
- Challenges
  - Different time periods
  - Different values by different people
  - High uncertainty (performance and more)

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Framework for Cost-Benefit Analysis

- Costs
  - Pilot costs are always higher than in full-scale deployment
  - Depend heavily on current status of grid readiness
- Benefits
  - AT&C loss reduction
  - Freeing up capacity (peak)
  - Avoiding load shedding
  - Avoiding blackouts
  - Improved power quality
  - Load planning
  - Asset optimization
  - CRM benefits
  - etc.

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CBA sample findings

- CSTEP helped create a toolkit for CBA
  - Stochastic model
- Very assumption driven
- For a single area (feeder size) in a Tier-3 city, gave a ***societal*** payback of between 3-7 years, depending heavily on
  - Present use of diesel / backups
  - Availability of additional power for utility to procure and sell at a premium
  - Did NOT require much AT&C improvements

How to move ahead?

- Utilities must propose a roadmap/plan for smart grids
  - What functionalities are desired?
    - Why (use/business cases)?
  - What is the architecture and cost?
- Pilot deployments
  - Learning Pilots
    - Learn about technology, its impact (benefits), consumer participation rates/happiness, etc.
  - Deployment pilots
    - Worry about price-points, integration, scalability, etc.
- Since we don't know the "best" solution, we must experiment, learn, and iterate…

Challenges in doing a Pilot

- Pilot may be limited to “off the shelf” components/design
- Need vendors/partners with SG experience and expertise
- Design goals
  - Open standards
  - Scalability
  - Modularity
- Must rethink the entire ecosystem of providers
  - This is not like R-APDRP
    - There is no SRS or template
    - The solutions are evolving and must be iterative
  - “Lowest Cost” per se is a false choice
    - Lifecycle costs matter
    - Performance (functionality) matters
    - Pilots will always be more expensive!

Pilot Projects: Possible Varying Functionality in stages (not necessarily linear)

- Smart Metering
- Reliability and Robustness (supply switching)
- Renewables, storage, and distributed generation
- Load control and Demand Response
  - Smart Appliances
  - Signaling to consumers and devices [who controls is TBD]
- Sensor networks, etc.

ICT for Power Systems:

Accounting → Auditing → Monitoring → Control

(R-APDRP)

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Thinking of the Future…We need Smart Grids

- Business as usual (BAU) will not be sustainable
  - Adding supply is necessary but not sufficient – must make consumption smarter
- Consumers must see and behave based on not just their average costs but their incremental impact on the grid
  - This will create a few losers but (hopefully) more winners
- Appliances and consumption will become smarter
  - Whirlpool announced that by 2015 ALL their selected household appliances will be smart grid capable (worldwide)
  - It's not a question of *when*, not *if*…

MESCOM/CSTEP Mini-Pilot

- Designed, implemented and demonstrated some functionalities (AMI, consumer Load control and street light control)
- Proof-of-concept (first of a kind) demo
- Adding a Smart Node with current technology static meters to achieve precision metering and load control
  - Mixed loads
  - Monitor usage (and losses) with high precision
  - Control/curtail loads
    - Street lights
    - Aggregate consumer loads
  - *Ability to end load-shedding at feeder level*
    - *All consumers can get assured (minimum) supply 24/7*
  - Total size ~90 nodes (few DTs)

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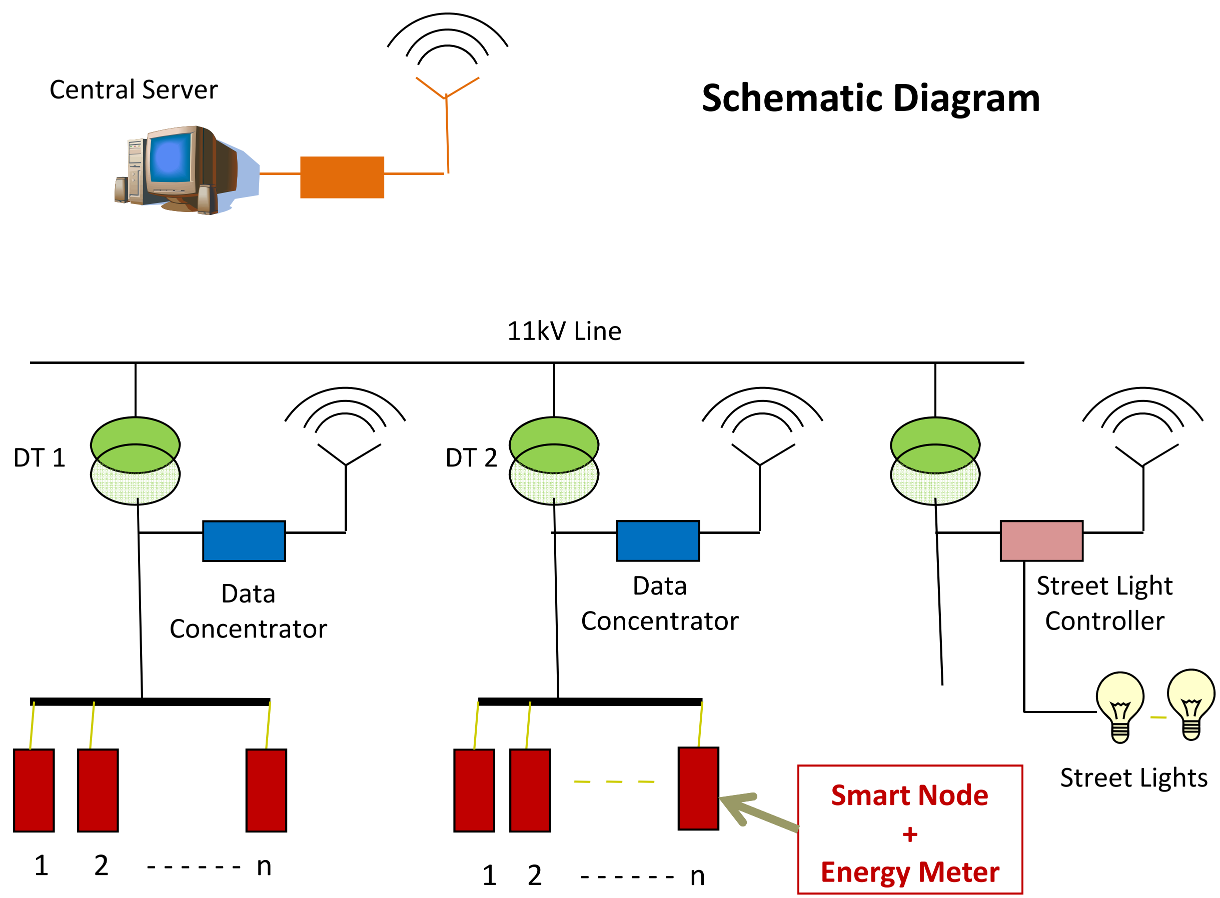
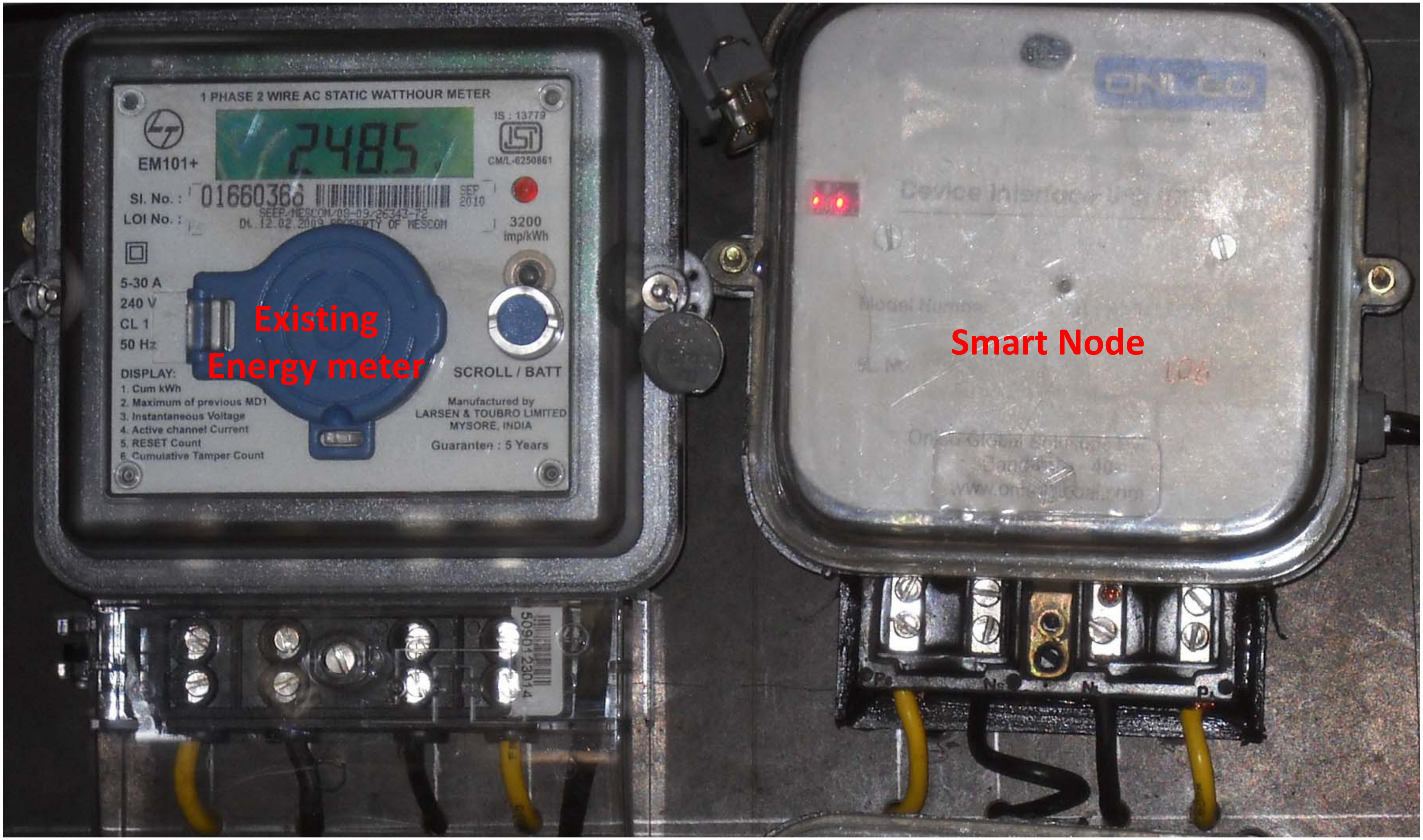
MESCOM Mini-Pilot

