Production cost modelling of the MSEDCL (Maharashtra) system in GridPath

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GridPath Workshop

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Draft results. Do not cite. Results will be finalised and published in an upcoming report.

Context for the presentation

- Increasing competitiveness of RE generation and battery storage
- Previous modelling studies using Plexos – a commercial electricity market modelling platform
- Need for open source, feature-rich power sector modelling platform
  - Accessible to the wider stakeholder community
  - Transparent implementation
  - Community support
- Demonstrate some of GridPath capabilities through replicating a Plexos MH model

Plan for the presentation

- Modelling approach
- Model setup and input assumptions
- Scenarios and results

Modelling approach for this analysis…1

- Focus on state level analysis
  - Demonstrate value and feasibility of large share of RE to state level decision makers
  - Maharashtra state utility (MSEDCL) system is modelled
- Limit the policy/regulatory instruments considered in the model to decisions that can be taken at the state level
  - Less dependence on interstate and central initiatives or regional/national level optimization
- Focus on system reliability and adequacy at least system cost, with conservative generation and storage cost trajectories and not considering difficult (but desirable) actions such as
  - Increased flexibility of base load plants
  - Diffused actions such as demand response and vehicle-to-grid

Modelling approach for this analysis…2

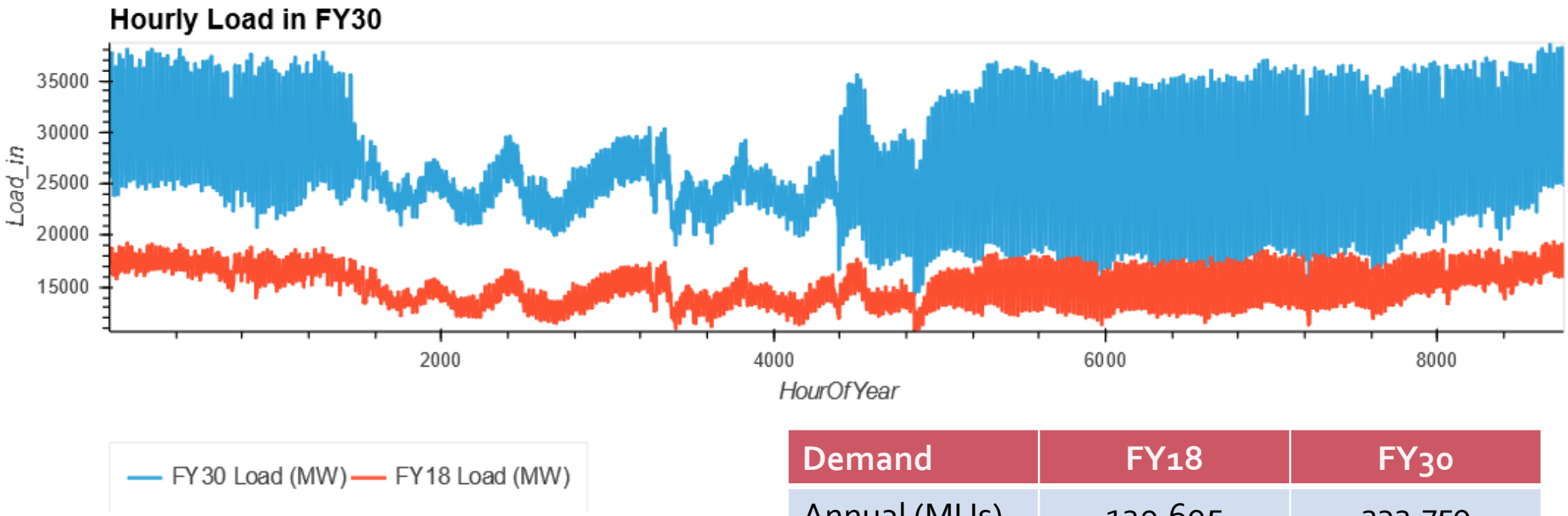
- Production cost simulation as opposed to capacity expansion
- Assume that necessary transmission system augmentation will happen by 2030
- Assess appropriateness of 'high' RE scenario, rather than 'maximum' RE scenario
  - Whether it is technically feasible and cost implications thereof
- Parameters considered for analysis
  - Reliability: Shortage quantum and profile
  - System operation in stress hours/months
  - Thermal PLFs, part-load operation, starts
  - RE curtailment
  - Variable/operational and total costs

MSEDCL model setup

- Base year : 2017-18
- Model year : 2029-30
- Transmission: copper plate
- Load profile : 2017-18 load scaled up to FY30 at 5% p.a.
  - Shift 4000 MW of non-monsoon night-time agricultural load to day time by FY30 as per solar feeder policy
- Unit-wise disaggregation of generation sources
- Profiles for new solar capacity generated using SAM
- Profile for new wind capacity scaled up (to ~28% CUF) from base year wind profile
- Costs as per current trends

Category	Contracted Capacity (MW) in FY18
State Genco Coal	10,162
State Genco Gas	672
State Hydro	2,352
Central Coal	4,471
Central Gas	404
Central Hydro	491
Central Nuclear	748
IPP Coal	5,585
Wind	3,641
Solar	654
Other RE	1775
Total	**30,955**

Load in FY18 and FY30



Demand	FY18	FY30
Annual (MUs)	129,605	232,750
Average (MW)	14,795	26,750
Peak (MW)	19,077	38,119
Trough (MW)	10,393	14,705

Thermal and hydro operational constraints

- Coal
  - Technical minimum 55% for all units
  - Ramp rates: 1-1.5 %/min
  - Min up/down time: 24 hours
  - Start costs: CEA's 2019 report on 'Flexible Operation of Thermal Power Plants for Integration of Renewables'
  - Availability: 85%
- Hydro
  - Koyna and Central Hydro: Yearly energy budget and monthly minimum energy based on generation data from past few years
  - Rest of the hydro: Generation profile provided based on past few years' data
- Open Cycle Gas ramp rate 4%/min

Model platform and settings

- **GridPath** – https://www.gridpath.io
- Open source software that offers production cost simulation and capacity expansion optimization among other things
- Comparable in functionality to industry-standard power systems modelling platforms
- Modular and can easily scale to adapt to new modelling requirements
- Relevant for transmission system operators, market operators, planners, regulators, distribution utilities, generators, researchers, etc.

- Single-stage unit commitment and economic dispatch optimised on a day-ahead basis
- Multiple passes to optimise thermal maintenance and hydro scheduling on annual basis
  - Thermal unit maintenance scheduled in high reserve periods
  - Reservoir based hydro generation optimised over the year, within exogenously provided monthly constraints

Scenarios

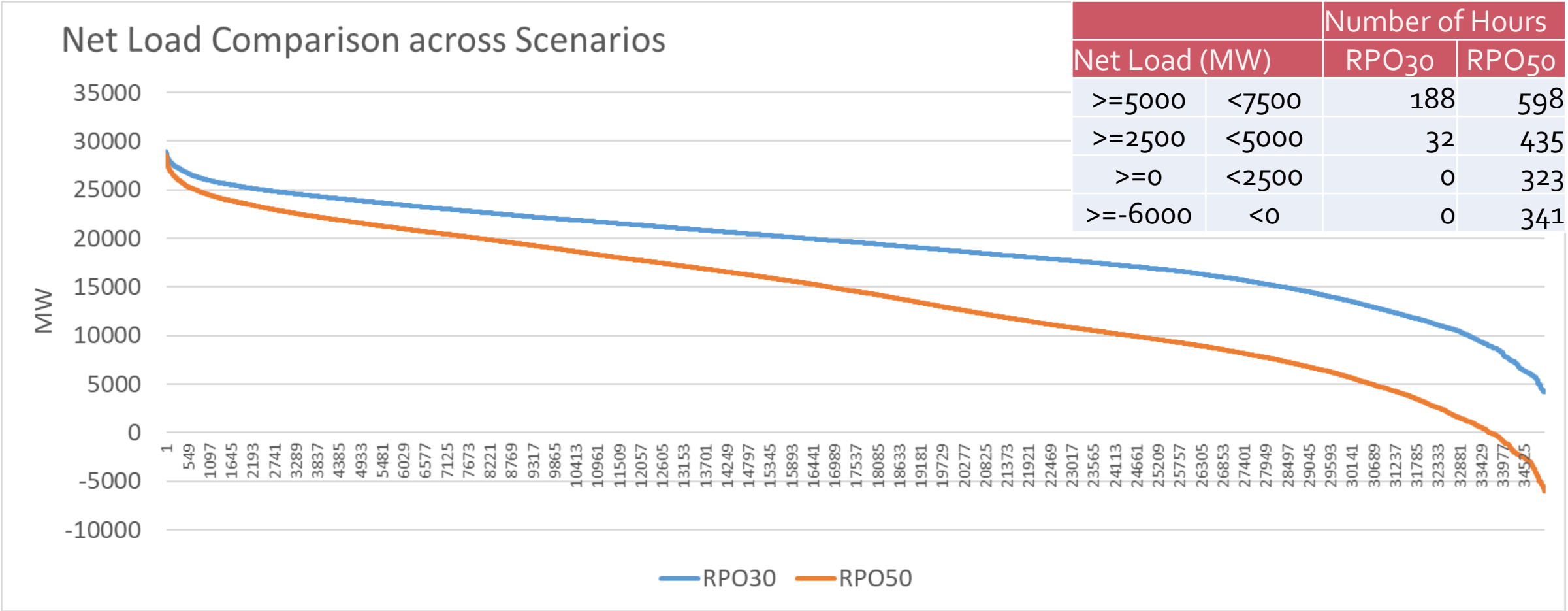
- Assumed addition of 2x660 MW in pipeline across all scenarios
- RPO30
  - 30% generation from RE sources in FY30
  - 2,000 MW open cycle gas available at Rs 12/unit (nominal in FY30)
- RPO50
  - Progressively increasing retirement of coal capacity in S1, S2 and S3 scenarios
  - 50% generation from RE sources in FY30
  - Battery: 3,000 MW/18,000 MWh + 2,500 MW/10,000 MWh
  - Market procurement of up to 2000 MW instead of open cycle gas at Rs 6.5-10/unit depending on time of day and season in RPO50S2 and RPO50S3

	RPO30	RPO50S1	RPO50S2	RPO50S3
Coal-based capacity (MW)	+ 6x660	+2x660 – 6x210	+2x660 - 12x210	Retirement as per CEA NEP
RE generation	30%	50%	50%	50%
Open Cycle Gas or Market	Gas	Gas	Market	Market
Battery storage	-	Yes	Yes	Yes

