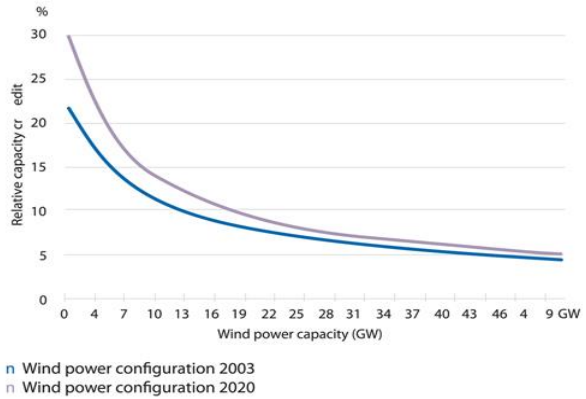


Methodology for
Capacity Credit of Generation Resources
&
Coincident Peak Requirement of Utilities
under
Resource Adequacy Framework




Integrated Resource Planning in India

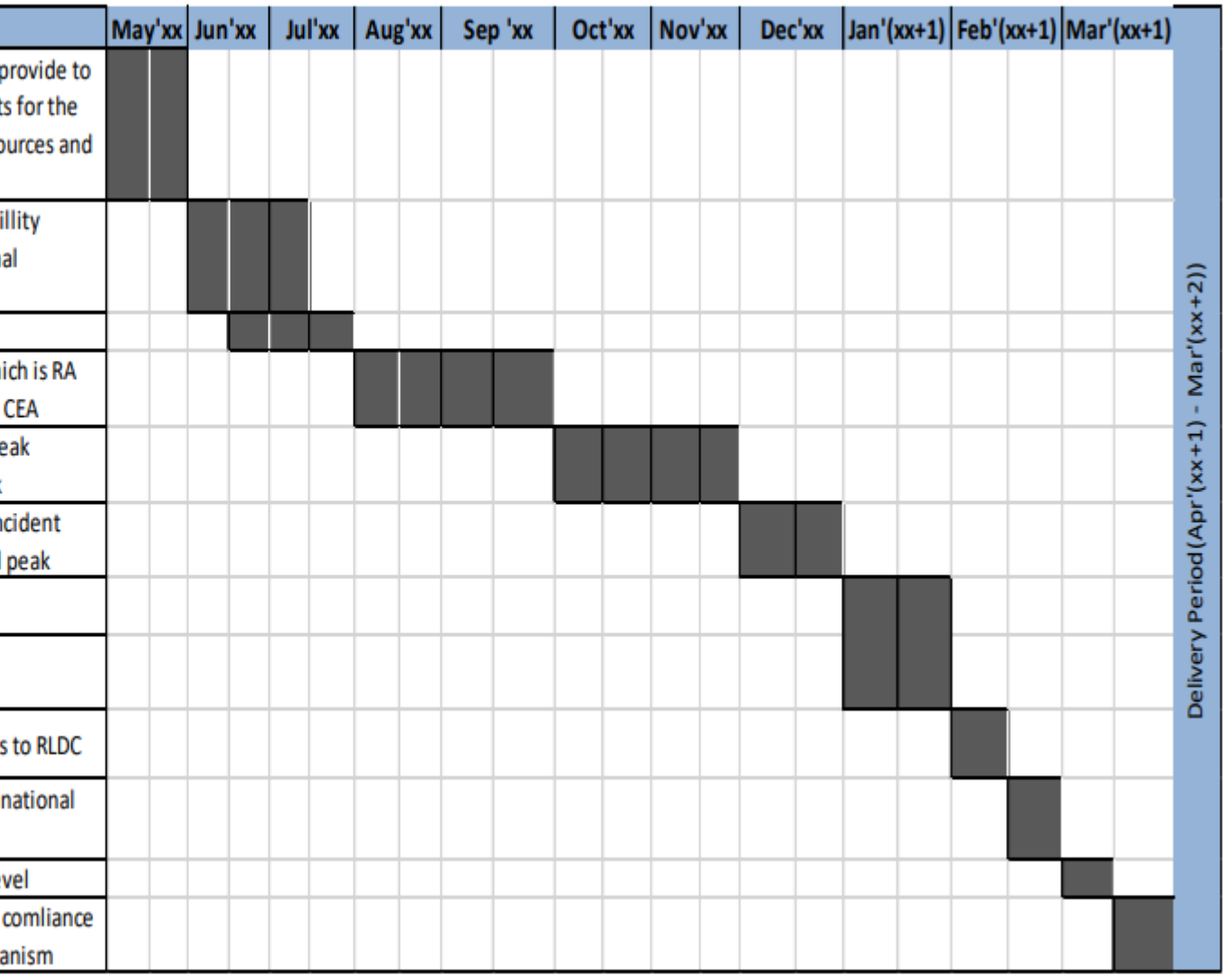
- **Electricity Act, 2003**
  - The Central Electricity Authority shall prepare a National Electricity Plan and notify such plan once in five years

- **CERC (Indian Electricity Grid Code) Regulations**
  - Load Generation Balance Report (LGBR) to be prepared by Regional Power Committees on an annual basis with monthly reviews
  - NLDC, RLDCs and SLDCs to carry out operational planning studies on weekly, daily and real time basis

- **Electricity Amendment Rules 2022**
  - Resource Adequacy Framework institutionalized through notification of Resource Adequacy Guidelines in 2023
  - Responsibilities assigned to CEA, NLDC/RLDCs, SLDC, CERC and SERCs

Resource Adequacy Guidelines 2023

Entity	Description
STU/SLDC	STU/SLDC, on behalf of distrubution licensees shall provide to CEA and NLDC the details regarding demand forecasts for the next 5 years, assessment of exisiting generation resources and other details required for LT-NRAP and ST-NRAP
CEA	To publish LT-NRAP containing National PRM, Reliabillity Metrics, Coincident peak, capacity credits and Optimal Generation mix for 10 years horizon.
NLDC	To publish ST-NRAP.
Discoms	LT-DRAP exercise for long term horizon(10 years) which is RA compliant as per coincident peak to be submitted to CEA
CEA	Vetting of discom's contracting plan for coincident peak contribution and to meet their own energy and peak
SERC	SERC to approve of discom's contracting plan for coincident peak contribution and to meet their own energy and peak
Discoms	To contract capacities as per approved plans.
	Submit contract capacities to STU/SLDC
STU/SLDC	STU/SLDC to submit state-level aggregated capacities to RLDC
RLDC	RLDC submit regional-level aggregated capacities to national level
POSOCO/NLDC	POSOCO/NLDS to check RA compliance at national level
	Any Shortfall shall be communicated to the SERC for comliance or is balanced through a national level auction mechanism



Why RA ?

Significant diversity in demand and supply patterns across States

North- south/East-West/Hilly – Non-Hilly States

Isolated state wise procurement planning

Over capacity in Some States

Fixed cost liability to many states

No mechanism to enforce and monitor capacity adequacy

Poor liquidity in the power market

Ensuring Energy Security

Meeting our increasing electricity demand Adequate Generation capacity addition

Judicious mix of capacity guided by scientific principles

Role of Central Electricity Authority

Publish Long-term National Resource Adequacy Plan (LT-NRAP) at the All-India level conforming to the reliable supply targets(section 3.1)

Publish the capacity credits for different resource types on a regional basis. (Section 3.1)

CENTRAL ELECTRICITY AUTHORITY

Specify the State/UT's contribution towards national peak. (Section 3.1)

Publish the national-level PRM as a guidance for all the States/UTs to consider while undertaking their RA exercises. (section3.1)

Coincident Peak

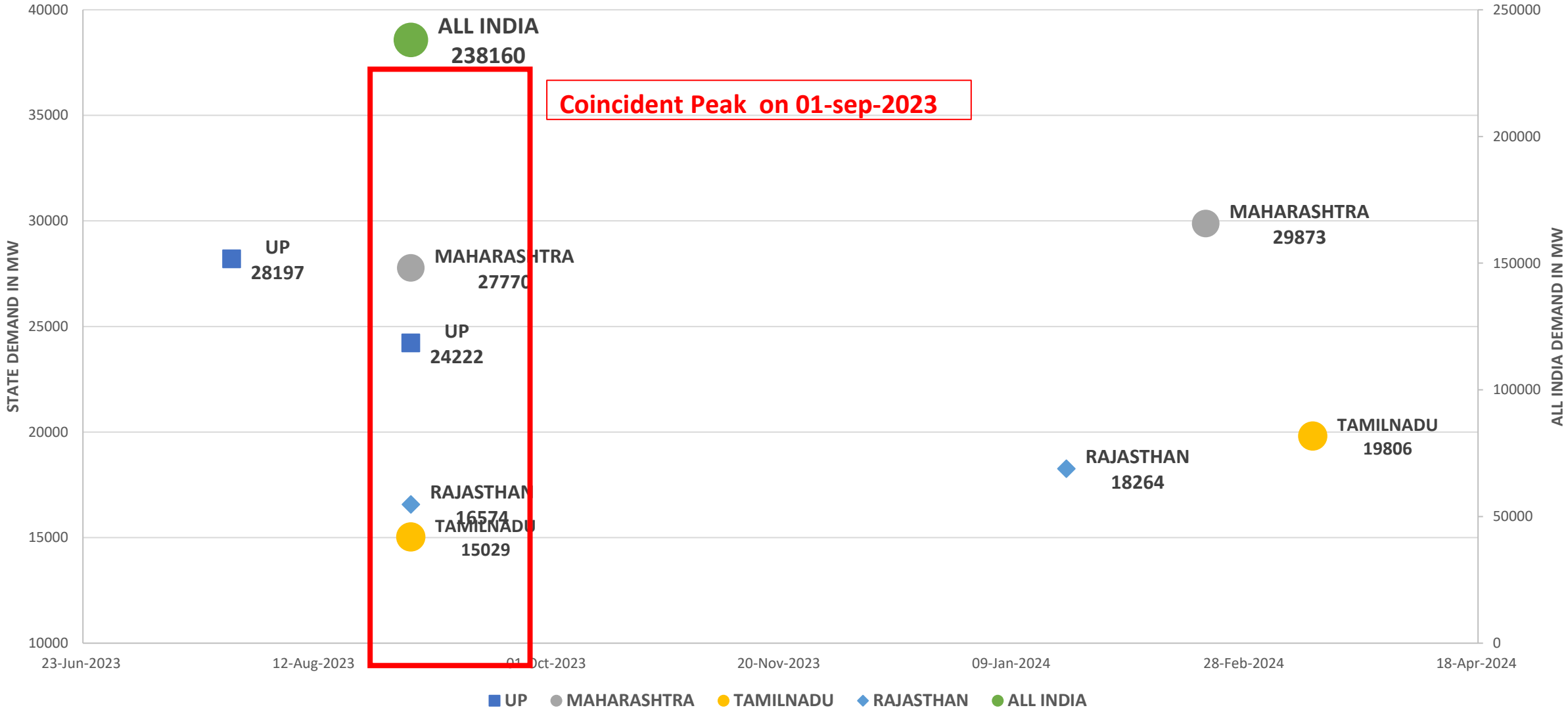
What is Coincident Peak?

