# SMART GRID TECHNOLOGY

## EE / EEE

## SEMESTER – FIFTH

***These important questions have been prepared using your previous exam papers (PYQs), verified concepts, and additional reference from trusted online academic sources. For deeper understanding, please refer your class notes as well.***



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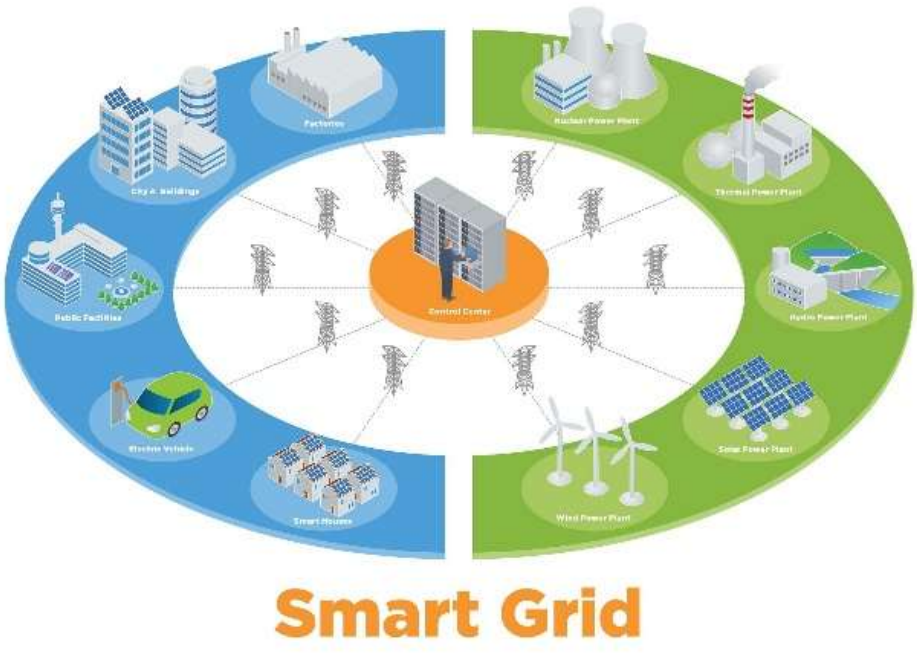
### 1️⃣ HIGH & LONG IMPORTANT QUESTIONS (90–95% expected)

1. Provide a detailed **comparative analysis** between the **Conventional Grid and the Smart Grid**. Discuss at least five fundamental differences in terms of communication, operation, and resilience.
2. Define **Smart Grid** and explain the concept and structure of the Smart Grid. Discuss the major **Opportunities and Barriers** associated with its implementation.
3. Describe the essential **Components and Architecture of Smart Grid Design**. Explain the role of **Advanced Metering Infrastructure (AMI)** and illustrate the architecture using a **block diagram**.



4. Explain the functionalities and significance of **Transmission Automation** and **Distribution Automation** as integral parts of the Smart Grid design.

5. Define a **Micro Grid**. Describe its structure and explain its typical **modes of operation** (grid-connected and islanded). State the primary benefits of using Micro Grids.
6. Write a detailed note on **Storage Technologies** used in the Smart Grid. Discuss how **Electric Vehicles (EVs) and PHEVs** influence the grid infrastructure, including vehicle-to-grid (V2G) concepts.

7. What are **Synchro-Phasor Measurement Units (PMUs)**? Explain their working principle and their critical role in **Wide Area Measurement Systems (WAMS)** for monitoring the grid.
8. Define the **Internet of Things (IoT)**. Elaborate on the various key **Applications of IoT in Smart Grid** operations. Discuss the crucial importance of **Cyber Security** for the Smart Grid and its components.

9. Define **Demand Side Management (DSM)**. Explain its objectives and elaborate on the concepts of **Demand Response (DR)** and **Energy Management** within the DSM framework.
10. Describe the fundamental requirements and **planning aspects** involved in developing a robust Smart Grid system.

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## 2️⃣ IMPORTANT & SHORT QUESTIONS (50–70% probability)

- Briefly explain the role of **Enablers of the Smart Grid** and state any three **Key Challenges** for Smart Grid implementation.
- What do you understand by **Renewable Integration** in the context of distribution automation?
- Briefly describe the environmental impact and economic issues related to **Distribution Generation (DG) Technologies**.
- Explain the concept of the **Two-way digital communications paradigm** in Smart Grid.
- What are the key elements considered in the **planning of smart grid systems**?

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### 3️⃣ "AA BHI SAKTA HAI" QUESTIONS (20–30% probability)

These cover logical extensions or concepts that may be indirectly tested.

- Briefly explain the control requirements for a **Hybrid Smart Grid** (AC/DC).
- Why is the planning of **Ancillary Services** important for the smooth operation of a Smart Grid?
- Write a short note on **Smart-grid activities in India**.

**QUICK REVISE**

## Unit-1: Introduction to Smart Grid

### 1. Definition and Concept

- **Smart Grid:** An intelligent, integrated network using digital communication and computer-based remote control automation.
- **Goal:** Enhance reliability, efficiency, security, and integrate Distributed Energy Resources (DERs).
- **Key Feature:** Enables **two-way flow** of both electricity and information.

