Study Committee C4

PS3 POWER SYSTEM PLANNING AND FLEXIBILITY CONSIDERATIONS

Paper 10761

Flexibility requirements of the KSA power system in presence of massive deployment of renewable energies

Mohammad Al Dahasi

Problem statement

- In line with KSA Vision 2030, **50% of energy requirements** of the KSA region will be driven by renewables
- About **60 GW of RES** to be deployed by 2030, due to which the planning and operation of the KSA power system is set to be transformed.
- This work evaluates the **system flexibility requirements** to accommodate ambitious renewable targets and the impacts on unit commitment and economic dispatch schemes.

RES Penetration into KSA grid & scenarios

- As shown in Figure 1, the introduction of renewables into KSA grid is assessed through project capacity scenario which defines the capacity of RES per operating areas per project site.
- Maximum site capacity scenario considers the maximum potential at a particular RES location which determines the worst operational regime for the KSA grid as shown in Figure 2.

Installed RES [MW] - Project Capacity Scenario

Area	CSP	PV	W2E	Wind	Total RES
COA		1,800		400	2,200
NEOA		355		800	1,155
NWOA	150	300			450
SOA		105			105
WOA	150	1,270	50	400	1,870
Total KSA	**300**	**3,830**	**50**	**1,600**	**5,780**

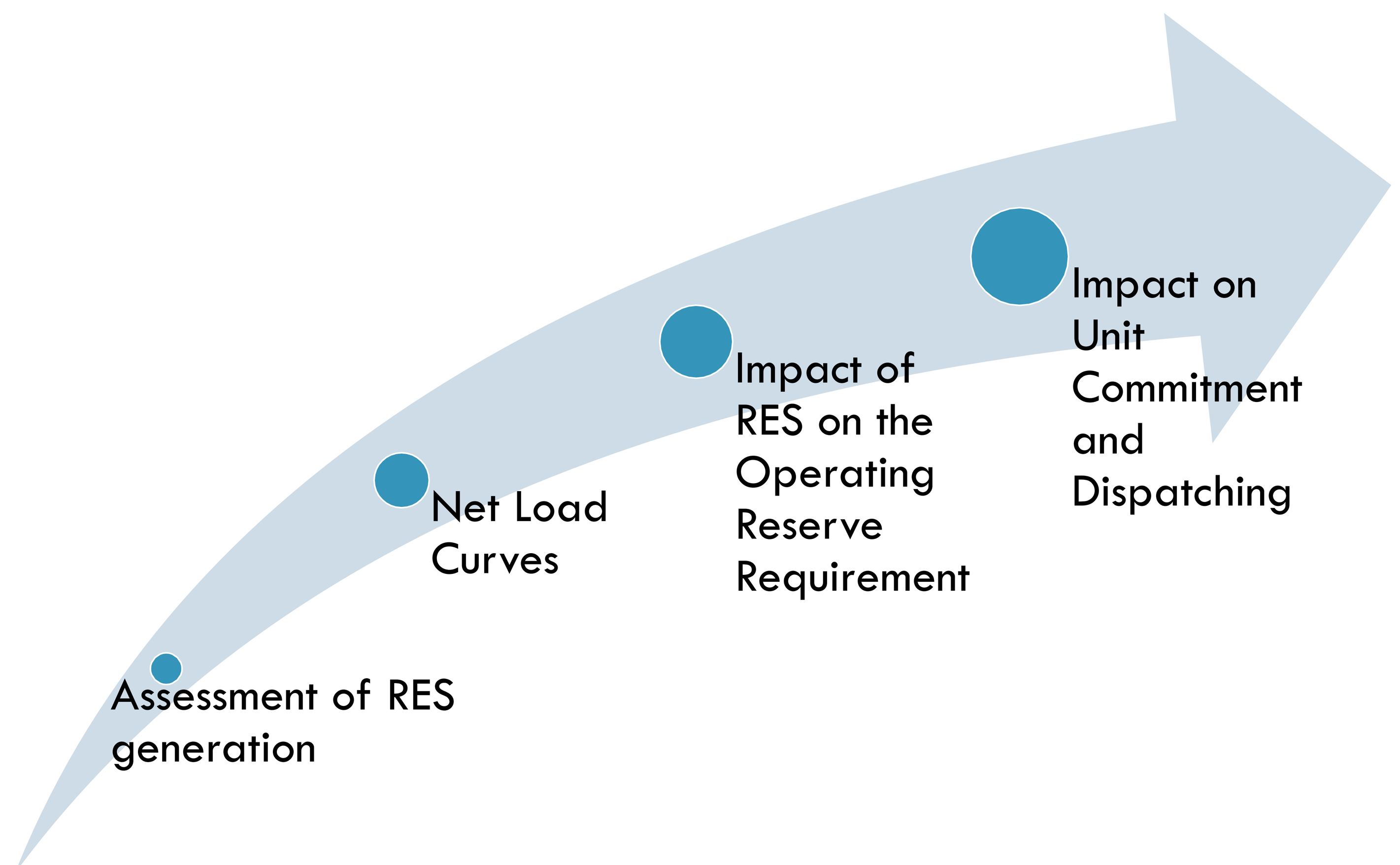
Fig1: Penetration of RES in KSA project capacity scenario