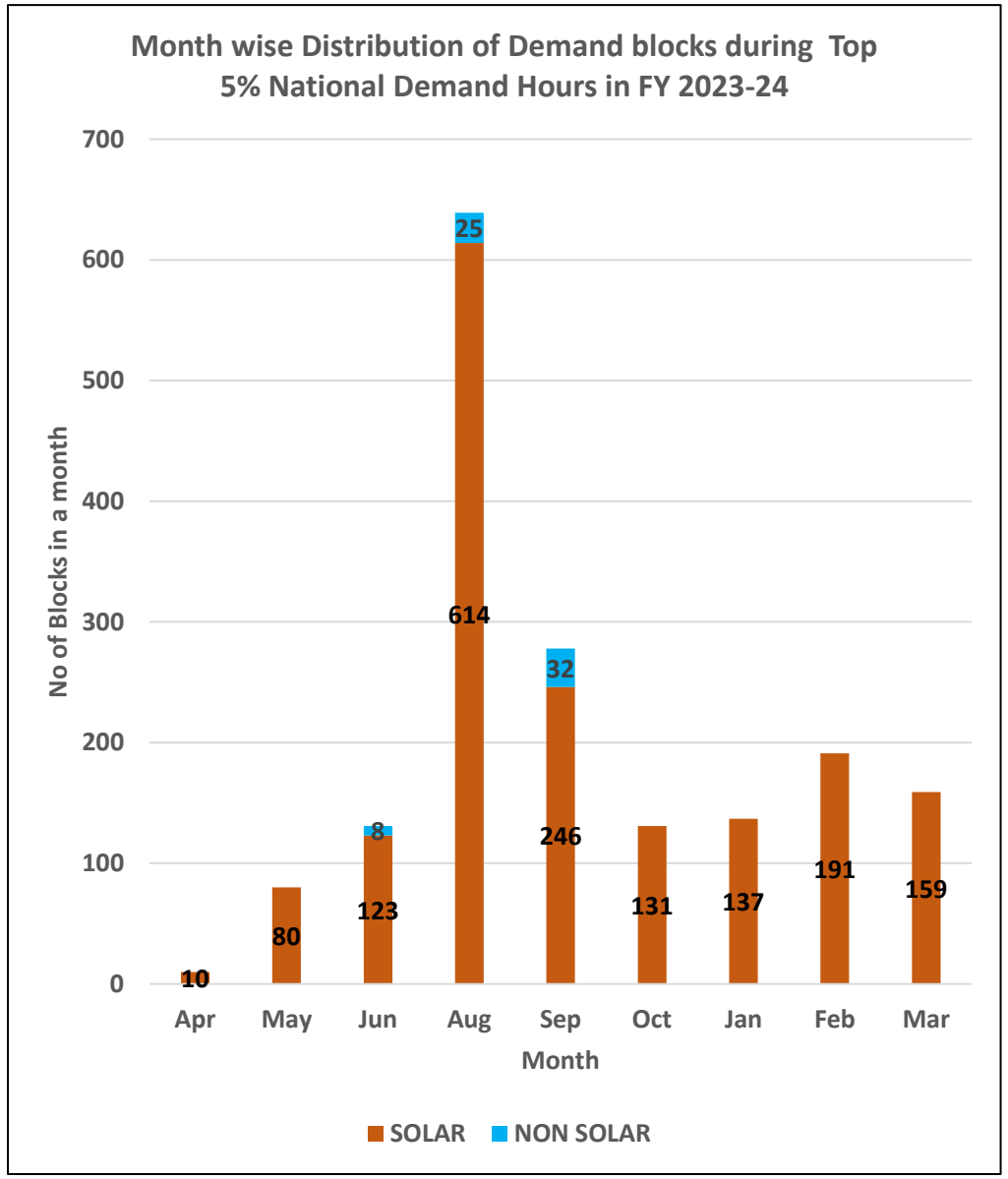
- Contribution of State/UT or Distribution Utilities during National Peak
- Top 5% of National Peak instead of Single Peak
- Determined separately for solar and non solar hours
- May or May not be same as own peak of State/UT

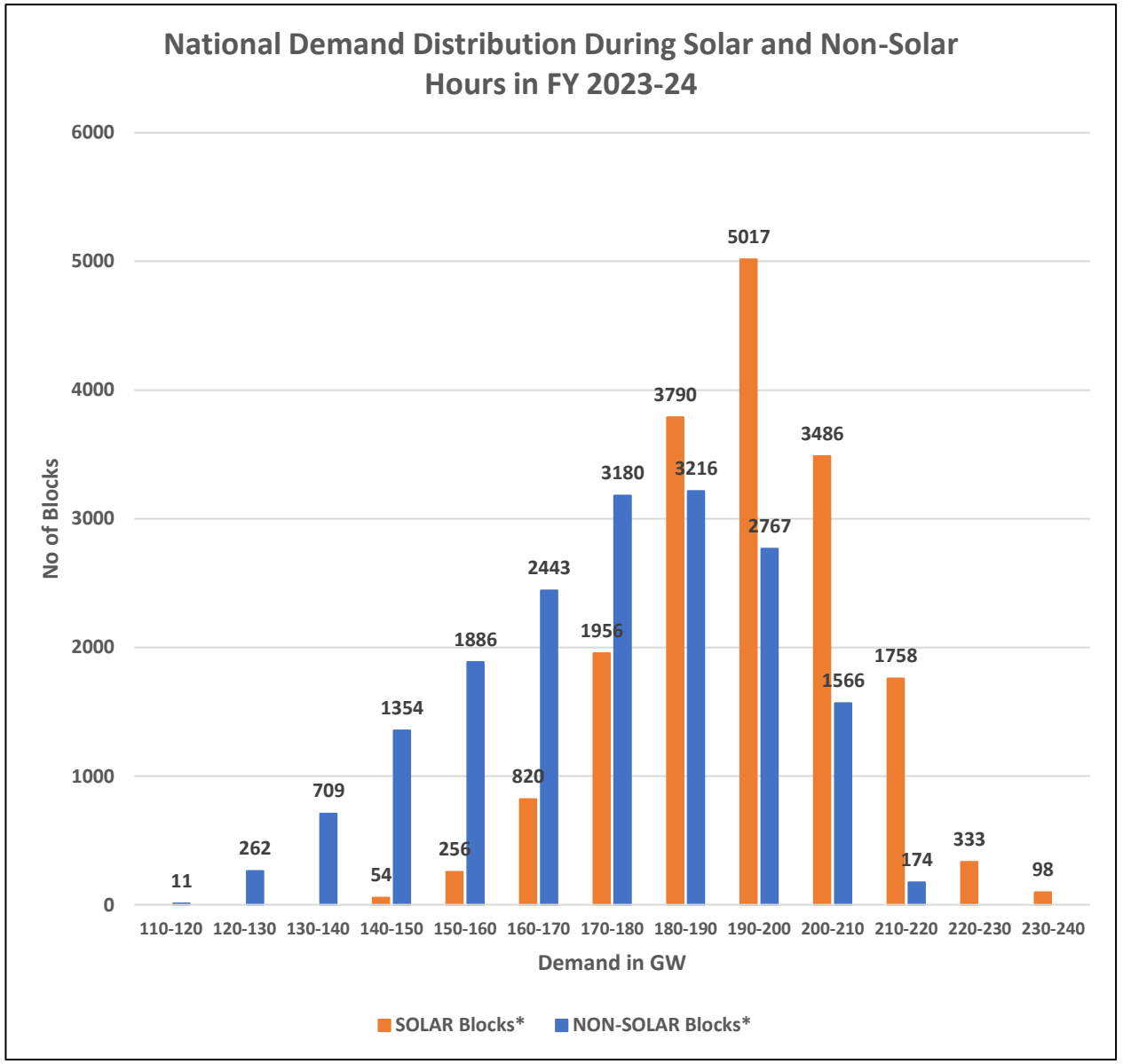
Resource Adequacy framework

- The utilities must ensure sufficient tied-up capacity from long-term, medium-term, and short-term (Bilateral only) as per their contribution to National Peak demand + PRM as well as their individual peak
- 100% tie-up for the first year and a minimum 90% tie-up for the second year to meet the requirement of their contribution towards meeting national peak to SERCs/JERCs

