Integration of energy

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The first set of VRE plants are deployed, but their impact is largely insignificant at the system level and the typical operating parameters of the system remain unchanged. Any effects are very localised, for example at the grid connection point of plants.

As more VRE plants are added, changes between load and net load become more noticeable with a minor to moderate impact on the system such as faster and more frequent ramping of generators. Upgrades to operating practices such as integrating forecasting into dispatch and making better use of existing system resources are usually sufficient to achieve system integration.

VRE determines the operation pattern of the power system and increases the uncertainty and variability of net load. Greater swings in the supply-demand balance prompt the need for a systematic increase in flexible operation of the power system that often goes beyond what can be readily supplied by existing assets and operational practice.

VRE output is sufficient to meet a large majority of electricity during certain periods, which may impact power system stability. A key operational challenge is related to the way the power system responds to maintain stability immediately following disruptions in supply or demand, which may involve advanced operational solutions and changes in regulatory approaches.

Rising shares of VRE mean that without additional measures VRE availability will exceed demand during many hours and be in overall surplus for periods of a day or more. Achieving such shares under decarbonisation goals in an economic and secure manner requires increased measures to support VRE utilisation, such as large deployment of demand response, energy storage and grids, and more extensive solutions to ensure stability at low levels of conventional supply.

Phase 6 applies to regions looking to meet extremely high shares of annual electricity demand with VRE. The main challenges in this phase include operating a system largely dependent on converter-connected resources and meeting demand during extended periods of low wind and sun availability. Addressing flexibility needs can involve long-duration energy storage or extensive electricity trade with other regions.

Depending on the institutional aspects of the system and markets, there are four key categories of infrastructure assets that feed flexibility into the system; these include: (a) power plants (both conventional and VRE); (b) electricity network interconnections; (c) energy storage; and (d) distributed energy resources.

Conventional power plants, electricity networks and pumped storage hydropower have historically been the primary sources of flexibility. However, operational improvements in VRE power plants, electricity networks and the advent of affordable distributed energy resources and battery energy storage systems, are enabling a wider set of flexibility options for consideration.

As power systems transition towards higher phases of system integration, these flexibility resources can work together to enhance system flexibility in a cost-effective, reliable and environmental sound manner. Modifications to policy, market and regulatory frameworks ensure that battery energy storage systems and distributed energy resources can participate in the power system to provide flexibility services.

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