Roadmap for integration of renewable generation into grid: issues & challenges

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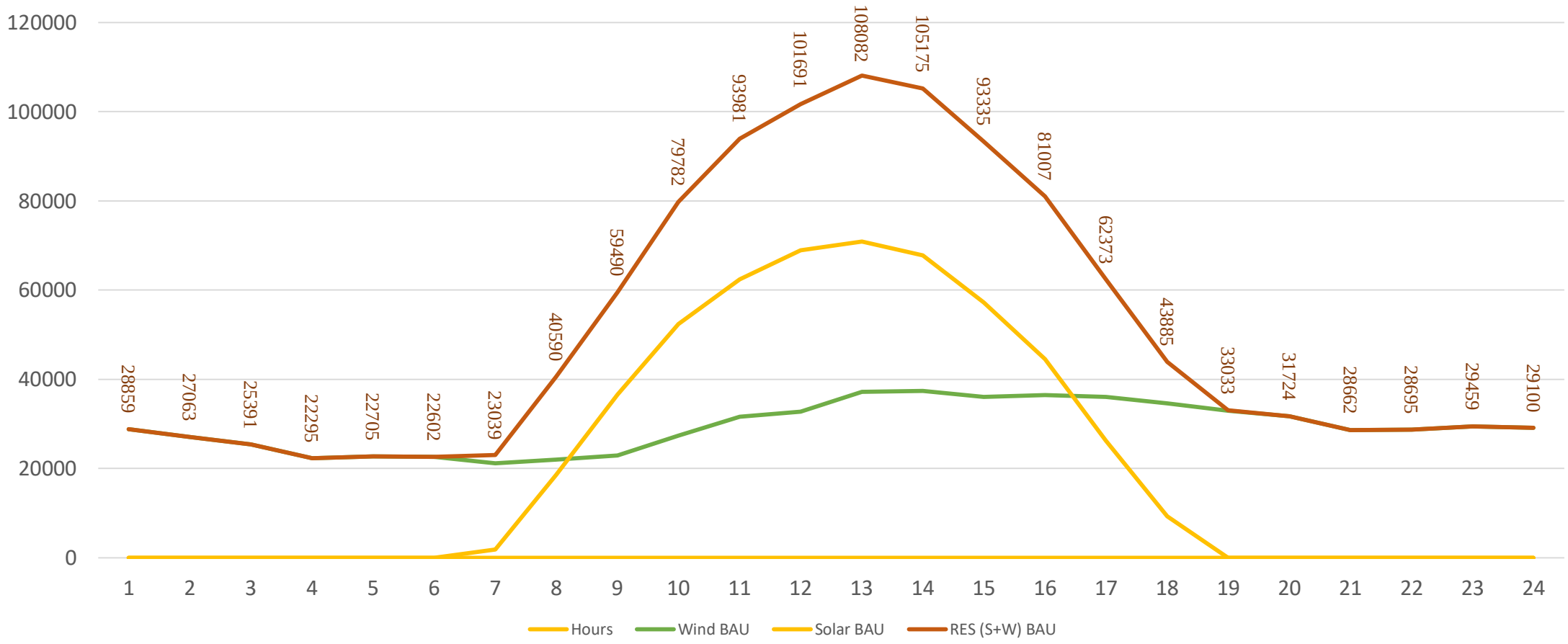
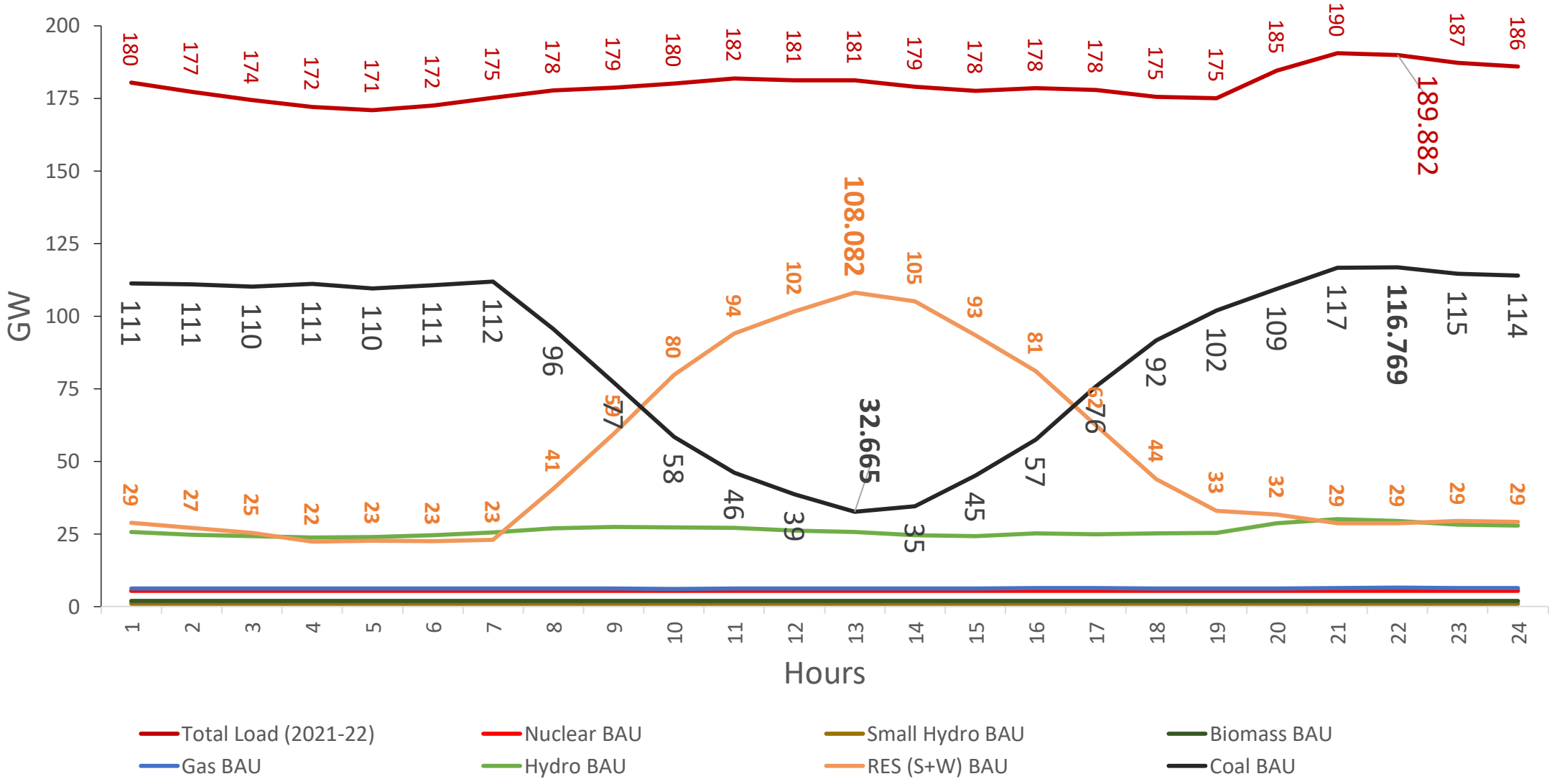
Installed capacity