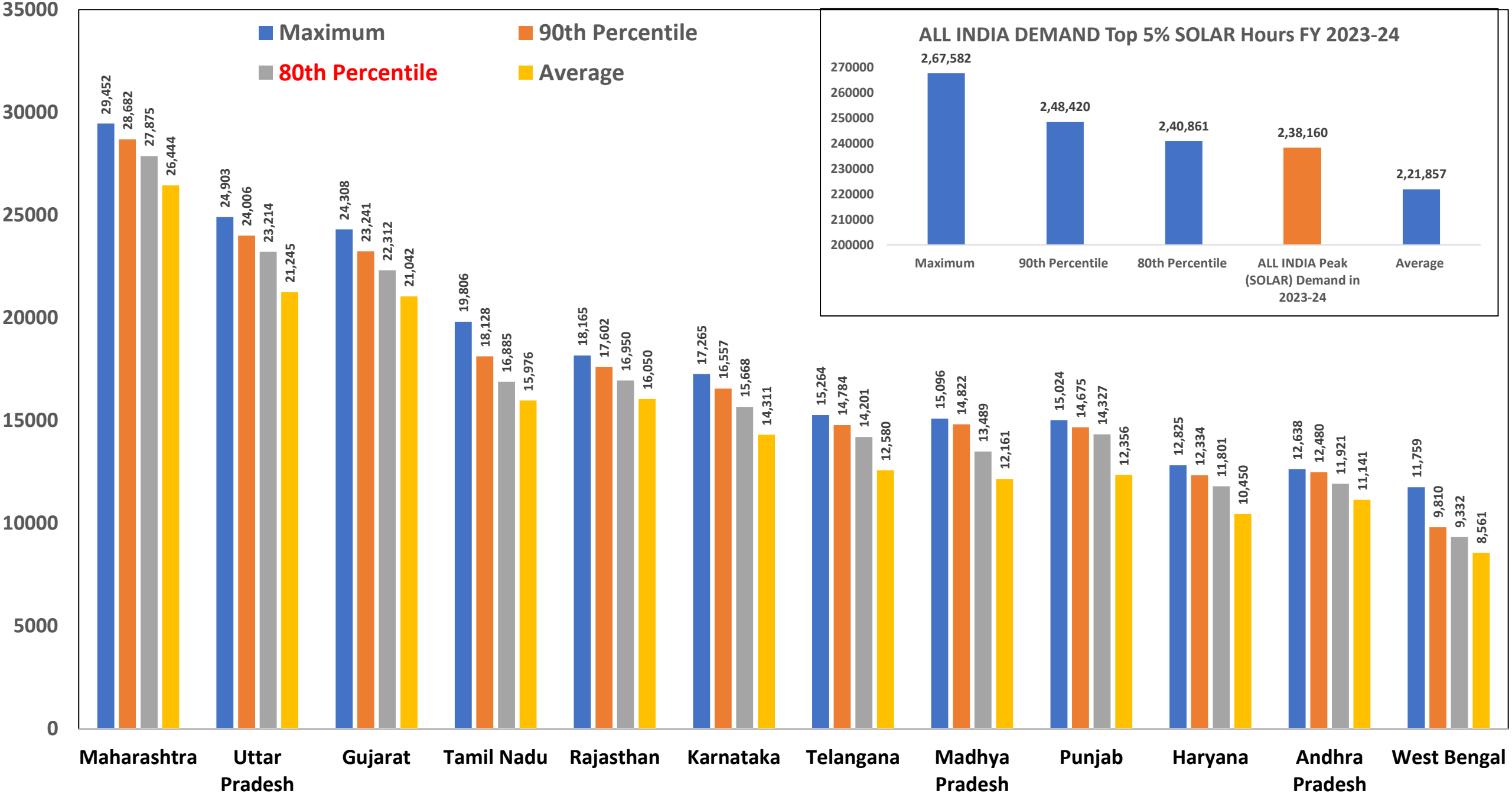
Coincident Peak vs Individual Peak



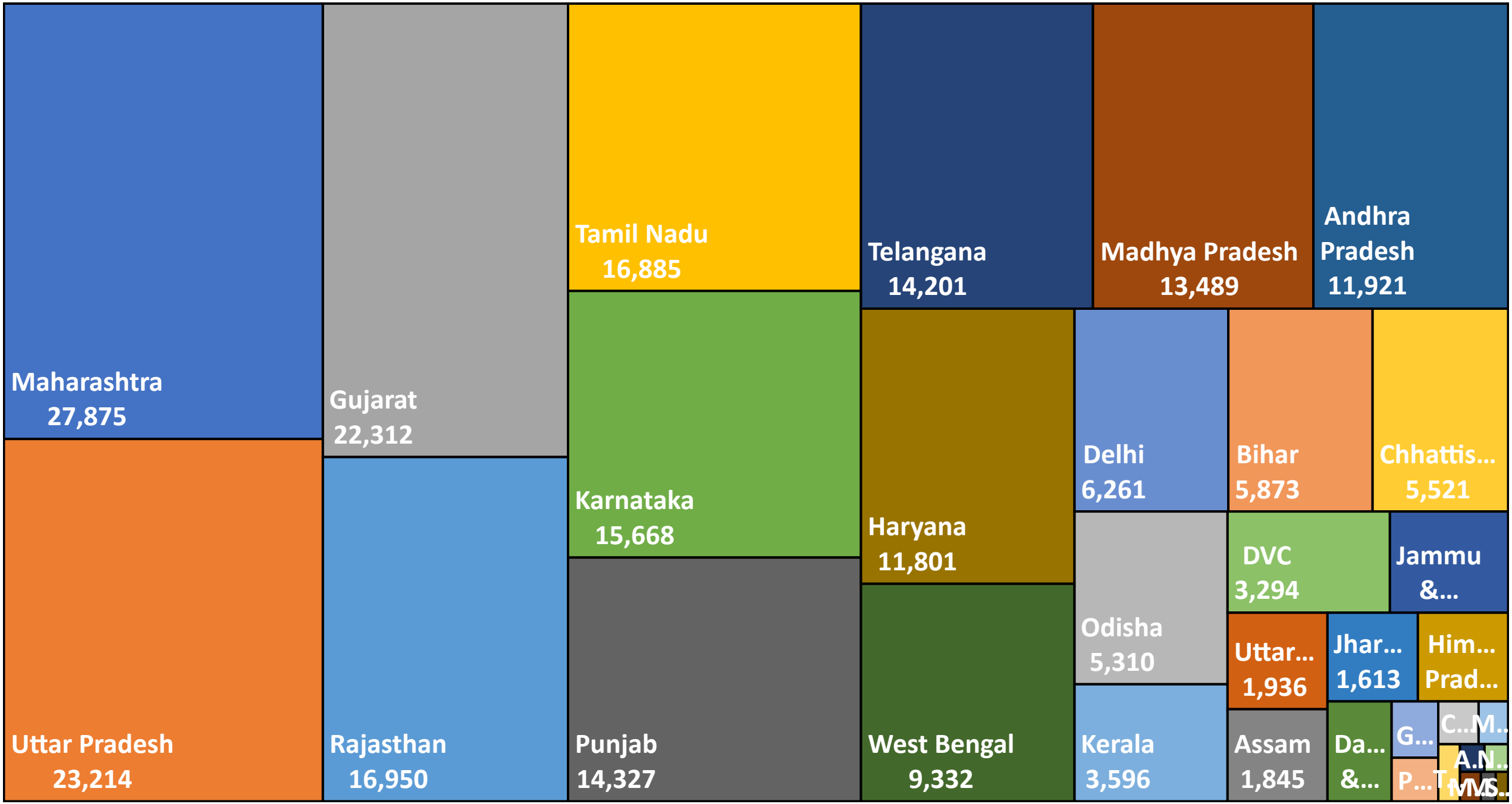

Month wise Distribution of Demand blocks during Top 5% National Demand Hours in FY 2023-24
No of Blocks in a month
700
600
500
400
300
200
100
0
10
80
123
8
614
25
246
32
131
137
191
159
Apr
May
Jun
Aug
Sep
Oct
Jan
Feb
Mar
Month
SOLAR
NON SOLAR

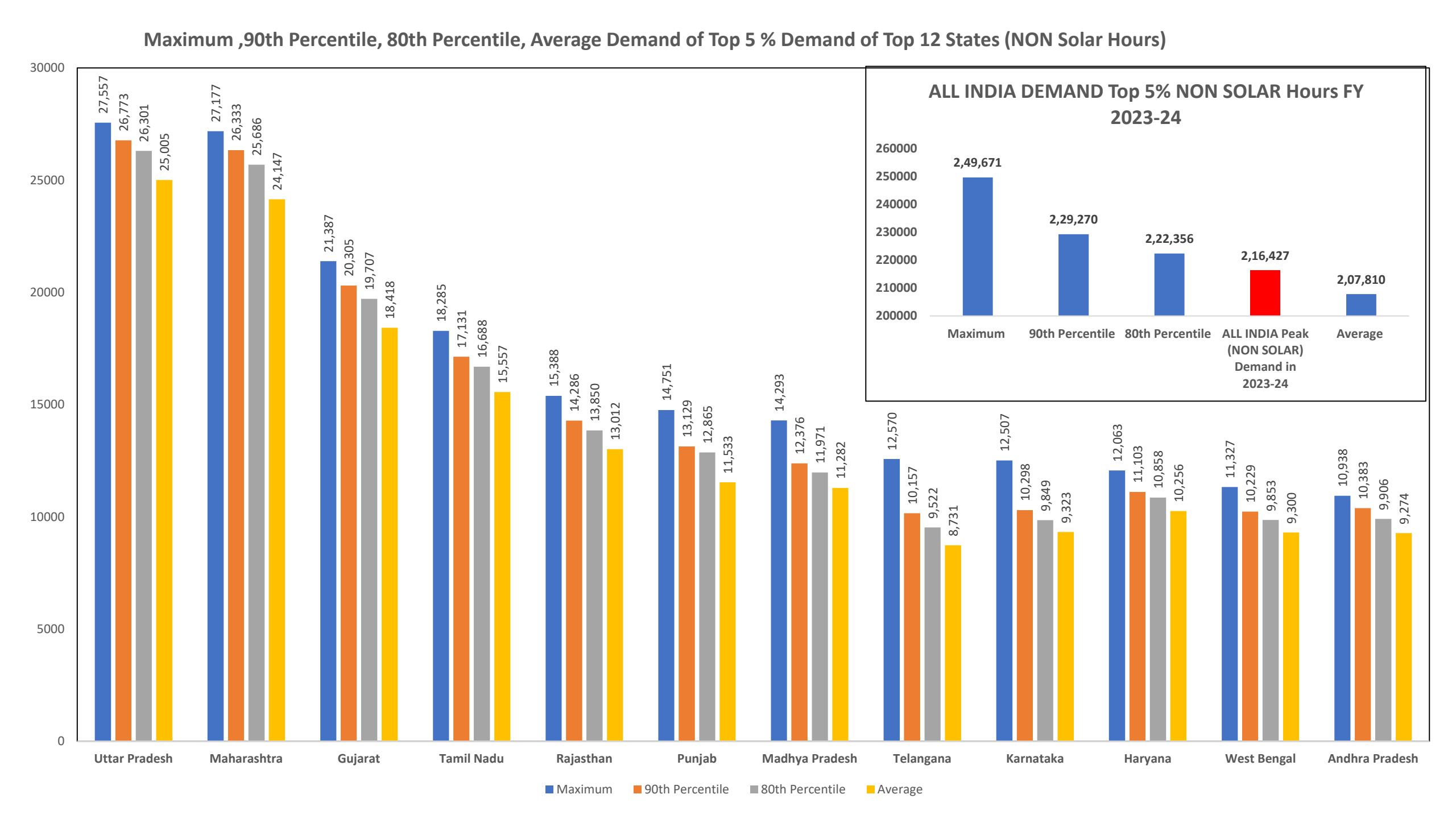

National Demand Distribution During Solar and Non-Solar Hours in FY 2023-24
No of Blocks
6000
5000
4000
3000
2000
1000
0
11
262
709
54
1354
256
1886
820
2443
1956
3180
3790
3216
5017
2767
3486
1566
1758
174
333
98
110-120
120-130
130-140
140-150
150-160
160-170
170-180
180-190
190-200
200-210
210-220
220-230
230-240
Demand in GW
SOLAR Blocks*
NON-SOLAR Blocks*

Maximum ,90th Percentile, 80th Percentile, Average Demand of Top 5 % Demand of Top 12 States (Solar Hours)