Installed RES [MW] - Maximum Site Capacity Scenario

Area	CSP	PV	W2E	Wind	Total RES
COA		4,900		1,000	5,900
NEOA		1,265		1,400	2,665
NWOA	150	500			650
SOA		160			160
WOA	300	3,070	50	2,000	5,420
Total KSA	**450**	**9,895**	**50**	**4,400**	**14,795**

Fig2: Penetration of RES in KSA maximum site capacity scenario

Comprehensive methodology applied to evaluate the impact of RES plans



Two step approach have been implemented, in which the **RES hourly production profiles** (based on real-time weather data) and **net load curves** are developed to determine the **impact of RES plans** on the KSA power system.

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Step-1: RES generation profiles

- RES (PV, Wind, CSP, & W2E) hourly production profiles generated for the planning horizon (year-2030)

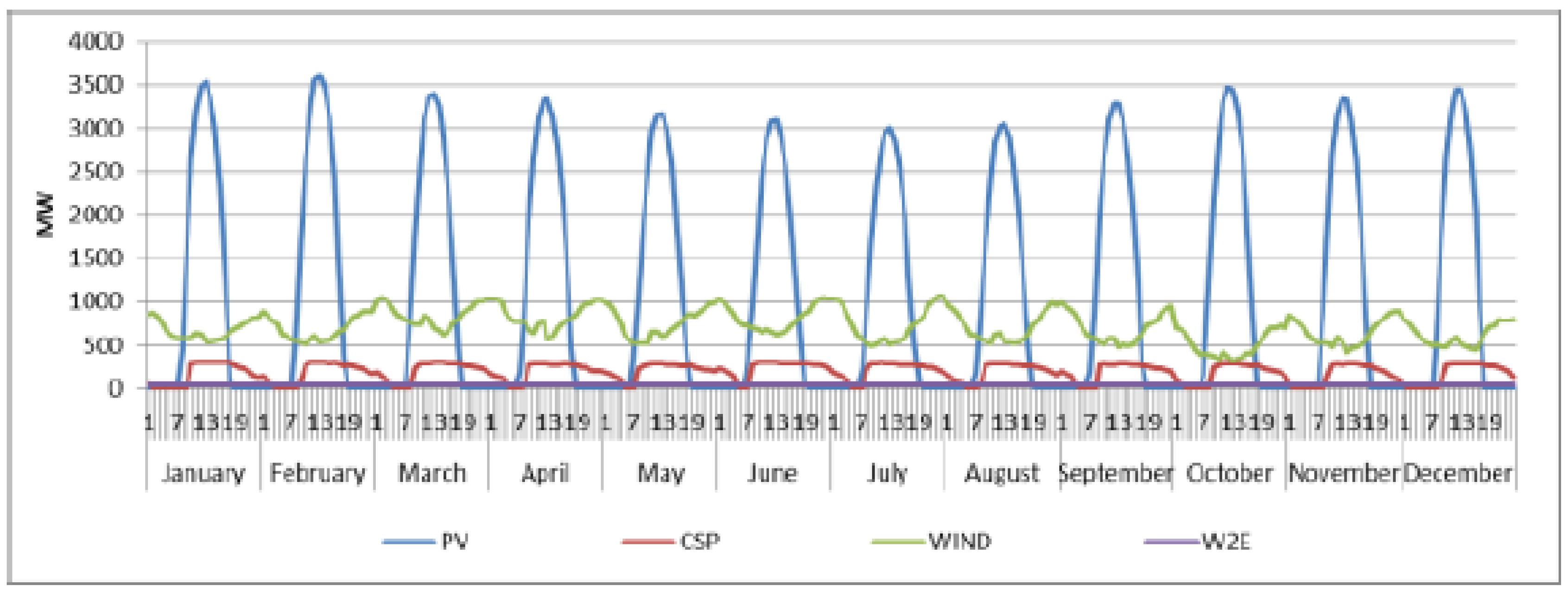


Fig3: Average generation of RES technologies

Step-2: Net load curves

- Load minus renewable generation (variable) provides the total load conventional power units must met.