Contracted capacity across scenarios

Contracted Capacity (MW) by FY30	RPO30	RPO50S1	RPO50S2	RPO50S3
State Genco Coal	11,490	10,230	8,970	7,550
State Genco Hydro	2,352	2,352	2,352	2,352
Central Coal	5,117	5,117	5,117	5,117
IPP Coal	5,585	5,585	5,585	4,470
New Coal	2,640	-	-	-
Wind	12,940	21,215	21,215	21,215
Solar	19,675	28,640	28,640	28,640
Others	5,233	5,233	5,233	5,233
Total	**65,031**	**78,372**	**77,112**	**74,577**
Flexible Gas/Market	2,000	2,000	2,000	2,000
Battery	-	5,500	5,500	5,500

Net load RPO30 vs RPO50



Net Load (MW)		Number of Hours RPO30	Number of Hours RPO50
>=5000	<7500	188	598
>=2500	<5000	32	435
>=0	<2500	0	323
>=-6000	<0	0	341

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MAINTENANCE AND HYDRO SCHEDULING

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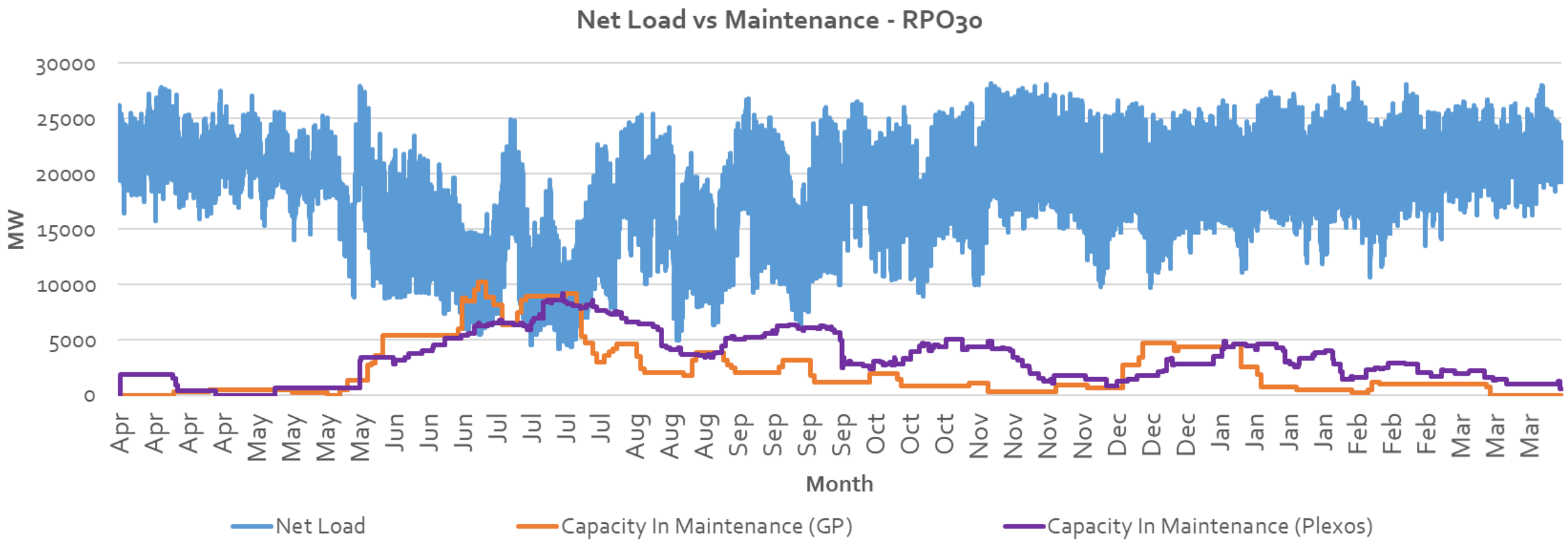
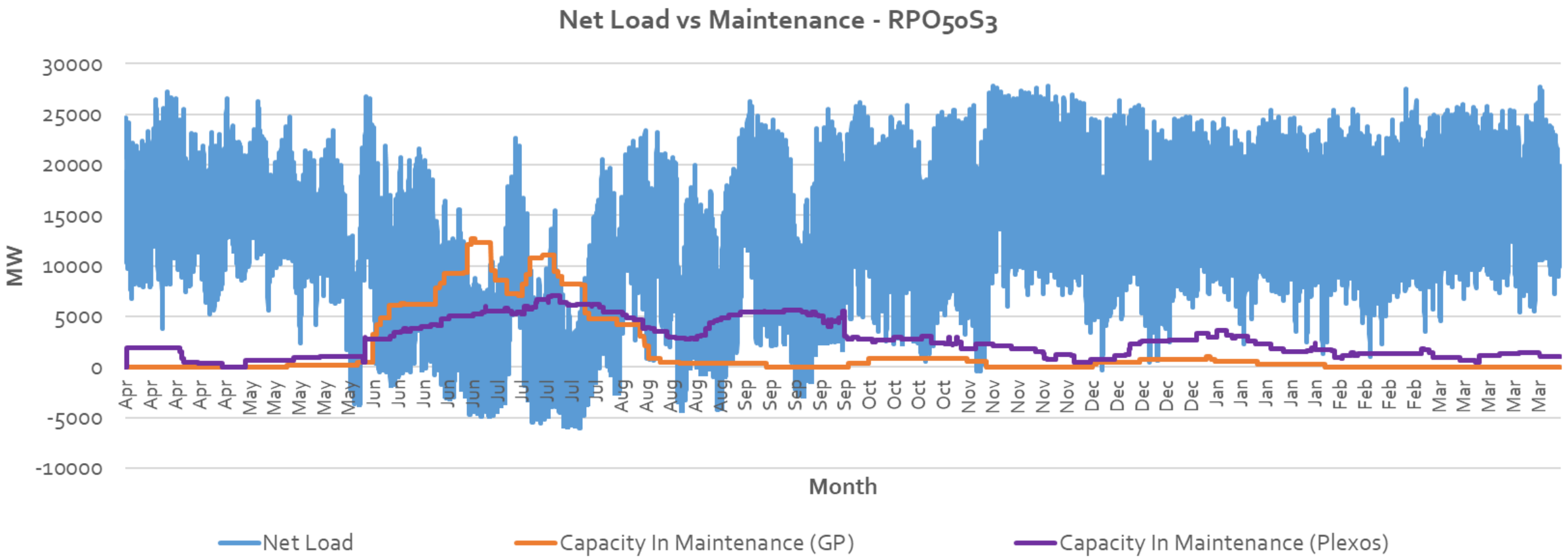
Maintenance schedule – RPO30



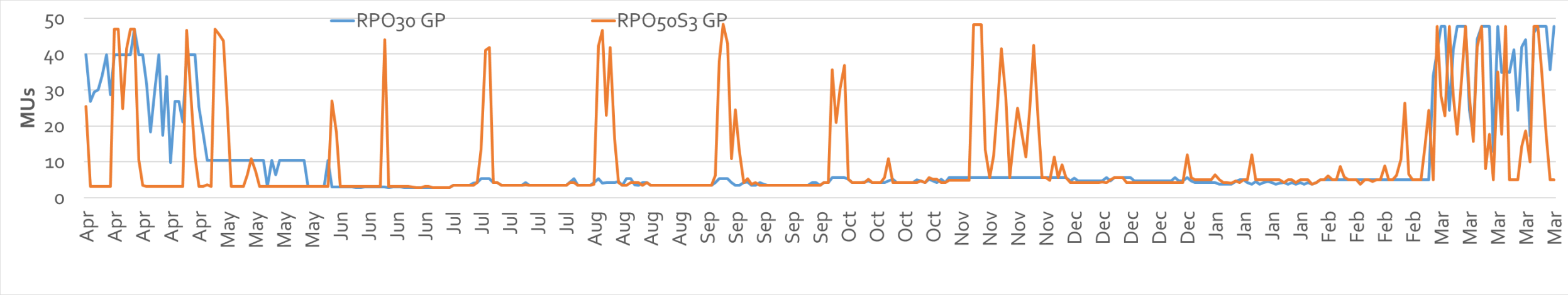
Plexos plot includes maintenance schedule of hydro capacity as well

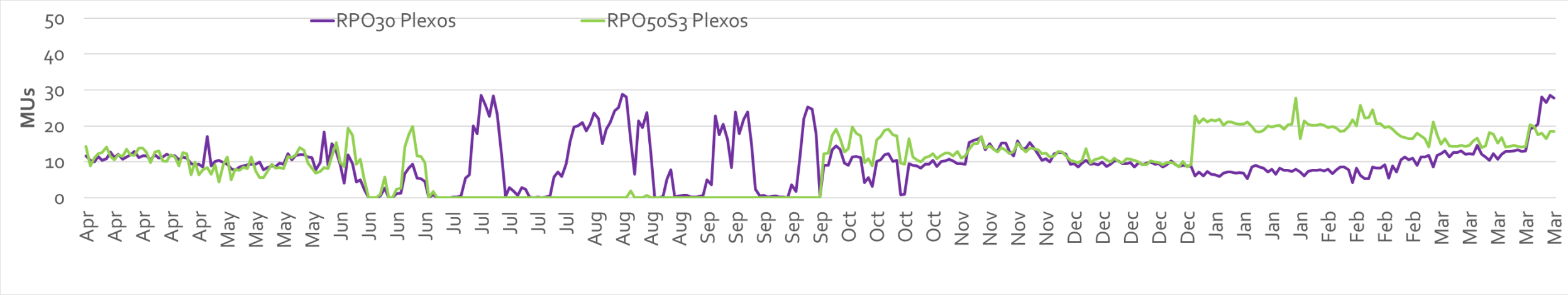
Maintenance schedule – RPO50S3



Plexos plot includes maintenance schedule of hydro capacity as well

Hydro generation schedule





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UNIT COMMITMENT AND DISPATCH