Adding a Smart Node (memory, logic, communications, and connect/disconnect switch) *with current technology static meters* to achieve precision metering and load control

Proof-of-concept (first of its kind) demo



Site of the Pilot Project at Mangalore:



Smart Node = Memory, Logic, Communications, and remote Connect/Disconnect

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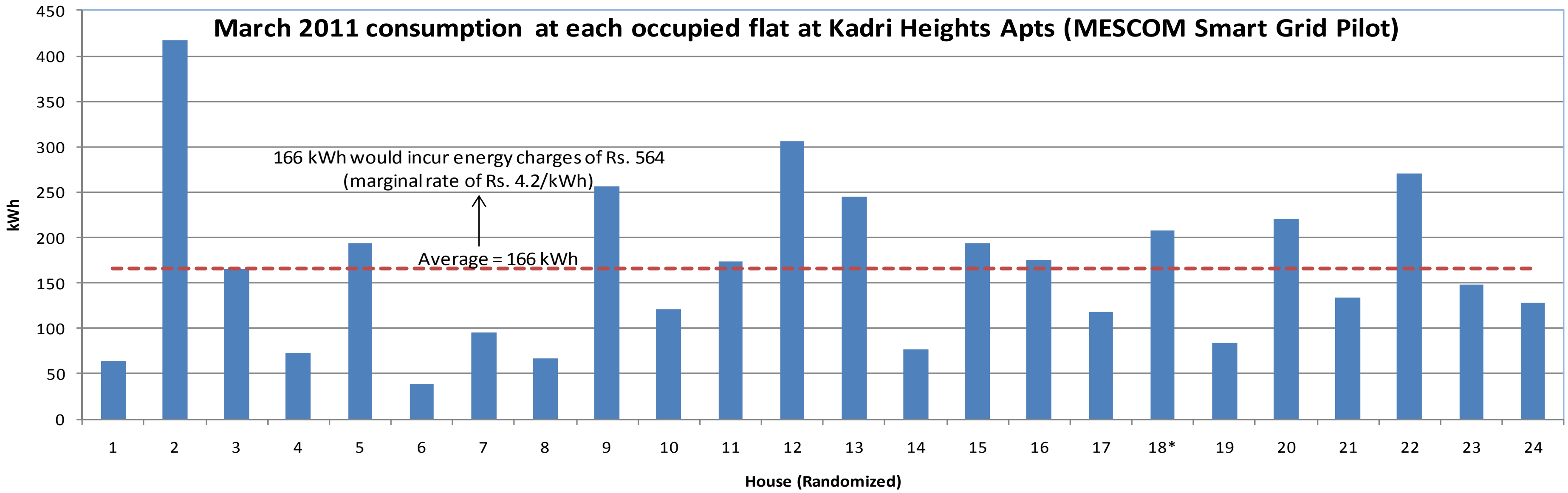
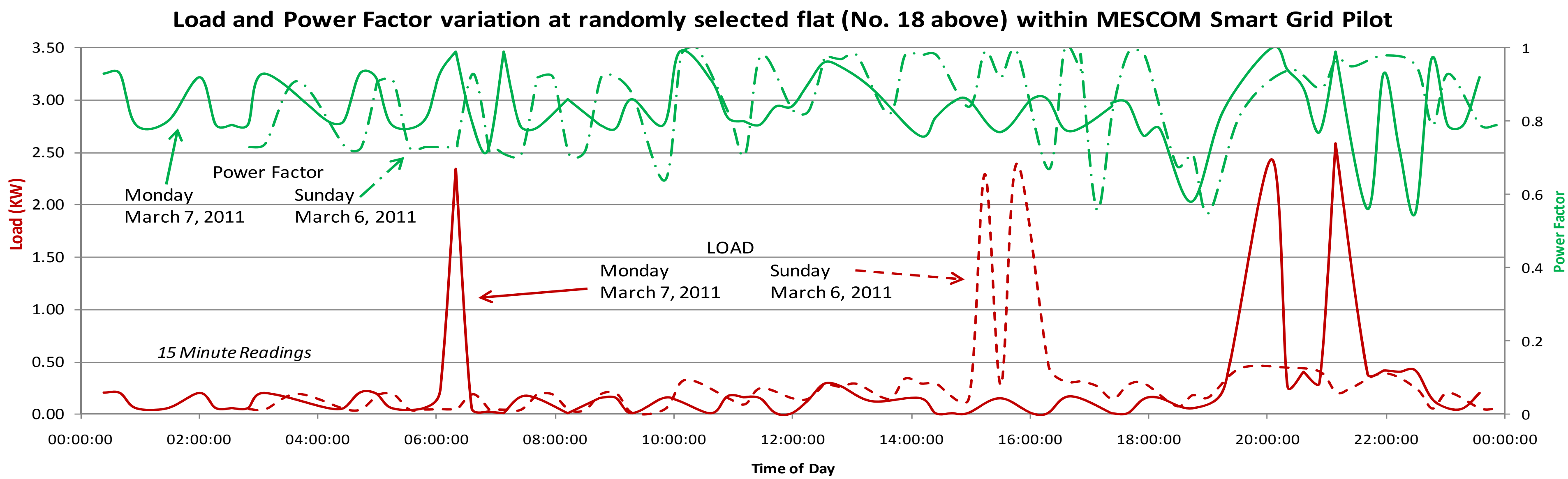
Observations from the mini-Pilot





Impacts on Consumers

- Carrots
  - No load shedding
  - Increased accuracy in Billing
  - (possible) Personalized data (e.g. Home Display)
  - Better knowledge and control over energy usage
  - Opportunity to reduce energy bills (Using ToU tariffs)
  - Option for pre-paid connection
  - Less Power outage or less momentary interruptions
  - Quick fault detection
  - Faster restoration of faults
  - Better Power Quality
  - No Regional Blackouts
- Sticks
  - Penalties for violations or non-compliance
  - Possibility of disconnection (remotely)
  - Increased accuracy in billing (bill may go up, and no more chicanery)

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Lessons Learned and Moving Ahead

- Scaling to thousands of consumers and then the city
  - Back end integration
  - Cyber security
  - In-home signaling and/or display
- New pricing schemes (with regulatory approval)
- Generating data for doing a TRUE cost-benefit analysis
- Business models that can be funded and viability

- Phased plan for moving forward…

What do we need?

