Policy and regulatory issues in the context of large scale grid integration of renewable energy in Gujarat

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Background

- TERI study of integrated renewable energy resource assessment for Gujarat
  - A GIS based RE potential assessment
  - Land use land cover analysis
  - Consideration of certain wasteland category only for wind and solar power installation
  - Water availability consideration for CSP potential
  - Solar wind hybrid installation potential
  - Development of GIS based atlas

Estimated RE potential in Gujarat

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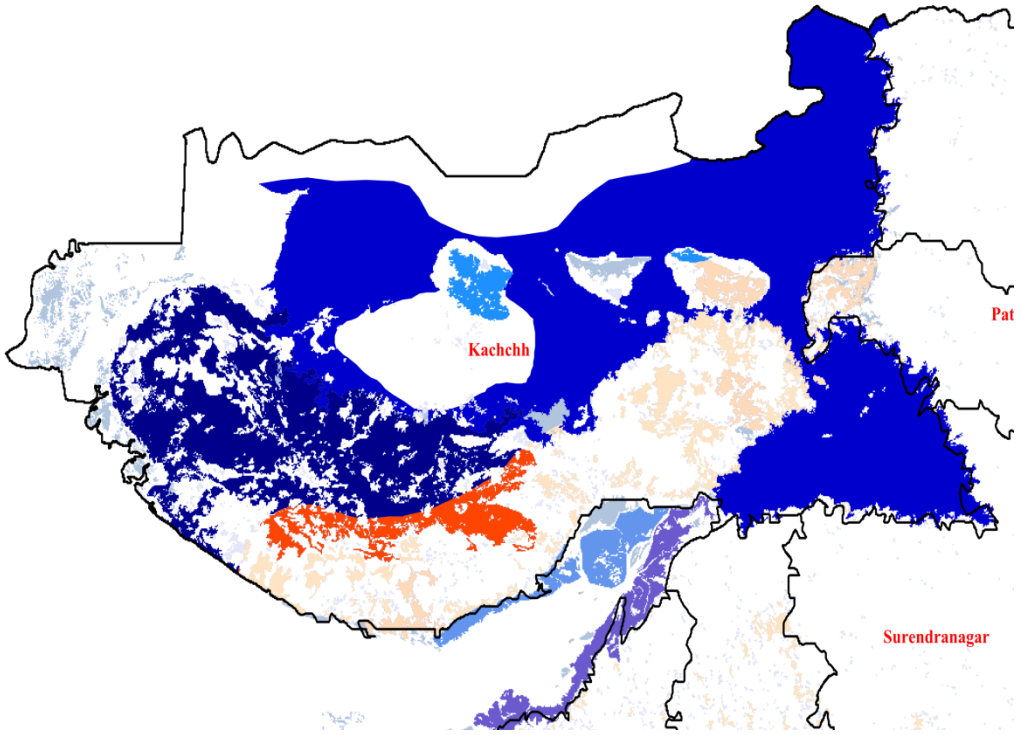
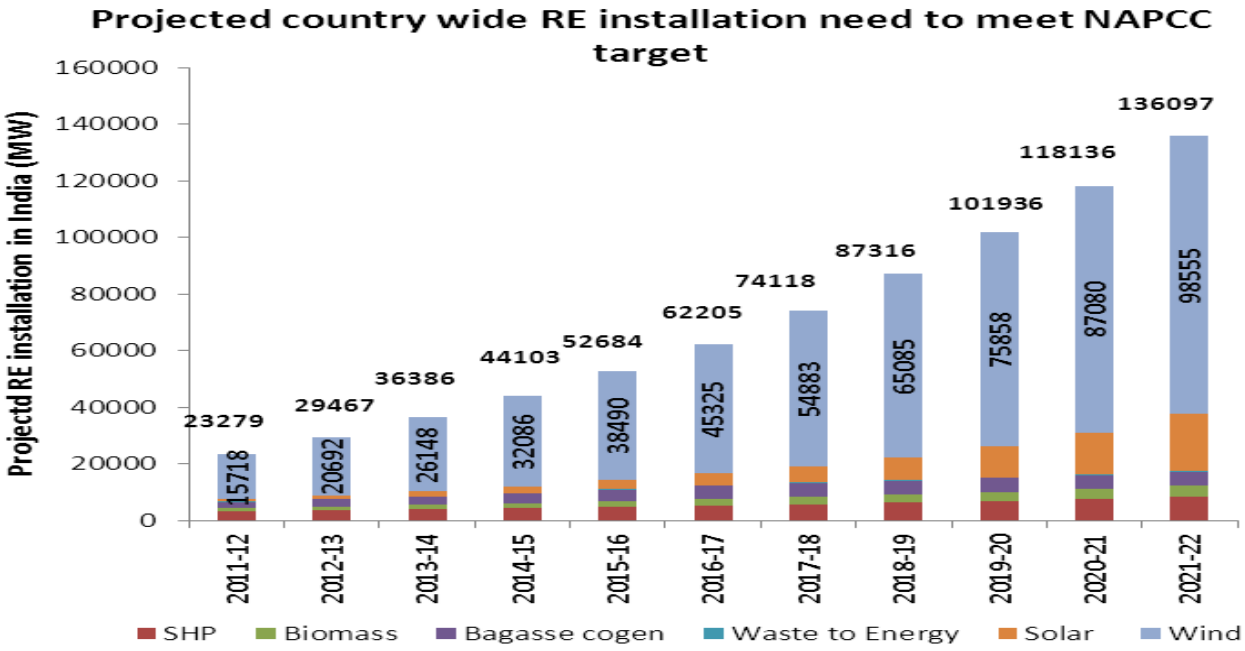
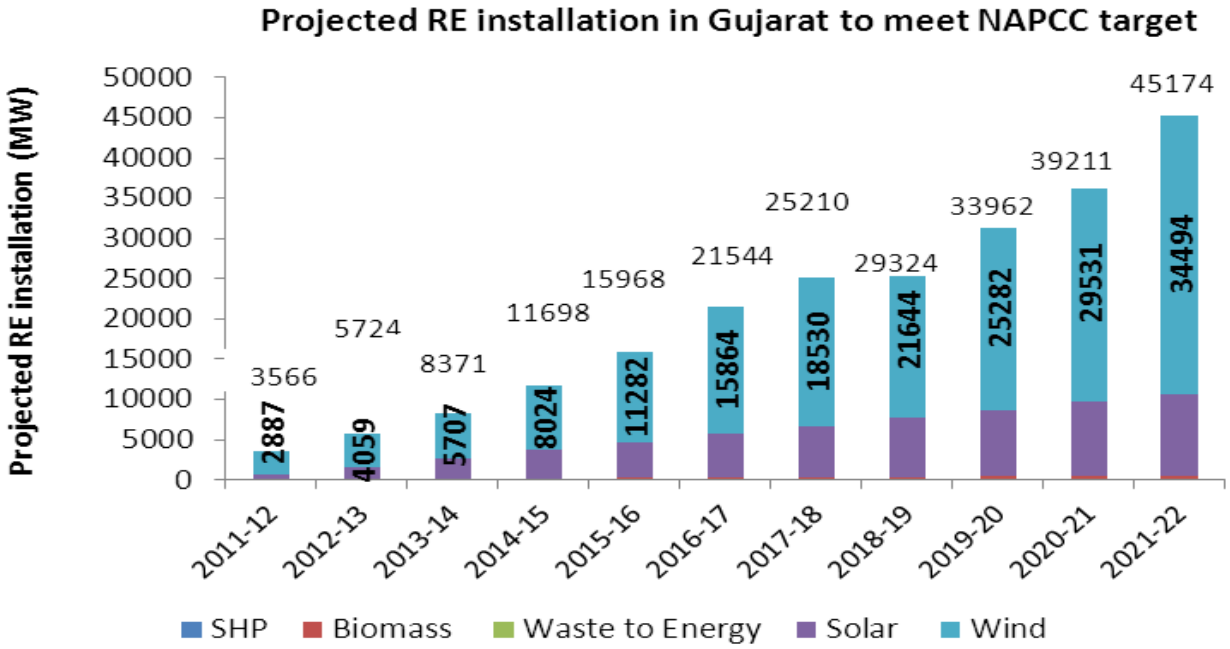
RE Technology	Estimated potential in Gujarat (GW)	Estimated potential in Kachchh (GW)
CSP with water availability (GW)	345.71	87.76
SPV Wind hybrid excluding CSP land (GW)	240.6	148.13
Only SPV excluding wind and CSP	21.36	8.92
Only wind excluding solar potential land (GW)	139.21	133.26
Biomass (GW)	1.89	0.07
Total integrated potential (GW)	**748.77**	**378.14**



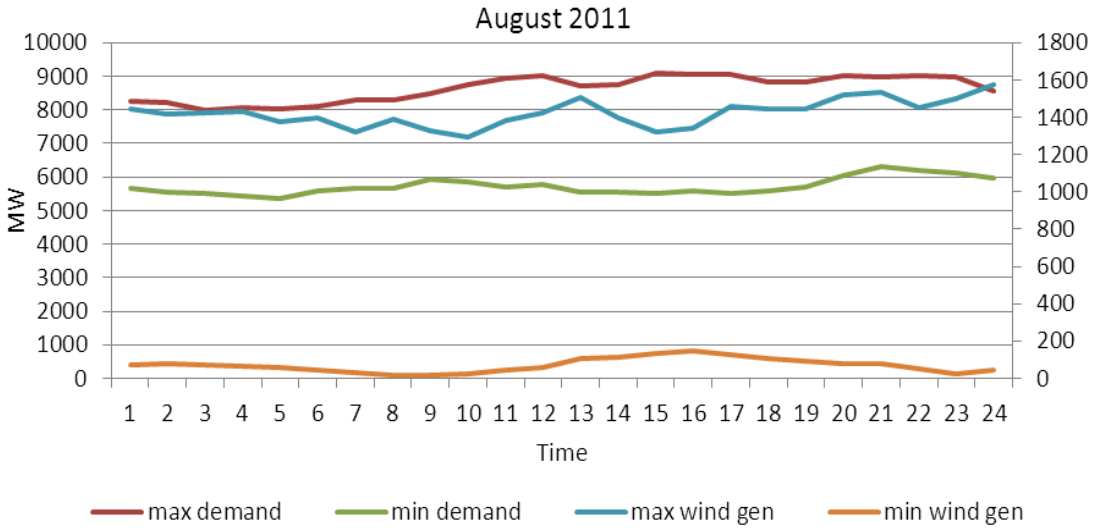
Gujarat - hub for RE generation in India



