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21st Century POWER PARTNERSHIP
Accelerating the transformation of power systems

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Corrigendum
Please note that despite our best efforts to ensure quality control, errors have slipped into *Status of Power System Transformation 2018*.
The text in pages 1, 6, 99, 100 has changed. It should be replaced by the following pages.

Status of Power System Transformation 2018

Advanced Power Plant Flexibility

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List of tables

List of Boxes

Encourage market and system operators to implement strategies for "faster" grids

Existing power plant flexibility can be more efficiently accessed by implementing faster scheduling and dispatch intervals (e.g. 5 or 15 minutes) and shorter gate closure periods. By dispatching the system at shorter intervals, the amount of conventional generation required to balance the system (i.e. regulation services) can be reduced. This is because the resources subject to economic dispatch are generally not allowed to alter their output for the hour, stranding whatever capability these plants may have to respond to flexibility needs within that hour. This effect is also driven by lower forecast errors (for both demand and VRE generation) as the time interval of scheduling, dispatch and gate closure is shortened.

Ultimately, this reduces the amount of conventional generation that must be held in reserve and improves the economics of running the power system. These reductions can thus free up power plant capacity for providing energy and other ancillary services. In general, faster markets and dispatch intervals can lead to a more cost-efficient power system (both in market and non-market structures), while financially encouraging more flexible power plant operations. Sub-hourly markets have been shown to provide price signals that incentivise higher-cost generators to provide intra-hour flexibility.[40]

Box 5.1 • Portfolio co-ordination at high shares of VRE. Case study by Kyushu Electric Power Co., Inc.

With 6 GW installed PV capacity, 16 GW peak load and 8 GW minimum daytime load, Japan's southern-most island, Kyushu has the highest VRE penetration in Japan. This has motivated the development of sophisticated operation strategies to optimise the capabilities of the existing thermal, reservoir hydropower and pumped storage hydropower plants.

To accommodate today's levels of variability and uncertainty, Kyushu Electric Power Co., Inc., currently applies six power system dispatch rules developed by the Japanese Organization for Cross-regional Coordination of Transmission Operators:

- Avoid generation from reservoir and pumped storage hydropower plants during daytime.
- Prioritise absorption of surplus electricity by pumped hydropower storage plants.
- Reduce the output of thermal generation plants to minimum stable levels.
- Export surplus electricity through cross-regional system's interconnection lines.
- Reduce the output of biomass power plants.
- Curtail solar PV and wind power as a last resort.

Example implementation of priority dispatch rules during sunny day

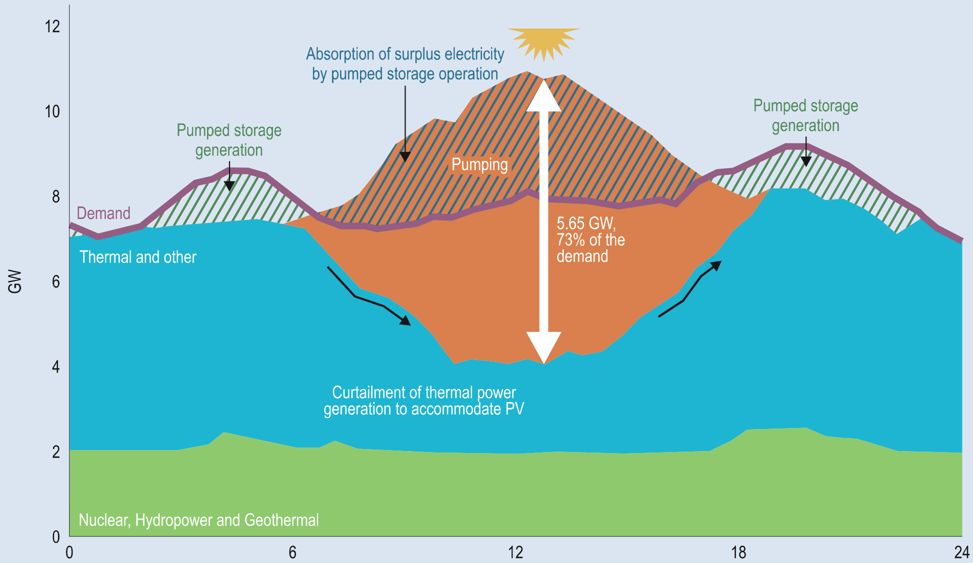
On 30 April 2017, PV output peaked at 13:00 peaked at 5.65 GW, or 73% of demand in Kyushu. According to the priority dispatch rules, pumped storage plants absorbed part of this generation, as they had spare storage capacity after releasing energy to cover the morning peak. As shown in

the need for the wind power plant to run below full load and can avoid incurring the associated production and revenue losses (EirGrid, 2017).

[40] See *Market Characteristics for Efficient Integration of Variable Generation in the Western Interconnection* by Michael Milligan and Brendan Kirby; www.nrel.gov/docs/fy10osti/48192.pdf.

Figure 5.2 below, thermal capacity ramped down toward their minimum stable levels, with hydro pumping helping to avoid complete plant shutdown. Pumped storage also helped cover the evening demand peak with stored PV electricity. Avoiding thermal generation shutdown is an important priority in Kyushu, as the start-time for steam generators is currently up to 8 hours and 2 hours for CCGT units.

Figure 5.2 • Portfolio management for VRE curtailment avoidance



Source: Kyushu Electric Power Co., Inc.

Key point • Portfolio management approaches can increase system flexibility, reduce operational costs and avoid VRE curtailment.

On this day, Kyushu's power system was close to the portfolio's current flexibility limit before requiring cross-regional exports or VRE curtailment. As PV output decreased at 1.3 GW/hour due to lower irradiation in the afternoon, thermal power plants were dispatched to increase their output while the pumping was stopped to accommodate the reduction in PV output.

Example of balancing solar PV forecast errors

PV forecast errors have also been one of the main issues, which can drive requirements for flexibility. On 5 May 2017, peak PV output was 2 GW greater than the intraday forecast. The day-ahead PV output forecast was modified at 04:00 am due to lower than expected PV output, resulting in an unexpected additional generation of 2 GW. In this case, pumped storage plants were able to supply additional energy in the morning and store available solar generation in the afternoon.

Economic incentives for more flexible power plant operation

Creation of new revenue streams to reward flexibility

As mentioned in Chapter 3, many legacy power plants that operate in today's power system were deployed with a specific expectation of generation behaviour in mind (e.g. a coal-fired power