- Improved solutions
  - IT adage: “Faster, Cheaper, Better – Pick any two”
  - Every ingredient exists today
    - Need these to become
      - Robust
      - Modular
      - Inter-operable
      - Standards-based
- Open, multi-stakeholder discussions
  - Harness SG Forum, perhaps
  - SGs succeed if the solution is right
    - SGs FAIL because of the consumer’s unhappiness

Before we get too fixated on "Standards"

(e.g. ISO)

Discussion with and Qs for the Regulators

- Pune model (Express Feeders)
  - Can a SG simply be extending this to a per consumer level?
- End diesel consumption
  - Can utilities charge a shortage premium? Clear willingness to pay!
- Time of Use or Variable Pricing
  - Hybrid may be best (some ToU, some grid-status based, e.g., Critical Peak Pricing)

Discussion (cont.)

- Pilots
  - More urban, many of them
  - Waiver? E.g., pricing?
    - Paper calculations of incentives likely to fall short
- Infinite possibilities – need guidance/clarity
  - E.g., Connect/disconnect
    - Can be fairer (lifeline)
  - Variable Maximum demand
    - Even Max. Demand can be set by ToD
- ToU
  - Ceiling/Floors on impacts on consumers?
  - Fund for asymmetric impacts?
- **Not a panacea**

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We're in this for the long run…

We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run

- Roy Amara

Welcome

Hon'ble Members of Forum of Regulators- Power

to

Presentation & Road Map for Deployment of

Smart Metering Solutions

A2Z Powertech Limited

Offering Future Ready Smart Metering Solutions Today

3rd February 2012, Bodhgaya

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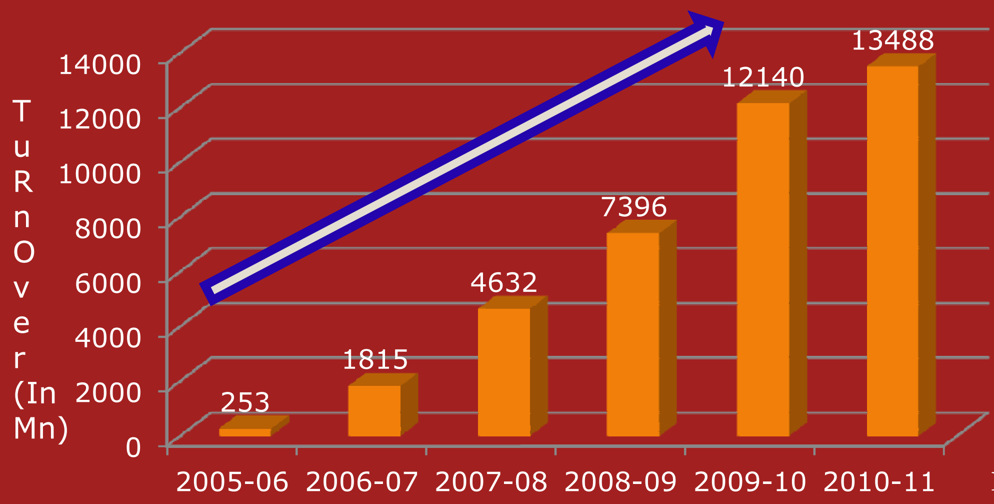
Introduction to A2Z Group

A2Z Group

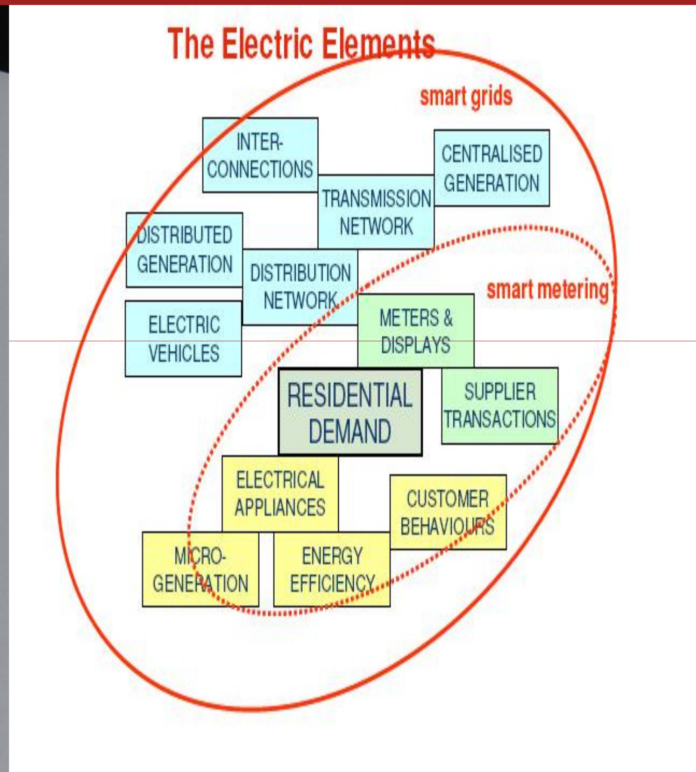
- A2Z Maintenance & Engineering Services Ltd
- A2Z Powercom Ltd
- A2Z Infrastructure Ltd
- A2Z Infraservices Ltd
- A2Z Powertech Ltd
- A2Z E Waste Ltd
- A2Z Water Solutions Ltd

1



Inspiration for Smart Metering Infrastructure

SMART METER-METRIX-m GPRS



2

A "Hybrid & Integrated AMI" solution with Post-Paid & Remote Pre-Paid Payment Options

Inspiration for Smart Metering Infrastructure

- A T&C losses piling up (ranging between 18% to 62% across various Indian SEBs/ DISCOMS) - High commercial losses primarily attributable to the high financial losses
- Metering inefficiencies comprise of a very high proportion of the AT&C losses – *Huge scope for commercial savings and performance improvement*
- A2Z Powertech to Assist Discoms in reducing A T &C Losses by offering State of Art Metering Solutions with overall objective of enhancing the Metering, Billing & Collection Efficiencies

Power sector may turn unviable if losses not checked, says prime minister

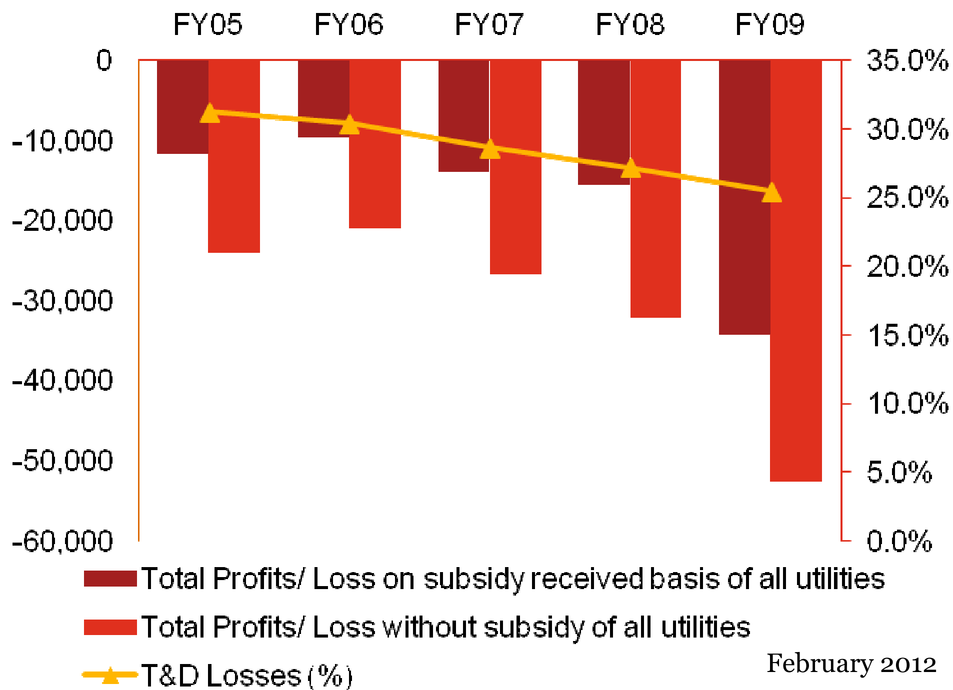
Published: Saturday, Jul 24, 2010, 13:03 IST
Place: New Delhi | Agency: PTI

The power sector could trip the country's growth story if states do not check the losses of the power utilities that totaled a staggering Rs 40,000 crore last fiscal, prime minister Manmohan Singh said today.