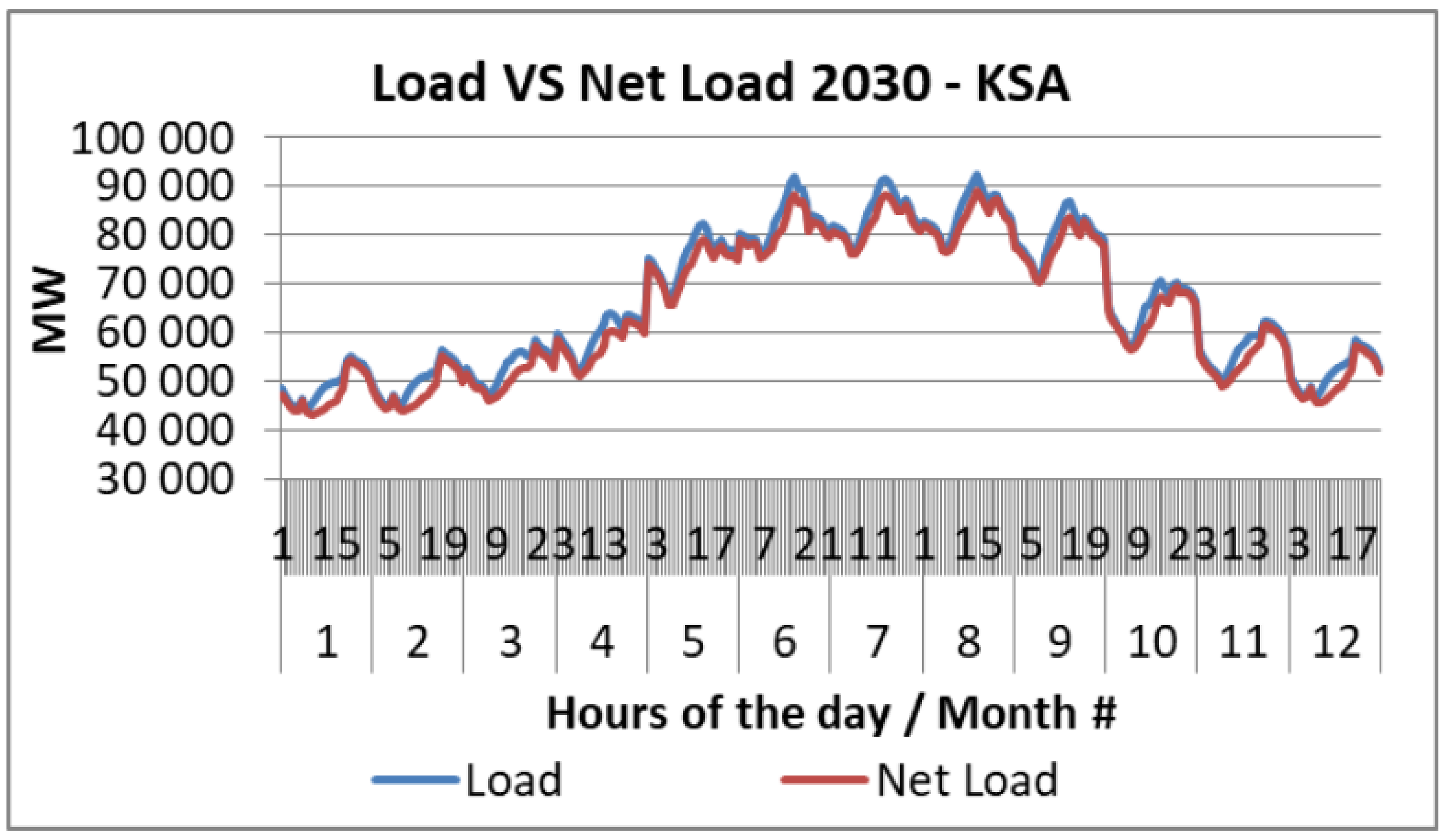
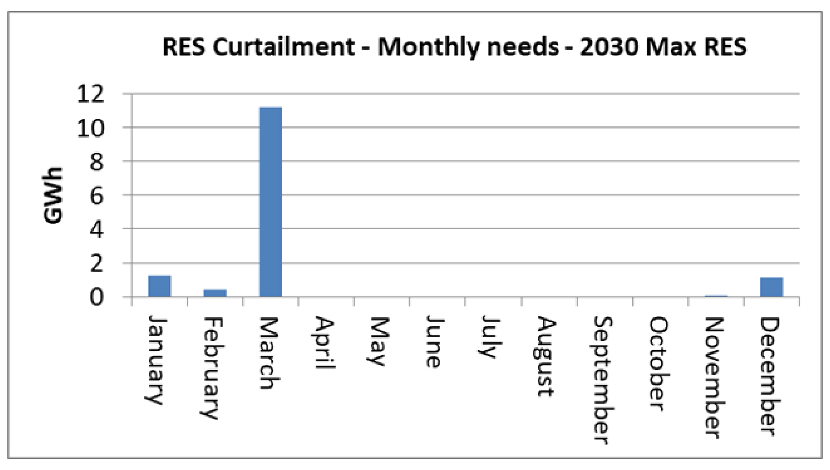
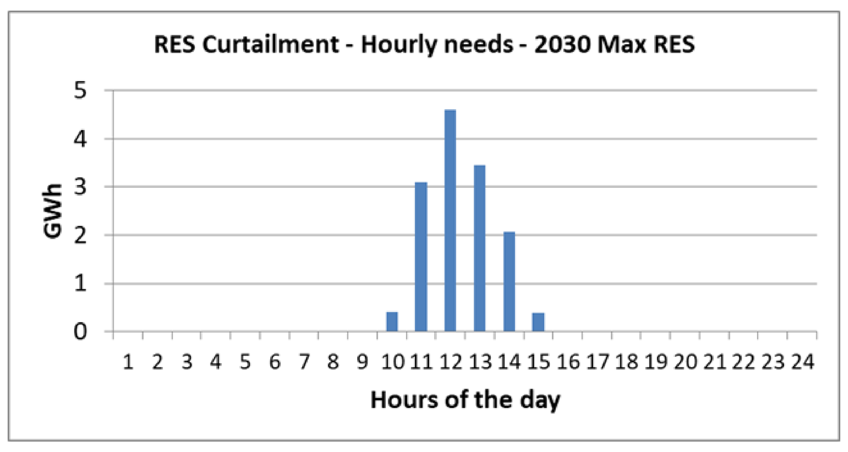