S.No.	Installed Cap. (GW)	2017-18	2021-22
1	Hydro	45	51
2	Coal +Lignite	197	217
3	Gas	25	26
4	Nuclear	6.7	10
5	Solar	22	100
6	Wind	34	60
7	Biomass	9	10
8	Small Hydro	4	5
	Total	344	479

Maximum Solar & Wind generation predicted on 27th July,2021



Demand & Generation on the day 27th July,2021



Power Demand on Critical Days of 2021-22

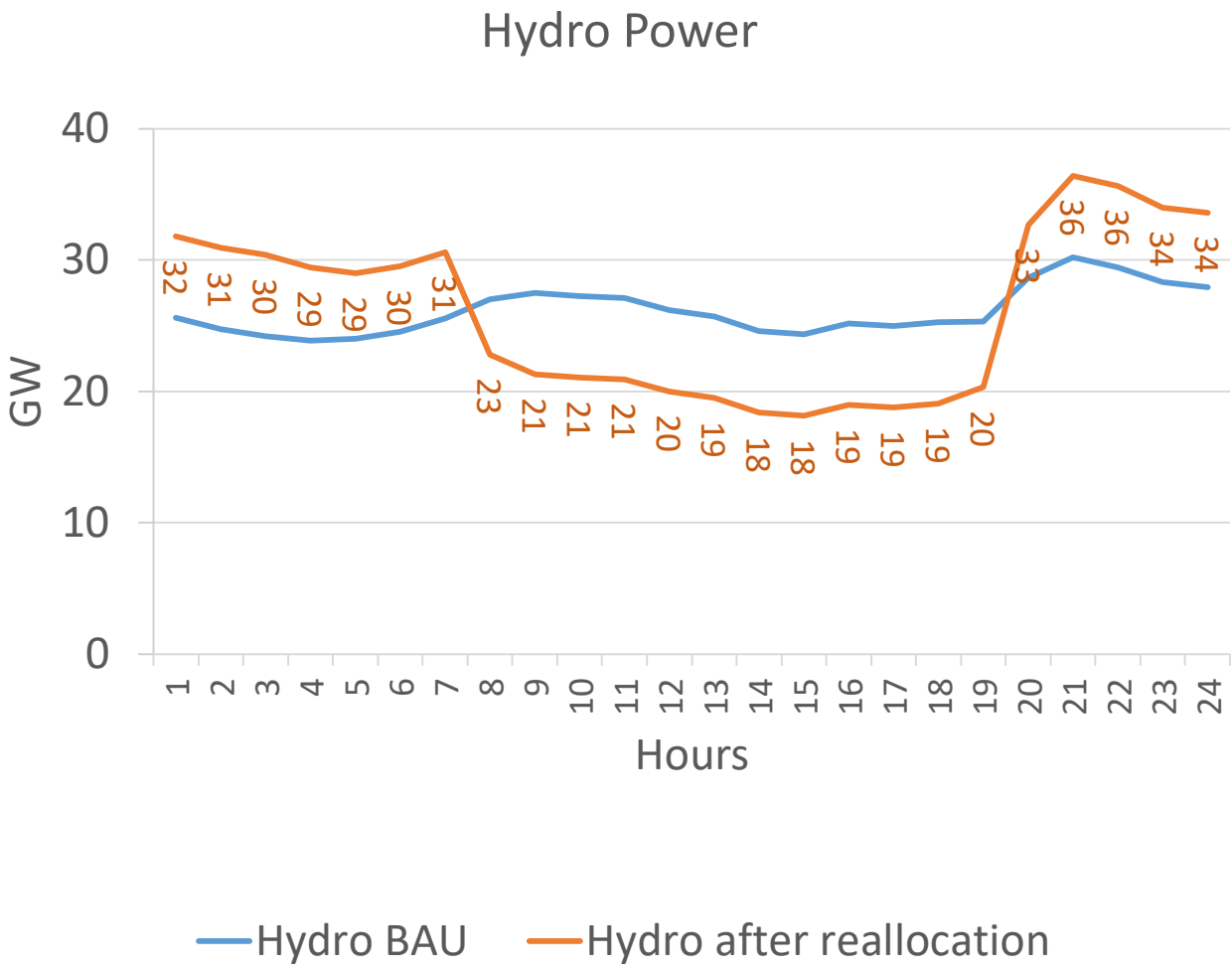
Day	Maximum Demand	Max RES (W+S)	Min. Coal Demand (MW)	Max. Coal Demand (MW)	MTL on critical day
19 April	194604	81274	65863	146917	41.23%
29 May	195640	90339	59368	138550	39.41%
25 June	197881	105715	40589	124800	29.91%
27 July	190480	108082	32665	116769	25.73%
15 August	189474	91355	37897	119009	29.29%
1 September	201308	72885	72037	139203	47.60%
18 October	205652	58364	98926	156765	58.04%
16 November	193583	68442	85361	151659	51.77%
29 December	197112	82185	82861	150421	50.67%
27 January	198222	75991	83623	150931	50.96%
4 February	201622	82015	81150	149265	50.01%
13 March	185585	74684	73474	140192	48.21%

Integration of 108 GW renewable generation and flexible operation of other type of generation