"The power sector is particularly important if we wish to achieve 9 per cent growth. Total loss in 2009-10 is estimated at Rs 40,000 crore. Unless corrected it will make the whole power sector unviable," Singh told a meeting of the National Development Council (NDC) in New Delhi.

He attributed these losses to low levels of tariff for some categories of consumers and high technical and commercial losses.

India has one of the highest transmission and distribution losses in the world. It lost 30 per cent of the total power produced (over 160,000 MW) in



Source PFC Report

[CERC TO CURB OVERDRAWING](#)

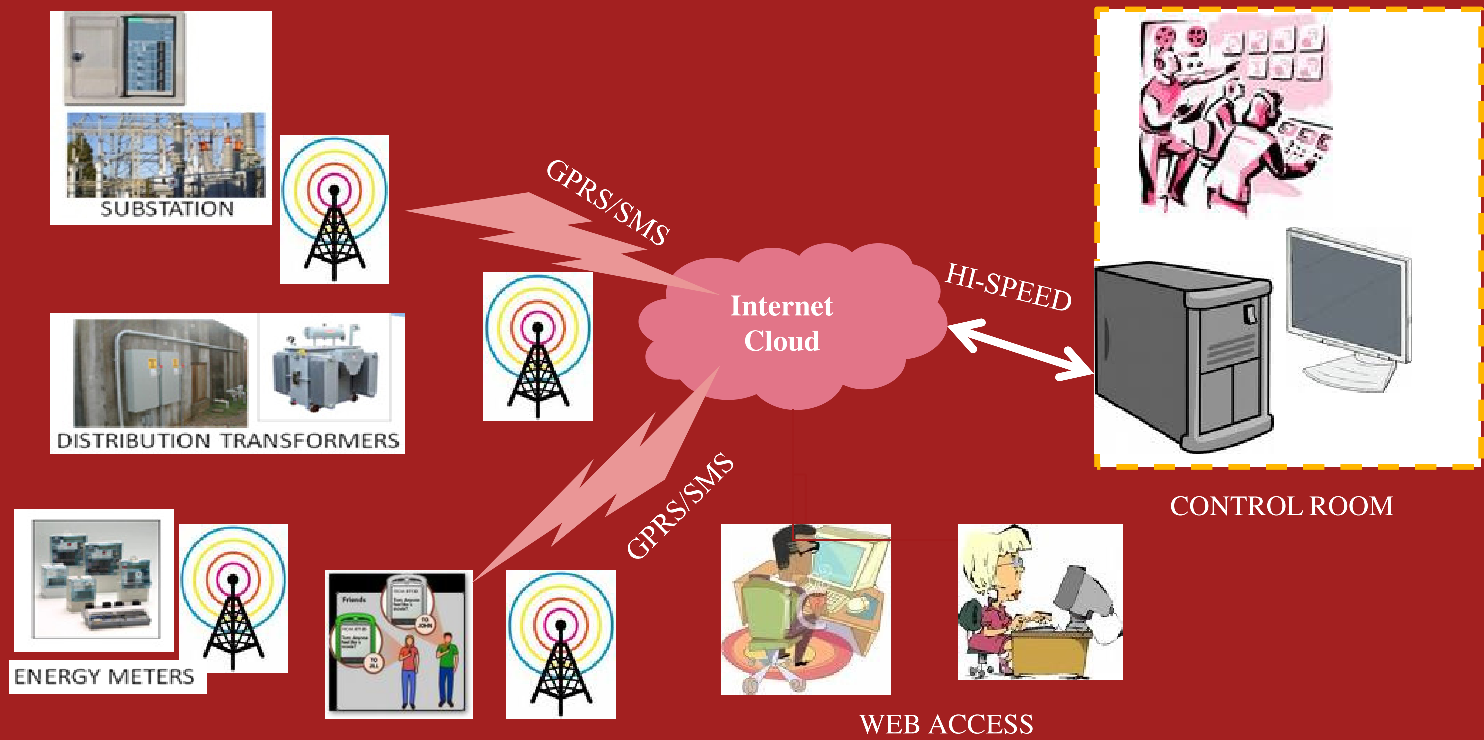
[EI IMPERATIVES](#)

Major Operational Challenges –Indian Discoms

- Asset Mapping / Management issues being addressed through R-APDRP scheme and under progress, still existing DISCOMS Metering Infrastructure lacks Smart Intelligence to undertake:-
  - Elimination of human intervention in data capturing process for Metering, Billing & Collection of Consumers -Authenticity of Metering DATA captured Manually?
  - Automation of Power Distribution Assets etc with legacy Power Distribution Infrastructure
  - Communication Capabilities with Base Computing Station - Capture On Real Time Basis Metering Details , Consumption patterns, Condition monitoring of Power Distribution Assets& any Exemptions -Temper Events etc of majority portion of Domestic & Commercial Consumers
  - Not equipped to remotely Manage Load Connection/ Reconnection to protect Assets from abnormal loadings thereby leading to higher field failure rates-Transformer Overloading , Burnouts and Line losses – technical loss directly linked to revenue
  - Minimize Energy Losses & maximize Revenue Collections at all levels
  - Meet with Regulatory & Statuary Compliances
  - Energy Accounting- Inventory/ MIS/ Power Distribution System up gradation based on dynamic info on Power Distribution Growth inputs-Identification of T&D Loss on line-Technical & Commercial loss segregated ?

In view of Non Availability of Consumer's Authentic DATA ,DISCOMS unable to effectively plead with Regulators For reformulation of Tariff Orders .

Smart metering solutions from A2Z



3 Real time Accounting → Auditing → Monitoring & Management → METRICS-m GPRS

What does A2Z-Geovas' SM/AMI solution offers..

Geovas SM/AMI Solution

- Concept to commissioning capabilities for the Smart Metering solution
- In-house developed solution tailored to suit local markets
- Domain experts in Distribution & Metering functions
- Value driven offering covering metering, AMI/AMR & Software
- Complete software customization and integration
- Local service support upto component level

Key features that METRIX- mGPRS Smart Meter provides..

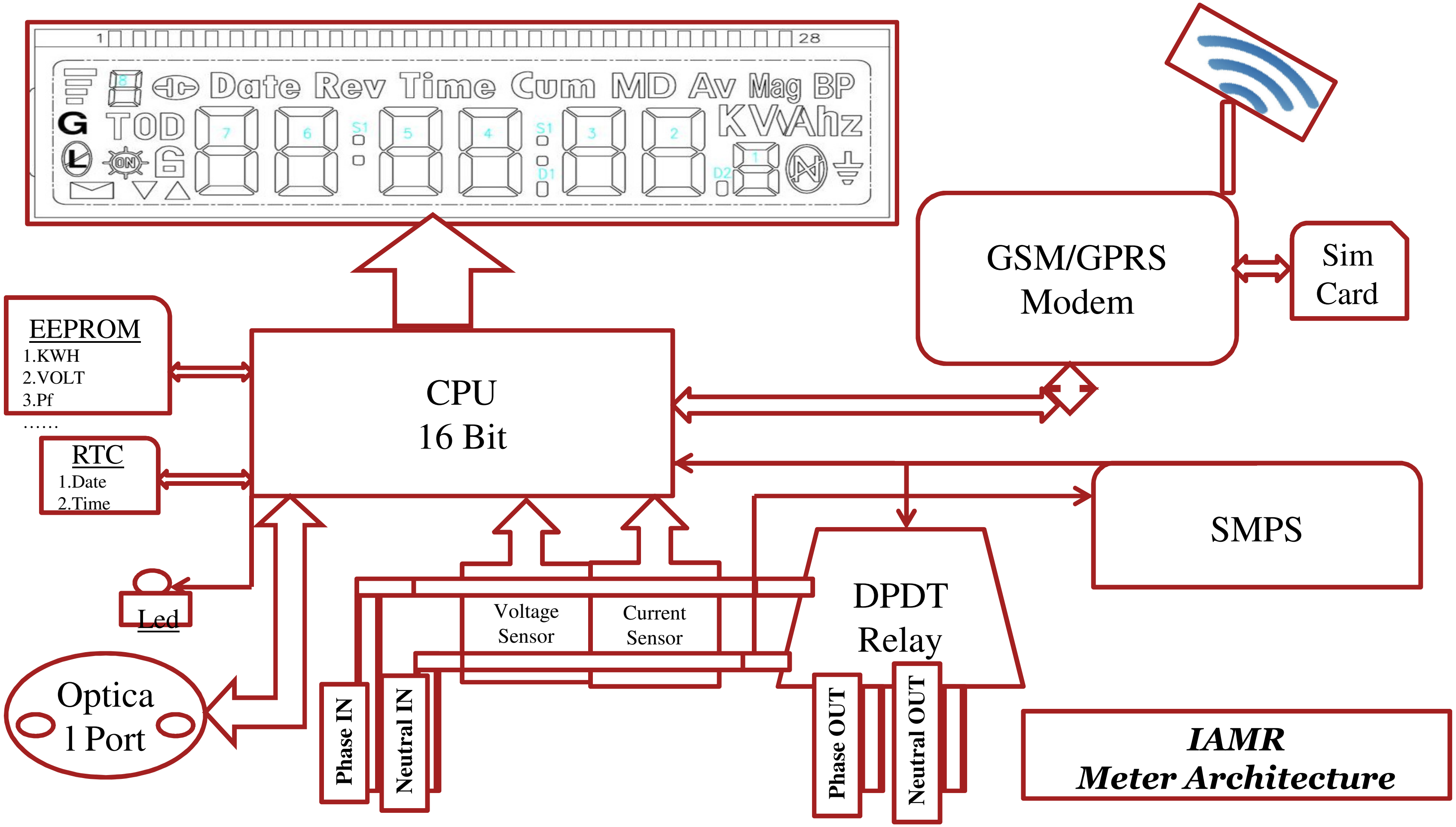
- ✓Measured Values and Units
  - ✓*Active Energy*
  - ✓*Maximum Demand*
  - ✓*Phase Voltage*
  - ✓*Line Current*
- ✓In-built GSM / GPRS Quad band modem
- ✓Sending data to server on demand
- ✓Sending data to server on scheduled basis
  - ✓*15 minutes*
  - ✓*30 Minutes*
  - ✓*1 Hour*
  - ✓*1 Day*
  - ✓*1 Month*
- ✓Instant Notification of tamper event to the server
- ✓Signal Strength indication on LCD
- ✓Load Survey with kWh/kW 30 minutes for 30 Days
- ✓Inbuilt relay for remote connection / disconnection upto 100A load

