



PART 1

Read the text below and answer questions 1–13.

THE CHALLENGE OF GRID INTEGRATION FOR RENEWABLE ENERGY

A

Wind and solar are now among the cheapest sources of new electricity in many markets, yet their rapid expansion has revealed a less visible constraint: the electricity grid. Building generation capacity is only part of decarbonisation; power must still be delivered at the right moment, in the right quantity, and within tight limits for frequency, voltage, and reliability. Unlike conventional plants that can be dispatched on demand, renewable output is governed by daylight, clouds, and weather fronts. This mismatch between when energy is produced and when it is needed forces system operators to balance supply and demand in real time while managing stress on networks that were not designed for such volatile, distributed inputs.

B

The first integration challenge is variability. Solar generation can fall sharply when a cloud bank crosses an urban area, and wind farms can drop output as atmospheric conditions change. Grids can tolerate fluctuations, but only if they have enough flexibility to respond quickly. Flexibility can come from fast-ramping generation, responsive demand, storage, or interconnections that allow shortfalls in one region to be covered by surplus in another. When these tools are missing, operators must sometimes curtail renewable generation even when it is available, simply because the system cannot safely absorb it at that moment. Paradoxically, this means clean energy can be “wasted” not due to a lack of turbines or panels, but because the grid cannot adjust fast enough to maintain stable operation.

C

A second challenge is geographical and architectural. Many legacy grids were built around large, centralised stations located near fuel supplies, sending electricity outward along transmission corridors to passive consumers. Renewable resources often appear in different places: wind may be strongest offshore or across remote plains, utility-scale solar may be concentrated in deserts, and rooftop solar sits deep inside distribution networks. These location shifts change power flows and can push lines beyond their intended operating patterns. In distribution systems designed for one-way delivery, large volumes of embedded generation can force power to flow in reverse toward substations, raising the risk of overloads, protection miscoordination, and local voltage problems. The



technical issue is not merely “more power,” but power moving in directions and magnitudes the network was never engineered to handle.

D

Stability adds another layer of difficulty. Traditional generators contribute inertia because their heavy spinning turbines resist abrupt frequency changes. Many renewable plants connect through inverters rather than synchronous machines, so they do not automatically provide the same stabilising effect unless their controls are specifically designed to do so. As inverter-based resources become dominant, grids must procure new services that were once provided implicitly by conventional equipment, including fast frequency response, voltage support, and fault ride-through. This shifts the problem from simply producing energy to producing grid-supporting behaviours. It also requires updated technical standards and grid codes so that inverters can behave in ways that sustain stability under disturbances rather than disconnecting or amplifying instability.

E

Forecasting has improved dramatically, but better forecasts do not eliminate uncertainty. Operators still need reserves for forecast errors—extra capacity that can respond quickly if wind underperforms, solar output drops unexpectedly, or demand rises faster than predicted. Procuring reserves costs money, and market rules do not always reward the resources that provide flexibility. In regions where price signals are weak or regulations are outdated, investment may rush into generation while flexible capacity and network reinforcement lag behind. Consequently, the system can look “rich” in renewable megawatts on paper while still being operationally fragile, because balancing the remaining uncertainty requires resources that are not being built at the same pace.

F

Storage is often presented as a universal solution, but its role is more specific, and it must be combined with demand-side flexibility. Batteries are highly effective for short-duration balancing, frequency regulation, and shifting surplus solar from midday to evening peaks, helping operators smooth rapid ramps and absorb brief variability. However, batteries are less suited to multi-day wind lulls or seasonal mismatches unless deployed at enormous scale, which raises cost, materials, and siting constraints. Longer-duration options such as pumped hydro, compressed air, or emerging thermal and chemical approaches may address extended shortages, but they can be harder to finance and permit. Demand response can therefore be just as important: industrial loads, commercial buildings, electric water heating, and especially electric vehicle charging can be scheduled to avoid stressing the system. When aggregated, these adjustments can operate like a virtual



power plant, though enabling this requires digital infrastructure, consumer protections, and market mechanisms that allow flexible demand to earn revenue.

G

Transmission and interconnection often deliver the largest reliability gains because they share resources across geography: when one region has excess wind, another may have high demand or strong sunlight. Yet permitting new lines can be slow, and public acceptance is often difficult, leaving many systems constrained by inadequate networks. Under these conditions, renewable growth can create transmission congestion, forcing curtailment even when the generation itself is cheap and available. Operators may use operational tools—dynamic line ratings, advanced power-flow controls, and congestion management—to squeeze more capacity from existing assets, but these measures have limits and do not automatically remove bottlenecks. Ultimately, integrating renewables is also an institutional challenge. Regulations, tariffs, connection rules, and planning processes determine whether flexibility and grid upgrades arrive on time. The most successful transitions treat the grid as an active platform: they coordinate generation with network planning, update standards for advanced inverters where needed, and design markets that value reliability services, not only energy delivered.

Questions 1–5

Choose the correct heading for each paragraph.

List of Headings

- i Why storage cannot solve everything
- ii The grid as an invisible constraint on clean energy
- iii Location shifts and new power-flow patterns
- iv Stability without traditional inertia
- v Forecasting improvements and the cost of uncertainty
- vi Consumers as the main barrier to decarbonisation
- vii When flexibility is missing, clean energy is wasted
- viii Why electricity prices always rise with renewables

1 Paragraph A

2 Paragraph B

3 Paragraph C

4 Paragraph D

5 Paragraph E



Questions 6–9

Choose **TRUE** if the statement agrees with the information given in the text, choose **FALSE** if the statement contradicts the information, or choose **NOT GIVEN** if there is no information on this.

6 The passage indicates that renewable generation can overload some lines because power flows may reverse in parts of the distribution network.

7 The passage suggests that improved wind and solar forecasting has reduced uncertainty so much that system operators no longer need reserves.

8 The passage suggests that batteries are primarily used for short-duration balancing rather than covering seasonal mismatches.

9 The passage states that dynamic line ratings are already widely deployed as standard practice in most regions.

Questions 10–13

Complete the table below. Choose **ONE WORD ONLY** from the text for each answer.

Renewable energy integration

Integration area	Resource or condition	Role/Consequence
Variability	Fast-ramping generation, responsive demand, storage and interconnections	Provide flexibility when renewable output changes.
System stability	Inverter-based resources provide less automatic stabilisation.	Traditional generators contribute 10; inverter-based systems require alternative stabilising services.
Short-term balancing	11 are highly effective for this role.	Smooth rapid changes and shift surplus solar to evening peaks.
Longer shortages	Pumped hydro, compressed air and emerging alternatives	Can be difficult to finance and permit.



Integration area	Resource or condition	Role/Consequence
Transmission	Inadequate network capacity	Can leave electricity systems 12 and force renewable curtailment.
Market design	Regulations, tariffs and connection rules	Should reward services that maintain 13, not only energy delivered.

Answer Key

1. ii
2. vii
3. iii
4. iv
5. v
6. TRUE
7. FALSE
8. TRUE
9. NOT GIVEN
10. inertia
11. batteries
12. constrained
13. reliability