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MARCH 2022

Vishwakarma Government Enginerring College

Department of Electrical Engineering

Vision

- To produce comprehensively trained, socially responsible and innovative electrical graduates to contribute to the society.

Mission

- To develop well equipped laboratories and infrastructure for conducive learning.
- To produce competent and disciplined electrical engineers to serve the nation.
- To help in building national capabilities for excellent energy management and to explore nonconventional energy sources.
- To produce electrical engineers with an attitude to adapt themselves to changing technological environment.
- To enhance entrepreneurship skills through startup.

PEOs

- Develop and conduct appropriate electrical experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
- Acquire and apply new knowledge as needed, using appropriate learning strategies through innovation.
- Work independently on a project or as a team leader.
- Get an employment in various government and private sector Companies, pursue research and innovation.

PSOs

- Use various electrical testing tools and equipments in industry, be an Entrepreneur, Enroll in post-graduate courses, Pursue Research and Innovation in the field of Electrical Engineering.
- Use knowledge of various electrical machines and electrical power system in solving complicated electrical circuits and networks by using latest design and simulation tools.
- Use technical expertise and suggest modifications in existing electrical systems.

HOD's Message

Electricity is the backbone of modern civilization. From lighting our homes to powering industries, transportation, healthcare, and digital infrastructure, every aspect of life today is intertwined with electrical energy. As the global population grows and economies expand, the demand for clean, reliable, and sustainable electricity is rising at an unprecedented rate.

In this dynamic scenario, the role of Electrical Engineers is more critical than ever. We are entering an era driven by innovations like Smart grids, electric vehicles, renewable energy systems, and intelligent automation. This transformation calls for engineers who are not only technically sound but also capable of solving real-world energy challenges with creativity and sustainability in mind.

At our department, we are committed to nurturing such future-ready professionals. Through hands-on learning, interdisciplinary exposure, and industry interaction, we prepare our students to be leaders and innovators in the power sector and beyond.

Let us embrace the responsibility and opportunity that lie ahead. The future of electricity is bright—and it is being shaped by you, the next generation of electrical engineers.

Warm regards,
Dr. H.D MEHTA
Head of Department
Electrical Engineering
VGEC-Chandkheda

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- **The Future of Electrical Grids: Towards an Intelligent, Sustainable, and Resilient Energy System**

SUSTAINABLE ENERGY: CHALLENGES AND SOLUTIONS

Prof. M.G. Jadeja

Introduction

The global energy landscape is undergoing a fundamental transformation in the 21st century. Driven by climate change, depleting fossil fuel reserves, and rising energy demand, the world is shifting focus from conventional systems to sustainable alternatives. Sustainable energy, primarily from renewable sources like solar, wind, hydro, and biomass, offers a long-term, clean solution. Yet, despite its immense potential, several challenges hinder its universal adoption.

According to the International Energy Agency (IEA) 2024 report:

- Renewable sources accounted for 30% of global electricity generation in 2023, up from 27% in 2022.
- Solar PV and wind power led the growth, contributing over 80% of new capacity additions.
- Still, fossil fuels supplied about 67% of total global electricity needs, showing a significant dependence remains.

To achieve net-zero emissions by 2050, renewables must provide nearly 90% of electricity generation worldwide, posing a monumental challenge ahead.
Challenges in Sustainable Energy Deployment

1. **Intermittency and Reliability**

- Solar and wind energy depend on weather and time. For example, solar power peaks during the day and drops to zero at night, while wind is often unpredictable. According to IRENA, this intermittency causes fluctuations that make it difficult to maintain a stable grid, especially when renewables exceed 50% of the energy mix.

2. Energy Storage Limitations

- Energy storage is essential for balancing supply and demand. However, battery storage capacity worldwide was only 28 GW in 2023. While this is a doubling from 2020, it is far from the estimated 620 GW needed by 2030 to support a clean transition.

3. Grid Integration and Infrastructure

- Many existing grids, especially in developing countries, are not designed for decentralized, variable generation. The World Bank estimates that $14 trillion will be needed globally for grid modernization between 2020 and 2050 to support renewables.

4. High Initial Costs

- Although renewable electricity is becoming cheaper (solar PV costs dropped 82% since 2010), initial setup—especially in offshore wind and storage—remains capital-intensive. For instance, offshore wind farms cost $2.5–4 million per MW installed.

5.Land and Resource Use

- Large-scale solar and wind projects need vast land areas. A 1 GW solar farm requires ~2,500 acres, which creates competition with agriculture and ecosystems. Additionally, rare earth minerals used in solar panels and wind turbines are geopolitically concentrated—70% of cobalt comes from the DRC, and China controls over 60% of lithium refining.