Integrated GSM/GPRS/LPR Module and Remote Connection & Disconnection Relay

Intelligence embedded to undertake Bi-Directional communication, DMS & Pre-Paid options

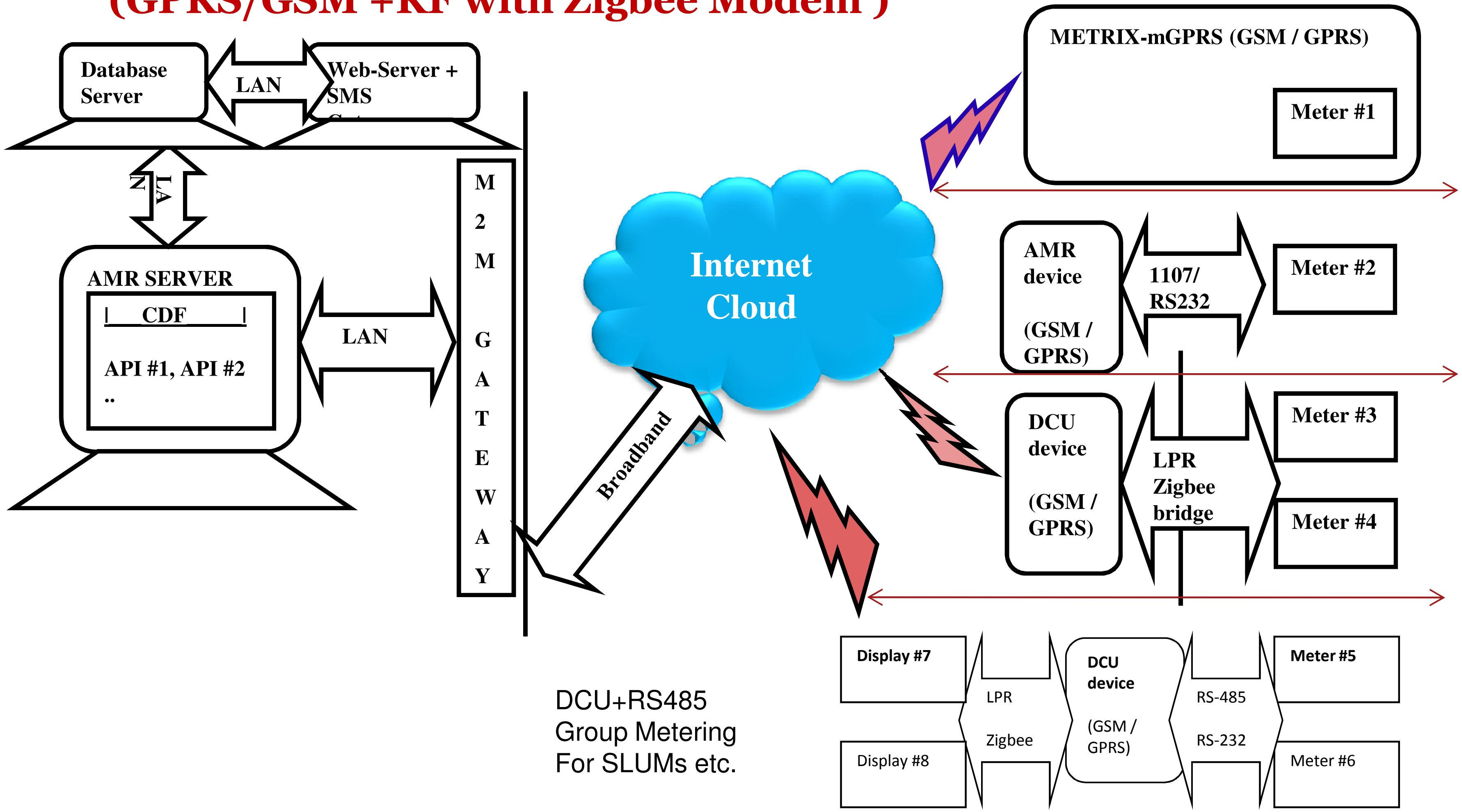
Robust integrated system for enhancing metering, billing & collection efficiencies

Integrated Meter -METRIX- mGPRS Smart Meter architecture



How does A2Z's Smart Meter server architecture looks..Various Options

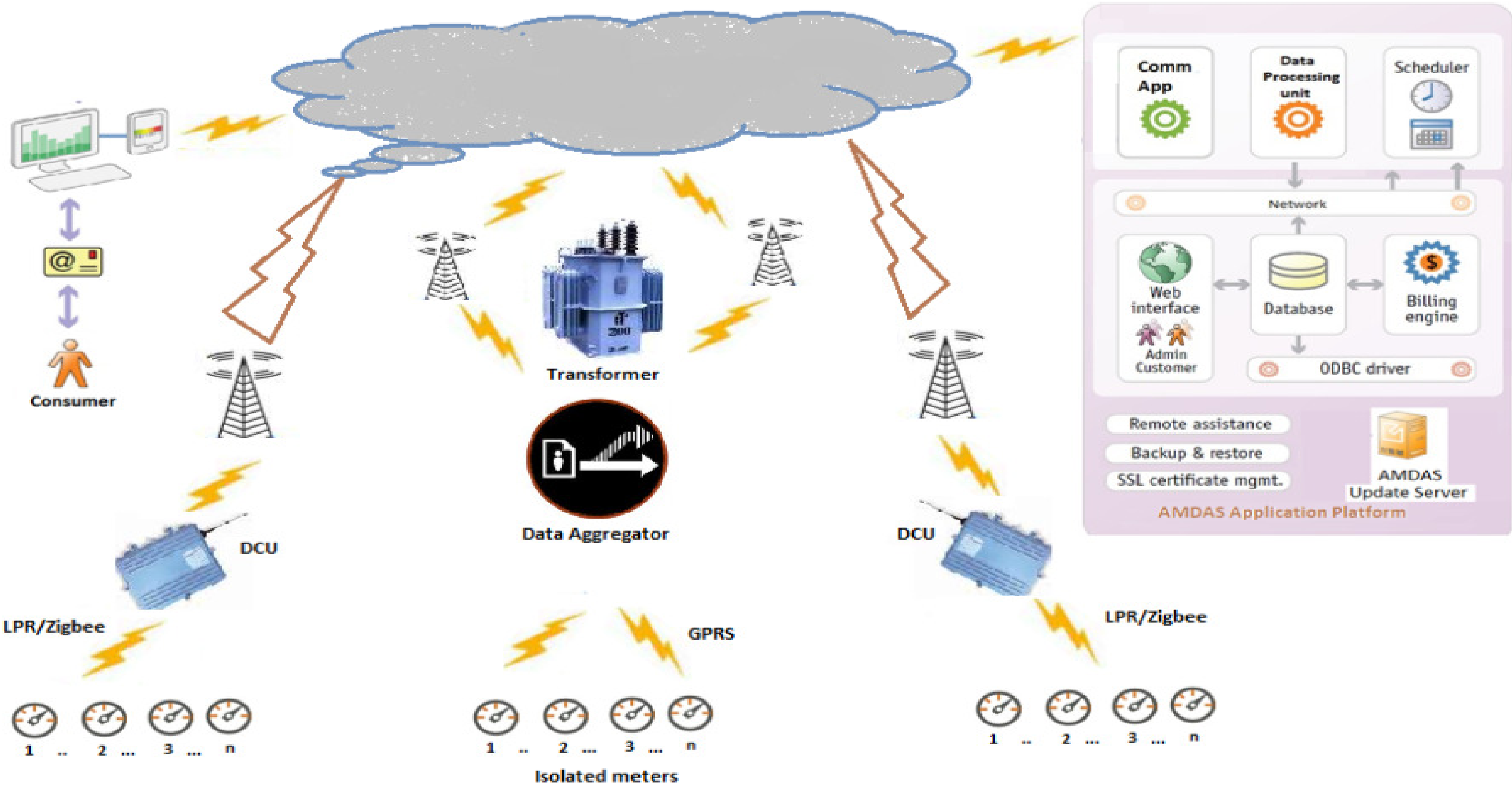
(GPRS/GSM +RF with Zigbee Modem)