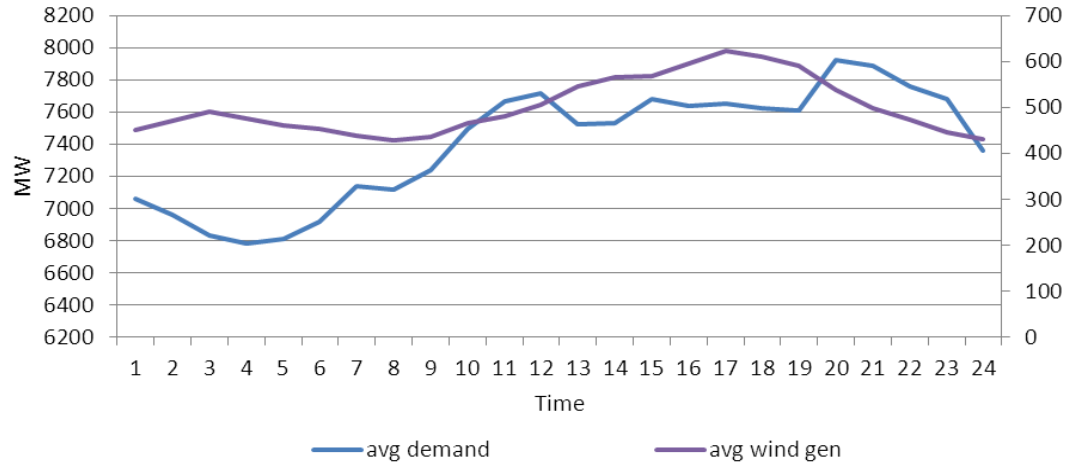


- NAPCC suggests the National RPO to be increased 1% annually from the 5% value of the base year 2009
- Based on the EPS-17, total energy demand of the country will be 1914508 MU by year 2021-22
- To meet 17% RPO target by 2021-22, **98555 MW** wind installation will be required apart from **20000 MW** solar
- Much of the power to be transported out of Gujarat.

Challenges in grid integration of renewables



In the month of August the range of meeting electricity demand by wind varies from 0 to 26.4%.



Wind and solar generation are quite variable which leads to

- Reactive power and voltage control issue
- Active power and frequency control issue
- Power balancing problems
- Power congestion
  Example: Congestion in Deodhar, Shivlakha, Shankhari networks . Overloading of 220/66 kV Shivlakha ICTs
- RE plants providing lesser grid support during system disturbances than the conventional in terms of MVAR/active Power regulation.

No major issues have been observed in Gujarat due to wind and solar energy variations till now

This scenario may change with increase in wind and solar energy penetration i.e. from current average of about 5% to more than 30%

Recommendations

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Policy Interventions

Focal area of intervention	Action required	Roles and responsibilities
Advance grid planning and network enhancement	<u>Grid planning</u> • RE potential based planning - "Integrated Energy Parks" on PPP mode – (experience from Charanka) • Creation of land banks for RE parks • Call for long term development plans of developers (5-10 years) <u>Grid strengthening</u> • Tariff based bidding for transmission network development <u>Funding</u> • Gujarat Green Energy Fund • State govt. grant • 13th Finance Commission • Any other	• GEDA/GPCL- Integrated energy parks- Site identification, land banks, bidding, developer selection etc. • GETCO – grid planning, tariff based bidding (PPP)

Recommendations….

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Regulatory Interventions

Focal area of intervention	Action required	Roles and responsibilities

Amendment in Grid Code	Provisions to be included
	• Grid code specific issue
	• Forecasting
	  • State level and central level (SLDC/RLDC/NLDC) forecasting center for RE
	  • SLDC to consolidate the forecasting from all project owners
		• GERC to introduce amendment in grid code
		• Forecasting- GERC directive to project developers and owners to provide the desired data to SLDC

Spinning reserves and ancillary market	• Hydropower, gas based spinning reserves
	• CERC regulations for implementation of ancillary markets serve as guidelines for Gujarat
	• Primary responsibility of procuring ancillary services (SLDC). SLDC to pay through ARR/ separate budget provision
	  • Manner of procurement of services (Power exchange, bi-lateral contracts, tendering etc)
	  • Tariff determination by GERC
	  • Fixed- For availability Rs/ MW/month
	  • Variable- As and when services is called for (Rs/kWh)
	• Energy storage: Potential energy storage technologies to be explored
		CERC and GERC – Regulations for implementation of ancillary market

Recommendations….

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Other measures		
Focal area of intervention	**Action required**	**Roles and responsibilities**
Advocacy and coordination	Coordinated planning at regional and central level for • RE forecasting and scheduling • Gujarat SLDC may take a lead in developing the forecast evaluation methodology • Spinning reserves and ancillary market • Transmission network planning	GEDA, GUVNL, GERC and GETCO with CTU / Central Govt.

Grid code analysis

Sl. No.	Parameters	Approach	Recommendations
1	Fault ride-through capability	Required / Incentive	1. Solar and wind generating stations connected at 66 kV and above shall remain connected during the network fault and they will have fault ride-through capability of not less than some defined time which needs to be a priori fixed according to local grid requirements. 2. Fault ride-through requirement should follow a pattern mentioning percentage reduction in the grid nominal Voltage vs. Time for which plant should not trip. 3. Old wind power plant may get incentive for fault ride-through capability
2	Active power and frequency control	Required	1. The plant shall be capable of power output reduction steps as directed by load dispatch center. 2. A set point given by the network operator must be reachable from any operation point in any operation mode
3	Power balancing	Required	Some of the generator should be kept for spinning reserve which can be done by formulating a proper pricing mechanism for such schemes. To bring out the proper framework some exhaustive studies should be done.

Grid code analysis..

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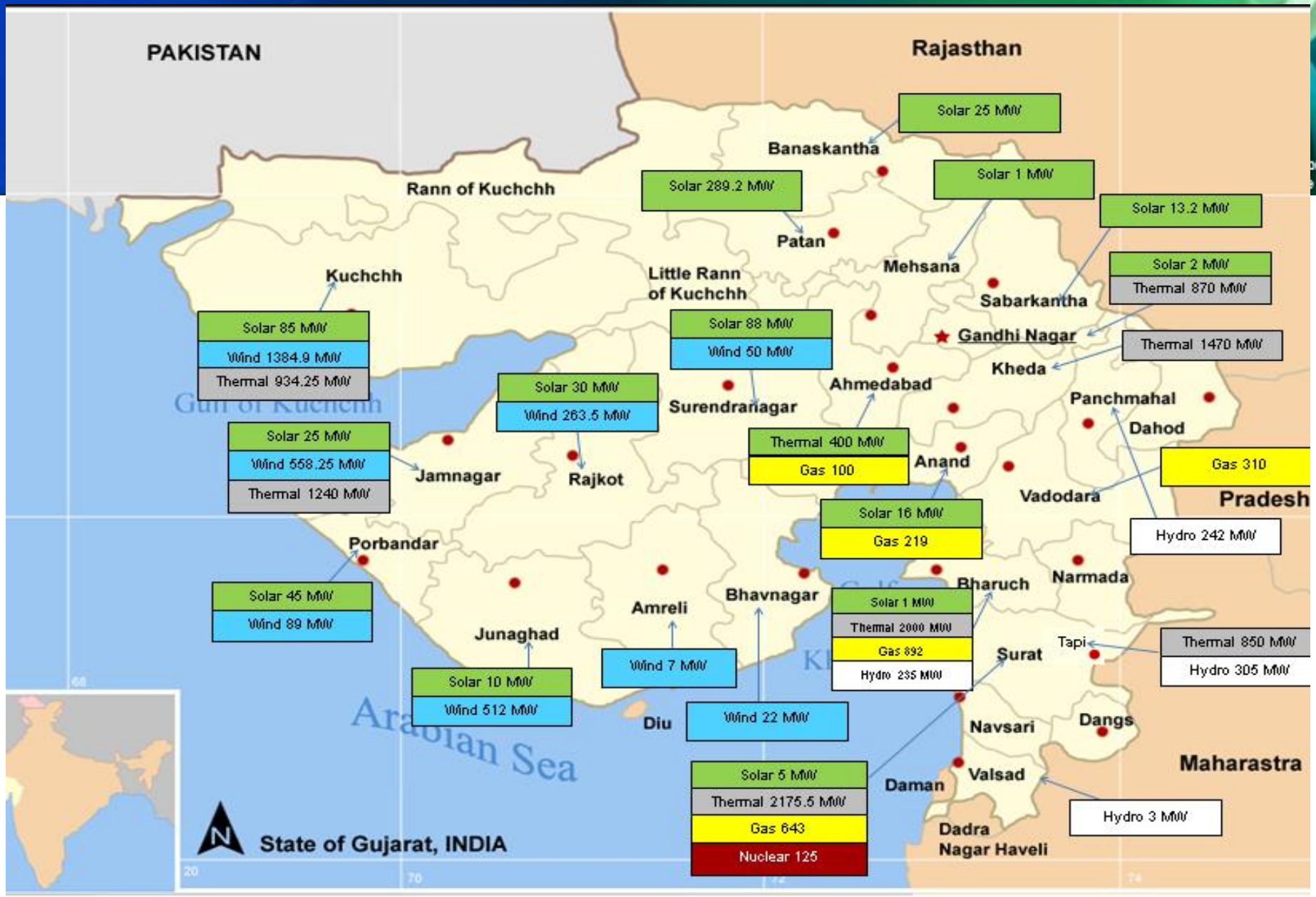
Sl. No.	Parameters	Approach	Recommendations
4	Reactive power supply	Required / Incentive	1. Solar and wind generating stations connected at 66 kV and above shall be capable of supplying dynamically varying reactive power support so as to maintain power factor within limits (a detail system study should be performed for defining the power factor limits). 2. To maintain the Reactive power/voltage control with high penetration of renewables, the Reactive power/ voltage control may be treated as ancillary service and the sources/devices contributing to reactive power for voltage control may also be appropriately incentivized. The proper pricing procedure can be formulated instead of flat pricing for reactive power exchanges (withdrawal/supply) by carrying out the exhaustive studies of various methods and their benefits and practical implications.
5	Forecasting	Required & Incentive	1. Forecasting should be carried out at developer level as well as at SLDC/NLDC level. 2. Standardisation of forecast evaluation methodology. Accuracy requirement may be worked out separately for high wind and low wind seasons
6	Power Quality	Required	The grid code should clearly mention the guidelines for power quality measures, e.g. allowable total harmonic distortion, flickers (e.g. 3% in Danish grid code).


