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Dispelling Myths: Coal cannot be cycled to manage the variability of renewables

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Dispelling Myths: Coal cannot be cycled to manage variability of renewables

India has bold goals for renewables that raise several considerations for future grid planning and operations. The inherent attributes of renewable electricity generation i.e. stochasticity, variability and geographic concentration are perceived as a challenge given the dominance of coal in India's electricity mix. More so when the grid is operated today far from optimally, with frequency drifts, load shedding, no provisions for reserve margins and an ancillary mechanism that is still in its infancy. The fact that India has a dominant coal fleet actually helps more than is visualised by the policymakers and grid operators. Common misperceptions about the role of coal for integration of renewables in India include:

1) Criticism that coal has limited flexibility to balance variability in renewables
2) Coal cannot be cycled (starting up, shutting down, ramping, operating at part-load, etc.) for integrating renewables
3) Need for setting up very high backup capacities and operating reserves other than coal for integrating renewables.

These myths can be easily busted by simulating the real-time power system operation through the use of economic generation dispatch modelling tools. The most widely recognised tool for such analysis is the Unit Commitment Model (UCM). UCM analyses the grid flexibility in its full context by measuring the curtailment risks for higher levels of renewable penetration into a portfolio of conventional generation. UCM simulations do so by accounting for the following techno-economic aspects of the power plants and the grid:

1) Renewable energy profiles and its correlation with load to arrive at the net load, i.e., load minus renewable generation
2) Physical characteristics of the power system such as transmission network configuration, different generation technologies with ramp rates, minimum up-time and down-time, cycling costs, transmission constraints, etc.
3) Institutional characteristics such as grid operation practices, scheduling, balancing area size, forecasting, etc.

Some Definitions

Cycling is the operation of a coal plant at varying load levels including starting up, shutting down, ramping up or ramping down, low-load conditions, etc., in response to the system load requirements.

Ramp rate is the speed at which a generator can increase (ramp up) or decrease (ramp down) its output.

Minimum down-time is the time needed to synchronise a generator to the grid frequency.

Minimum up-time is the time for which a generator should operate once the unit is running; it cannot be turned off immediately.

Technical Minimum is the lowest output level of a generator below which the reliability as well as the efficiency and cost of generator output are affected.

UCM is the optimal scheduling of output levels, turn on/off decisions for generating units considering the technical and economic constraints of the generators and transmission system.

It is well known that the wind curtailment in Tamil Nadu has gone up substantially in recent years. In 2015, the grid accepted only ~7 BUs compared with ~11 BUs in 2012[1]. The reduction in grid acceptance could have been potentially addressed with the use of coal cycling. This is illustrated by using the UCM for a representative week, considering the conventional generation portfolio in Tamil Nadu (without considering any constraints imposed due to

[1] TNERC, KPMG Research

prevalent regulatory and operational practices), plus a load and renewable profile that reflects different combinations of variability and magnitude.

Figure 1 highlights the variability of renewable generation in Tamil Nadu for the week starting 3 August 2015, while Figure 2 demonstrates its impact on the load profile. A description is provided below:

- The yellow, green and orange areas in the graphs represent 15-minute variations in load, wind and solar generation, respectively.
- The blue area represents the net load, i.e., load minus wind and solar generation. It is observed from the load and the net load shapes that integrating renewables leads to longer peaks, steeper ramps and deeper turn downs thereby increasing the requirements of flexibility and cycling in the conventional generation mix. The ramp-up and ramp-down rates of the net load increased to 1,300 MW and 2,500 MW, respectively, in a 15-minute block with the addition of renewables compared with 600 MW and 1,700 MW, respectively, without any renewables.
- The net load shape represents the load that must be supplied by conventional generators such as coal, gas, hydro (storage) and hydro (run of river) without any loss of load or curtailment in renewables. Curtailment occurs when renewable generation exceeds demand or when the conventional portfolio is not able to follow the variability in the net load, leading to issues in maintaining grid security.

Figure 1: Variability in Wind and Solar profiles for a representative week of August (MW)