DCU+RS485
Group Metering
For SLUMs etc.

How does A2Z's Smart Meter server architecture look..Various Options

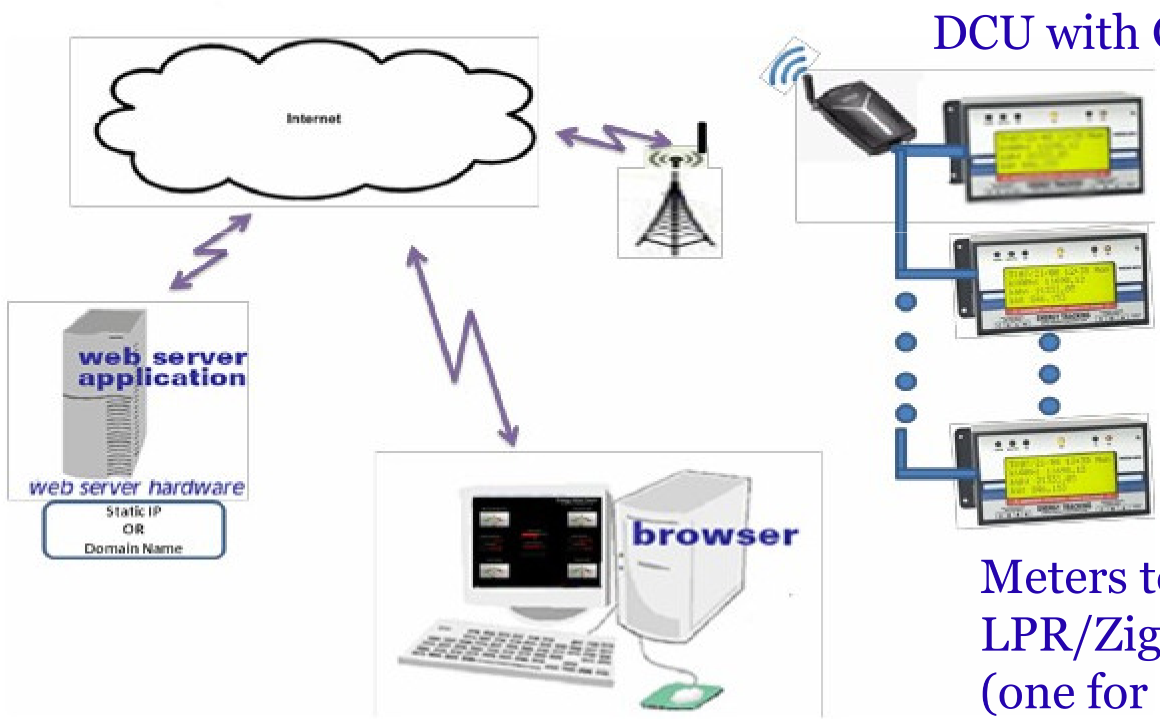
(GPRS +LPR/DCU/DT) Cloud Architecture



How does A2Z's Smart Meter server architecture look..Various Options

(GSM/GPRS +LPR/DCU) Architecture for Appt Complex

DCU with GSM/GPRS

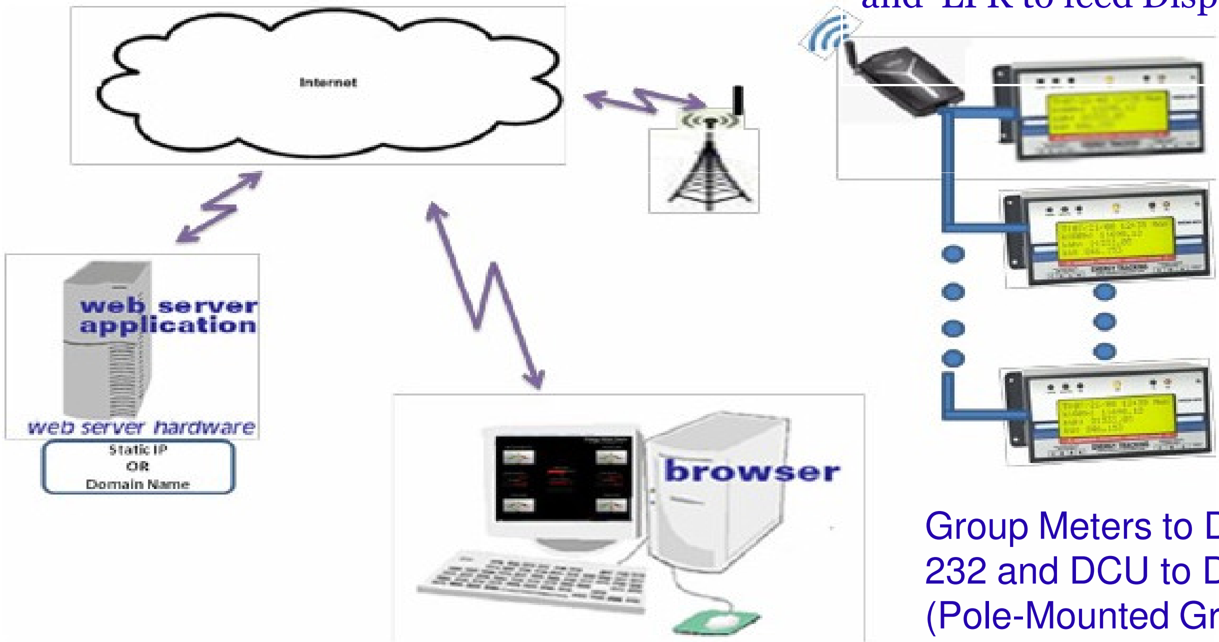


Meters to DCU over LPR/Zigbee/Mesh (one for each building of Appt complex)