PAKISTAN
Rajasthan
Solar 25 MW
Banaskantha
Solar 289.2 MW
Solar 1 MW
Rann of Kuchchh
Solar 13.2 MW
Patan
Mehsana
Solar 2 MW
Thermal 870 MW
Kuchchh
Little Rann of Kuchchh
Sabarkantha
Solar 85 MW
Wind 1384.9 MW
Thermal 934.25 MW
Solar 88 MW
Wind 50 MW
Gandhi Nagar
Thermal 1470 MW
Kheda
Solar 30 MW
Wind 263.5 MW
Ahmedabad
Surendranagar
Panchmahal
Dahod
Solar 25 MW
Wind 558.25 MW
Thermal 1240 MW
Thermal 400 MW
Gas 100
Anand
Gas 310
Jamnagar
Rajkot
Vadodara
Pradesh
Solar 16 MW
Gas 219
Hydro 242 MW
Porbandar
Narmada
Bharuch
Solar 45 MW
Wind 89 MW
Amreli
Bhavnagar
Solar 1 MW
Thermal 2000 MW
Gas 892
Hydro 235 MW
Junaghad
Tapi
Thermal 850 MW
Hydro 305 MW
Surat
Wind 7 MW
Solar 10 MW
Wind 512 MW
Diu
Wind 22 MW
Navsari
Dangs
Arabian Sea
Maharastra
Solar 5 MW
Thermal 2175.5 MW
Gas 643
Nuclear 125
Daman
Valsad
Hydro 3 MW
Dadra
Nagar Haveli
State of Gujarat, INDIA

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Gujarat RE installation as per 17% state RPO target by 2021-22

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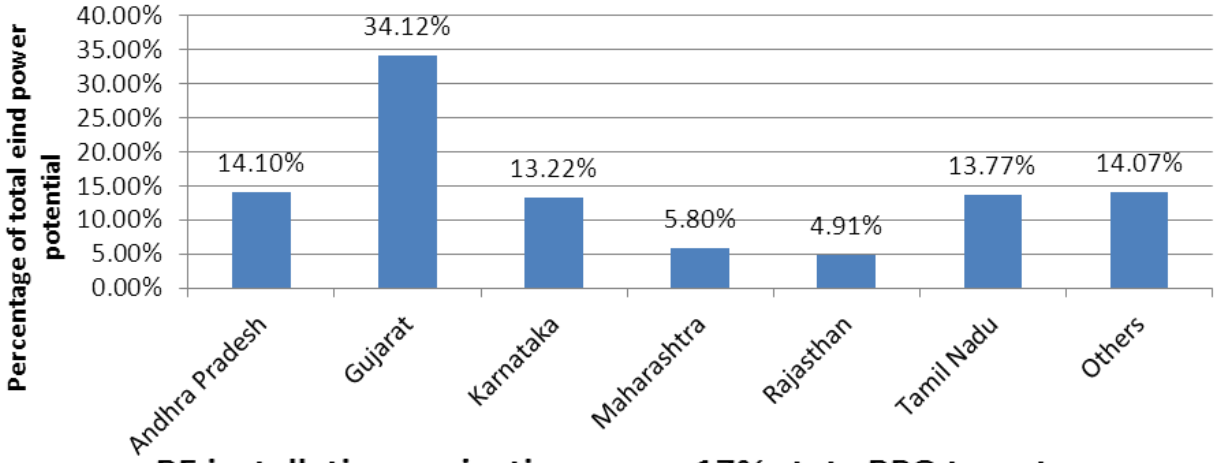
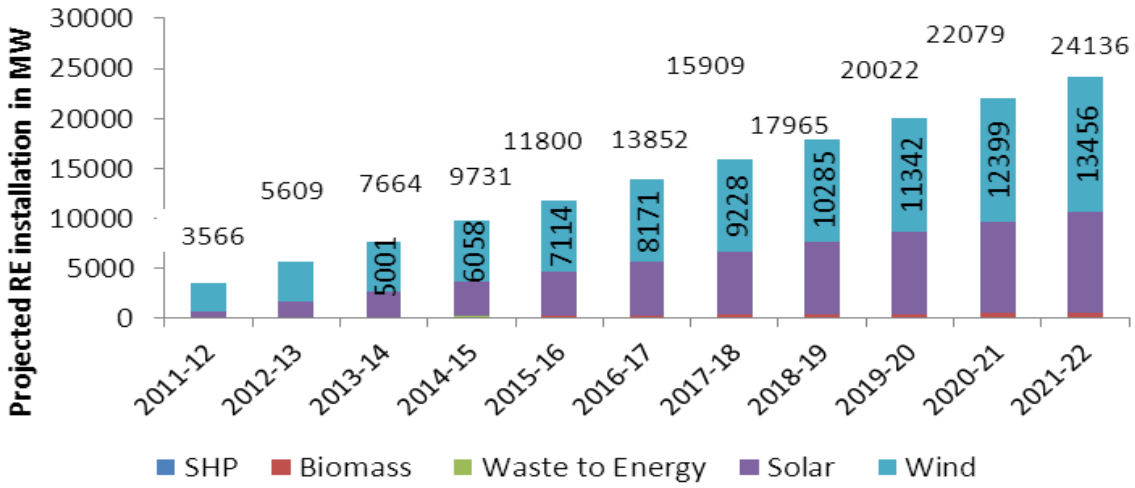
State wise percentage of total wind power potential in India at 80 m hub height



RE installation projection as per 17% state RPO target for Gujarat



Estimated integrated RE potential in Gujarat

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District	CSP with water availability (GW)	SPV Wind hybrid excluding CSP land (GW)	Only SPV excluding wind and CSP	Only wind excluding solar potential land (GW)	Biomass (GW)	Total integrated potential (GW)
Ahmedabad	1.61	1.45	1.01	0.00	0.06	4.13
Amreli	5.87	6.91	0.00	0.11	0.14	13.03
Anand	0.00	0.00	0.00	0.00	0.02	0.02
Banaskantha	7.74	5.87	0.27	0.95	0.08	14.90
Bharuch	22.74	1.84	0.00	0.24	0.04	24.86
Bhavnagar	3.93	9.04	0.00	0.01	0.19	13.17
Dahod	24.96	5.34	0.00	0.00	0.02	30.32
Gandhinagar	0.80	0.07	1.00	0.00	0.03	1.90
Jamnagar	37.11	12.67	0.41	1.04	0.21	51.44
Junagadh	3.94	5.26	0.38	0.00	0.19	9.77
Kachchh	87.76	148.13	8.92	133.26	0.07	378.14
Kheda	5.48	2.72	0.00	0.00	0.04	8.24
Mahsana	0.33	0.39	0.76	0.00	0.05	1.53
Narmada	17.76	1.69	0.00	0.00	0.03	19.47
Navsari	0.48	0.59	0.14	0.10	0.01	1.32
Panchmahal	7.21	3.39	0.00	0.00	0.01	10.61
Patan	7.03	1.20	0.00	1.87	0.04	10.14
Porbander	0.00	0.94	0.00	0.00	0.04	0.98
Rajkot	17.61	11.19	2.46	0.08	0.23	31.57
Sabarkantha	14.49	5.83	5.27	0.00	0.09	25.68
Surat	25.88	3.70	0.60	0.01	0.03	30.23
Surendranagar	4.26	4.29	0.00	1.11	0.14	9.79
The dangs	0.00	0.51	0.00	0.00	0.02	0.54
Vadodara	44.00	5.34	0.00	0.00	0.10	49.45
Valsad	4.71	2.24	0.13	0.43	0.02	7.53
Total	**345.71**	**240.60**	**21.36**	**139.21**	**1.89**	**748.77**