Step-1

Coordinated Effort: Hydro Flexing

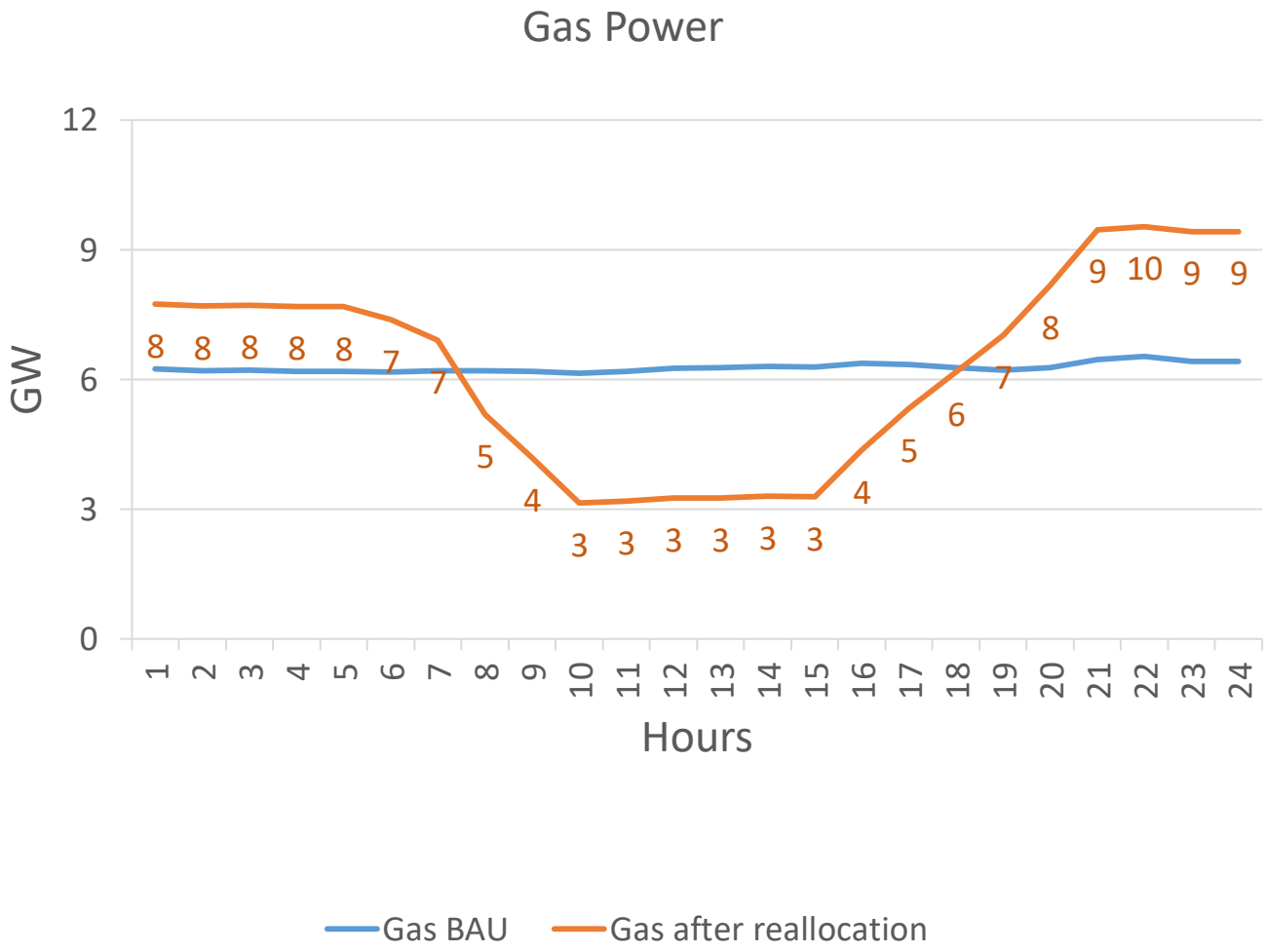
- Graph includes 1205 MW of under construction PS.
- Energy recovery of 70% is considered for PS
- Pumped storage solve flexibilisation problem in two ways
  - Consumes power in afternoon
  - Supplies power in morn./even. Peak
- Regulatory intervention: incentives or high tariff for supporting grid



