



PART 2

Read the text below and answer questions 14–26.

BEYOND GENERATION: THE INTEGRATION CHALLENGE

A

The past decade has delivered record levels of investment in low-carbon electricity, and the physical visibility of that shift is unmistakable: wind turbines on horizons, solar farms across former industrial land, and rooftop panels on suburban streets. Yet as variable renewable energy (VRE) expands, a less visible constraint has become decisive: integration. Generating clean electricity is only the first step. Delivering it reliably, at the right time and in the right place, requires grids, markets, and operating practices built for a different era. The integration challenge is therefore not a single technical “gap” but a systems problem, in which physics, institutions, and incentives must evolve together.

B

Traditional power systems were designed around dispatchable assets—large controllable stations that could be scheduled to follow demand. Operators adjusted output through the day using predictable dispatch and maintained stability through synchronous machines whose behaviour was well understood. VRE disrupts this logic because its output is weather-driven. A sudden change in wind speed or a thick band of cloud can alter supply within minutes, forcing operators to carry additional balancing capacity and to manage frequency deviation within tight limits. The operational question becomes one of flexibility: how quickly the system can respond when supply moves unexpectedly, and how much reserve is required to do so safely without unnecessary cost.

C

Flexibility can be supplied by multiple resources, each with constraints. Fast-ramping generation can increase or decrease output quickly, but it may still rely on fossil fuels and therefore conflicts with decarbonisation goals if used extensively. Hydropower can respond rapidly where geography and water availability allow. Demand response aims to treat consumption as adjustable rather than fixed: factories can shift processes, commercial buildings can adjust cooling set-points, and households can delay discretionary loads. However, demand response depends on smart metering, clear price signals, and a willingness to participate. Without these enabling conditions, the theoretical flexibility remains unavailable, and operators must revert to more costly backup options.

D

Storage is often presented as the “ultimate” integration tool, but its role is more nuanced and time-dependent. Batteries excel at second-to-second and hour-to-hour balancing:



they provide frequency support, ramping capability, and smoothing of short swings in VRE output. Yet longer-duration storage remains limited either by expense or by the conditions required for deployment. Pumped hydro can store large amounts of energy, but it needs suitable sites and lengthy approval processes. Hydrogen can, in principle, store energy seasonally, but it introduces conversion losses and requires infrastructure for production, storage, and end use. The implication is not that storage is unimportant, but that no single technology can cover every timescale everywhere.

E

The physical grid can become a bottleneck even when generation is abundant. Renewable resources are frequently located far from major demand centres: winds are strongest on coasts and plains, while solar potential peaks in sunny interior regions. This spatial mismatch produces congestion when transmission capacity is insufficient. In such cases, clean electricity may be curtailed—deliberately reduced—because it cannot be transported to where it is needed or because local network constraints would threaten stability. Expanding transmission and strengthening interconnection are therefore essential, yet permitting delays, land access disputes, and local opposition can slow projects for years, creating a situation in which new generation arrives faster than the wires required to carry it.

F

Market design shapes both investment and day-to-day operation, and high VRE penetrations can generate counter-intuitive price outcomes. In some regions, wholesale prices fall to very low or even negative levels during periods of abundant wind and solar, a phenomenon sometimes described as price cannibalisation. While low prices can benefit consumers in the short term, they can also undermine revenue for generators and weaken the investment case for resources that provide flexibility but run infrequently. In effect, the system needs capacity for tight conditions—calm evenings, cold spells, network outages—yet the market may fail to reward it if scarcity events are rare. This is why many systems introduce additional payments for reliability and ancillary services, attempting to align profitability with system value.

G

Integration also depends on technical services that are easy to overlook because they are rarely visible to end users. Conventional turbines naturally provide inertia, helping the system resist sudden changes in frequency. As inverter-based resources expand, operators must procure alternatives such as synthetic inertia, fast frequency response, and voltage support. These services can be delivered by batteries, advanced inverters, synchronous condensers, or specialised power-electronics equipment, but they require



standards, testing, and coordination across the grid. Ultimately, successful integration is achieved through a portfolio rather than a single breakthrough: better forecasting, diversified flexibility, faster network permitting, robust market signals, and demand-side participation. The integration challenge, therefore, is also governance—aligning institutions and incentives so that clean electricity already being generated can be delivered dependably.

Questions 14–18

The text has seven paragraphs, **A–G**. Which paragraph contains the following information? Choose the correct letter, **A–G**. **NB** You may use any letter more than once.

- 14** A reference to market prices that can drop below zero when supply is abundant.
- 15** A description of rapid weather-driven changes in output that force operators to keep extra balancing capacity available.
- 16** A statement that the integration challenge is also a matter of governance.
- 17** An explanation that some clean electricity cannot be delivered because the network cannot carry it to demand centres.
- 18** A point that storage capable of covering long gaps is limited either by expense or by where it can be built.

Questions 19–22

Select the correct answer.

- 19** Why does the passage suggest demand response may not work without additional conditions?
 - A** It depends on fossil-fuel generators being available at all times.
 - B** It requires new transmission lines before consumers can take part.
 - C** It relies on metering, price signals and willingness to participate.
 - D** It can only operate where hydropower is the main source of electricity.
- 20** What does the passage suggest about batteries?
 - A** They are mainly useful for storing energy over whole seasons.
 - B** They are particularly effective for short-term balancing and frequency support.
 - C** They remove the need for other sources of flexibility.
 - D** They are primarily used to solve permitting delays for grid expansion.
- 21** What issue is associated with where renewable resources are located?



- A** They are often distant from major demand centres, creating transmission constraints.
- B** Their output cannot be forecast accurately enough for system operation.
- C** They prevent consumers from shifting electricity use away from peak periods.
- D** They make wholesale electricity markets unnecessary.

22 The passage suggests that periods of very low or negative prices may

- A** ensure stable long-term income for all generators.
- B** reduce the need for investment in transmission networks.
- C** demonstrate that storage has become redundant.
- D** discourage investment in resources needed only during tight conditions.

Questions 23–26

Complete the summary below. Choose **NO MORE THAN TWO WORDS** from the text for each answer.

Maintaining system stability

Variable renewables can alter supply within **23**, so operators must keep system frequency within tight **24** When transmission capacity is insufficient, electricity may be **25** because it cannot be moved to where it is needed. As inverter-based generation expands, operators may procure **26** to reproduce the inertia that conventional turbines provide naturally.

Answer Key

14. F

15. B

16. G

17. E

18. D

19. C

20. B

21. A

22. D

23. minutes



24. limits

25. curtailed

26. synthetic inertia