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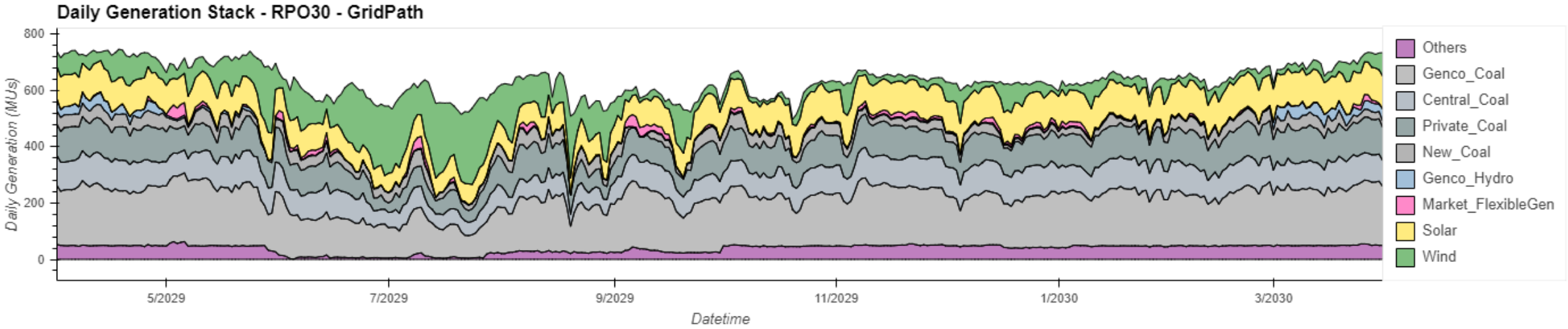
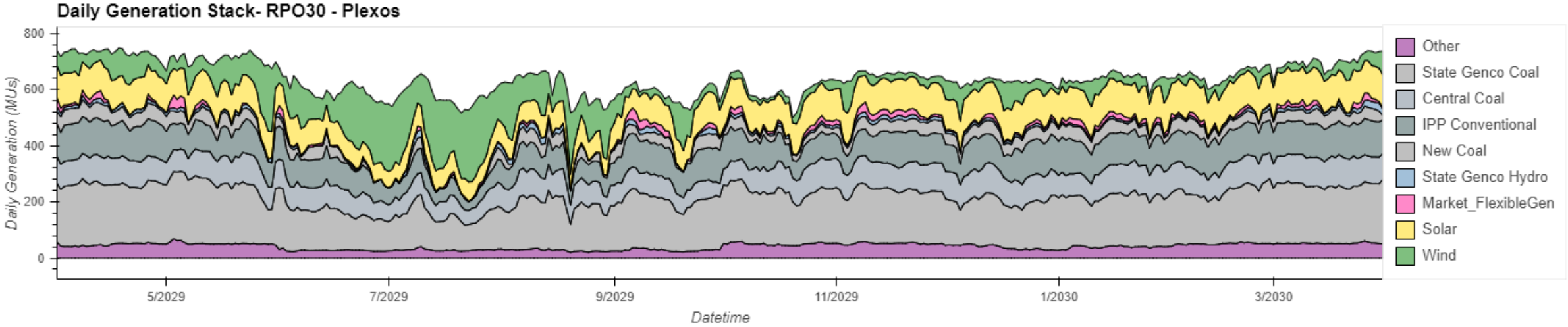
Daily generation stack – RPO30





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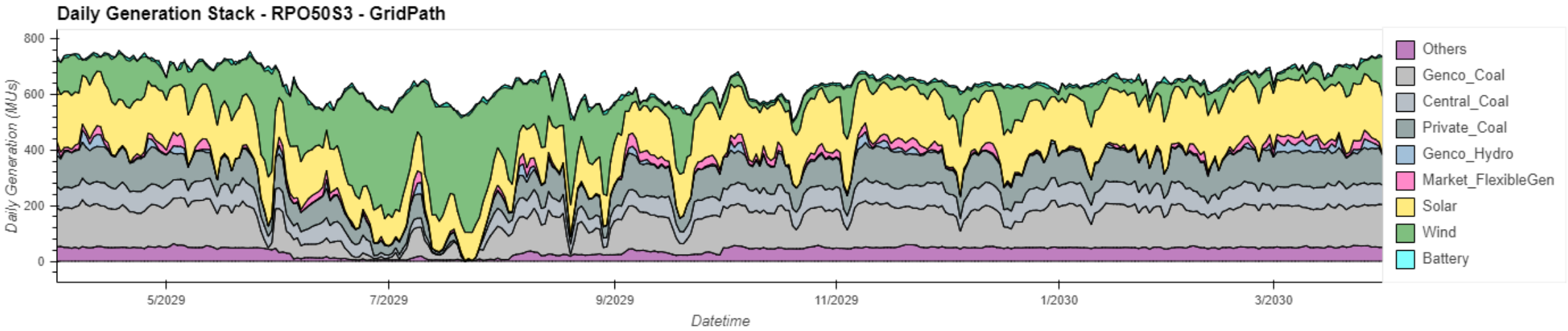
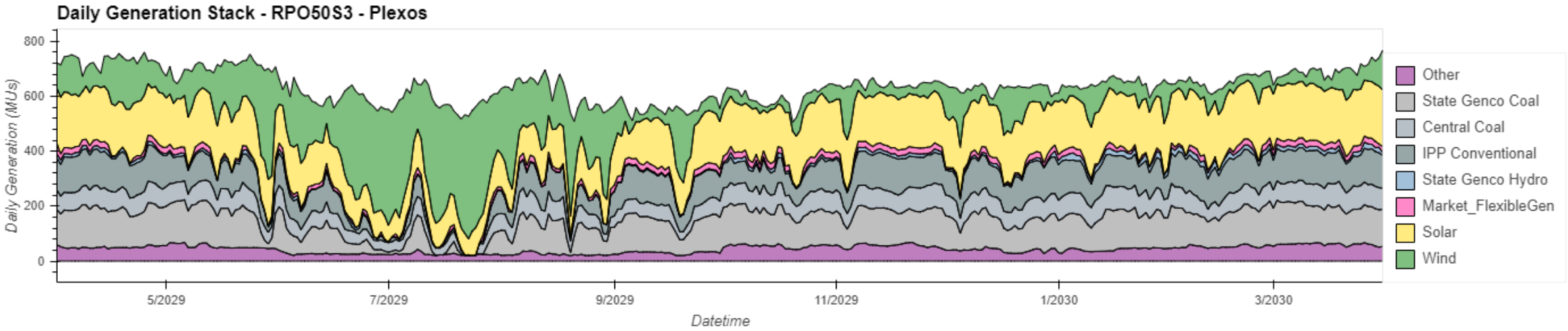
Daily generation stack – RPO50S3





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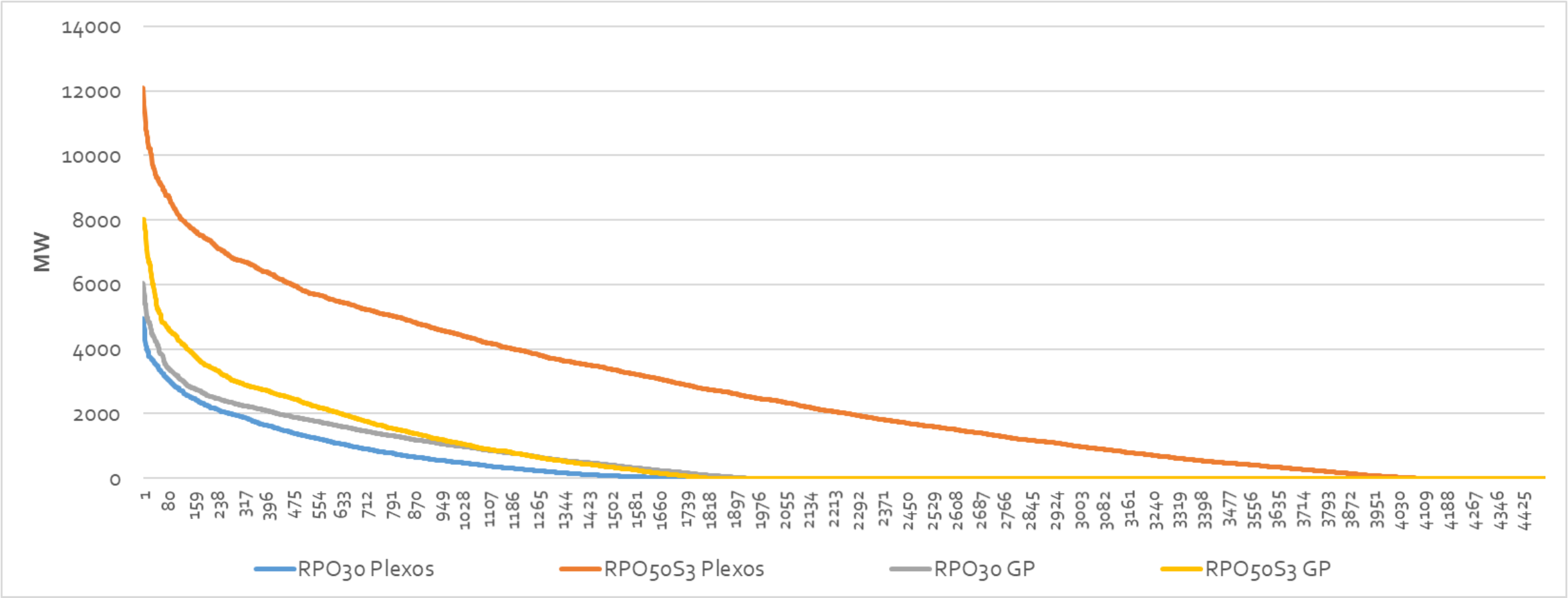
Shortage duration curves across scenarios