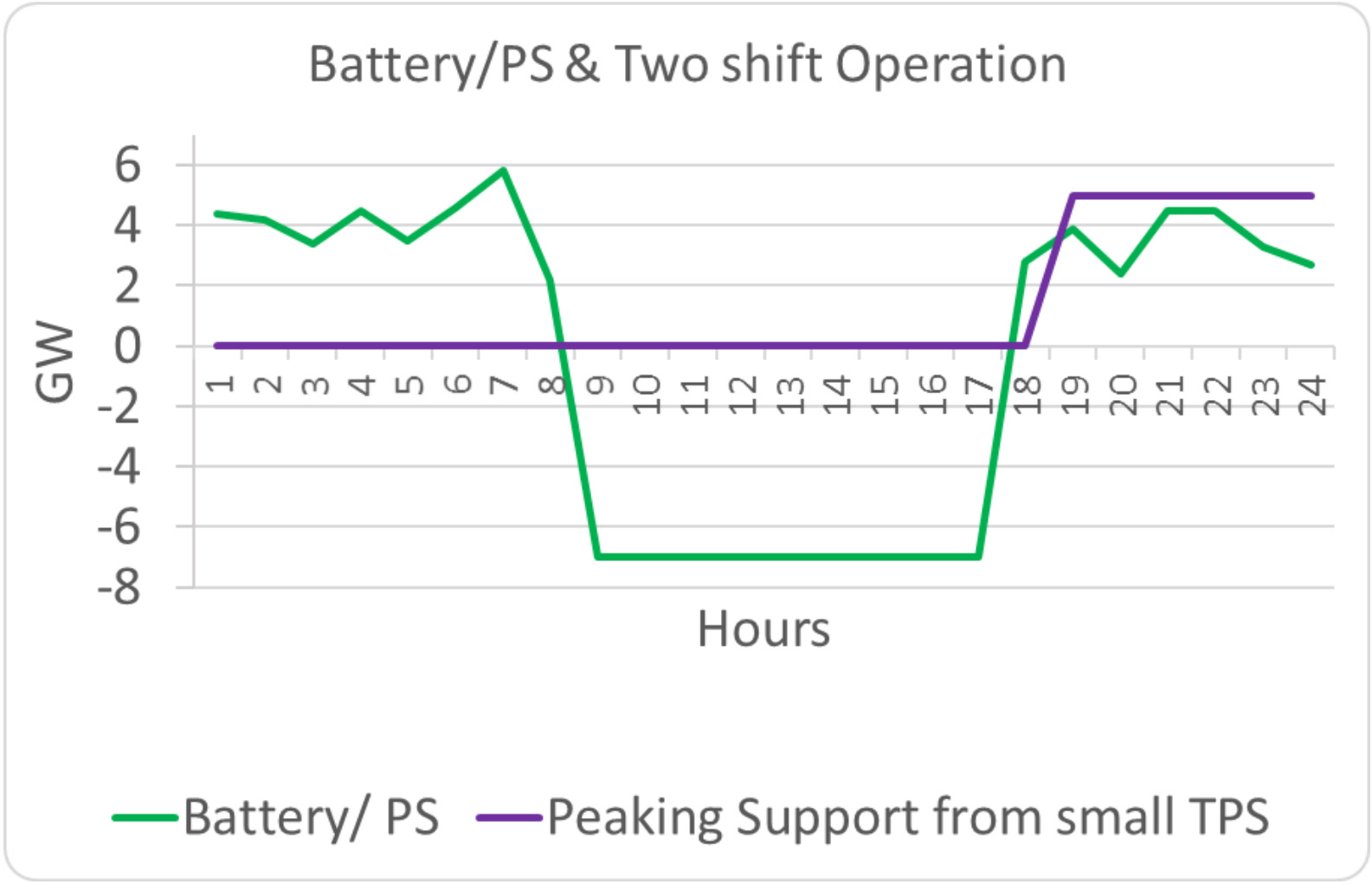
Step-2

Coordinated Effort: Gas Flexing

- Gas plants do not flex much as of today
- In 2022, we need Gas to vary from 3 to 8.5 GW



Step -3 & 4


Battery/PS & Two shift Operation
GW
6
4
2
0
-2
-4
-6
-8
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hours
Battery/ PS
Peaking Support from small TPS