How does A2Z's Smart Meter server architecture look..Various Options

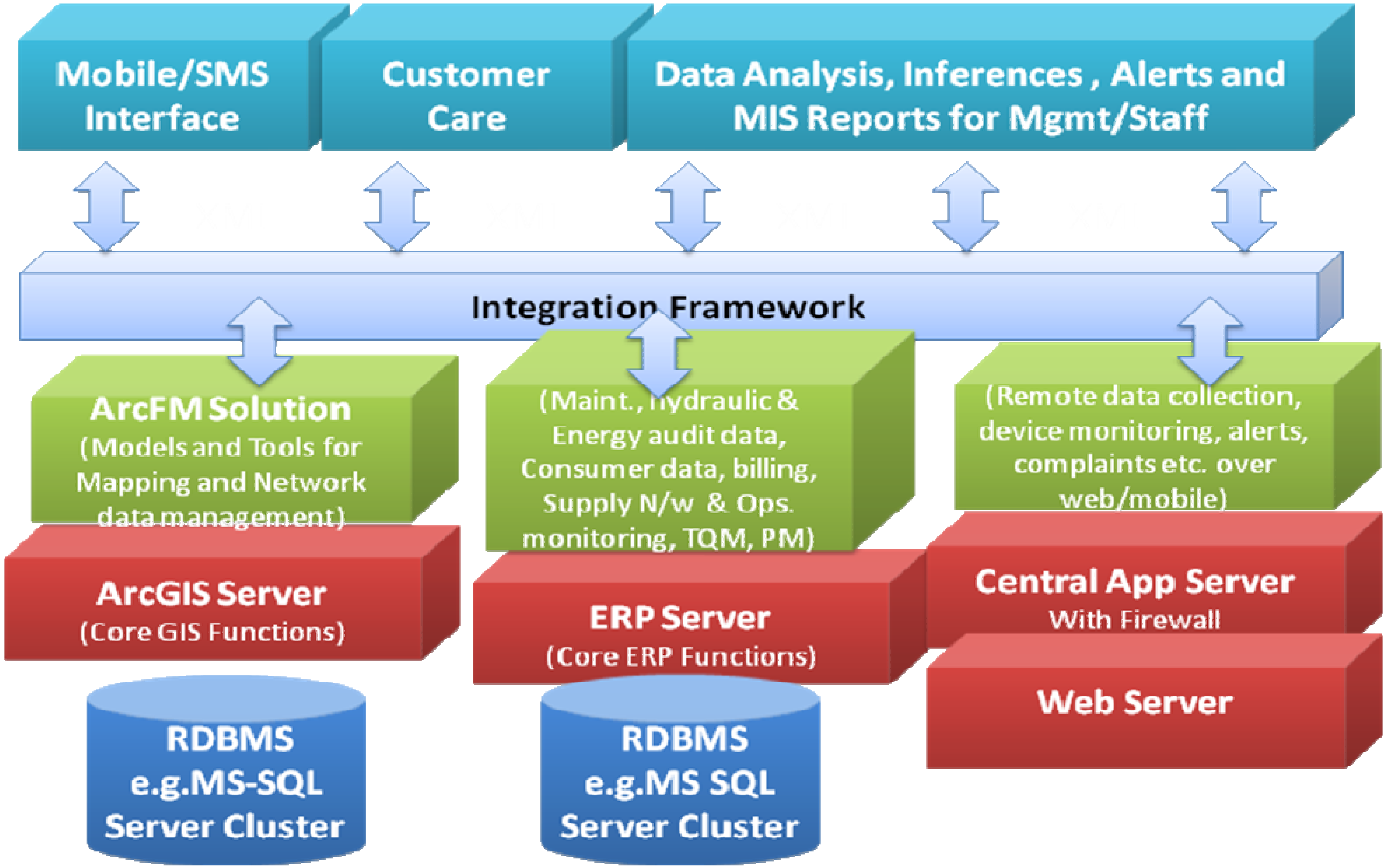
(GSM/GPRS + RS-485/232 + LPR/DCU) Architecture for Pole mounted Group Metering in Slum etc. areas.

DCU with GSM/GPRS link to AMR Server and LPR to feed Displays

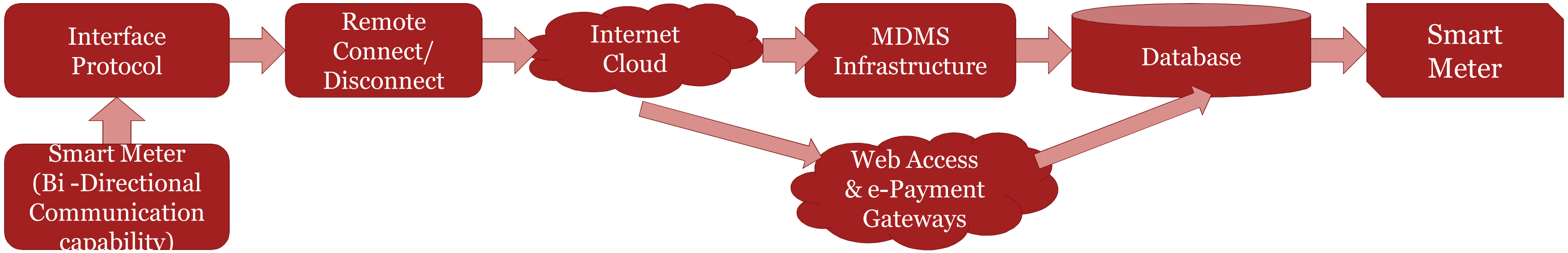


Group Meters to DCU over RS-485/ RS-232 and DCU to Displays over LPR (Pole-Mounted Group Metering for Slums etc.)

Integration Framework with ERP & GIS Servers



How does A2Z's AMI work..



Functionality

- 15 min. (programmable) Interval data
- Remote connect/disconnect
- On Demand meter reading
- Web-based dashboard portal

Impact on Business processes

- Revenue Cycle Management
- Customer Relationship Management
- Energy Accounting and Audit
- Load Management

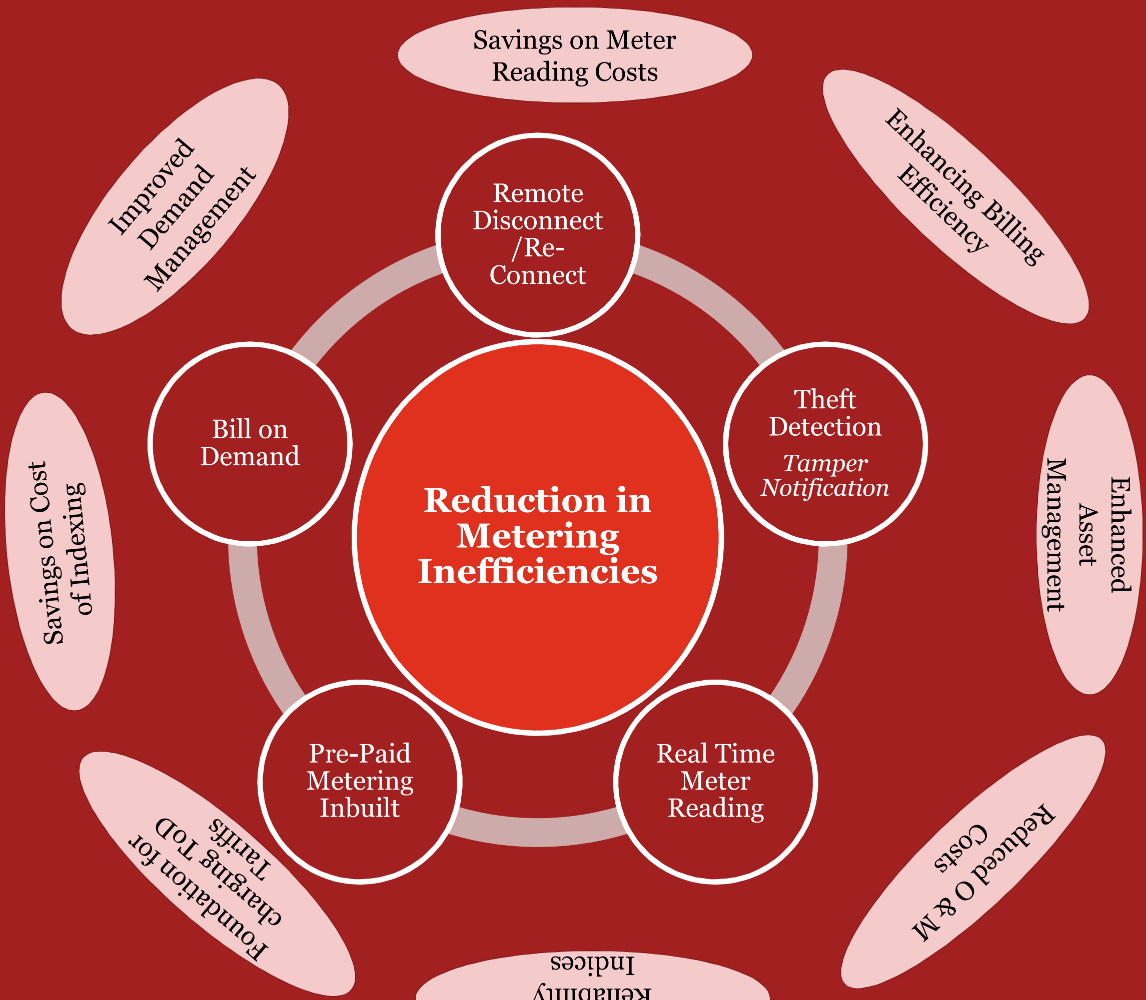
Enabler

- Lowers energy consumption
- Improves system – power availability
- Better energy consumption info
- Elimination of consumer complaints