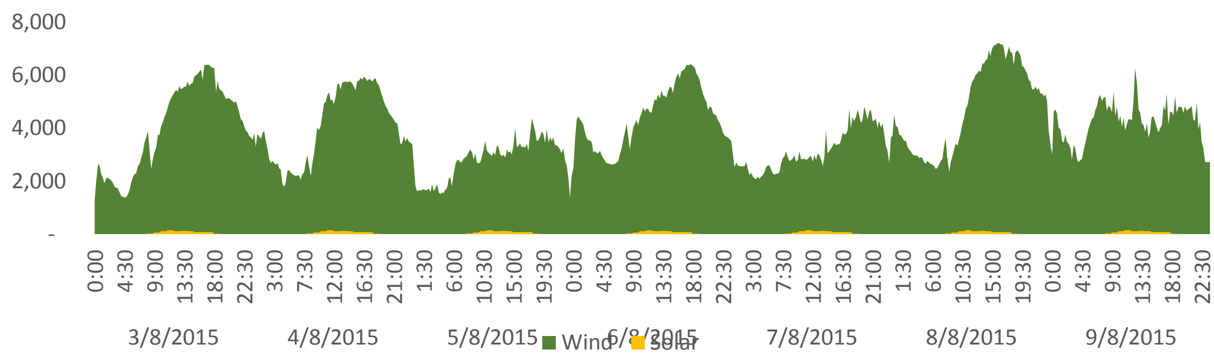
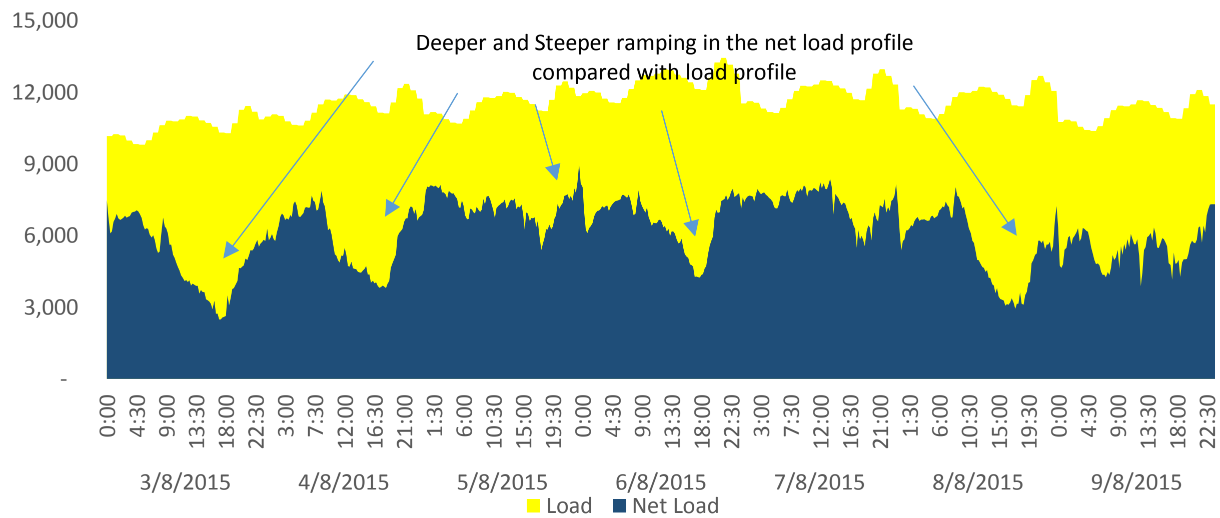


Figure 2: Comparison of Variability in Load and Net Load for a representative week of August (MW)



Source: KPMG analysis based on data obtained from RLDC, TNSLDC, SRPC reports

The flexibility of various generators was assessed through the UCM for their ability to quickly adjust to the net load shape while meeting the technical constraints of ramp rates, minimum up/down time and output levels (i.e., technical minimum)[2]. The objective was to understand the cycling capabilities of coal by focusing on its techno-economic characteristics only, without considering any constraints owing to regulations, commercial aspects, etc.

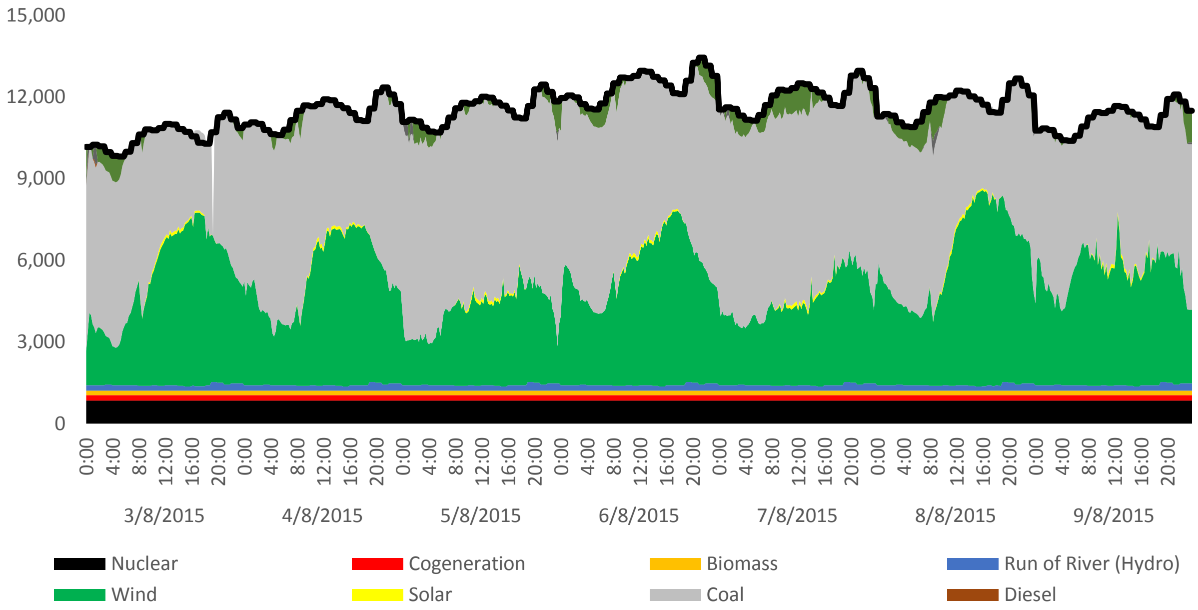
The UCM results revealed that the grid has the capability to support renewable energy penetration ranging from a minimum of 12% to a maximum of 62% of the generation mix without any loss of load or curtailment in renewables (Figure 2). Higher renewable energy penetration only increased the load following requirements for coal; i.e., the level of outputs needed to be varied over different time blocks without any need for turn-off or turn-on conditions for coal. The entire conventional generation portfolio acted together as a pool to provide the ramping requirements and the flexibility for balancing the variability in renewables.