Step-5

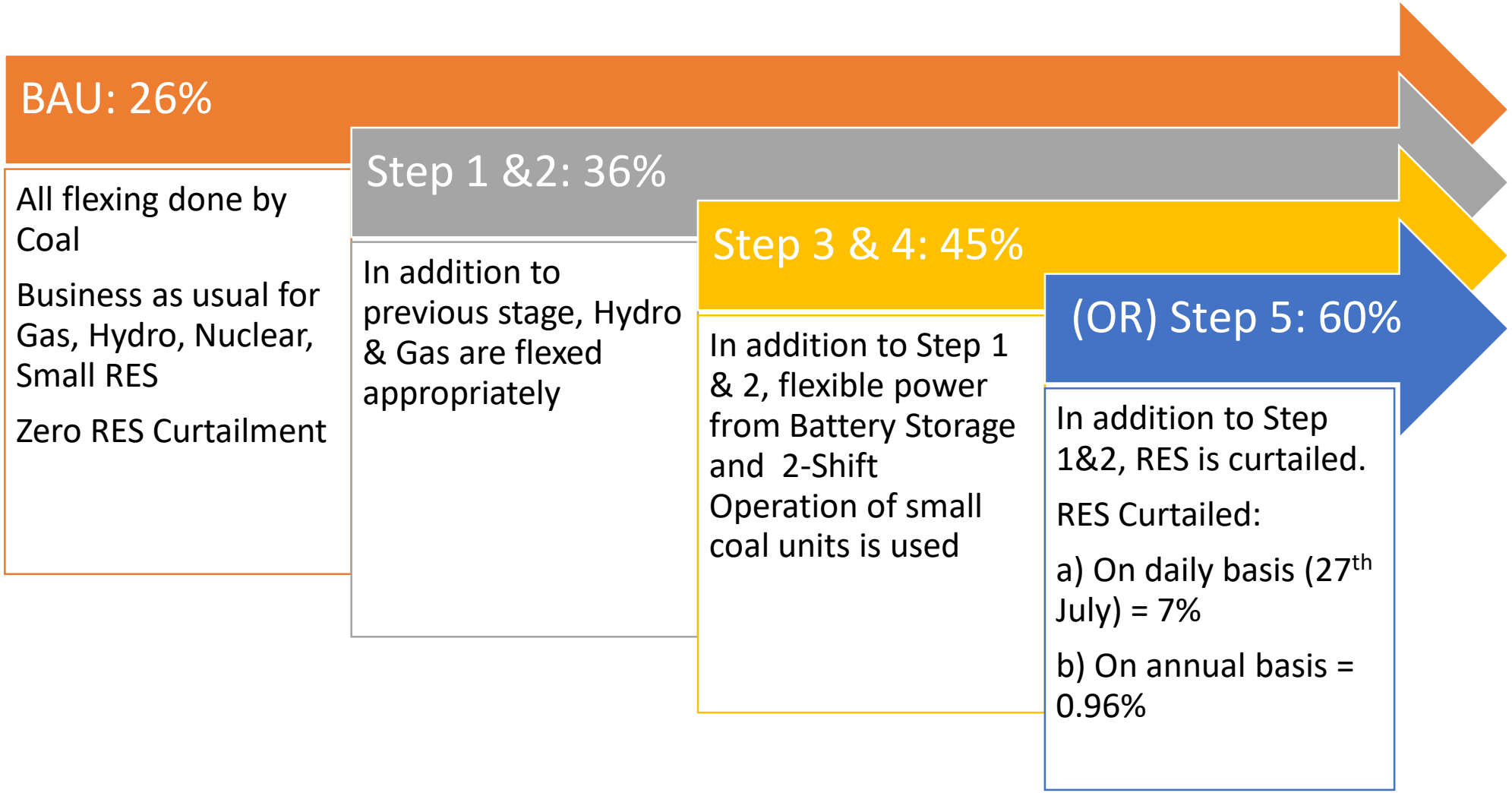
RES Curtailment

S.No.	Season	MU of RES produced	MU of RES curtailed	% of RES curtailed
1	Monsoon	100815	2555	2.53%
2	Non-Monsoon	173488	73	0.04%
3	Overall	274303	2628	0.96%
Overall % RES curtailed				**0.96%**