Differentiator

- Plug & play with proactive system architecture
- Interoperability across AMI Value Chain
- Ready to use as remote Prepaid/Post-paid
- Highly resistant for all tamper and installation conditions
- Built-in mobile application

A2Z Smart Metering Infrastructure-Benefits



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Benefits realised with A2Z 's smart metering solution with AMI vis-à-vis conventional meters

Sr. No.	Features	Conventional Meters	Pre-Paid Meters	A2Z's METRIX-mGPRS-AMI
1.	Real time metering status	X	X	√
2.	Load Management by utility	X	X	√
3.	Bi-Directional Communication	X	X	√
4.	Managing Consumer Profile	X	Not on Real Time basis	√
5.	System Parameter Monitoring	X	X	√
6.	Utility Asset Mapping	X	X	√
7.	Distribution Assets operation management	X	X	√
8.	Smart Metering applications compatibility	X	X	√
9.	Theft detection	X	Not on Real Time basis	√
10.	Remote Connect/Disconnect facility	X	X	√
11.	Bill on demand (through mobile applications)	X	X	√
12.	Accurate identification of T&D Losses	X	X	√
13.	Load Management by consumer	X	X	√

Tangible Benefits Intangible Benefits

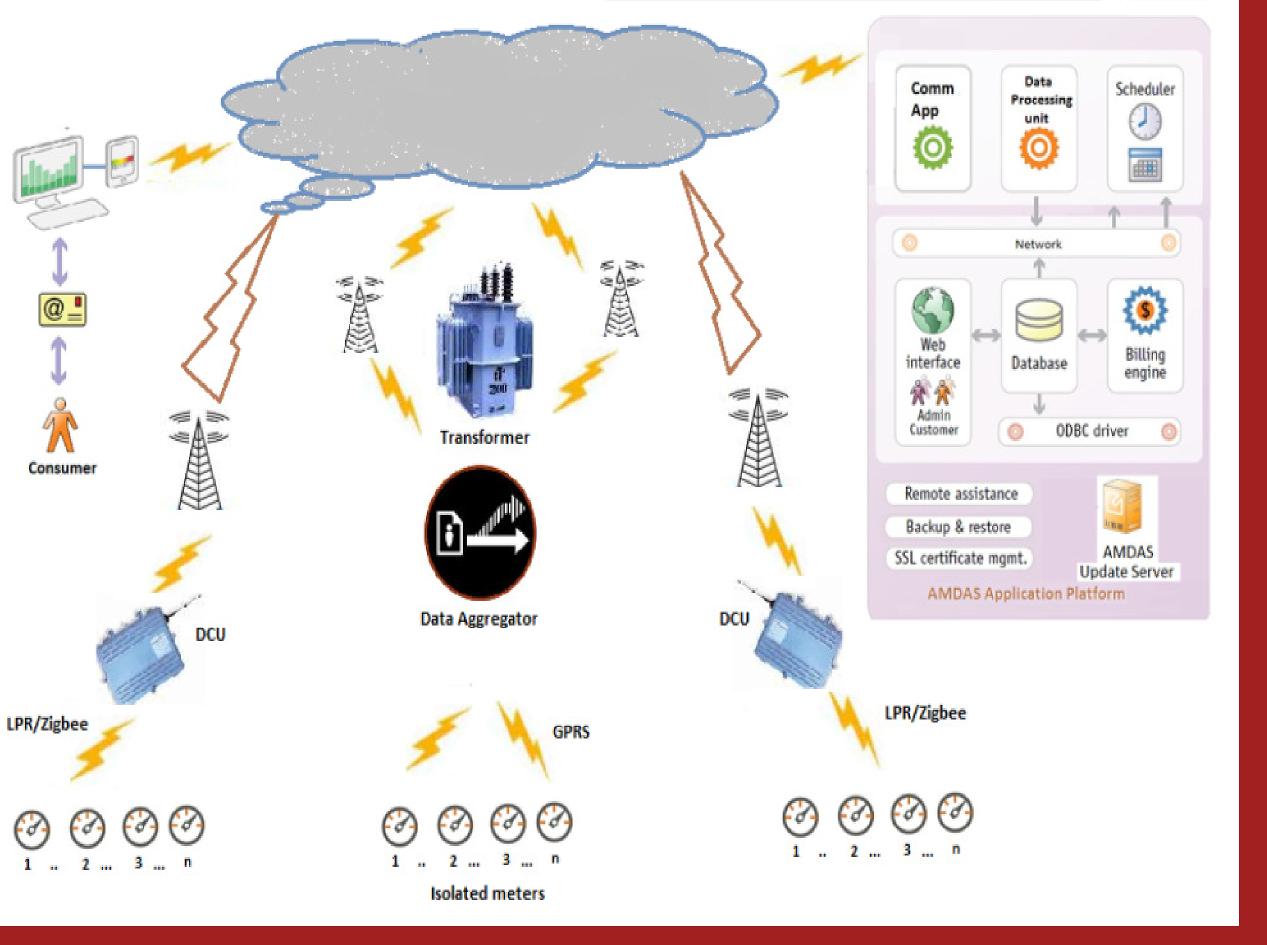
What quantifiable benefits can be achieved..

Expected Benefits Quantified into Revenue	% of Total Benefits	Basis of Assumption for saving calculation
Revenue due to Energy Savings	~85%	Additional revenue due to percentage reduction in AT&C Loss
Savings on Meter Reading	~3%	Meter reading cost per meter
Savings due to reduction in Erroneous Billing	~0.3%	Per unit cost of revisit, Per unit cost of rebilling, % of no. of cases
Savings due to reduction in Bill on Demand/Duplicate Bills	~0.03%	Per unit cost of printing in utilities where bill is not available online & % no. of cases
Savings due to reduced Theft Investigation	~0.3%	Proportionate salary savings of investigating officer per feeder
Savings due to reduced QoS Related Complaints	~0.02%	Per unit cost of revisit and percentage of no. of cases
Savings due to reduced O & M Costs	~1%	% decrease in O&M Cost per feeder
Savings due to reduction in Meter Carrying Costs	~0.15%	Meter Carrying cost, percentage Defective meters annually(o/s Warranty)
Savings due to Remote Disconnect/Re-Connect facility	~.10%	Per unit cost of revisit and % of no. of cases
Savings due to Improved Working Capital Management	~10%	

Major Contribution; Minor Contribution (< 1%); Meager Contribution (< 0.1%)

** Benefits are result of correction in meter inefficiencies and VAS*

A2Z Smart Metering Infrastructure - Demonstration



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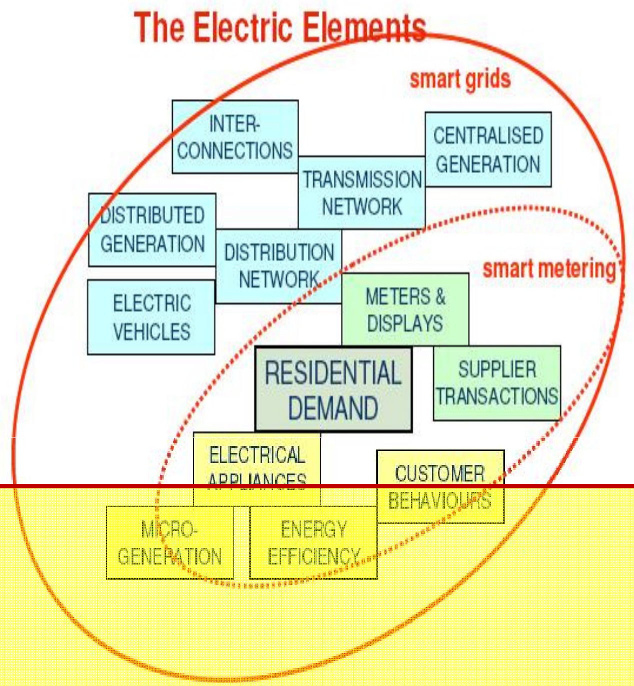
Thank You



Contact Us:
Hemant Passi
Head-Business Development,
a2z Powertech Limited,
Gurgaon - 122016 (Haryana).
M: +91-9958221008
Fax: +91-124-4776176
www.a2zgroup.co.in

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