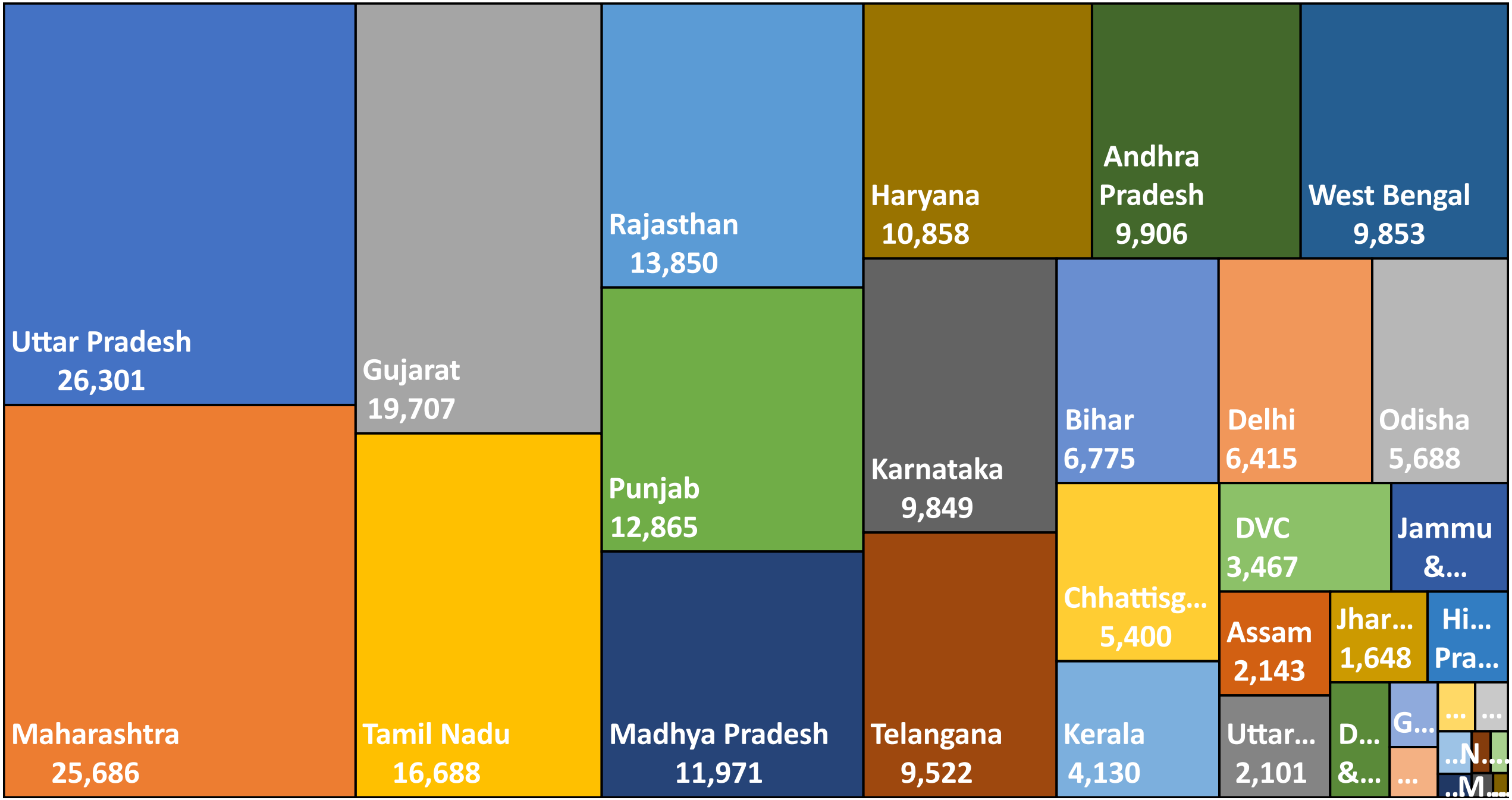


State Wise Coincident peak in MW(Solar)in FY 2023-24




Maximum ,90th Percentile, 80th Percentile, Average Demand of Top 5 % Demand of Top 12 States (NON Solar Hours)
30000
25000
20000
15000
10000
5000
0
27,557
26,773
26,301
25,005
27,177
26,333
25,686
24,147
21,387
20,305
19,707
18,418
18,285
17,131
16,688
15,557
15,388
14,286
13,850
13,012
14,751
13,129
12,865
11,533
14,293
12,376
11,971
11,282
12,570
10,157
9,522
8,731
12,507
10,298
9,849
9,323
12,063
11,103
10,858
10,256
11,327
10,229
9,853
9,300
10,938
10,383
9,906
9,274
Uttar Pradesh
Maharashtra
Gujarat
Tamil Nadu
Rajasthan
Punjab
Madhya Pradesh
Telangana
Karnataka
Haryana
West Bengal
Andhra Pradesh
Maximum
90th Percentile
80th Percentile
Average
ALL INDIA DEMAND Top 5% NON SOLAR Hours FY 2023-24
260000
250000
240000
230000
220000
210000
200000
2,49,671
2,29,270
2,22,356
2,16,427
2,07,810
Maximum
90th Percentile
80th Percentile
ALL INDIA Peak (NON SOLAR) Demand in 2023-24
Average

State Wise Coinicident peak in MW(Non Solar)



Capacity Credit

What is Capacity Credit?

- Capacity Credit refers to firm capacity available during peak demand period.
- Capacity Credit of Conventional Sources is based on availability.
- Capacity Credit of VRE Sources is calculated using Statistical analysis.

Resource Adequacy framework

At National Level

∑ Source wise Installed capacity (ALL INDIA) * Capacity Credit of the source= National Peak Demand *(1+National PRM)

For Distribution Licenses

∑ Source wise tied up capacity (Distribution licensee) * Capacity Credit of the source= Contribution to National Peak *(1+National PRM)

Capacity Credit-Conventional

- Capacity Credit (CC) of Conventional Sources (Coal, Gas, Nuclear) = Installed Capacity *(1- Auxiliary Power) *Availability
- CC of Hydro, Biomass, and geothermal energy=Seasonal Availability, Past generation data
- CC of PSP, BESS = Name Plate Capacity

Generation Sources	Capacity Credit(p.u.)
Coal	0.7-0.8
Nuclear	0.6-0.7
Gas	0.7-0.8
Hydro#	RoR- 0.25-0.3, With Storage- 0.6-0.7
Biomass#	0.3
PSP@	0.5-1
BESS@	0.5-1

@ The availability of energy-limited sources is dependent on the duration of peak demand hours. For example, the availability of a BESS of 2h is only 50% during high demand period of 4h in a day
 # Highly Seasonal in Nature

Capacity Credit- VRE

Top 10% Demand methodology

- Median of VRE Profile during Top 10% demand Hours.
- Easier to calculate
- Doesn't take into account time of day(Solar ,Non Solar).