- Negligible amount of RES curtailment goes a long way in ensuring integration of clean power.
- The period June to August is period of high RES.
- Almost all curtailment of RES will happen in this period

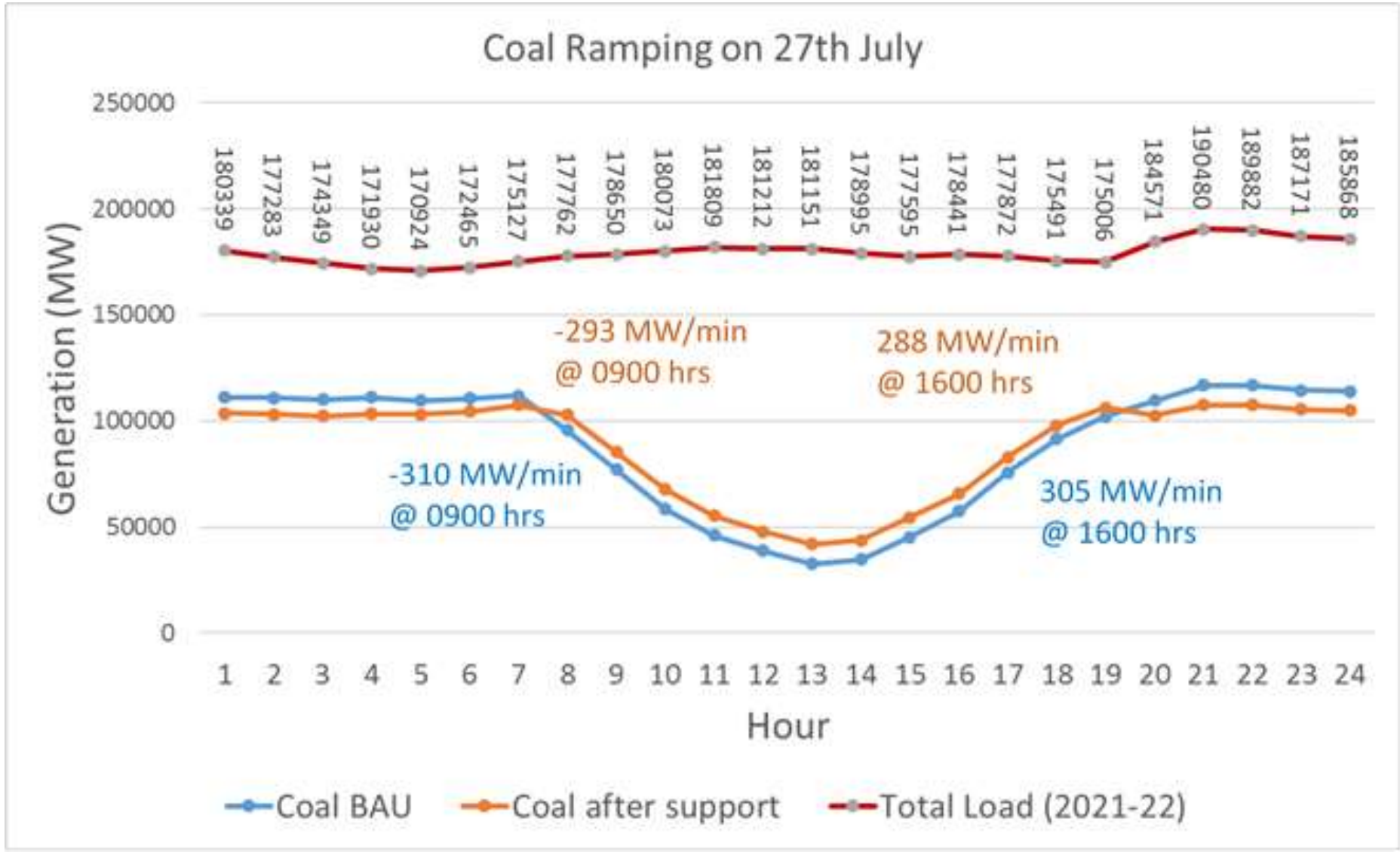
Monsoon : June – August (3 Months)
Non Monsoon : Sept – May (9 Months)