15-min blocks

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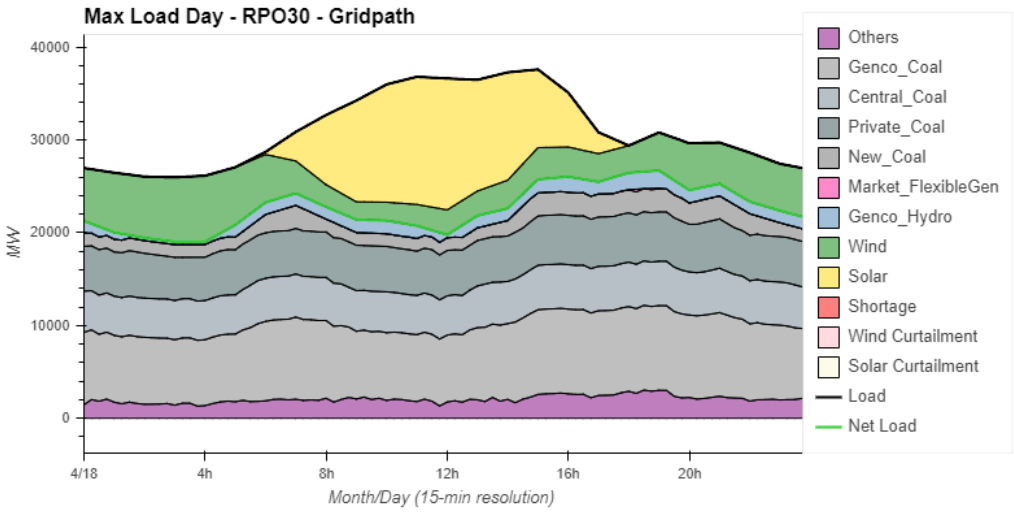
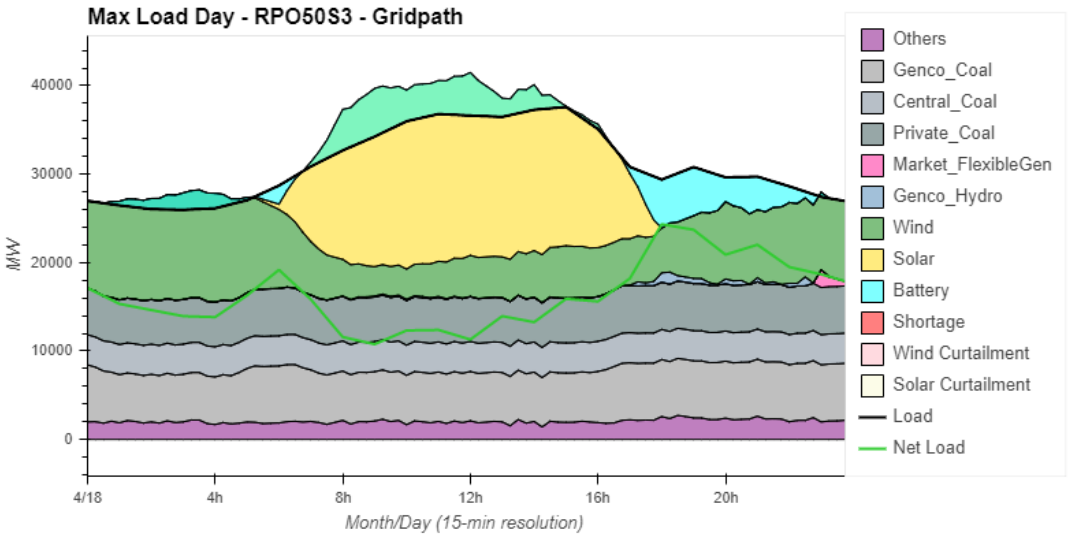
Summary of dispatch results across scenarios

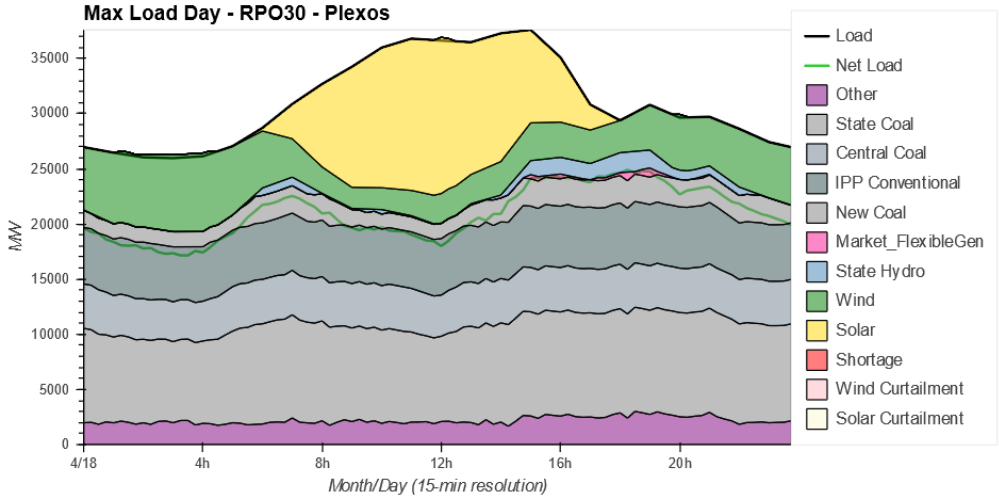
	Gridpath				Plexos			
	RPO30	RPO50S1	RPO50S2	RPO50S3	RPO30	RPO50S1	RPO50S2	RPO50S3
Shortage (MUs)	625	20	150	768	430	166	632	2958
Shortage (% of load)	0.27%	0.01%	0.06%	0.33%	0.18%	0.07%	0.27%	1.27%
RE curtail (MUs)	821	2724	2604	2407	1176	3668	3475	3351
RE curtail (%)	1.28%	2.49%	2.38%	2.2%	1.84%	3.39%	3.2%	3.08%
Market/Gas (MUs)	2416	608	1792	5095	3401	1818	4034	5551
Gross Coal PLF (%)	72%	62%	65%	71%	72%	62%	64%	69%
Coal starts/unit	8.4	12.4	11.6	10.3	6.1	11.1	10	9.4

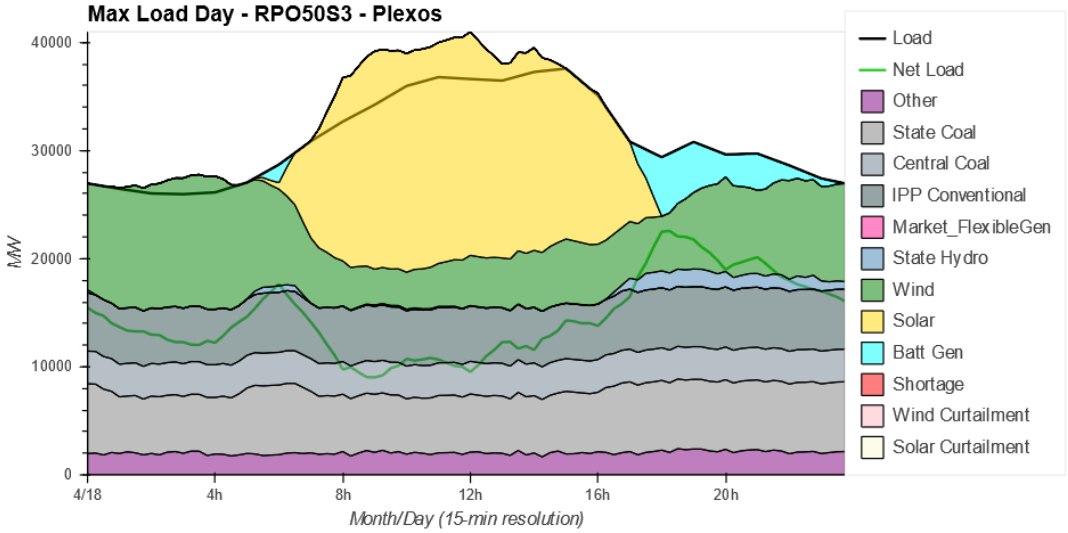
5-8% lower total power purchase costs across the RPO50 scenario runs and modelling platforms as compared to the RPO30 scenario, not considering transmission costs etc.

High load day dispatch RPO30 and RPO50S3









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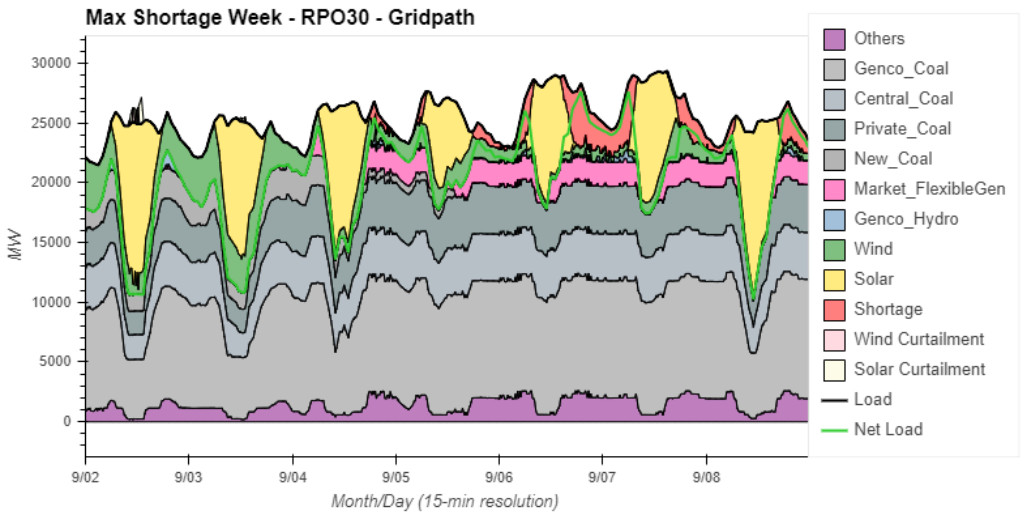
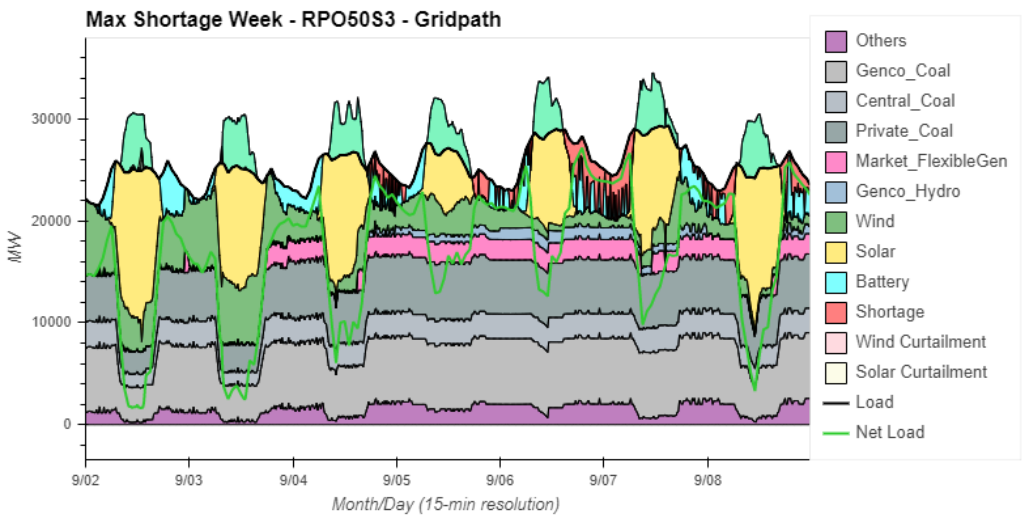
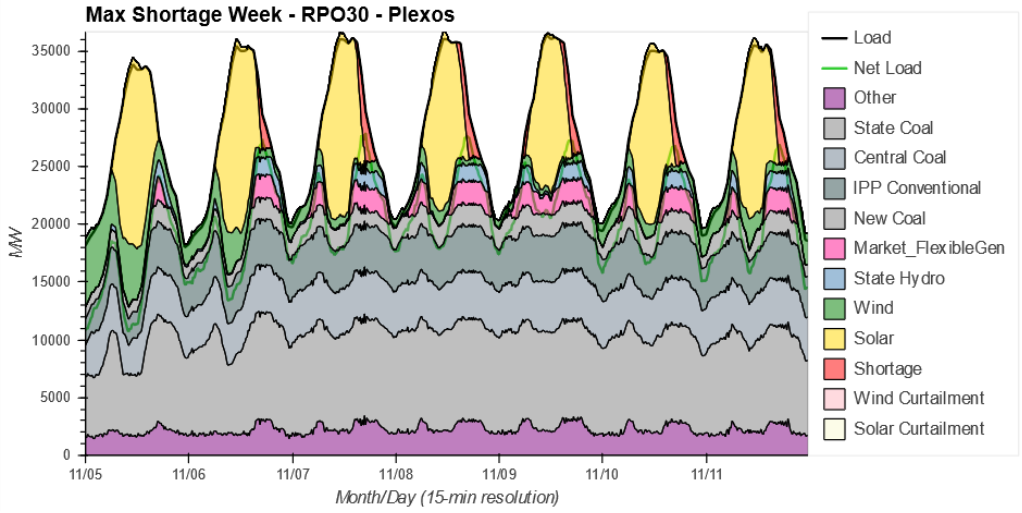
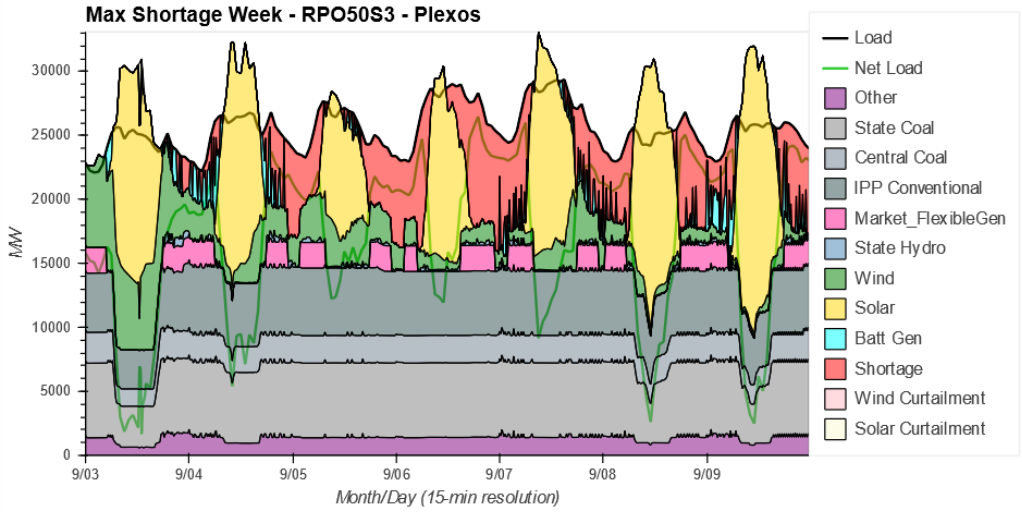
Max shortage week – RPO30 and RPO50S3