Power sector profile of Gujarat

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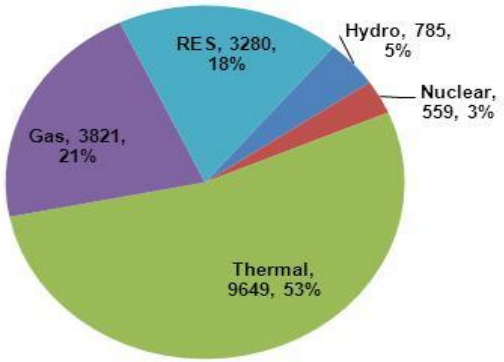
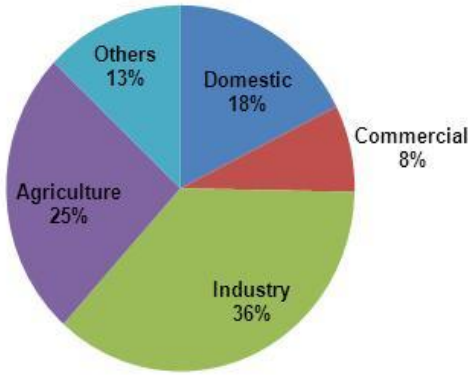
Installed capacity in MW (as on 31 March 2012)



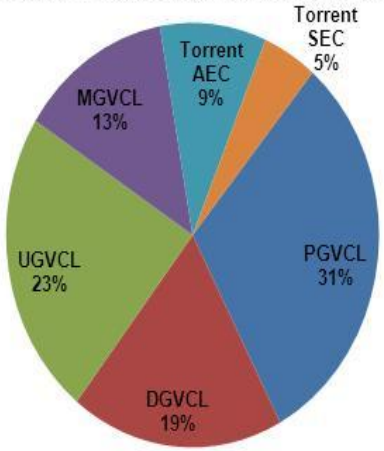
Installed capacity	Share
State	28%
Private	53%
central	19%

RES includes- solar, wind, biomass
Source: SLDC Annual report 2011-12

Category wise consumption in 2010-11



Discom wise energy catered in 2011-12



Source: Tariff orders of discoms , 2012

- **Installed capacity of about 18,093 MW as on 31st March 2012**
- **Captive power plant capacity 5642 MW (109 MW wind)**
- **Most of the conventional plants located in Central and South Gujarat (56% in south, 17% in Central)**
- **Low peak and energy shortage is of 2% and 0.4% respectively in 2011-12**
- **Gujarat is a major seller of energy in the short term market. Contributed around 11.3% and 48% of electricity sold on IEX and PXIL respectively.**
- **Conventional power plants located mostly in Central and Southern Gujarat**

Overview of Gujarat RE sector

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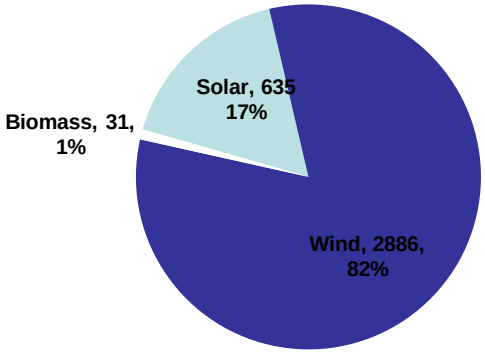
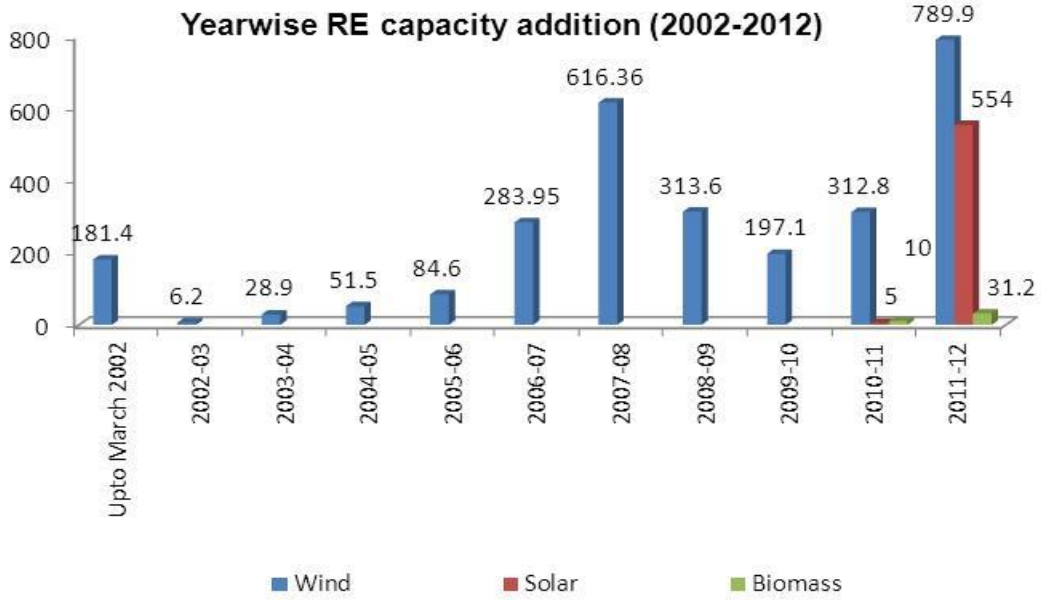
Breakup of RE installed capacity (as on 31 March 2012)





Source: SLDC Annual report 2011-12 , C-WET

Immense RE potential 749 GW
TERI estimated integrated resource potential shows

- **Wind- 139.2 GW**
- **Solar CSP*- 345.71 GW**
- **Solar PV-21.36 GW**
- **SPV wind Hybrid 240 GW**
- **Biomass- 1.89 GW**
- **Tidal-6.8 GW**

- **RE contributed 18% of the installed capacity and 5.3% of the electricity generation in 2011-12**
- **Wind and solar dominate the RE portfolio**
- **Historical capacity addition trends show significant growth in wind and solar capacity.**
- **Wind and solar concentrated in Kutchh and Saurashtra regions**

RPO and REC status in Gujarat

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Year	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
RPO target	1%	1%	2%	2%	Wind -4.5% Solar-0.25% Others-0.25% Total- 5%	Wind -5% Solar-0.5% Others-0.5% Total -6%	Wind -5.5% Solar-0.5% Others-0.5% Total -7%
RPO compliance	NA	2.07%	NA	2.55%	NA	Wind -4.3% Solar-0.26% Others-0.15% Total – 4.7%	

- **Gujarat has historically been able to meet its RPO targets**
- **Shortfall experienced in 2011-12, probably for the first time**

Out of 3279 MW, 321 MW registered under REC (wind -316.9 MW, biomass and biofuel-cogen- 4.2 MW)
The fourth ranked state in terms of REC accredited and registered projects (after TN, Maharashtra, and UP)

Solar energy injection pattern

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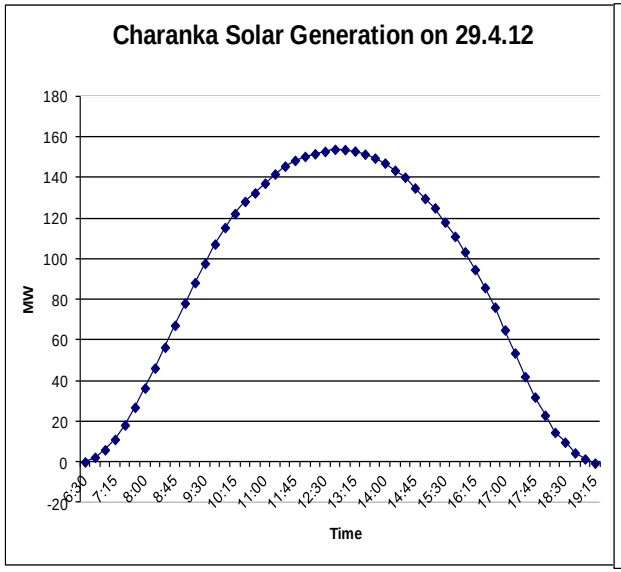
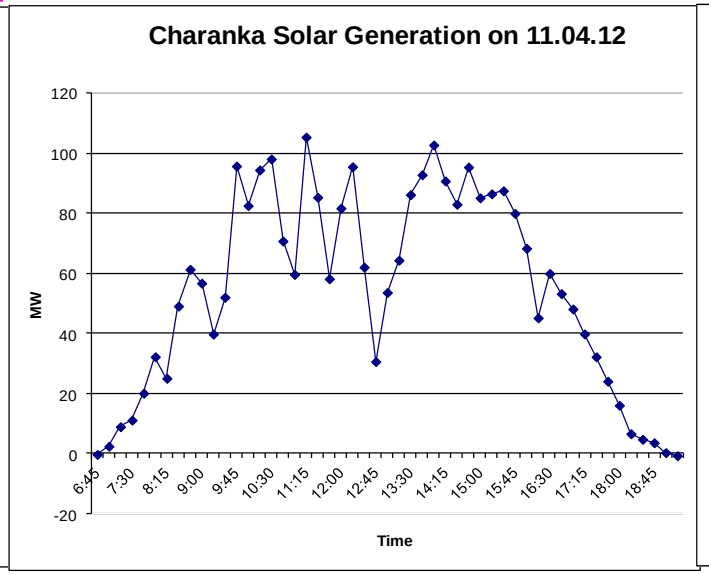
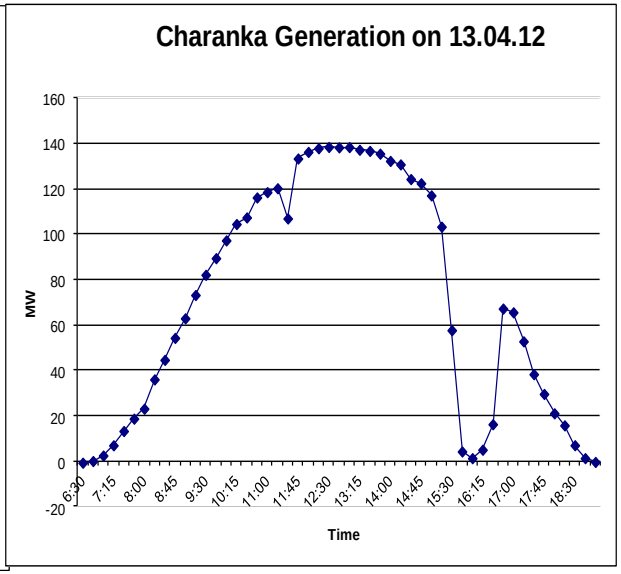
Generation in a normal Sun-shine day:



Varying Output:

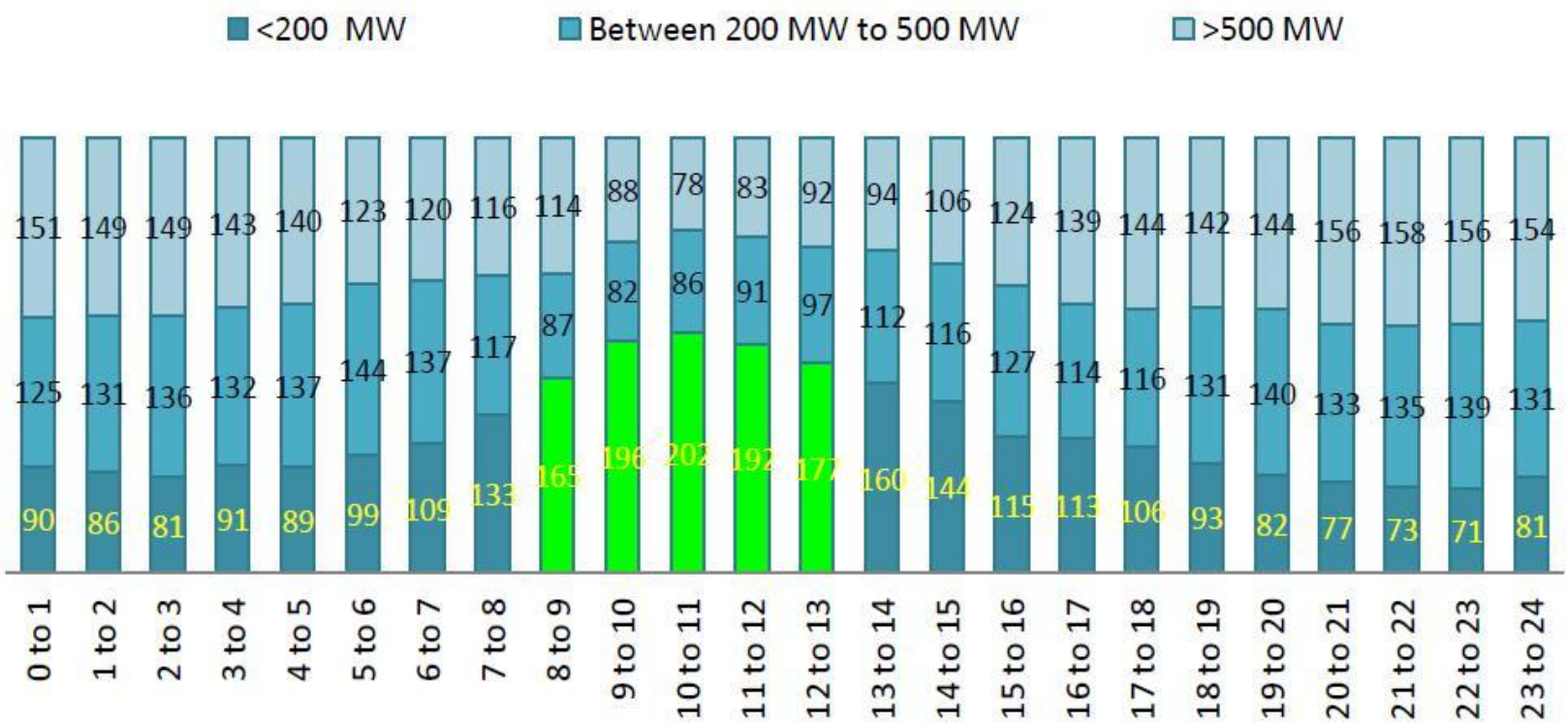


Sudden Variation in Generation:



1. **Generation from solar is higher during 9:00 hrs. to 16:00 hrs. in a normal sun-shine day.**
2. **Like wind there is also reasonable varying output and sudden variation in case of solar.**
3. **Number of days of variation in a year is likely to be less than wind.**

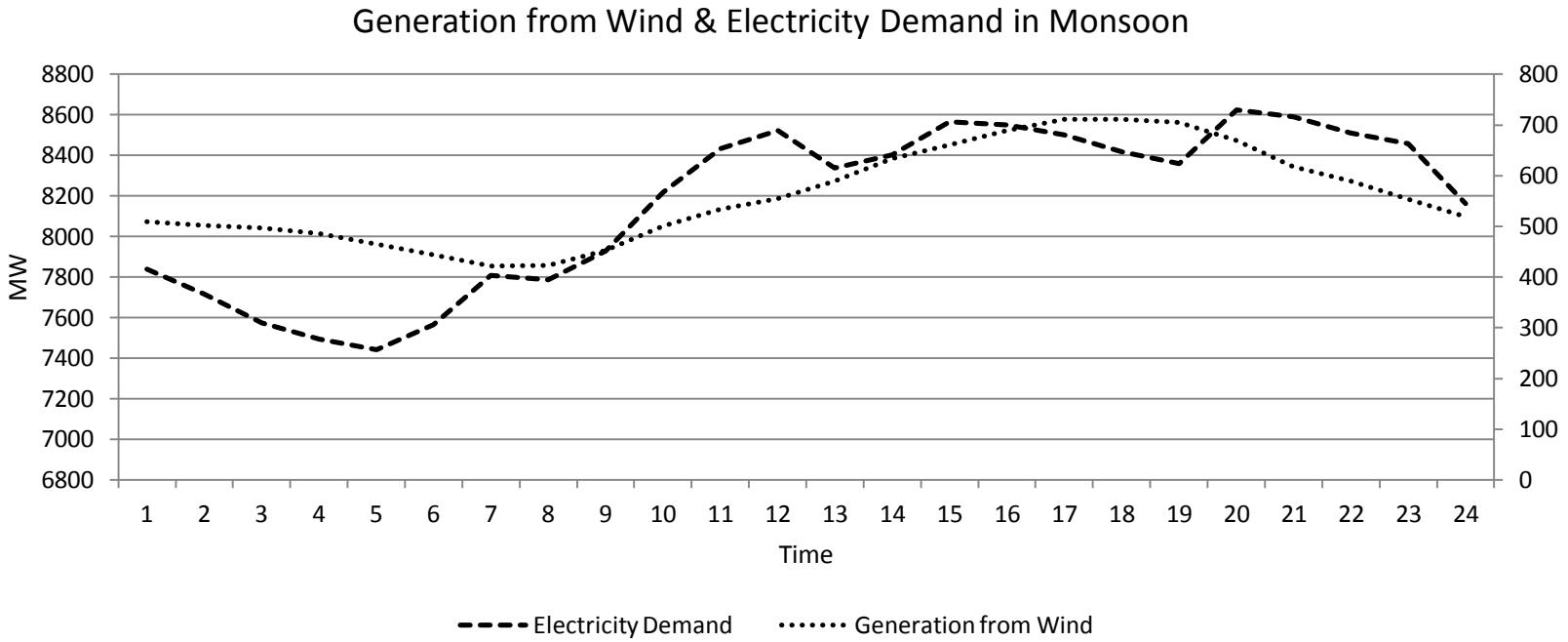
Hourly wind energy injection trend during the year 2011-12



Source: Gujarat SLDC annual report 2011-12

From the above graph, it is observed that the wind energy injection between 8:00 hrs. to 13:00 hrs. during the year is quite less.

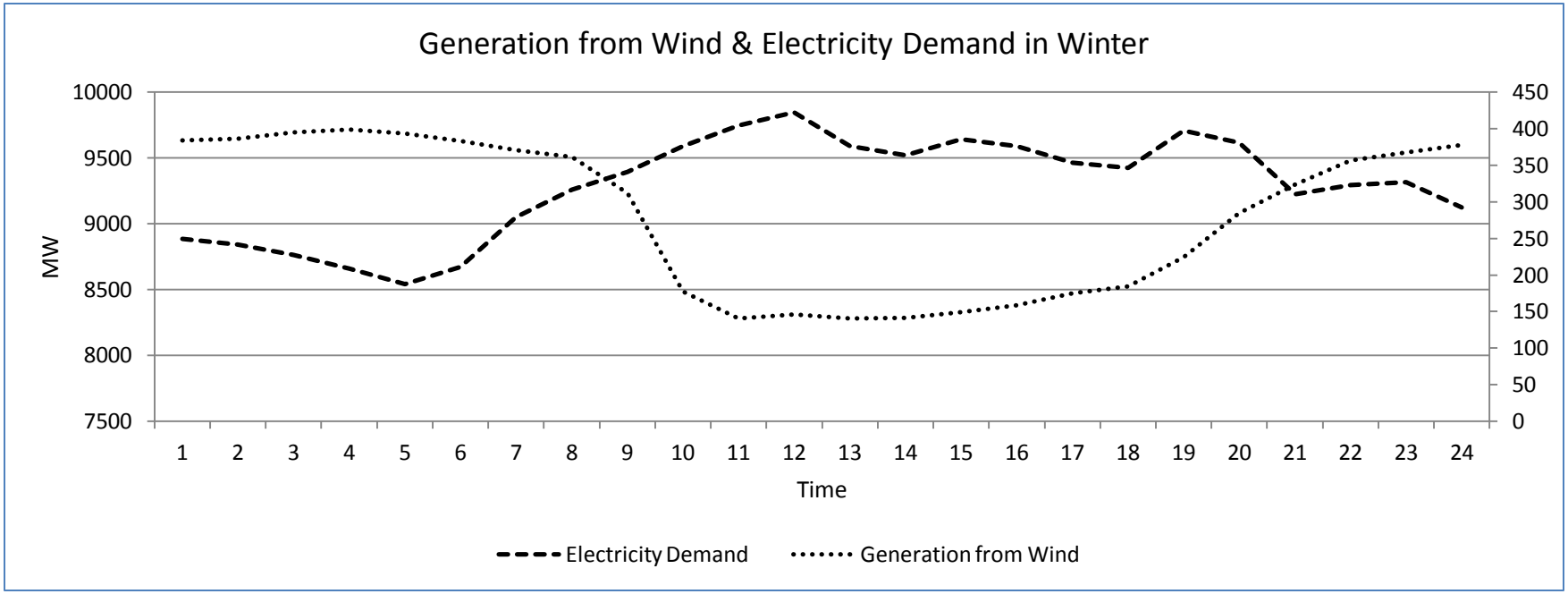
Pattern of total electricity demand and generation from Wind in Gujarat