Lowest MTL Case – 27th July 2018



Summary of all steps

E	**27th July,2021, 108 GW RES generation integration**		
		Evening	**Morning**
1	Generation required from thermal power plant during peak MW	116769	111872
2	5000 MW capacity (small & old unit) from 17:00 to 23:00 hrs.	5000	0
3	2-shift opn. of Gas plant - addl. 3000 MW peak support	3000	3000
4	Peak support from running pump storage	2300	2300
5	Peak support from under construction pump storage	1200	1200
6	Re-allocation of hydro generation, MW	1700	1700
7	Addl. peak support from Battery or Pump storage system MW	7000	7000
8	Balance generation required from thermal power plant (1)-(2)-(3)-(4)-(5)-(6)-(7) MW	96569	96672
9	Considering 10% reserve, coal capacity (MW)	107299	107413
10	**Capacity on bar assuming 7% APC , MW**	**115375**	**115498**
11	Min. thermal gen.(MW) required on 25th june,2021	32665	32665
12	Gas gen. is replaced by thermal generation during Solar gen., MW	3000	3000
13	Consumption of under construction pump storage, MW	2300	2300
14	Consumption of runing pump storage, MW	1200	1200
15	Re-allocation of hydro generation increases thermal generation, MW	1700	1700
16	Addl. Consumption of BS/ PS, MW	7000	7000
17	Min. coal gen. required on 27th July,2021 (11)+(12)+(13)+(14)+(15)+(16), MW	47865	47865
18	**Min. Generation assuming 9% APC at partial load, MW**	**52599**	**52599**
19	Avg. min. load of running coal fired unit (%)	45.59	45.54


Coal Ramping on 27th July
Generation (MW)
250000
200000
150000
100000
50000
0
180339
177283
174349
171930
170924
172465
175127
177762
178650
180073
181809
181212
181151
178995
177595
178441
177872
175491
175006
184571
190480
189882
187171
185868
-293 MW/min
@ 0900 hrs
288 MW/min
@ 1600 hrs
-310 MW/min
@ 0900 hrs
305 MW/min
@ 1600 hrs
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
Coal BAU
Coal after support
Total Load (2021-22)

Step-6

Demand Side Management

1. Supply of electricity to agriculture sector by dedicated feeders

- Agricultural consumption = 173185 MU
- Agricultural consumption = 17.30 %
- Connected load = 108834529 kW
- Nos. of consumers = 20918824