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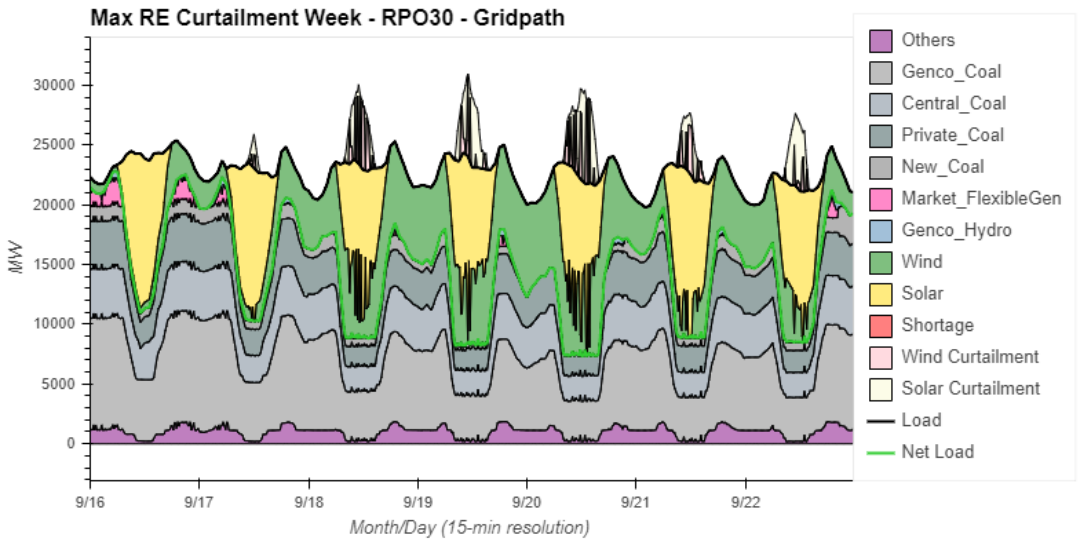
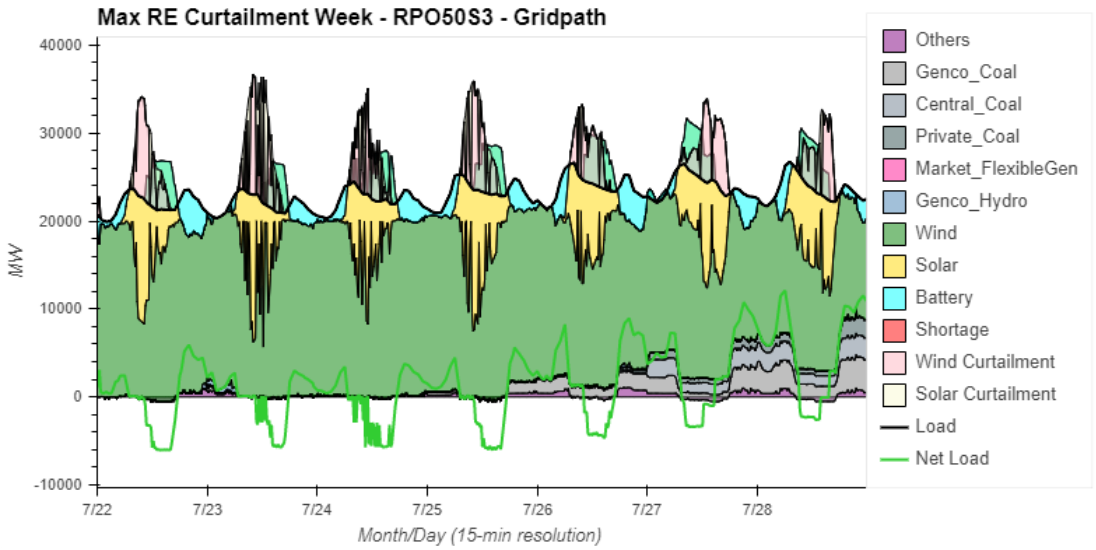
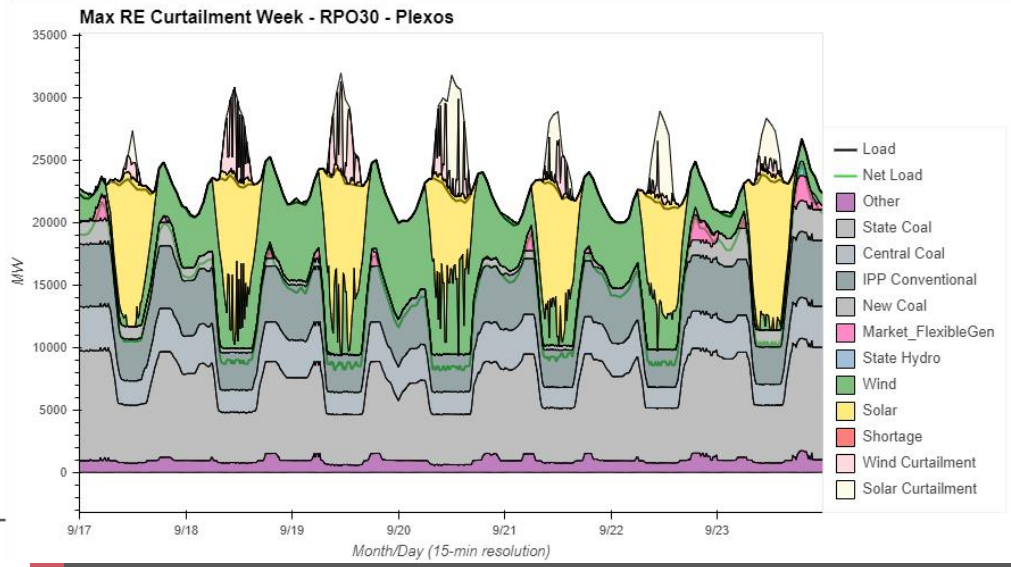
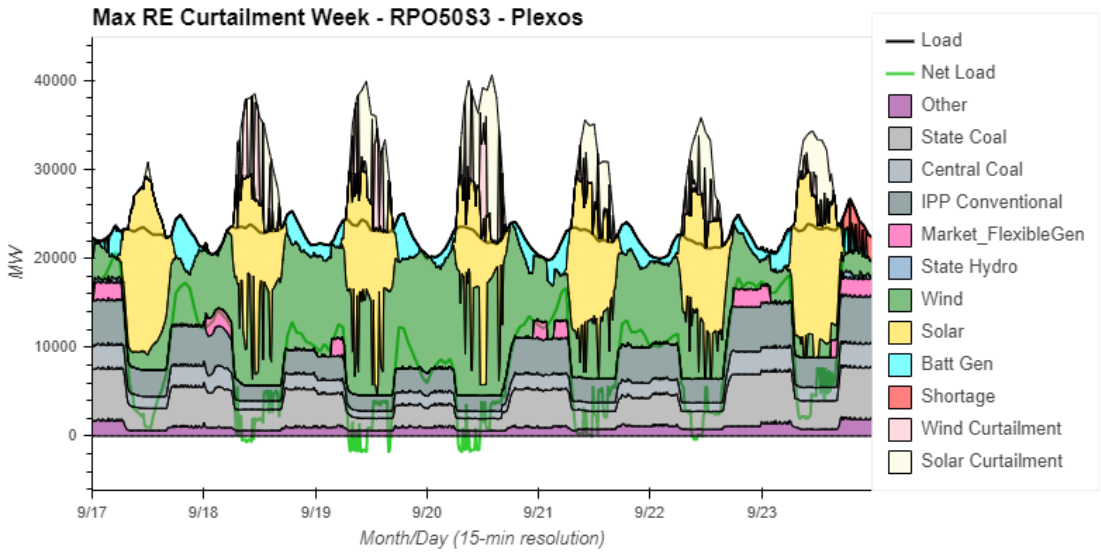
Max curtailment week – RPO30 and RPO50S3