Fig4: load versus net load for Y-2030





Hourly simulation of KSA power system conducted for years 2020, 2024, & 2030

Fig5: power flows across various internal corridors of KSA system

Unit Commitment & Dispatching

- Around 9% reduction in CO_2 Emissions and around 15% reduction in Oil based fuels and 5% in natural gas.
- RES curtailment observed during minimum (low) load seasons (winter).

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National Grid SA
الشركة السعودية للكهرباء
Saudi Electricity Company
نعمل بإتقان من أجلكم

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Results-Impact of RES on system reserves

RES (and net load) variability has been analyzed at 1 hour and 10 minutes levels.

- Hot spinning reserve, provided by the synchronous units in service
  - ✓ Increase of app. 200 MW, +20% respect to the reserve for load only
- Cold reserve, provided also by the units that can be switched on in short time
  - ✓ increase of app. 900 MW, +20% respect to the reserve for load only. Peaks in some areas: NEOA (+185%) and NWOA (+65%)

Results-System flexibility

Start-up requirements

- ✓ A reduction of start-ups of oil-fired power plants because their production is replaced by RES.
- ✓ An increase in the number of the start-ups of Gas Turbine Units in NEOA. This is caused by the high variability of wind generation installed in the area. In general, we have also a slight increase in the number of start-ups for the NG power plants.
- ✓ The highest average number of cycles occurs in NEOA. This occurs because NEOA has a low load, especially in 2020 and a high level of wind generation that introduces high variability in the net load. However, considering that many GTs are present in the area, such high values for the average number of cycles are not considered critical, even if to be monitored.

Results-Ramping

Ramping requirements

- ✓ The most critical situation is during low load conditions, where there is less thermal generation in operation
- ✓ The maximum 1-hour ramps can be covered in less than 13 minutes; therefore, there is a margin to modulate thermal production to cover 1-hour ramps.
- ✓ The maximum 10-minutes ramps are much lower than 1-hour ramps (around 1,700 MW in the scenario with maximum RE capacity) and can be covered in 2 minutes in 2030 and 4 minutes in 2020.
- ✓ Therefore, there is margin to modulate thermal production to cover both 1-hour and 10-minutes ramps.

Conclusions

- Different RES technologies have different impacts in the unit commitment and dispatching during the day.
- Wind is more variable than PV, and this leads to an increase of the operating reserve requirements. A proper balance between these two technologies should be considered, in order to find the optimal trade-off.
- The areas most impacted by the introduction of renewables are the NEOA and NWOA, because characterized by important RES expansions, despite their low load.