1. **In Monsoon(Jun-Sep), electricity demand is minimum and Wind generation is maximum (compared to other seasons)**

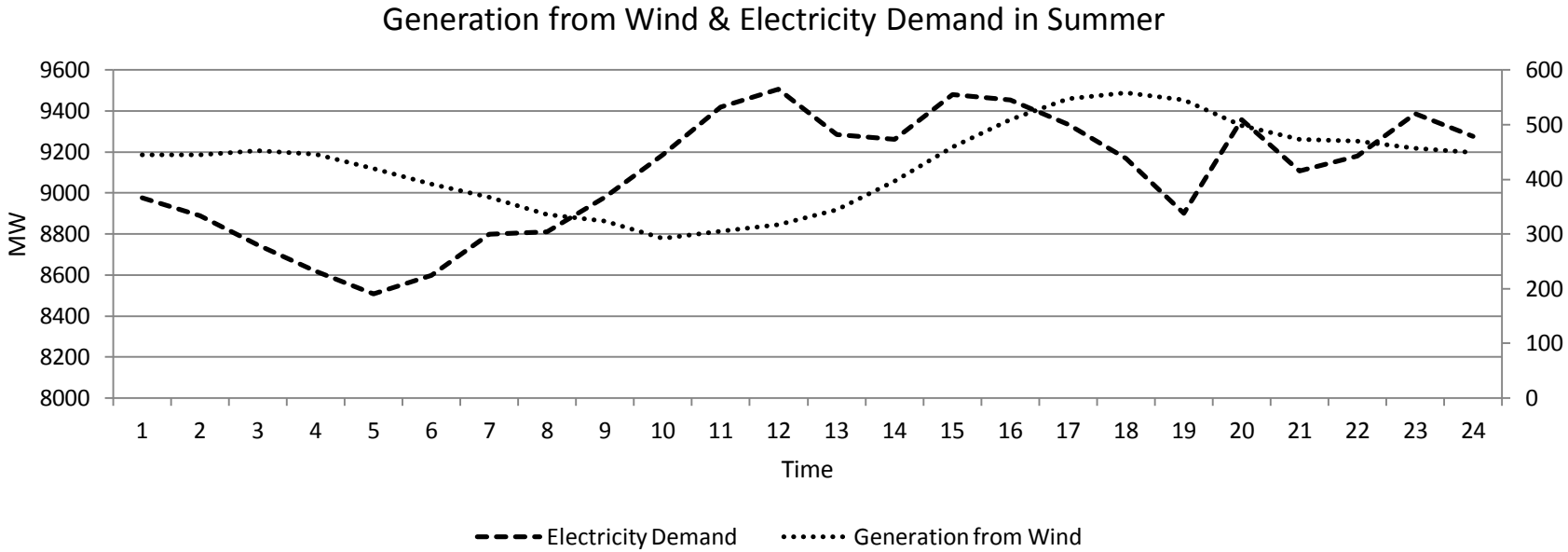
2. **Wind availability pattern in monsoon almost matches with electricity demand pattern during the peak hours.**

Pattern of total electricity demand and generation from Wind in Gujarat



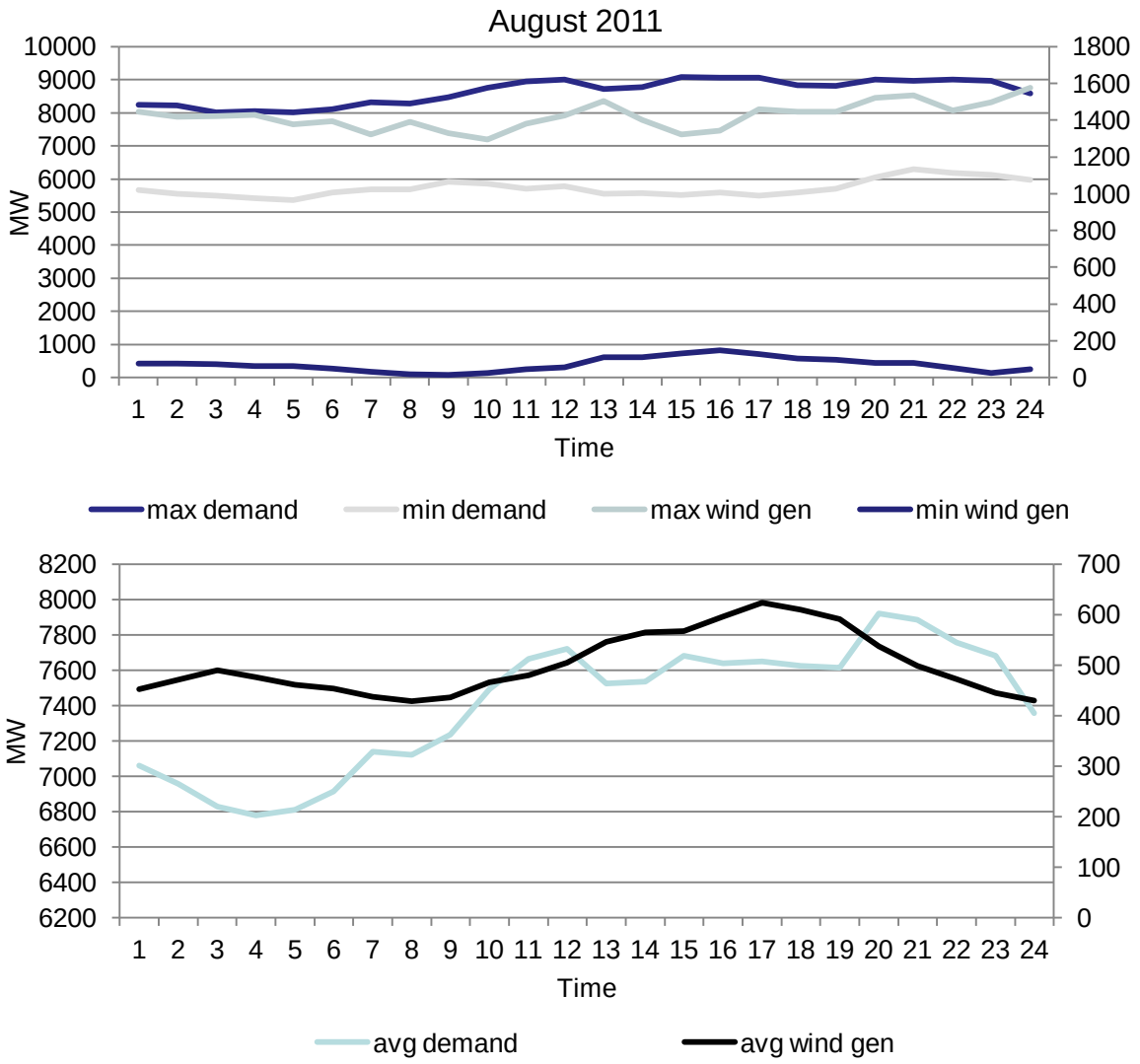
1. **In winter(Oct-Jan), electricity demand is maximum and Wind generation is minimum as compare to other seasons.**
2. **Wind availability pattern in Winter doesn't match significantly with demand pattern.**
3. **Agricultural demand along with heating load in winter is high as compare to other seasons.**

Pattern of total electricity demand and generation from Wind in Gujarat



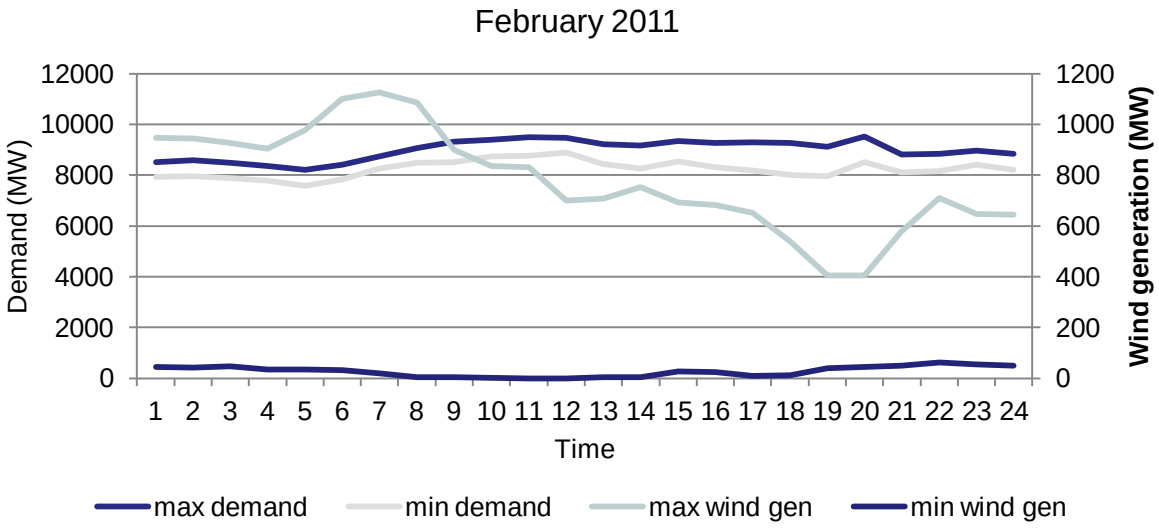
1. **In Summer(Feb-May), both electricity demand and Wind generation are moderate**
2. **For some number of hours in a day wind variability pattern matches with load variation.**
3. **There is a significant contribution of agricultural load (summer crops; Bajri, paddy etc.) along with cooling loads in summer.**
4. **Demand drops sharply in the evening time (between 18:00 hrs to 20:00 hrs) due to shifting of load from agriculture to domestic.**