6.Policy and Regulatory Gaps

- According to REN21's 2024 Global Status Report, over 130 countries have renewable energy targets, but only 36% have comprehensive grid and energy market reforms that support renewable integration.

Innovative Solutions and Future Outlook

- International efforts like the International Solar Alliance (ISA) and the EU Green Deal are promoting investment, innovation, and policy reforms. Countries are also committing to carbon pricing and green financing to support renewable expansion.
- Education and Workforce Development
- The IEA estimates that the transition to clean energy could create 14 million new jobs by 2030 globally. Educational institutions must now align curricula with skills needed in the solar, wind, and energy analytics sectors.

Conclusion:-

- Sustainable energy is a necessity, not an option. While significant challenges exist, global progress, innovation, and collaborative efforts are paving the way for a cleaner future. By addressing intermittency, storage, policy, and investment, the world can move toward a resilient, inclusive, and net-zero energy system.

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BREAKING THE MOLECULE: INSIDE INDIA'S GREEN HYDROGEN MISSION AND ITS GLOBAL IMPACT

Prof. D.V. Makwana

Introduction

As the world races towards a net-zero carbon future, nations are redefining their energy landscapes. Among the most promising disruptors is green hydrogen—a clean, zero-emission fuel produced through water electrolysis powered by renewable energy. India, with its vast solar and wind potential, is uniquely positioned to become a global hub for green hydrogen production. With the formal launch of the National Green Hydrogen Mission (NGHM) in 2023 and an ambitious vision for 2030, India is strategically positioning itself at the forefront of this transformative technology.

This article delves into the science of green hydrogen, India's policy interventions, industrial projects, and how this molecule will reshape global energy geopolitics.

Green hydrogen is produced by splitting water (H_2O) into hydrogen (H_2) and oxygen (O_2) via electrolysis powered entirely by renewable sources. Unlike grey hydrogen (from natural gas) or blue hydrogen (grey hydrogen with carbon capture), green hydrogen is emissions-free from production to end-use.

Types of Electrolyzers:

Type	Electrolyte	Op. Temp.	Advantages
Alkaline Electrolysser	Aqueous KOH/NaOH	60°-80°C	Mature, cost-effective
PEM (Proton Exchange Membrane)	Solid Polymer Electrolyte	50°-80°C	Compact, high-purity hydrogen
Solid Oxide Electrolyser	Solid Ceramic	500°-850°C	Highest efficiency, suitable for industrial heat integration

India's Green Hydrogen Roadmap:-

The National Green Hydrogen Mission (NGHM), approved in January 2023, allocates ₹19,744 crore (~US$2.3 billion) to catalyze hydrogen production, electrolyser manufacturing, and create hydrogen hubs.

Key Targets by 2030:

Parameter	Target
Green Hydrogen Production	5 MMT per annum
Renewable Capacity for H2	125 GW
Electrolyser Manufacturing	15 GW annual capacity
Emmission Reduction	50 MMT CO2/year

Strategic Focus Areas:

- Large-scale electrolyser manufacturing
- Green hydrogen hubs (energy, fertiliser, refining sectors)
- Export-oriented projects (Middle East, Japan, Europe)
- Grid balancing via hydrogen-based storage systems

Leading Industrial Initiatives in India (Major Projects)

Organization	Capacity(TPA)	Electrolyser Tech	Status
NTPC	10 MW plant at Ramagundam	PEM	Operational
IOCL	5 KTPA at Mathura Refinery	Alkaline	Commissioning phase
Reliance Industries	100 KTPA at Jamnagar (Phase-1)	PEM + Alkaline	Under Construction
ACME Group	0.3 MMT export-oriented Oman Project	PEM	MoU signed
Greenko-ONGC	1 MMT annual production	Integrated Renewable + Storage	Pre-Feasibility complete

Global Hydrogen Targets and India's Position

Country	Green H2 Target (2030)	Production Cost (Expected)
India	5 MMT	$1/kg
EU	10 MMT	$2-3/kg
Japan	3 MMT	$2/kg
USA	10 MMT	$1/kg
Australia	4 MMT	$1.5-2/kg

India's Competitive Edge

- Lowest renewable tariffs globally (as low as ₹2.15/kWh for solar)
- Surplus land availability for giga-scale projects in Rajasthan, Gujarat
- Proximity to Middle East and EU markets