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COAL FLEET OPERATION

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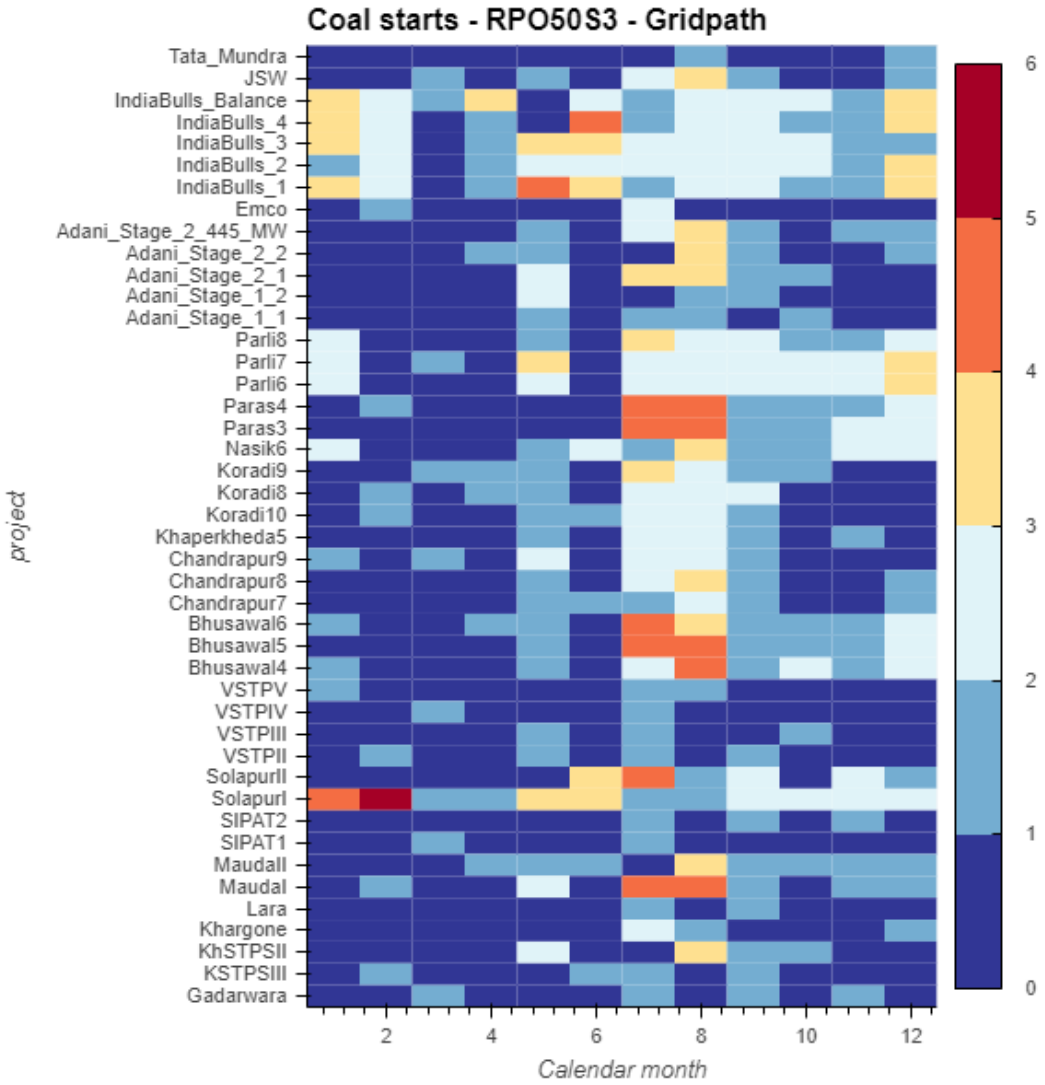
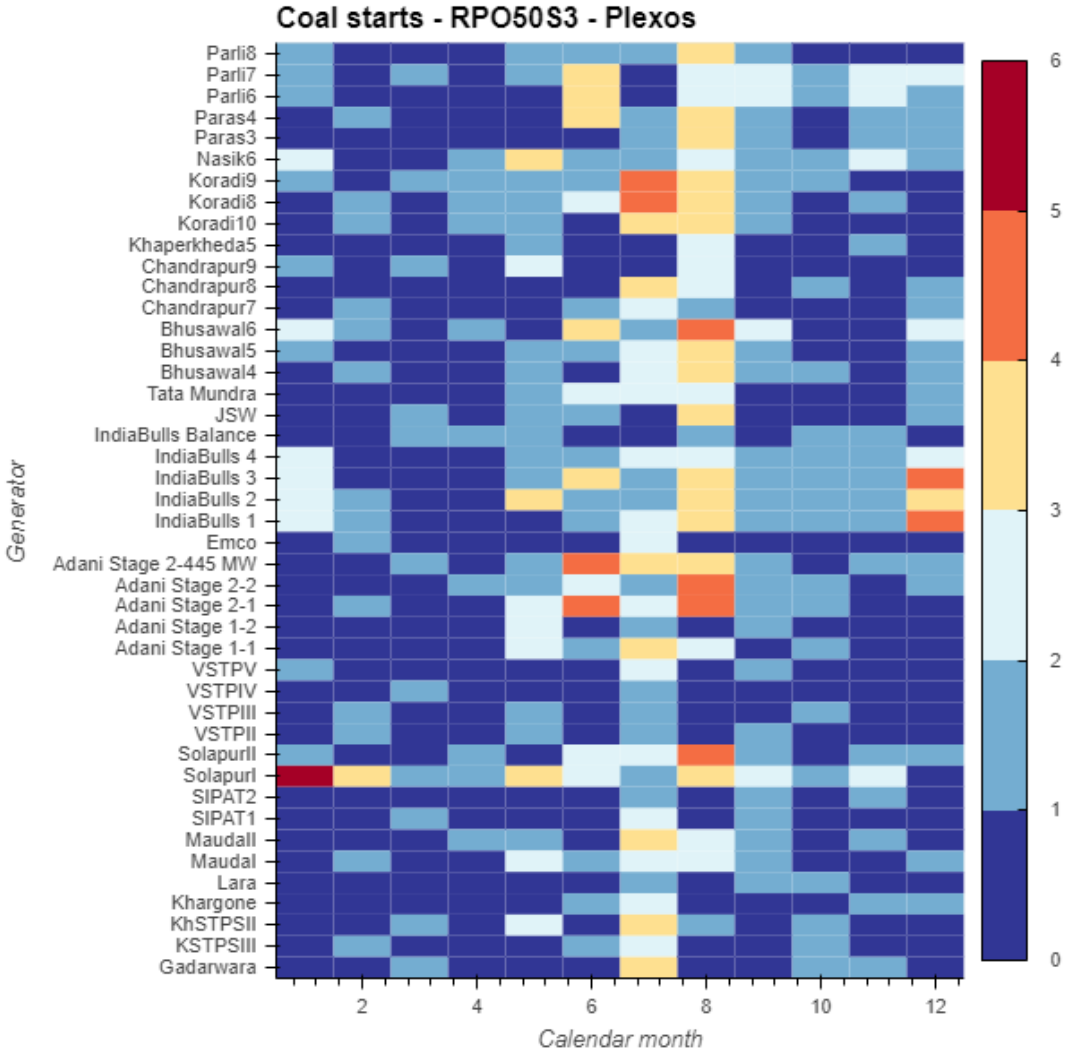
Coal starts – RPO50S3