### 2. Conventional Grid Vs. Smart Grid

| Feature | Conventional Grid | Smart Grid |
|---|---|---|
| **Power Flow** | One-way (Generation $\to$ Load) | Two-way (Allows for DG, Storage) |
| **Communication** | Little/None | Ubiquitous Two-way Digital |
| **Control** | Centralized, Slow | Distributed, Automated, Real-time |
| **Monitoring** | Non-real-time, Limited | Real-time (using PMUs/Sensors) |

### 3. Opportunities & Challenges

- **Opportunities:** Higher self-healing capability, reduced outages, integration of Electric Vehicles (EVs), consumer empowerment (Demand Response).
- **Barriers/Challenges:** High investment cost, **Cybersecurity threats**, standardization issues, regulatory complexity.

**Unit-2: Smart Grid Architecture**

**1. Architecture Overview**

- The architecture is often described through various interacting layers (domains) such as **Generation, Transmission, Distribution, Customer, Market,** and **Operations**.
- **Core Principle:** Integration of **Information Technology (IT)** with **Operational Technology (OT)**.

**2. Advanced Metering Infrastructure (AMI)**

- **AMI:** The full system enabling two-way communication with smart meters.
- **Components:** Smart Meter, Communications Network, and Meter Data Management System (MDMS).
- **Function:** Enables **Time-of-Use (TOU)** pricing, remote connect/disconnect, and real-time outage detection.

**3. Automation**

- **Transmission Automation:** Focuses on stability and security; uses **PMUs** and **WAMS** for wide-area situational awareness.
- **Distribution Automation (DA):** Focuses on efficiency and reliability; uses automated switches, sensors, and reclosers to locate and isolate faults quickly (**Self-Healing Grid**).

**Unit-3: Distribution Generation Technologies**

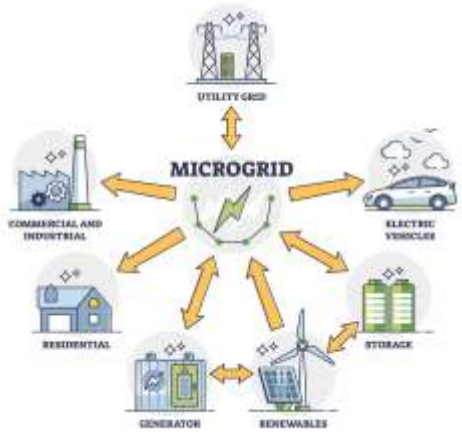
**1. Distributed Generation (DG) and Renewables**

- **DG:** Small-scale power generation sources (e.g., Solar, Wind) located near the point of consumption.

- **Renewable Integration:** Requires advanced power electronics and controls to manage variability and ensure grid stability.

**2. Micro grids**

- **Definition:** A localized power system (sources and loads) that can operate connected to the main grid or autonomously in **island mode**.




- **Benefits:** Enhanced local resilience, increased reliability during main grid outages, and better local power quality.

**3. Storage Technologies**

- **Role:** Mitigate the intermittency of renewables and provide ancillary services.
- **Examples:** Battery Energy Storage Systems (BESS), Pumped Hydro, Flywheels.

**4. Electric Vehicles (EVs) and PHEVs**

- EVs act as **large mobile loads**.
- **V2G (Vehicle-to-Grid):** Concept where EV batteries can supply power back to the grid during peak times, utilizing them as flexible storage assets.

**Unit-4: Communication Technologies and Smart Grid**

**1. Communication Paradigm**

- **Two-way digital communications:** Essential for enabling real-time control, data exchange, and automation across the grid.

- **Technologies:** Fiber Optic, Wireless (Cellular/Mesh), Power Line Carrier (PLC).

**2. PMUs and WAMS**

- **Synchro-Phasor Measurement Units (PMUs):** High-speed sensor devices that provide synchronized voltage and current phasor measurements using a GPS clock.
- **Wide Area Measurement Systems (WAMS):** Network of PMUs used for real-time monitoring and control of the transmission system over large geographical areas.

**3. Internet of Things (IOT)**

- **IoT in Smart Grid:** Interconnection of intelligent devices (sensors, smart appliances, smart meters) to collect and exchange data for optimization.
- **Applications:** Asset monitoring, predictive maintenance, automated energy management.

**4. Cyber Security**

- **Necessity:** Protecting the critical infrastructure (SCADA systems, communication networks, data) from cyber attacks.
- **Focus Areas:** Data integrity, system availability, and confidentiality.

**Unit-5: Smart Grid Planning**

**1. Planning Aspects**

- Requires detailed technical and economic studies to ensure the new infrastructure (communication and power) can meet future demand while maximizing reliability and efficiency.
- **Focus:** Interoperability, standardization, and long-term financial viability.

**2. Operation and Control**

- **AC Grid:** Standard frequency control and voltage stability management.

- **DC Grid:** Better suited for renewables (PV) and storage; avoids reactive power issues.
- **Hybrid Grid:** Combines AC and DC networks, utilizing converters for smooth integration and control.

### 3. Demand Side Management (DSM)

- **Goal:** To influence customer usage patterns to reduce peak demand or shift consumption to off-peak hours.
- **Demand Response (DR):** Incentives or mandates to reduce consumption during high-price/high-demand periods.
- **Energy Management (EM):** Optimizing energy use within buildings using intelligent control systems.

### 4. Ancillary Services

- **Function:** Services necessary to support the transmission system (e.g., frequency regulation, voltage support). Smart Grids allow DG and storage to participate in providing these services.