Potential CO_2 abatement: 50 MMT/year by 2030

Challenges and Mitigation

Challenge	Solution
High electrolyser CapEx	Domestic manufacturing incentive (PLI Scheme)
Renewable power intermittency	Co-located hybrid (Solar + Wind + Storage) Projects
Japan	Seawater desalination co-located plants
USA	Green Hydrogen purchase obligations (GHPOs) in draft policy

Strategic Relevance in India’s Energy Transition

- Decarbonising hard-to-abate sectors: fertiliser, refining, steel, shipping, and aviation.
- Energy security: Reducing fossil fuel imports (~85% dependence currently)
- Balancing renewable grid fluctuations via hydrogen storage
- Boosting export economy through green ammonia and hydrogen derivatives

Future Outlook and Global Impact

By 2030, India envisions:

- 125 GW of renewable energy dedicated for green hydrogen
- 5 MMT annual production capacity
- Becoming a top 3 global exporter of green hydrogen and ammonia

The International Renewable Energy Agency (IRENA) forecasts green hydrogen will constitute 12% of global energy demand by 2050. India, through early investments and policy leadership, stands to shape this emerging market, ensuring both domestic decarbonisation and international energy diplomacy advantages.

India’s Green Hydrogen Mission is not merely a decarbonisation initiative but a strategic industrial policy move to capture future energy markets. As the nation builds giga-scale renewable capacity, electrolyser factories, and green hydrogen valleys, it positions itself as a global nucleus for hydrogen technology development, manufacturing, and trade.

The molecule of the future has arrived — and India’s bold mission is breaking it apart to power a cleaner, resilient, and geopolitically independent energy future.

THE FUTURE OF ELECTRICAL GRIDS: TOWARDS AN INTELLIGENT, SUSTAINABLE, AND RESILIENT ENERGY SYSTEM

Prof. Nisha B. Lodha

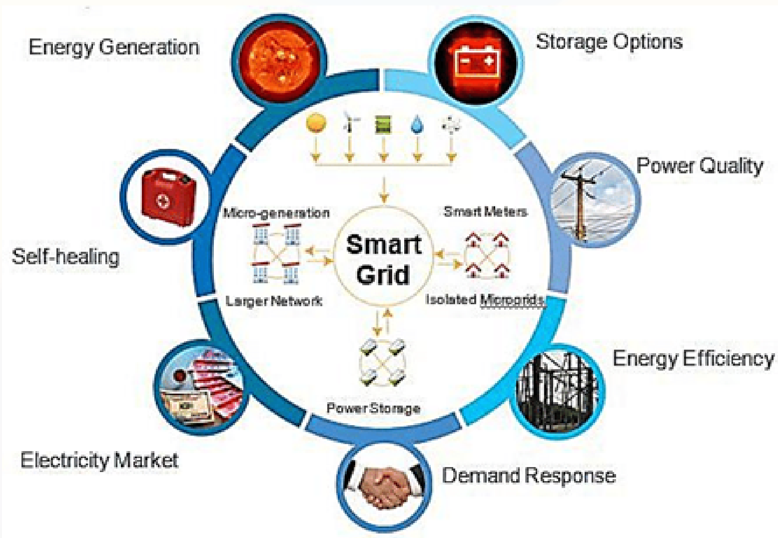
1. Introduction

Traditional power grids were designed for one-way electricity flow—from centralized power plants to consumers. However, with the global push for decarbonization and the increasing demand for reliability and flexibility, these grids are rapidly transforming. The Future Electrical Grid is envisioned as a dynamic, bidirectional, digital, and distributed system capable of integrating Distributed Energy Resources (DERs) such as solar PV, wind, and storage technologies.

2. Key Features of Future Electrical Grids

2.1. Decentralization

- Generation shifts from centralized fossil-fuel plants to localized renewable sources like rooftop solar, community wind farms, and microgrids.
- Prosumers (consumers who produce electricity) play an active role in balancing demand and supply.



2.2. Digitalization

- The integration of Internet of Things (IoT), Artificial Intelligence (AI), and Big Data Analytics enables real-time monitoring and predictive maintenance.
- Smart Meters provide granular visibility into consumption, facilitating demand response and dynamic pricing.

2.3. Bidirectional Energy Flow

- Energy not only flows from generation to consumption but also between consumers, prosumers, storage, and the grid.
- Vehicle-to-Grid (V2G) technologies will enable electric vehicles to store and return energy to the grid.

2.4. Flexibility and Resilience

- The future grid must accommodate variable renewable generation with energy storage systems and advanced grid control mechanisms.
- Microgrids can isolate themselves during faults, ensuring energy security during disruptions.