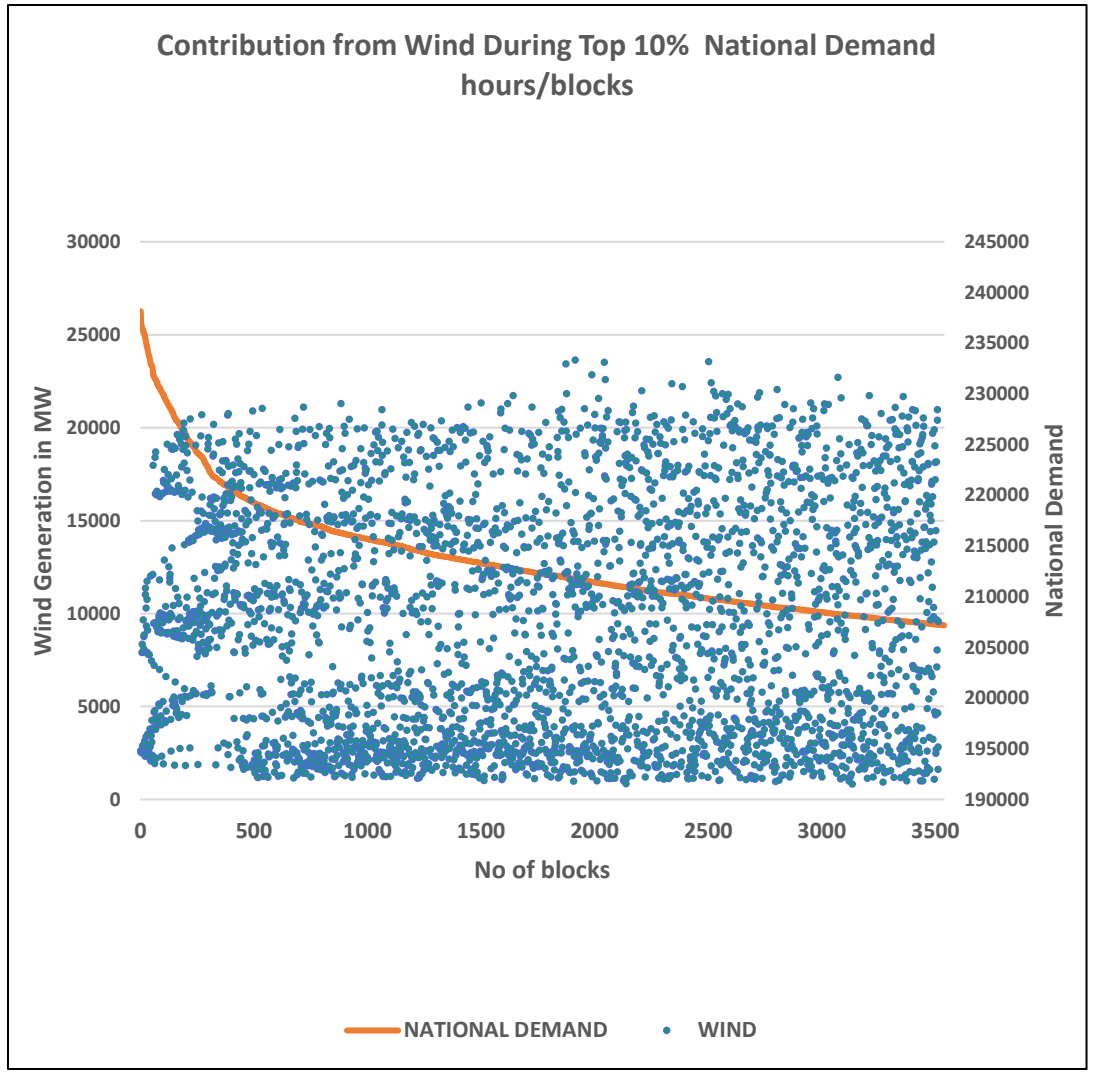
Solar Vs Non-Solar Hours

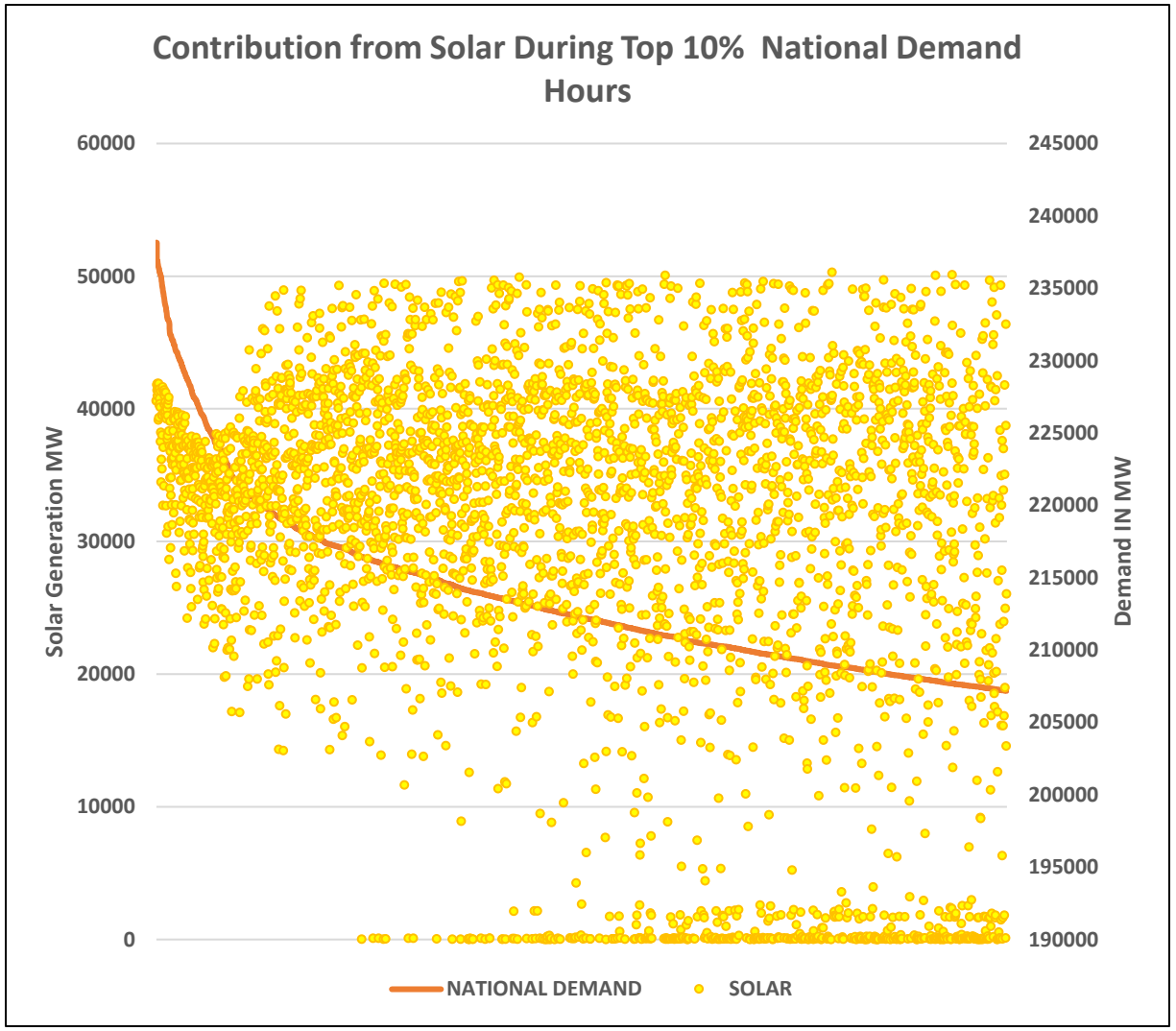
- Top 5 % of demand during Solar and Non-Solar Hours.
- Median of Profile during Top 10% demand Hours
- Variation of Wind CC during Solar vs non-Solar Hours

Critical Day Analysis

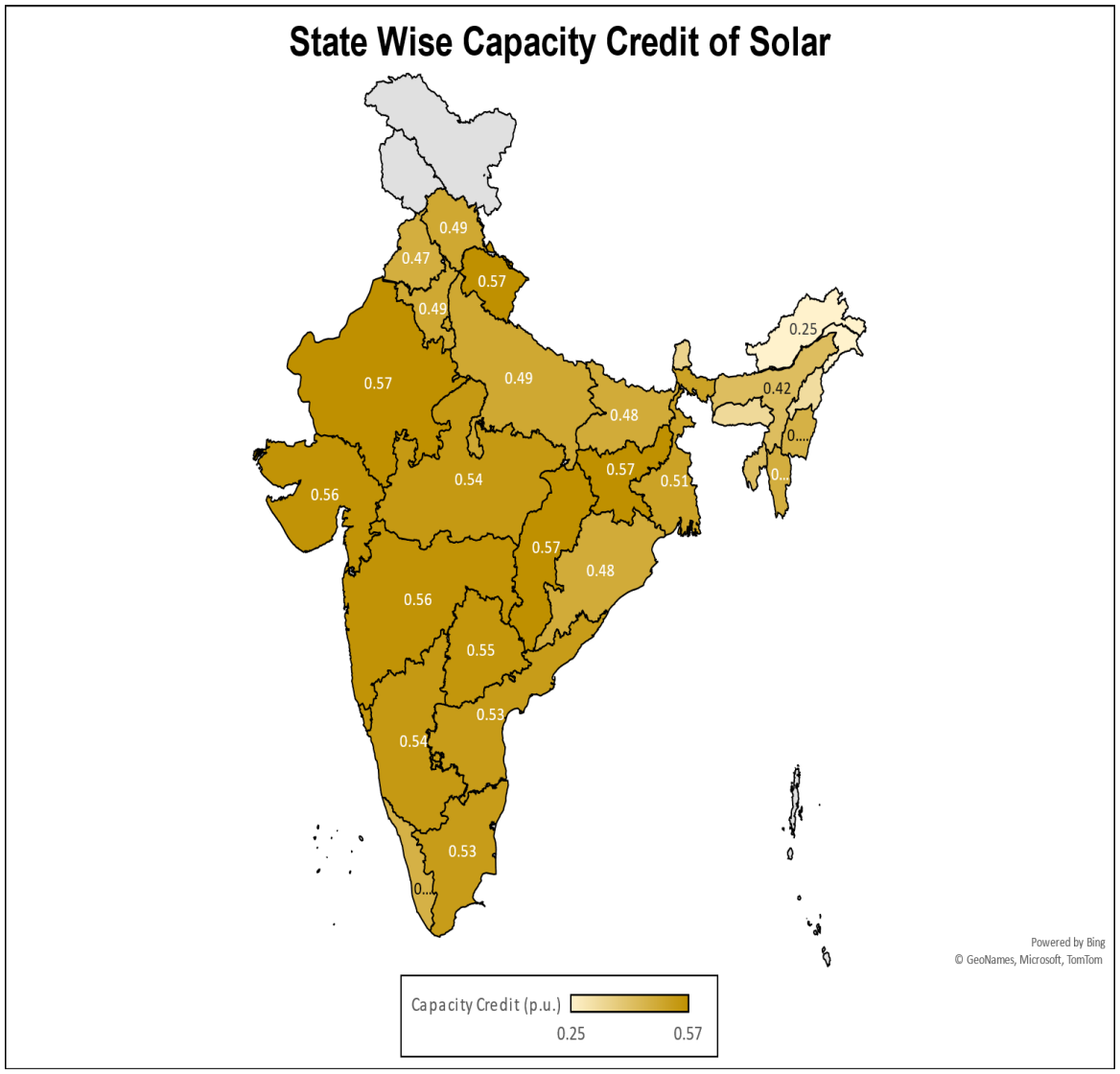
- Critical days instead of Critical blocks
- Both Demand & RE generation instead of only high Demand period
- High Demand- Low RE, Medium Demand-LOW RE days
- K means clustering algorithm
- Computationally complex