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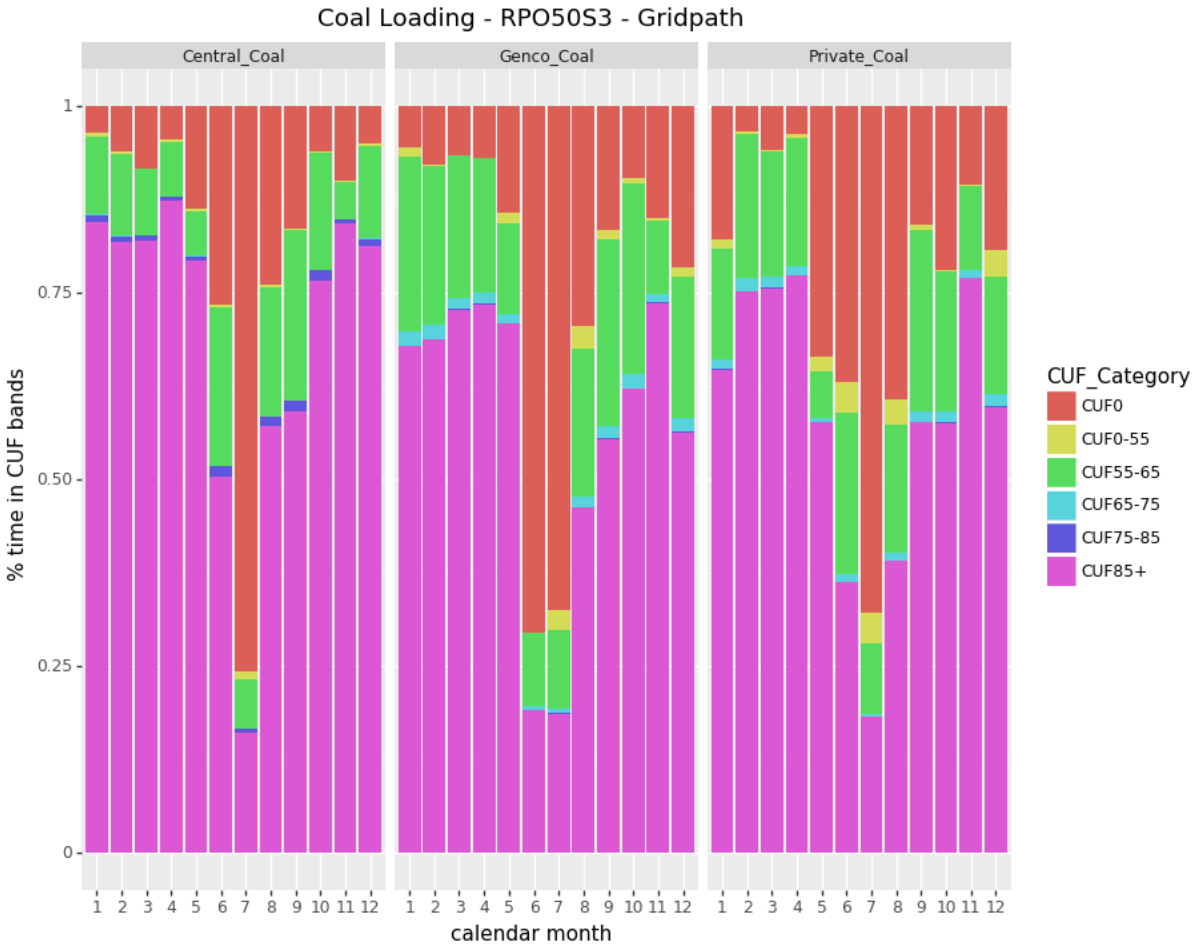
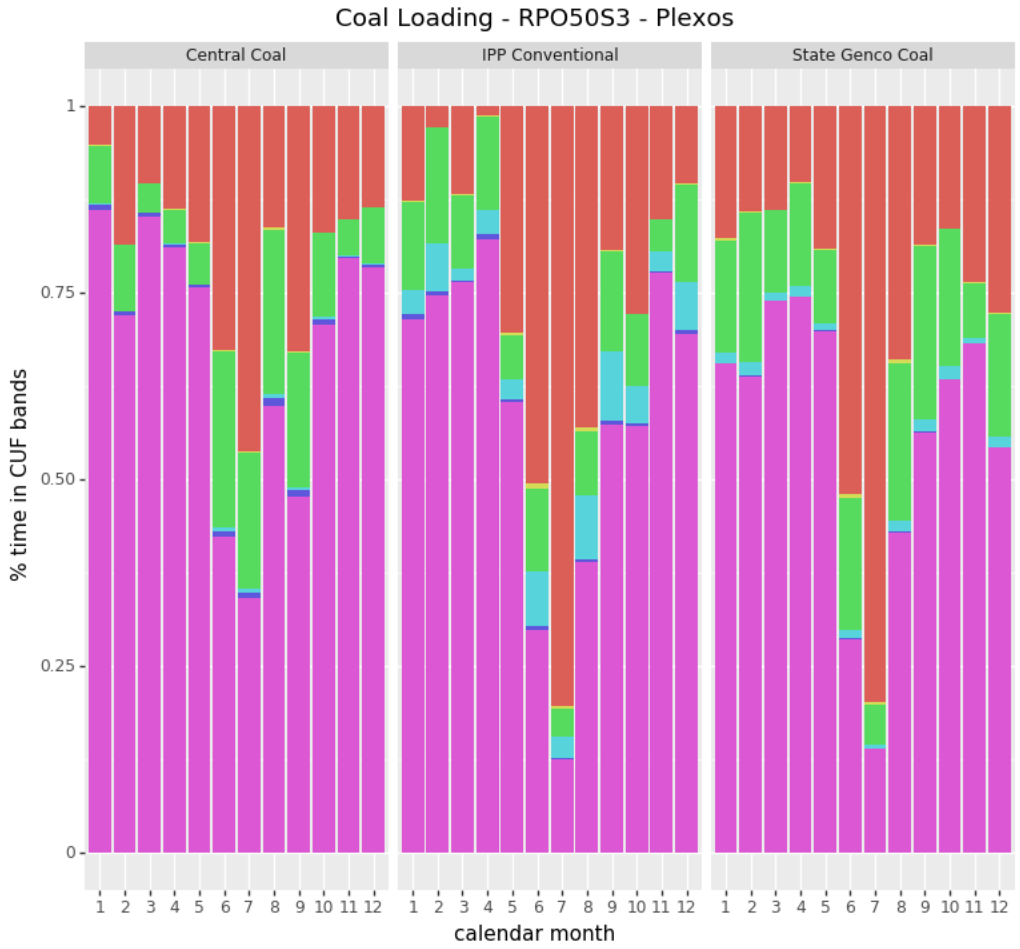
Coal unit loading – RPO50S3





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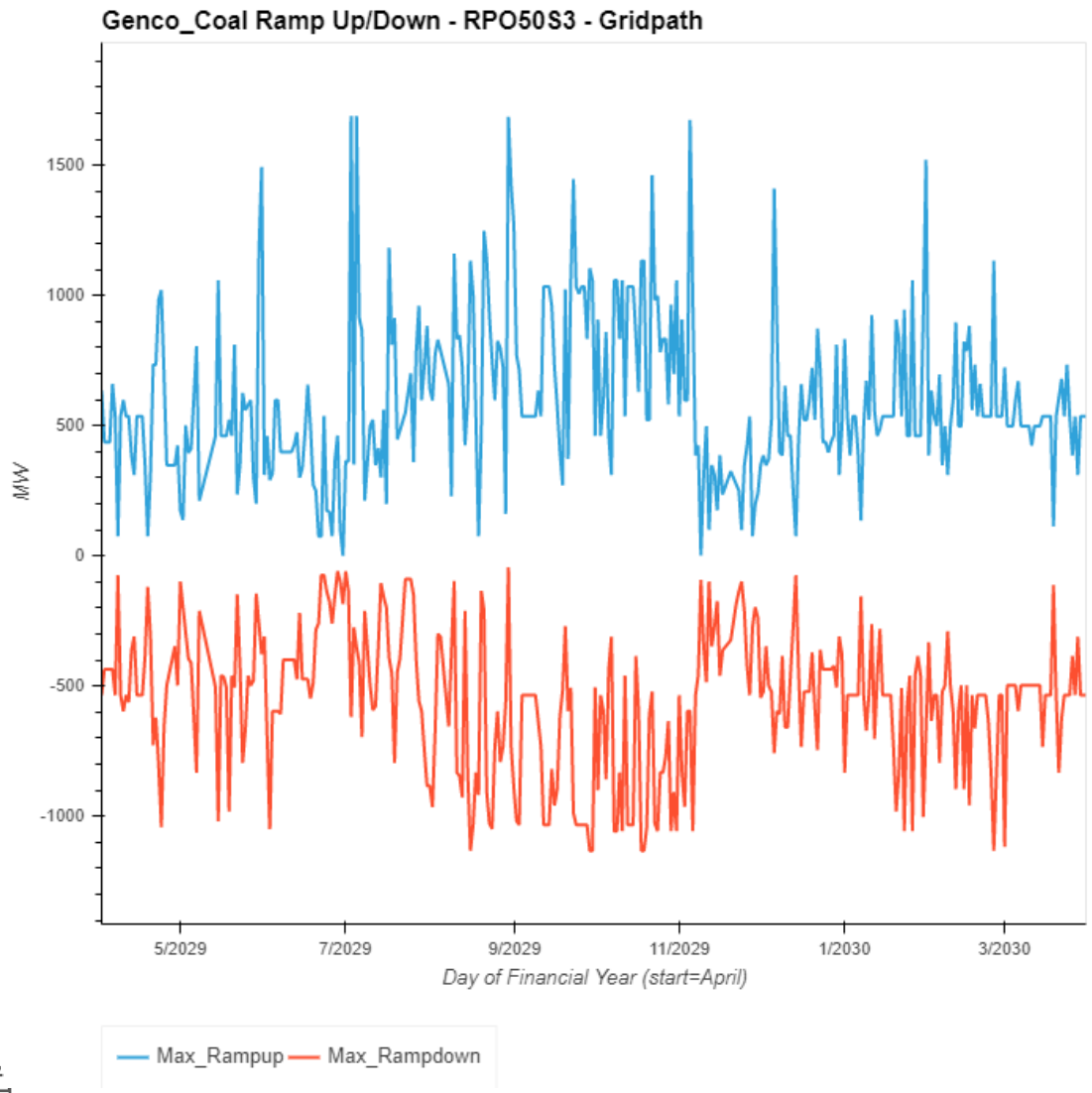
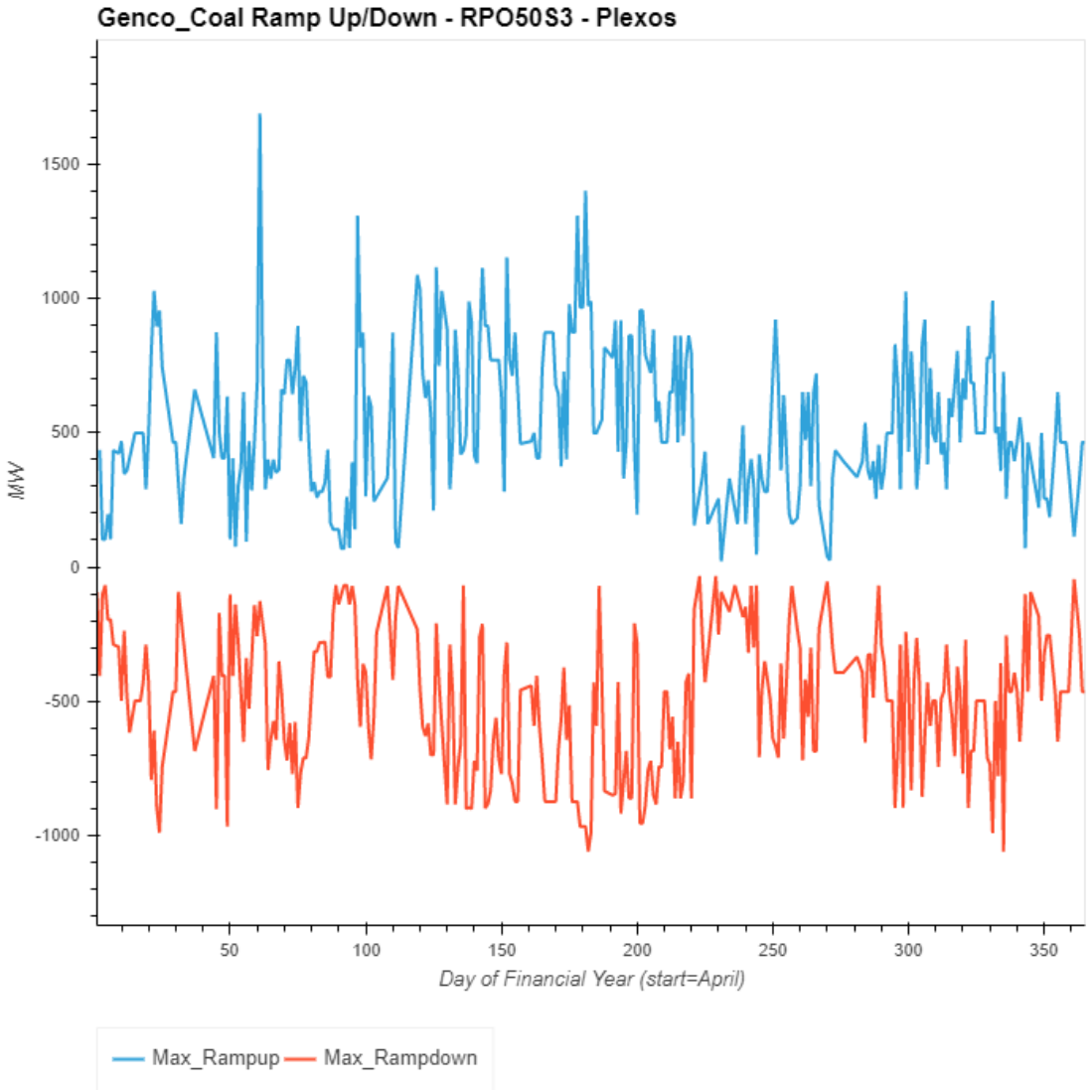
Daily max coal ramps in 15 min block