3. Enabling Technologies

3.1. Renewable Energy Integration

- Solar and Wind Power will dominate future electricity generation.
- Hybrid Energy Systems combine multiple renewable sources for stable supply.

3.2. Energy Storage

- Battery Energy Storage Systems (BESS) balance fluctuations in renewable generation.
- Emerging technologies include hydrogen storage, pumped hydro, and supercapacitors.

3.3. Smart Inverters and Power Electronics

- Intelligent inverters control the output of solar PV and battery systems, enhancing voltage and frequency stability.
- Solid-state transformers (SSTs) will play a key role in future smart substations.

3.4. Communication Infrastructure

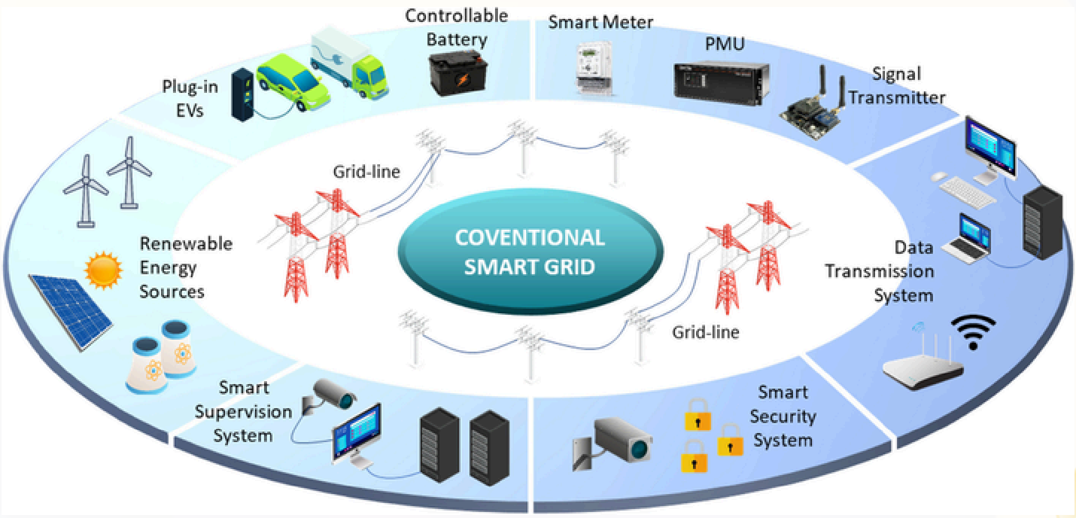
- 5G and optical fiber networks enable real-time communication between grid assets.
- Edge computing ensures local decision-making for rapid grid responses.

4. Challenges in Implementation

The transition to a future-ready electric grid presents several critical challenges. Grid stability becomes a concern with high renewable energy penetration, as the intermittent nature of sources like solar and wind can lead to voltage and frequency fluctuations. The growing digitalization of grid infrastructure increases vulnerability to cyberattacks, making robust cybersecurity protocols essential. Policy and regulatory frameworks must evolve to accommodate active prosumer participation, flexible tariffs, and decentralized energy markets. Additionally, the high upfront investment required for advanced infrastructure, storage, and automation technologies can be a major barrier, especially for developing regions. Lastly, the lack of standardization and interoperability among equipment from different vendors hampers seamless integration and efficient grid operation. Addressing these challenges is key to ensuring a secure, efficient, and sustainable power system.

5. The Role of Artificial Intelligence (AI)

- AI will be the brain of the future grid, providing:
- Load Forecasting for better planning.
- Predictive Maintenance of critical equipment.
- Fault Detection and Isolation (FDI) to improve reliability.
- Grid Optimization through real-time control and automated decision-making.



6. Towards the Energy Internet

The Energy Internet (EI) concept envisions a future where electricity networks operate like data networks—intelligent, interconnected, and decentralized. Inspired by Internet of Things (IoT) principles, the EI integrates multiple energy carriers—electricity, heating/cooling, and fuels—with dynamic pricing and real-time market participation.

7. Conclusion

The Future Electrical Grid represents more than just an upgrade to existing infrastructure; it is a complete transformation of how energy is generated, distributed, and consumed. Driven by technological innovation, environmental imperatives, and socio-economic changes, this evolution demands collaborative efforts among utilities, governments, industries, and consumers. The result will be a cleaner, smarter, and more resilient energy ecosystem capable of supporting a sustainable global future.

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