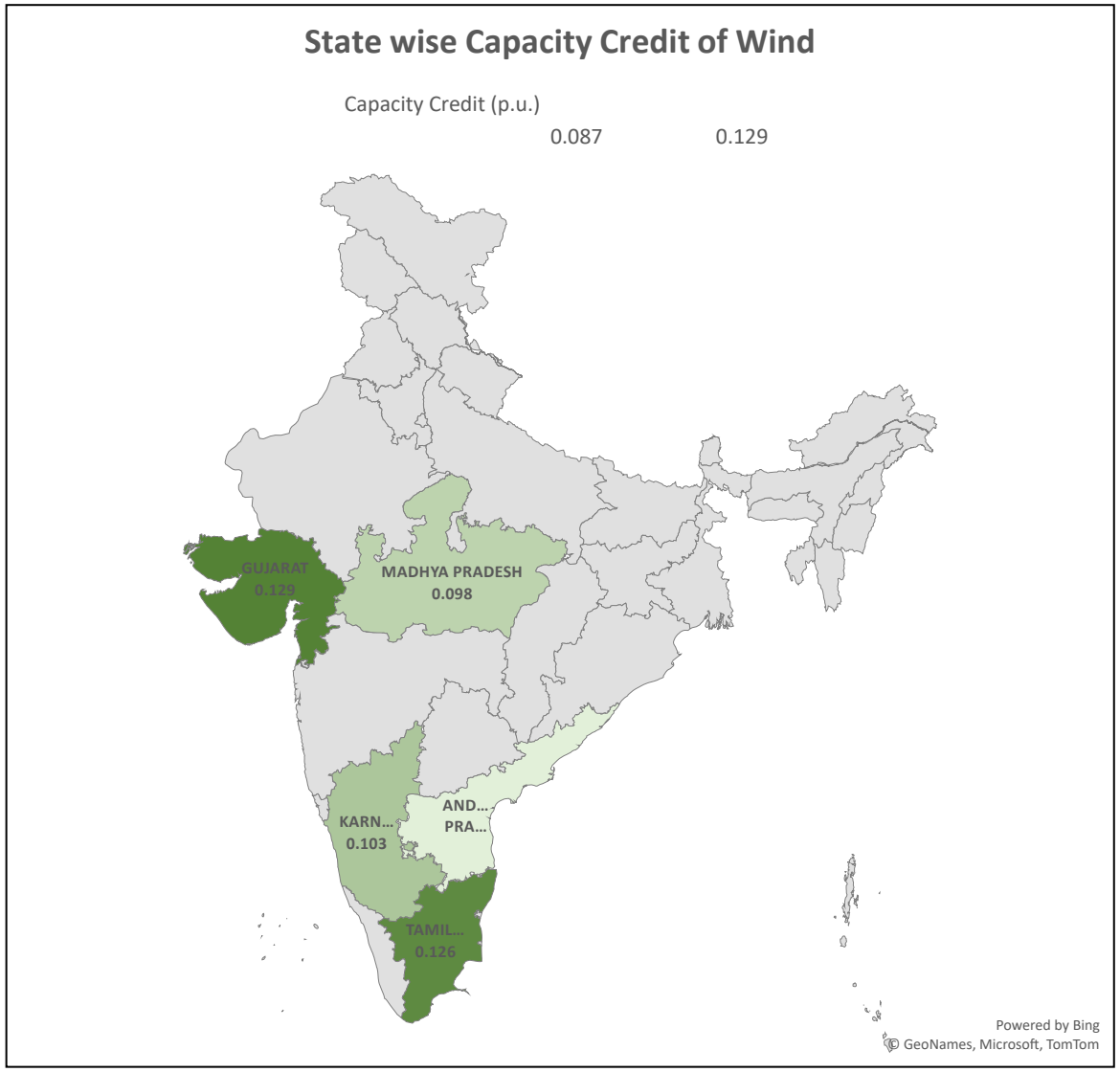
Top 10% Demand Methodology





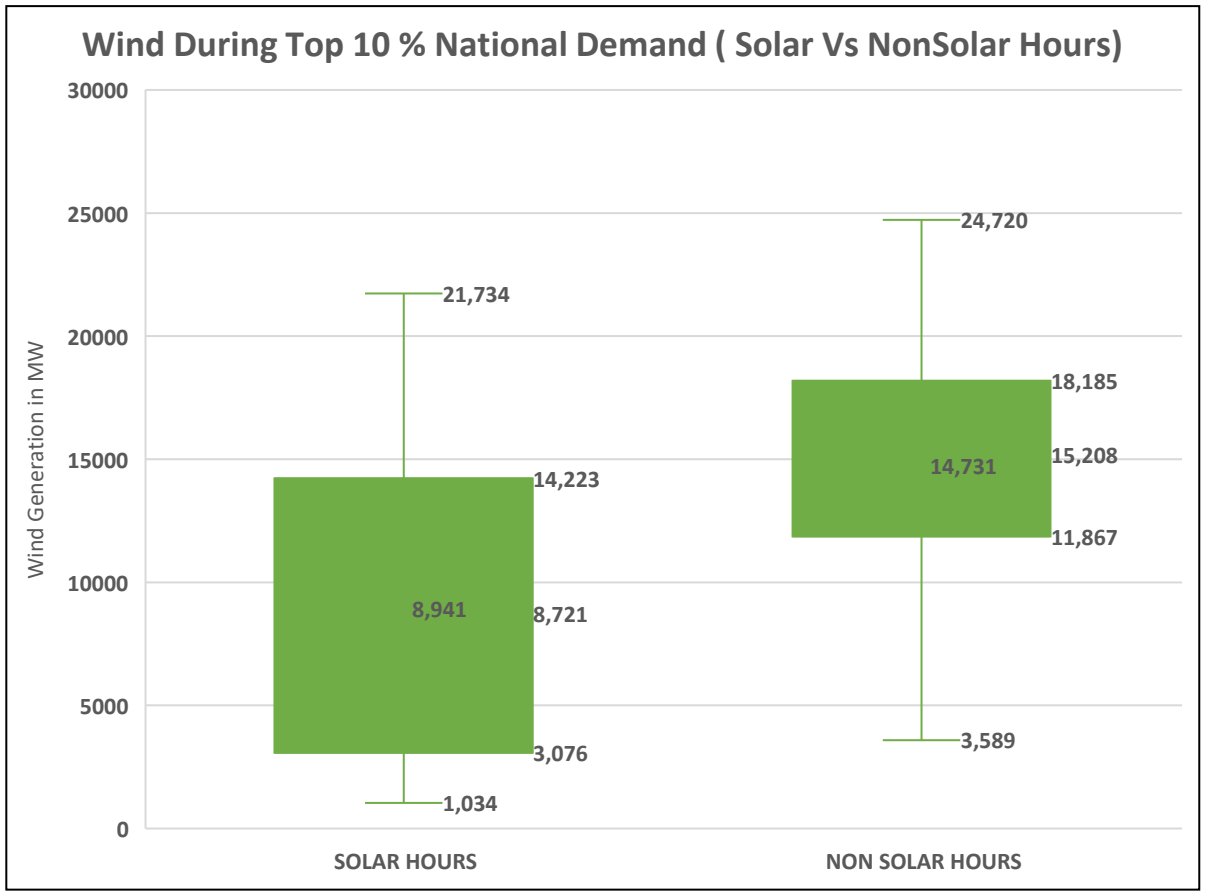
Capacity Credit- 10% demand methodology

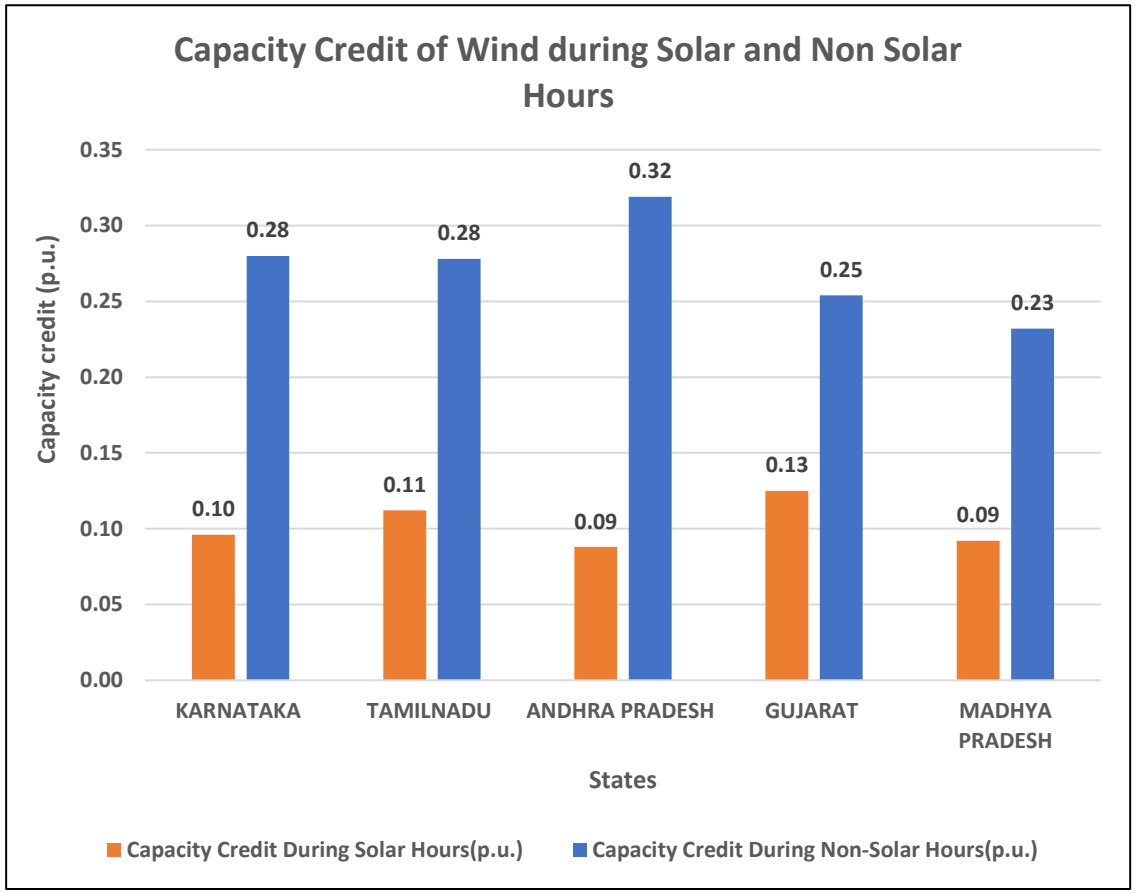




Capacity Credit-Solar vs Non Solar Methodology

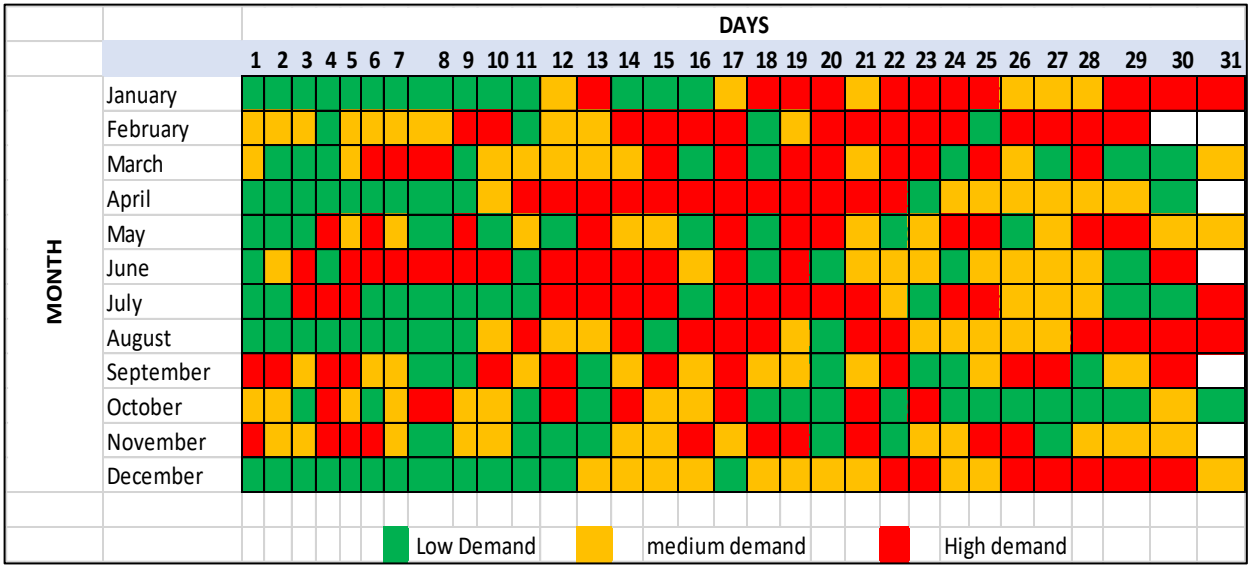
- Capacity credit of Solar is Similar to the 1st method
- Capacity Credit of Wind is different in Solar and Non-Solar Hours