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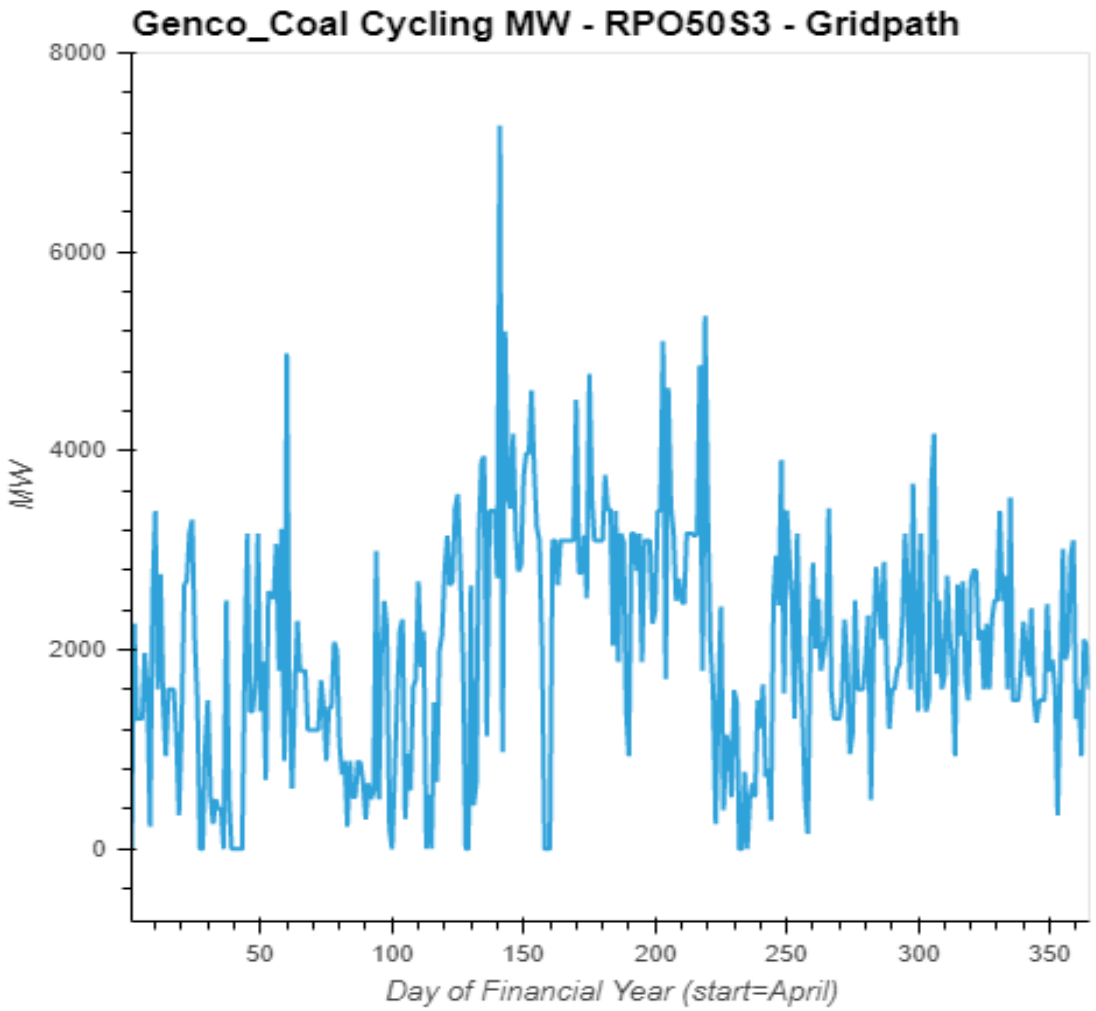
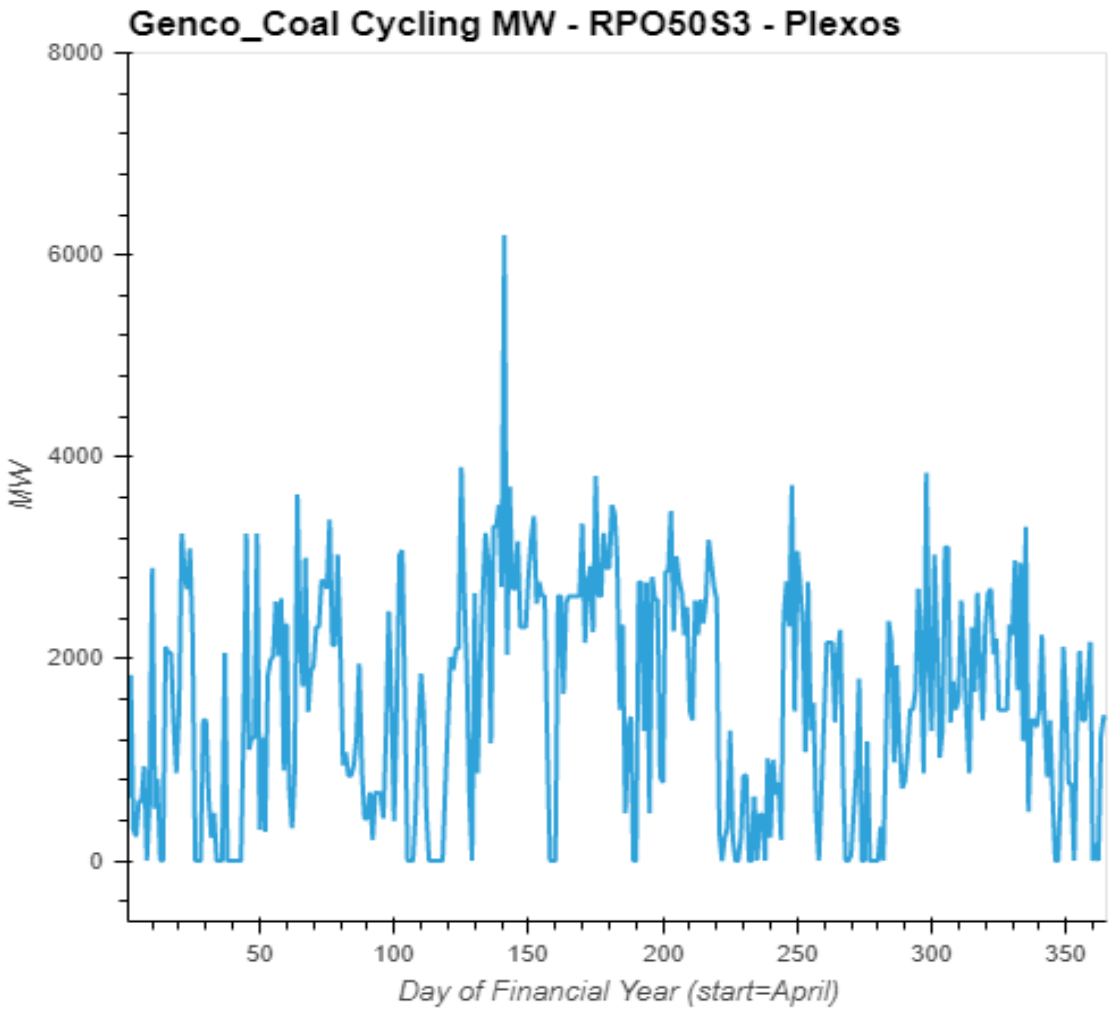
Daily cycling of coal based capacity





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KEY INSIGHTS AND CONCLUSION

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Key Insights

- Possible to meet demand in 2030 without any 'net addition to coal fleet' and with 50 % energy contribution from RE
  - Operation of coal plants within acceptable technical limits (technical min, ramp rates etc.)
  - However, retirements have to be planned carefully
- Solar feeder, day time AG load, significantly helps in solar absorption
- For reliability, necessary to procure 'peaking' power ~ 15 - 35% PLF depending on the scenario
  - high cost (either low PLF or market)
- Desirable to have seasonal, short term procurement to meet seasonal high load
- Coal availability, cost and flexible operation ability important considerations in both scenarios
- Demand response measures are essential to avoid sudden shortage for even few hours a year (~ 20 – 30 hrs.)

Some recommendations

- Some actions / policies that should be considered as part of Multi-year Tariff (MYT) framework
  - Seasonal tariffs
  - Expanding ToD regime to 5/10kW+ and adjusting peak tariff slot
  - Seasonal short term procurement
  - Peak / exigency power procurement approval
- Initiating procurement of grid scale battery storage on pilot basis
- Ensure/expand solar feeder
- Transmission planning for 50% RE scenario
- More structured and rigorous RE procurement approach (location, profile etc.). Value to the system rather than just least cost approach needs to be adopted.

Conclusion

- Results of the GridPath MH model are comparable to those of the Plexos model
- Key insights from the results remain the same
- Similar results across two different platforms increases confidence in the insights
- Minor differences in the results need further investigation

Next Plans

- Capacity expansion
- Wider regional model
- Will make MH model public in due course

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Contact: energy.model@prayaspune.org

THANK YOU

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