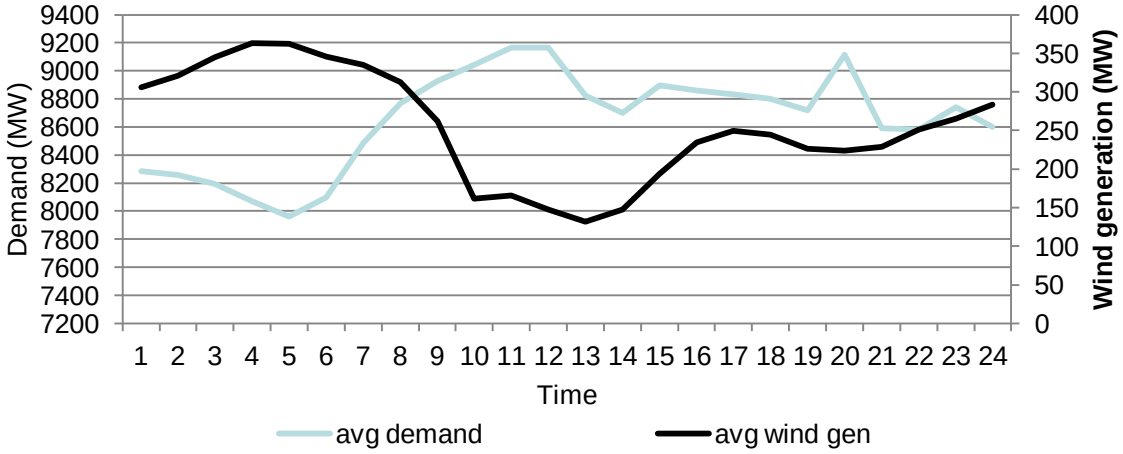
Electricity demand and generation in high wind season



- Electricity generation from Wind in the month of August follows demand pattern.
- High wind and high demand: Wind is capable of meeting around 15% - 17% of electricity demand.
- Low wind and low demand: wind is capable of meeting 0 to 2.6% of electricity demand.
- High wind and low demand: there is a case that at 24:00 hour wind is meeting 26.4% of electricity demand.
- Low wind and high demand: wind contributes maximum of 1.6% towards electricity demand.
- In the month of August the range of meeting electricity demand by wind varies from 0 to 26.4%

Electricity demand and generation in low wind season





- Electricity generation from Wind in the month of February doesn't follow the demand pattern.

- High wind and high demand: Wind is capable of meeting around 4.2% - 12.9% of electricity demand.

- More variability in the wind availability has been observed in the month of February.

- Low wind and low demand: wind is capable of meeting 0 to 0.8% of electricity demand.

- High wind and low demand: there is a case that at 7:00 hours **wind is meeting 13.6 % of electricity demand**

- **Low wind and high demand: wind contributes maximum of 0.7% towards electricity demand**

RE penetration scenario

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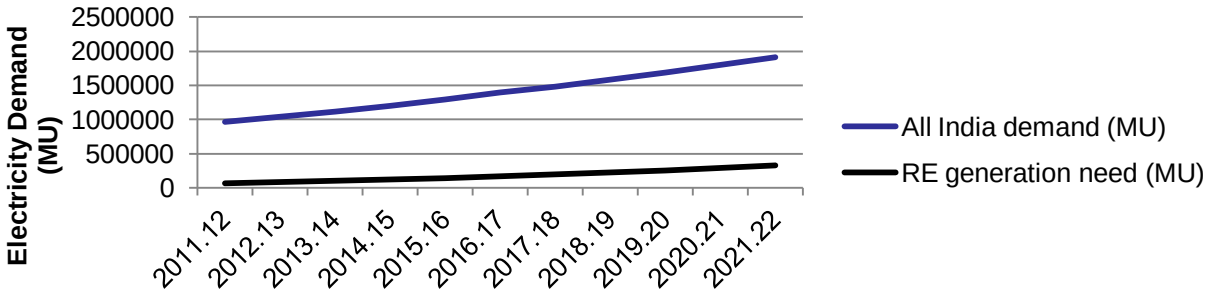
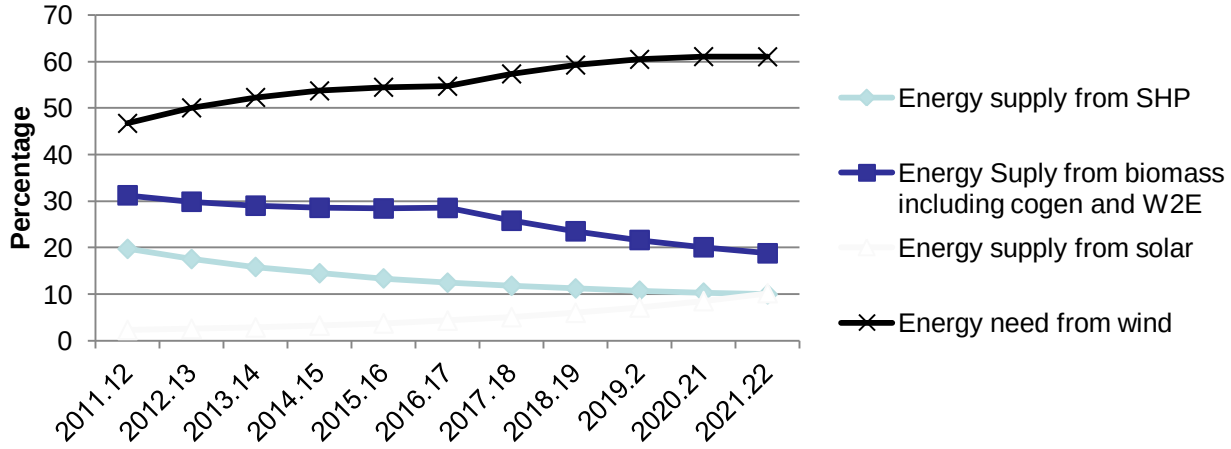
All india RE generation demand as per NAPCC RPO target



Percentage contribution of various RE sources in total national RE demand



1. **17% National RPO target by year 2021-22**
2. **SHP and biomass power addition as per historical growth rate**
3. **Solar power addition as per JNNSM target**
4. **Rest of the RE generation is assumed through wind only**