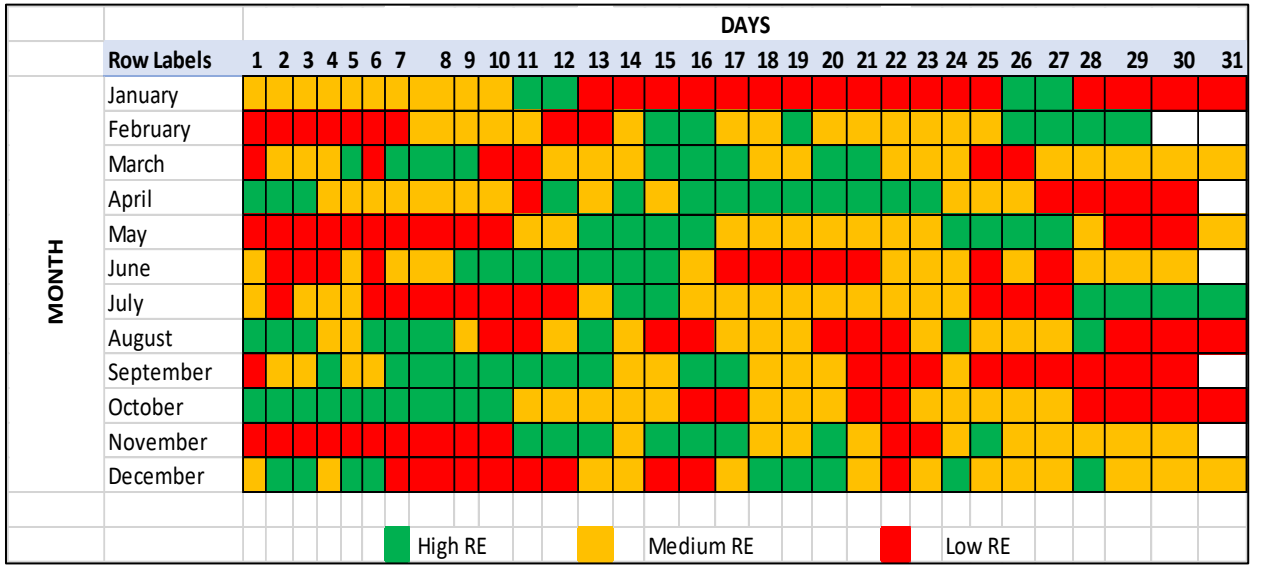


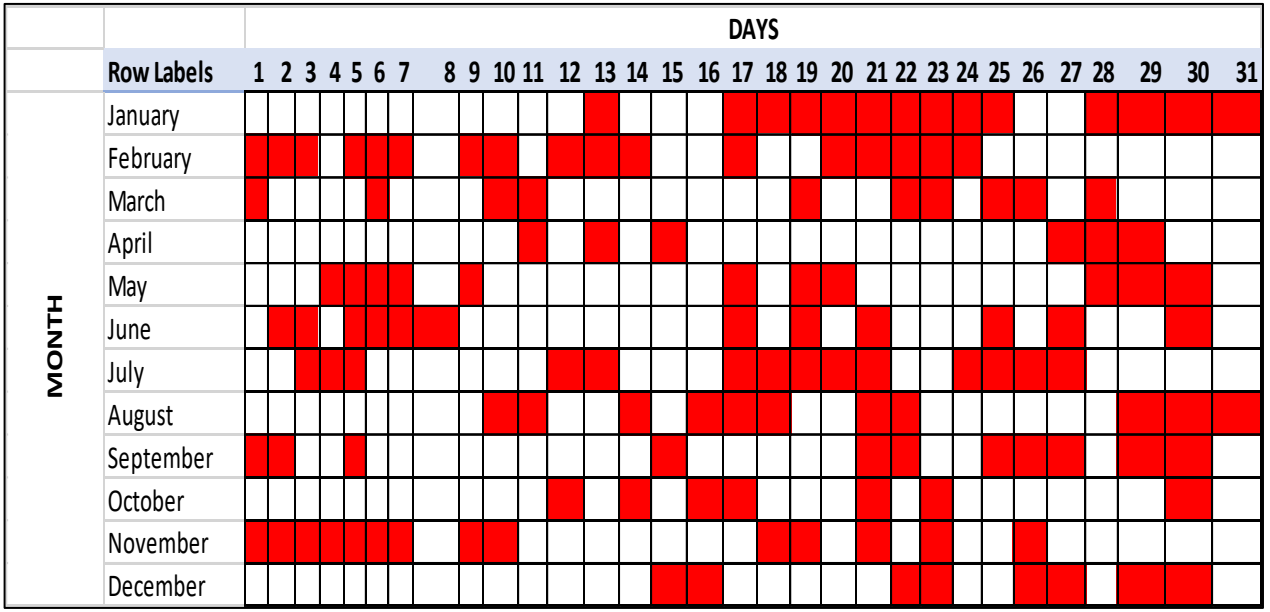


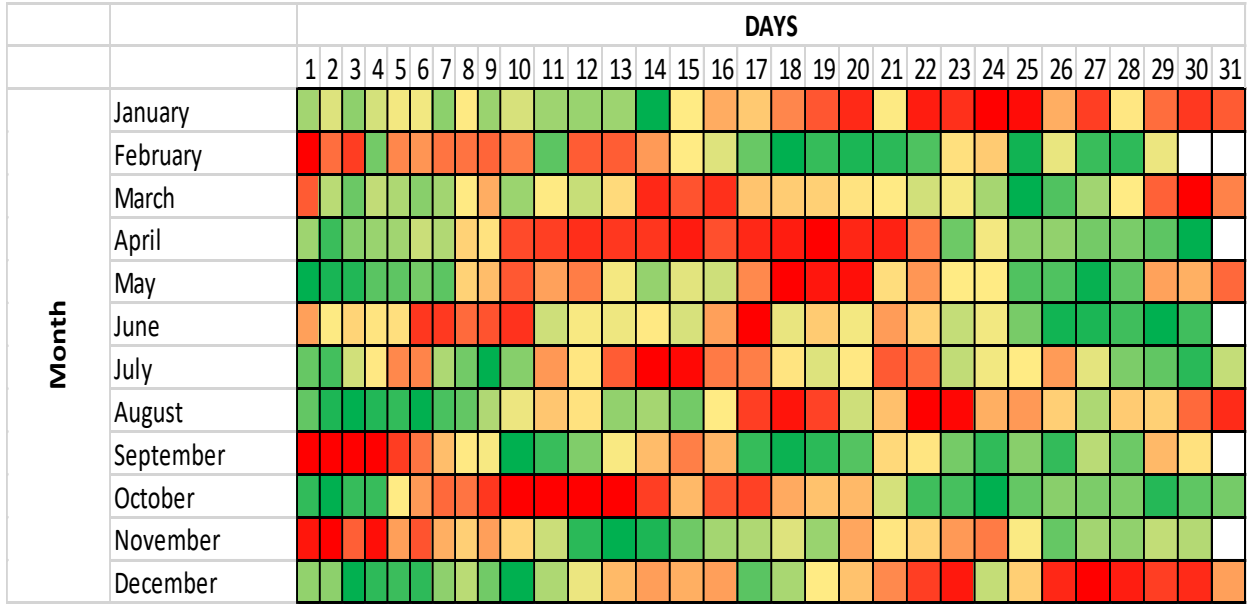
Capacity Credit-Critical Day Analysis

HIGH RE-Low Demand	**High RE-Medium Demand**	**High RE-High Demand**
Medium RE-Low Demand	**Medium RE-Medium Demand**	**Medium RE-High Demand**
Low RE-Low Demand	**Low RE-Medium Demand**	**Low RE- High Demand**

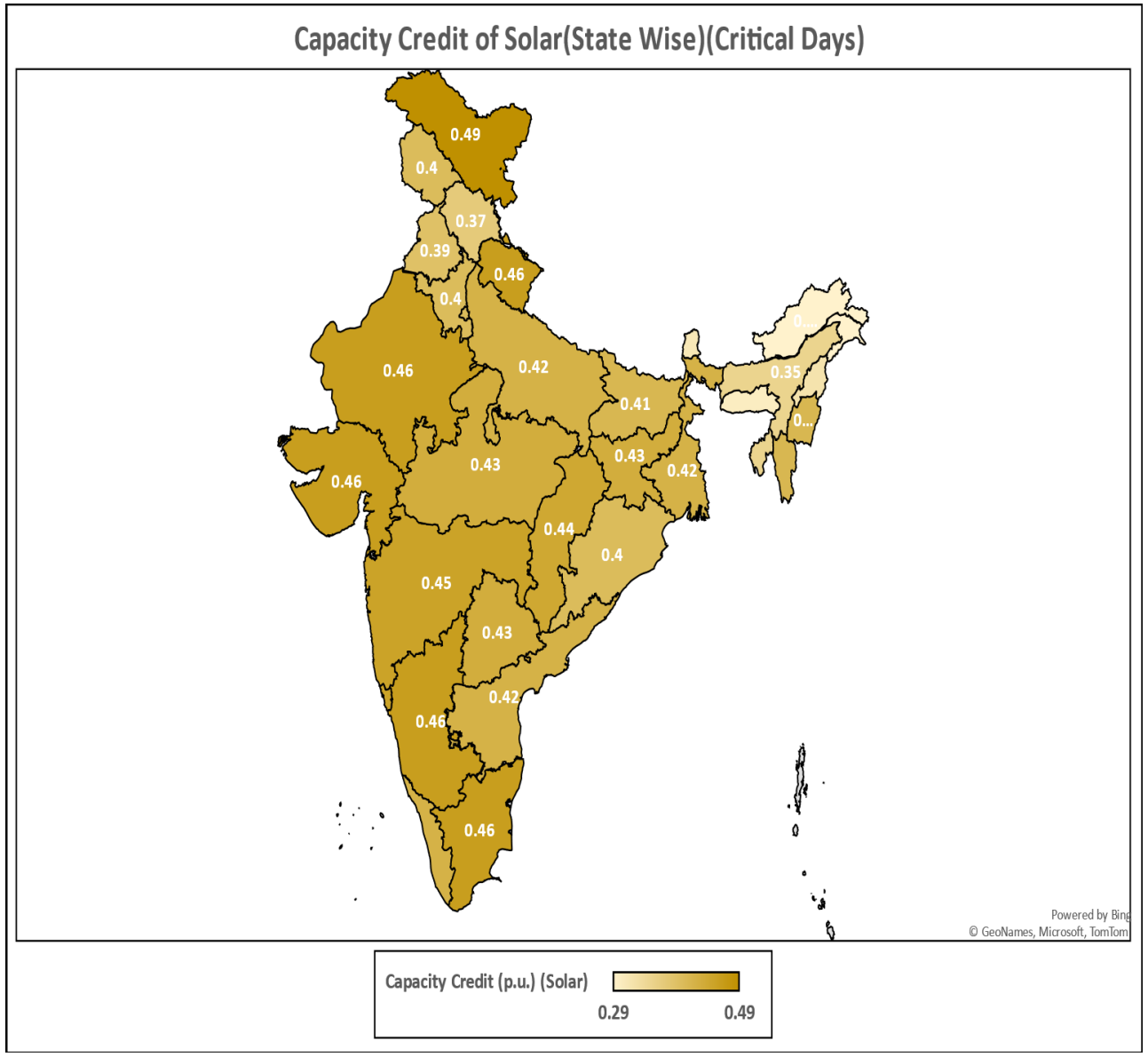

DAYS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
MONTH
January
February
March
April
May
June
July
August
September
October
November
December
Low Demand
medium demand
High demand