Table 1: Key Assumptions for UCM

S. No.	Technical Parameter	Value	
1.	Installed Capacity Mix (MW)	Thermal	10,554
		Hydro	2,267
		Nuclear	120
		Wind	7,279
		Solar	300
		Biomass	215
		Cogeneration	659
2.	Auxiliary Consumption	Coal-7% Nuclear-4% Gas/Diesel-3% Hydro-1%	
3.	Technical Minimum Schedule – min output	55%	
4.	Ramp up/down rates	5%/min for Coal plants 7%/min for Gas plants 9%/min for Diesel plants	
5.	Initial State of Generators	Operational	
6.	Must Run	Nuclear, Renewables, Run-of–River generators	
7.	Minimum Up time	2-6 hours	
8.	Minimum Down time	1-6 hours	
Source: KPMG Research			

[2] The key technical assumptions for UCM modelling are summarised in Table 1. Given the data paucity and disparity in various technical parameters of generators, the assumptions are based on standards as per Indian Electricity Grid Code (IEGC), 2015, CEA Technical Standards for Construction of Electrical Plant and Electric Lines Regulations, 2010, and industry norms.

Figure 3: Optimised Scheduling of the conventional generation portfolio in Tamil Nadu (MW)



Thus, it is evident that coal has enough flexibility to cost-effectively integrate renewables, but, as operated today, that flexibility remains largely underutilised. The current regulatory and operational practices restrict access to the existing flexibility in coal, which leads to curtailment of renewables. Certain amount of coal cycling is already prominent in states particularly during morning and evening peak loads, but higher renewable penetration exacerbates the cycling frequency. This increases the risk of plant wear and tear in addition to lower fuel efficiencies at partial output levels. Therefore, coal cycling needs to be supported with appropriate compensation factoring in the inefficiency and burden due to wear and tear. A few specifics of the constraints imposed by the extant regulatory and operational practices for access to flexibility in coal and possible resolutions are:

1) Current scheduling regulations allow revisions in day-ahead schedules only when signalled four time blocks ahead, i.e., 60 minute in advance. Such scheduling practices reduce the balancing flexibility available to the grid operator. Scheduling closer to the real-time operation such as on a sub-hourly level with revisions at 5-minute to 15-minute intervals will allow full access to the ramping capability of coal, and decrease the integration costs and curtailment risks for renewables.
2) Regulatory interventions are required to incentivise flexibility in the existing conventional generation fleet. Flexibility requirements for coal should encompass standards on technical minimum, ramp-up and ramp-down rates, cycling, etc. Flexible Generation Obligation on states with high renewable energy penetration should be explored.
3) An efficient mechanism through which the grid operators both at the state and regional levels have access to capacity reserves should be evolved. This may be achieved by withholding a part of the capacity in certain coal plants having higher ramping capabilities from daily scheduling and dedicating it for reserve margins. Such margins seem to be feasible in the current scenario where a large number of coal plants are operating at sub-optimal PLF levels.
4) Finally, states should assess the economic trade-offs of whether to add new generation capacity for balancing renewables or pay higher operating and maintenance costs, higher cycling costs and reliability costs to the existing coal fleet to meet the demands of renewable integration.

Integrating renewables in a reliable and affordable manner needs an unprecedented change in the existing market design, regulatory framework and grid practices. The conventional wisdom about the limitations of coal in renewable integration needs to be better understood. To this end, policymakers should formulate new rules and regulations for increasing the role of coal cycling in integrating renewables.

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