RE penetration scenario

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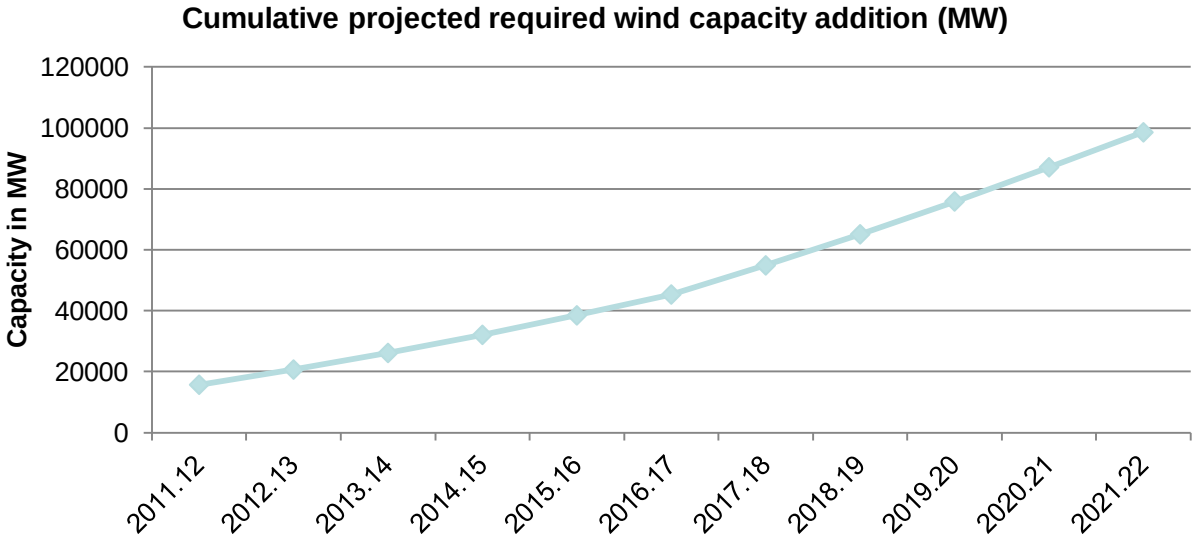
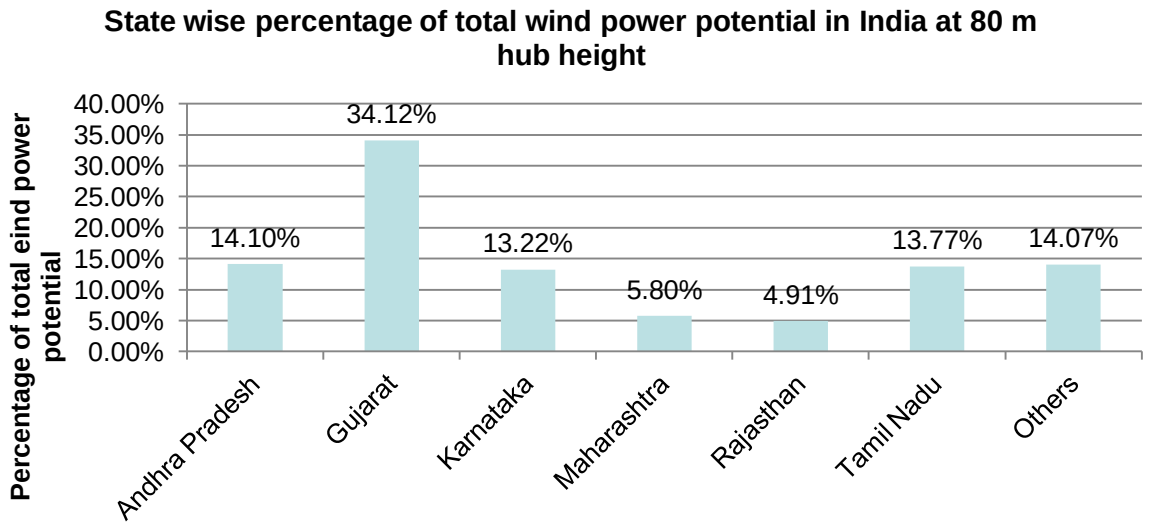
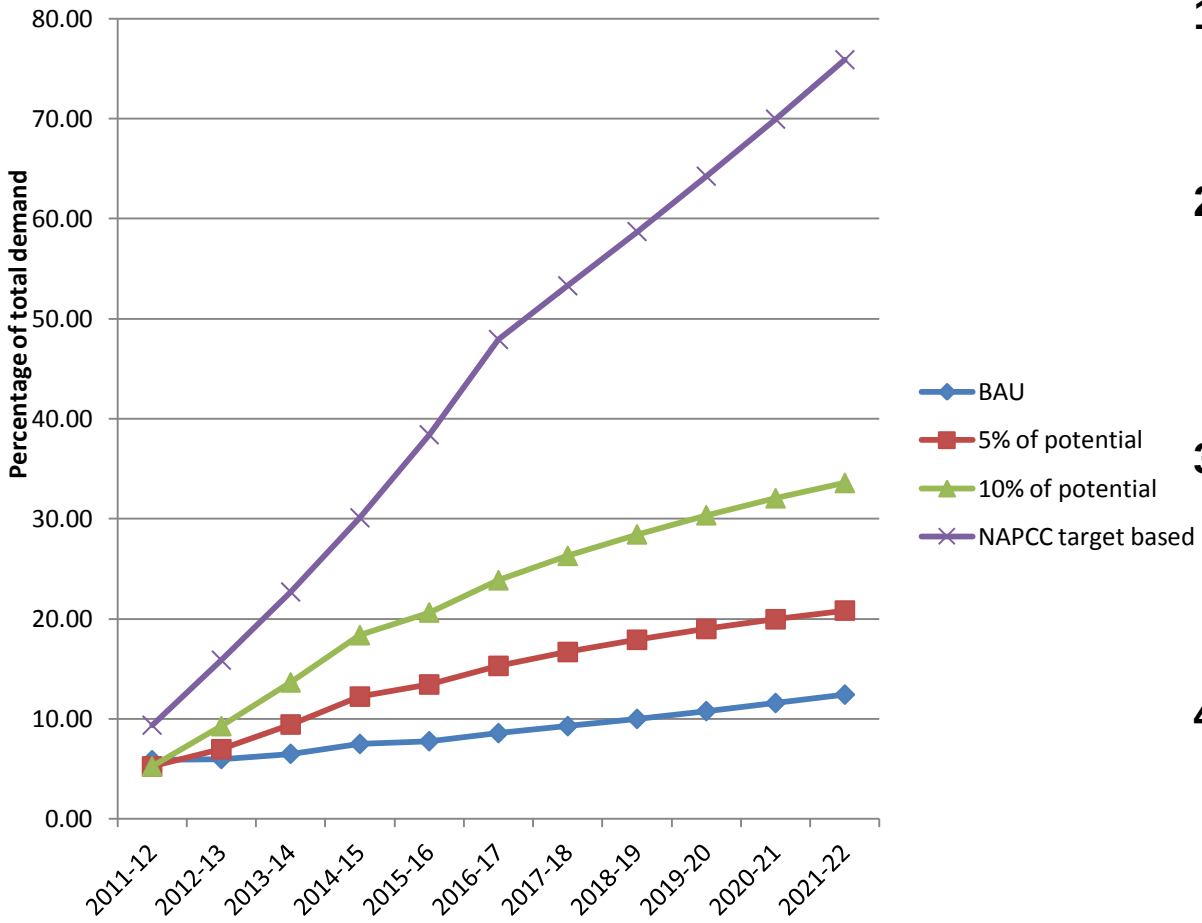




1. **Total wind capacity addition of about 100 GW would be required by 2021-22 to meet the NAPCC national RPO target**
2. **Gujarat having the maximum potential will be the most preferable state to contribute towards wind power installation**

RE penetration scenario in Gujarat



1. **BAU- GEDA plan up to 2016-17 and then constant capacity addition**
2. **5% of potential- Assuming tapping of 5% of solar and wind potential by 2021-22**
3. **10% of potential- Assuming tapping of 10% of solar and wind potential by 2021-22**
4. **NAPCC target based scenario**

Operation of grid with wind generation

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Scenario-1: An affirmative scenario, i.e. Wind generation follows load variation

- **Not an issue in grid operation**

Scenario-2: Load remain constant along with increase in wind generation

- **Backing down of conventional power plants**
  - Conventional power plants are asked to back down their generation during light load periods to accommodate RE.
  - Backing down is done on the basis of merit order dispatch.

Scenario-3: Load remain constant along with drop in wind generation

- **Needs spinning reserves- Gas based power plants are being used as spinning reserve**
- **load shedding**
  - Generally shedding is not being practiced in Gujarat.
  - Only in extreme cases the load regulation is done during high demand and low wind availability period if conventional power plants unable to meet the required demand.
  - Equal %age of reduction in load at each feeder is followed on priority basis for load shedding.
- **If frequency permits, there is possibility of over drawl at the prevailing rate.**

- **SLDC analyses the trend of wind generation and plans for conventional backing down.**
- **Till now SLDC has been able to manage it most of the time**

GETCO methodology for grid expansion planning

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- 17th EPS data
  - **Peak demand and discom wise energy demand projections**
- Anticipated generation capacity addition in Gujarat
  - **both conventional and renewable**
- System study
  - **It follows CEA transmission system planning and design criteria**

- Currently RE addition anticipated based on pending applications mainly
- **Maximum load of wind and solar is considered as 80% of installed capacity.**

- GETCO has prepared the transmission plan for 12th five year plan and looking for the funding for it

Power congestion issues in Gujarat

- Congestion in Deodhar, Shivlakha, Shankhari networks . Overloading of 220/66 kV Shivlakha ICTs
- RE plants providing lesser grid support during system disturbances than the conventional in terms of MVAR/active Power regulation.

- No major issues have been observed due to wind and solar energy variations till now

This scenario may change with increase in wind and solar energy penetration i.e. above 30% average from current average of about 5%

Solutions for future RE integration management

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- Wind power forecasting
- Grid strengthening
- Advanced grid planning
- Spinning reserves and ancillary market
- Properly defined RE grid integration regulations
  - **Grid codes**
  - **CEA grid connectivity standards etc.**

Wind power forecasting

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- Developers have started giving their forecast data
- As per developers analysis the forecasting models are not predicting accurately
  - **Error level in forecasting is huge (50% to 300%)**
  - **Generally the error of forecasting is higher in low wind season than the high wind season.**

- Is Gujarat ready for taking forecasted data and use it
  - **Yes**
    - **Gujarat has the ABT meters installed for 15 min interval energy data recording**
    - **RTUs are placed at all 220 kV and above s/s for remote data transfers to SLDCs**

Our suggestion

- Apart from the Developers forecast there shall be a forecasting unit at SLDC level to centrally forecast for all Wind farms. This UNIT will also be responsible for managing all RE related data
- **RE data management centres to be set up at SLDC and ARLDC level**
- **SLDC may also hire independent consultant for renewable energy forecasting**

Advance grid planning

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It is suggested that

- GETCO along with GEDA and GUVNL shall consider the RE potential distribution in the state for future network planning
- GEDA/GETCO may invite the future development plans (5-10 years) from wind and solar power developers, for the advance planning of grid network.
- Gujarat govt./GETCO to coordinate and collaborate with central govt./CTU for
  - **Grid network within state**
  - **Interstate network**
- Integrated Solar and Wind Parks
  - **Will help in advance grid planning and competitive bidding**
  -

Spinning reserves/storage

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- Hydropower and gas based power plants are considered as good spinning reserve for balancing of power
- At present about 785 MW of Hydro and 2164 MW of Gas based power plants capacity is operational in Gujarat.
- Hydro power is limited in the state
  - **Interstate collaboration needs to be sought for sharing of hydro generation capacity to address the variability of RE generation in the state**
- Gas based power plants will be the main source in Gujarat for spinning reserves so there is a need for coordinated planning of gas based power plants along with the renewable energy development planning
- Gas based power plants should be installed in high solar and wind potential areas to act as spinning reserve. Gas turbines could run at certain capacity (about 50% of rated capacity) for break even and rest could act as spinning reserve.
- solar and wind hybrid systems need to be installed in potential areas
- Gujarat is blessed with a large capacity of tidal energy. Issues of limited hydro resource in Gujarat can be minimised by utilising tidal potential.
- Potential energy storage technologies to be explored.

Thank You