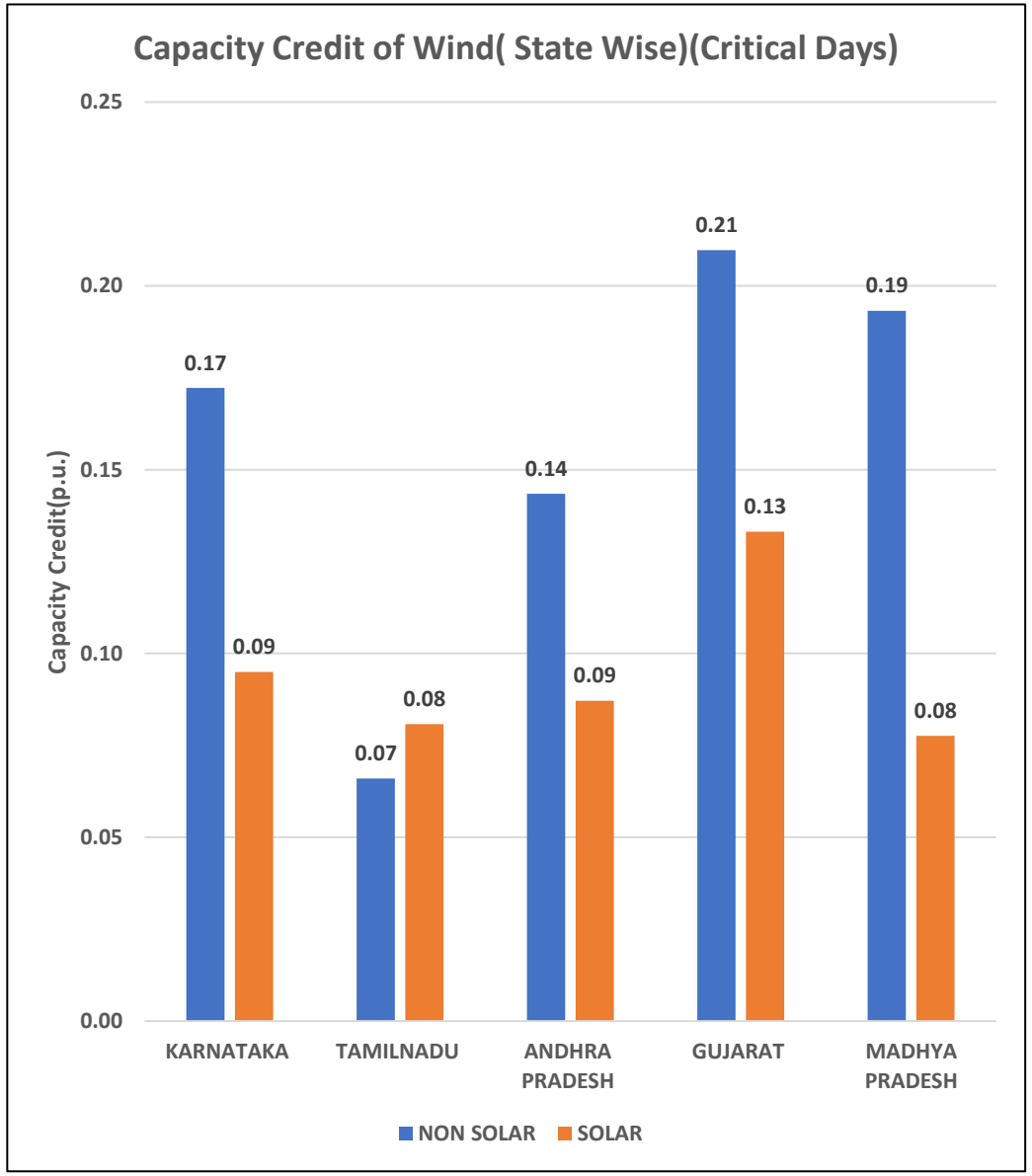

DAYS
Row Labels
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
MONTH
January
February
March
April
May
June
July
August
September
October
November
December
High RE
Medium RE
Low RE


DAYS
Row Labels
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
MONTH
January
February
March
April
May
June
July
August
September
October
November
December


DAYS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Month
January
February
March
April
May
June
July
August
September
October
November
December

Capacity Credit of VRE Sources(Critical Days)





Conclusion

- For Coincident Peak -**The solar vs. non-solar(Top 5% demand hours) methodology**
- For Capacity Credit- **The critical day's analysis**
- Concept paper available on CEA website. Comments can be mailed to **ceirpcea@nic.in**

Coincident Peak During Solar Hours(FY 2023-24)

State/UT	Maximum of Coincident Peak (top 5%) _SOLAR Hours	90th Percentile of Coincident Peak (top 5%) SOLAR Hours	80th Percentile of Coincident Peak (top 5%) SOLAR Hours	Average of Coincident Peak (top 5%) SOLAR Hours	Own Peak(Solar Hours)
Chandigarh	399.0	373.6	346.2	296.3	399.0
Delhi	7433.2	6708.7	6260.8	5595.2	7433.2
Haryana	12825.3	12334.0	11800.8	10449.8	12825.3
Himachal Pradesh	2057.1	1875.2	1609.0	1477.0	2151.0
Jammu & Kashmir	3037.8	2562.8	2402.9	2280.1	3179.0
Punjab	15023.5	14674.9	14326.6	12355.8	15297.3
Rajasthan	18165.4	17602.3	16950.0	16049.8	18264.2
Uttar Pradesh	24903.1	24005.7	23214.0	21245.2	25230.3
Uttarakhand	2399.2	2095.0	1935.8	1816.9	2519.6
Chhattisgarh	5940.4	5782.7	5521.1	5098.9	6247.1
Dadra & Nagar Haveli	1334.0	1309.7	1288.8	1246.9	1336.2
Gujarat	24308.2	23240.7	22312.1	21041.9	24308.2
Goa	631.3	569.7	526.2	500.7	686.1
Madhya Pradesh	15095.5	14821.6	13489.3	12161.2	15099.2
Maharashtra	29452.0	28681.9	27874.8	26444.0	29873.0
Andhra Pradesh	12638.3	12480.1	11921.3	11140.5	12668.0
Karnataka	17264.8	16556.8	15667.8	14310.8	17889.4
Kerala	4420.2	3898.3	3596.3	3453.7	4635.8
Puducherry	479.7	433.3	407.6	384.4	504.7
Tamil Nadu	19806.4	18128.3	16885.2	15975.9	19806.4
Telangana	15264.4	14783.5	14200.9	12579.7	15421.4
Bihar	6774.8	6220.0	5873.2	5259.1	7544.0
DVC	4060.6	3478.0	3293.9	3186.9	4060.6
Jharkhand	1898.2	1693.1	1613.4	1495.1	1968.3
Odisha	6713.5	6232.8	5310.2	4862.0	6911.5
Sikkim	109.5	97.9	74.1	66.3	127.5
West Bengal	11758.7	9809.5	9332.3	8560.6	11758.7
Arunachal Pradesh	162.3	141.7	136.5	125.4	223.5
Assam	2133.5	1996.5	1844.6	1637.6	2377.3
Manipur	161.4	135.4	123.8	111.2	240.8
Meghalaya	298.6	279.3	253.0	230.6	436.0
Mizoram	116.0	98.8	87.8	79.2	158.7
Nagaland	163.2	150.5	131.4	117.3	172.3
Tripura	353.3	278.4	249.5	220.6	417.8
Sum Total	267582.4	248419.5	240861.2	221856.8	272171
ALL INDIA Peak (SOLAR) Demand in 2023-24	238160.4				

Coincident Peak During Non Solar Hours(FY 2023-24)

State/UT	Maximum of Coincident Peak (top 5%) NON-SOLAR Hours	90th Percentile of Coincident Peak (top 5%) NON-SOLAR Hours	80th Percentile of Coincident Peak (top 5%) NON-SOLAR Hours	Average of Coincident Peak (top 5%) NON-SOLAR Hours	Own Peak(Non Solar Hours)
Chandigarh	375.9	347.9	339.5	307.6	381.3
Delhi	7122.8	6602.9	6414.8	5927.6	7164.1
Haryana	12063.1	11102.7	10857.6	10255.6	12166.9
Himachal Pradesh	1699.8	1476.9	1365.9	1219.5	2193.3
Jammu & Kashmir	2873.8	2444.6	2360.7	2171.9	3270.6
Punjab	14751.1	13129.0	12865.4	11532.6	14751.1
Rajasthan	15387.8	14285.9	13849.6	13012.0	15725.3
Uttar Pradesh	27557.4	26772.8	26300.6	25005.3	28197.1
Uttarakhand	2343.9	2153.1	2100.7	1940.4	2439.9
Chhattisgarh	5938.7	5498.2	5400.0	4936.5	6234.1
Dadra & Nagar Haveli	1324.6	1286.5	1275.5	1244.5	1324.6
Gujarat	21386.8	20305.3	19707.3	18418.1	21386.8
Goa	660.3	605.9	577.3	532.7	707.7
Madhya Pradesh	14292.9	12376.0	11971.0	11282.0	14741.5
Maharashtra	27176.8	26333.2	25685.7	24146.6	28167.0
Andhra Pradesh	10938.4	10382.6	9906.0	9273.6	10965.8
Karnataka	12506.5	10297.9	9848.8	9322.6	13546.2
Kerala	4956.9	4261.4	4129.5	3859.9	5277.1
Puducherry	508.9	468.9	450.3	422.4	521.4
Tamil Nadu	18285.2	17131.1	16687.9	15556.6	18526.5
Telangana	12570.3	10156.9	9521.7	8731.3	14658.9
Bihar	7270.1	6935.9	6774.8	6440.8	7544.5
DVC	3870.1	3624.5	3467.3	3352.6	3870.1
Jharkhand	1873.7	1694.1	1647.9	1523.5	1908.0
Odisha	6741.3	5910.5	5687.9	5197.1	7029.0
Sikkim	92.1	74.8	67.6	51.4	122.7
West Bengal	11326.5	10228.5	9852.8	9300.1	11326.5
Arunachal Pradesh	172.3	156.5	148.7	133.0	183.6
Assam	2393.7	2225.5	2143.0	1909.9	2399.8
Manipur	192.0	150.7	136.6	106.8	221.3
Meghalaya	321.2	281.0	268.6	226.2	399.0
Mizoram	116.3	102.6	96.2	75.4	153.2
Nagaland	163.5	151.7	147.6	121.8	180.0
Tripura	416.0	313.8	301.1	271.4	416.0
Sum Total	249670.8	229270.0	**222355.8**	207809.7	258101
ALL INDIA Peak (NON SOLAR) Demand in 2023-24	**216427**				

Thank You.!