2000 MW load is shifted from night hours to peak solar gen. hour it will improve 2% MTL

2. Charging of Electric vehicle when solar generation is available – this will also improve MTL

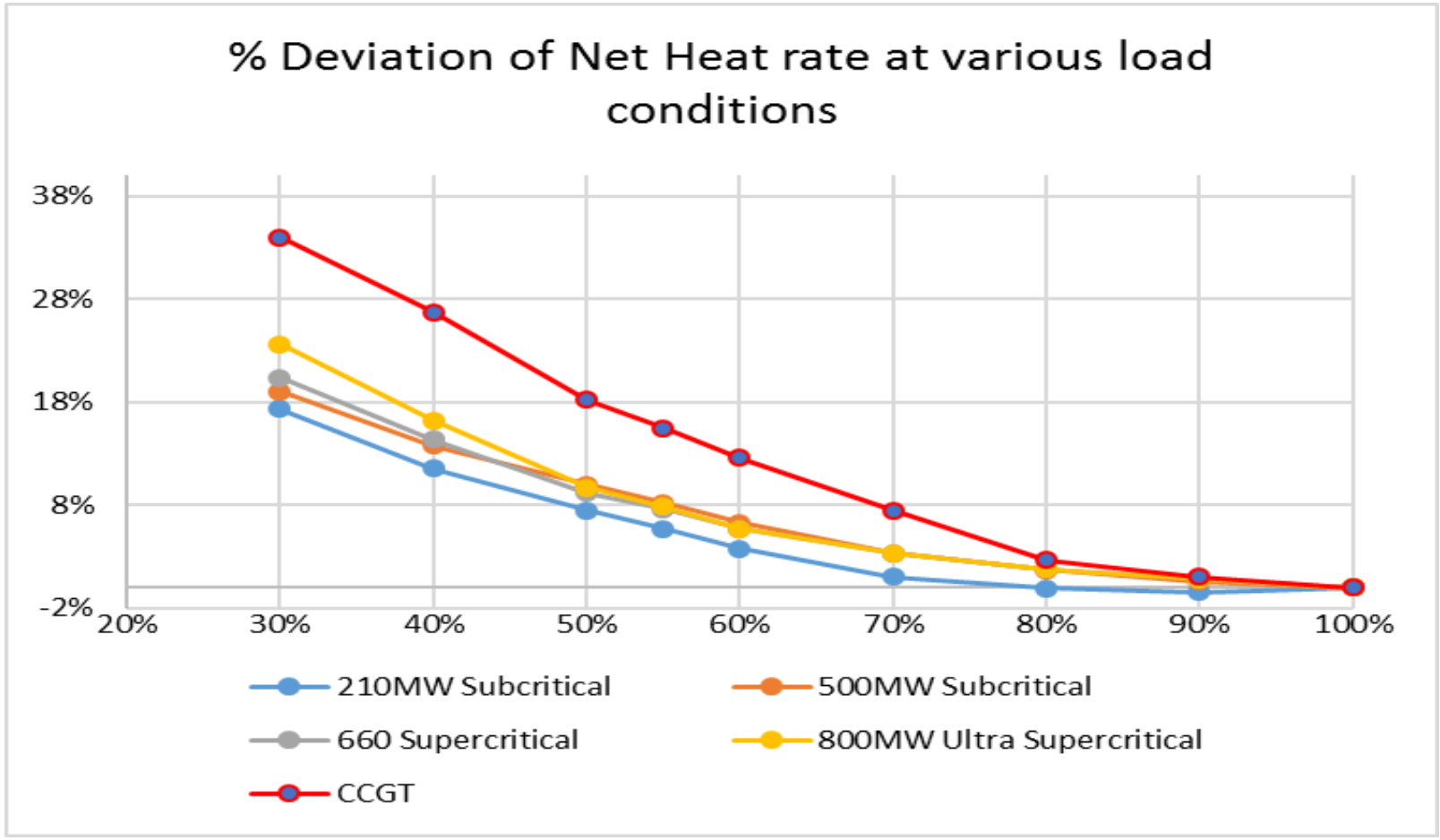
Flexible operation of thermal unit: issues & challenges

Thermal Min Load - Future Scenarios and Roadmap

	Worst Case	Monsoon	Non Monsoon	Best Case
BAU: Only Coal	26	42	55	63
Stage 1: Hydro + Gas	36	52	65	73
Stage 2: Battery + TSO	46	62	74	-
Stage 3: 1% RE Cut	70	70	-	-

- Coordinated Effort: Coal, Gas, Pumped Storage, Battery Storage participate in flexing
- 0.96% Renewable energy is cut on annual basis

Cost due to increase in Heat Rate and Auxiliary Power Consumption (APC).



Categorization of power plants

Symbol	Category	Capacity Range	Capacity	No. of units	
x	Base Load	660 to 800 MW	68160	98	
y	Flexible	490 to 600 MW	70770	133	
z	Very Flexible	195 to 360 MW	67640	285	
TSO	Two shift operation	< 151 MW	10564	110	
	Total		217134	626	

Option-A: Lowest MTL Case, Step 1,2,3 & 4

Category	Evening Load on each category based on MOD (MW)	No. of units	MTL of each category as a whole	Afternoon Load on each category based on MOD (MW)
x	52380	75	50.00%	26190
y	41890	78	44.00%	18432
z	23280	90	40.00%	9312
Total	117550	243	45.88%	53934

ECR range- 0.84 to 2.38

Option-B: Lowest MTL Case, Step 1,2,3 & 4

Stage 2					
Category	Evening Load on each category based on MOD (MW)	No. of units	Average MTL of each category as a whole	ECR range of the category	MTL range of the category
x	52380	75	50.00%	0.84 to 2.38	45% to 55%
y	41890	78	44.00%	1.20 to 2.36	40% to 50%
z	23280	90	40.00%	1.10 to 2.30	35% to 45%
Total	117550	243	45.88%	0.84 to 2.38	

Units having higher ECR are proposed to run at lower loads than units having lower ECR within the same category.

Expenditure involved in flexible operation

Capital expenditure required to implement measures at plant level for flexible operation of thermal unit. The number and type of interventions required would vary from plant to plant depending on the age of unit and scope of works. Further the retrofits will depend on the unit design type, size, coal quality, historical operation and maintenance and age of the units.

Operational expenditure due to increase in

Heat Rate and Auxiliary Power Consumption (APC).

Operation and Maintenance (O&M) due to reduction in life of components.

Oil consumption due to frequent start/ stops.

Regulatory intervention to compensate suitably for supplying power at 50% and below MTL.

Thank you