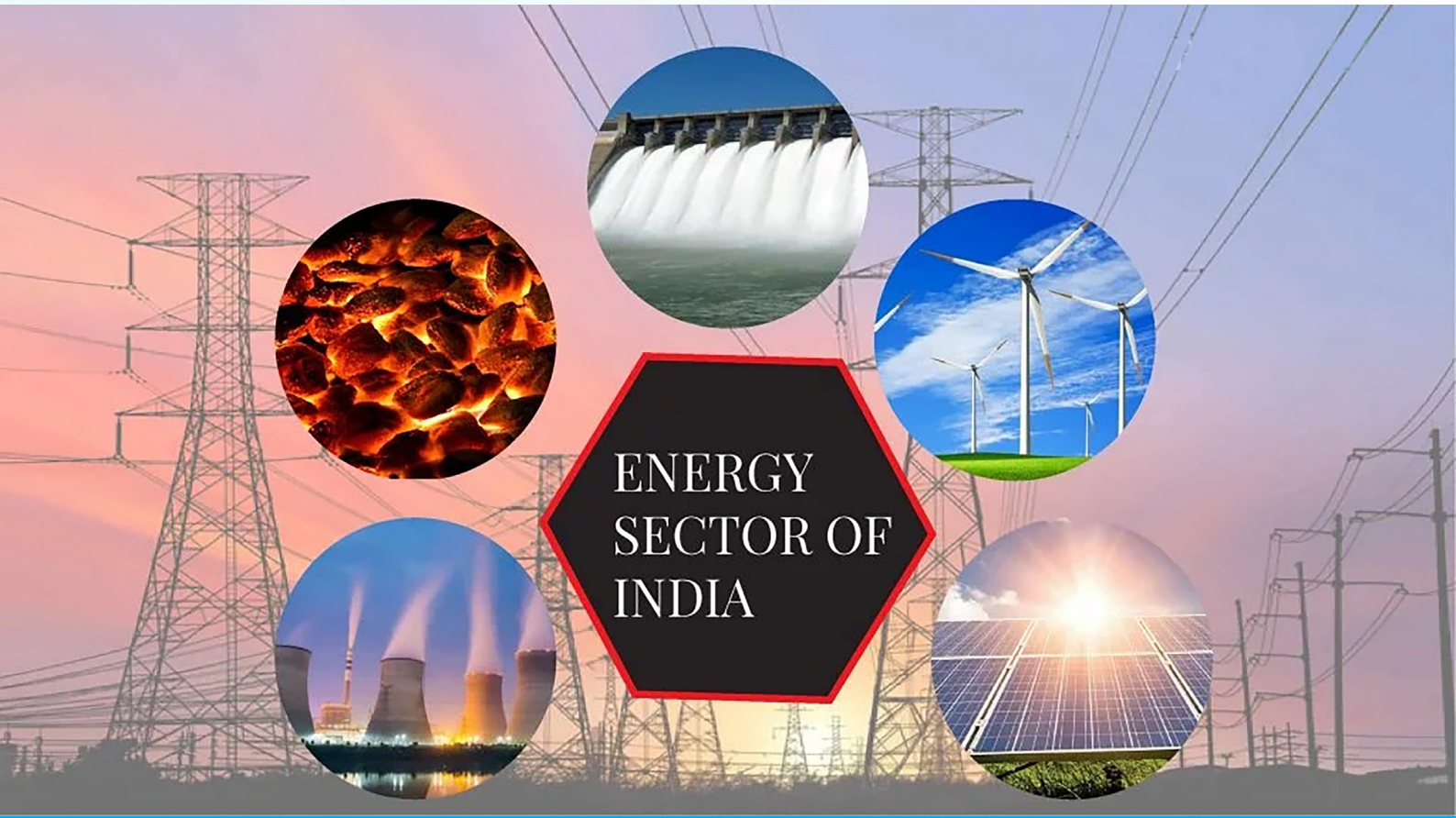
NEXT IAS

GIST OF YOJNA

Energy Sector in India

February, 2025



Delhi Centre (ORN):

Vivekananda House: 6-B, Pusa Road, Metro Pillar no. 111, Near Karol Bagh Metro, New Delhi-110060

Ph.: 8081300200 | **E-mail:** info@nextias.com | **www.**nextias.com

CHAPTER 1: PM-KUSUM: EMPOWERING FARMERS WITH SOLAR ENERGY SOLUTIONS

INTRODUCTION

The **Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM)** was launched by the **Ministry of New and Renewable Energy (MNRE) in 2019** to promote the installation of **off-grid solar pumps** in rural areas and reduce dependence on conventional grid electricity.

- The scheme also facilitates grid-connected solar energy solutions for agricultural purposes.

COMPONENTS:

Component A: Decentralized Solar Power Plants

- **Target: 10,000 MW** of solar capacity through **small solar power plants** (up to **2 MW** each).
- **Location:** Preferably within **5 km radius of notified substations** to minimize **transmission losses and costs**.
- **Power Purchase:** Local **DISCOMs** will procure electricity at **pre-fixed tariffs** set by the **State Electricity Regulatory Commission (SERC)**.

Component B: Standalone Solar Agriculture Pumps

- **Target: 20 lakh standalone solar-powered agricultural pumps**.
- **Capacity:** Individual farmers can install **solar pumps of up to 7.5 HP** to replace **diesel-based irrigation systems** in off-grid areas.
- **Financial Support:**
  - **30% subsidy** by the **State Government**.
  - The remaining cost to be borne by the **farmer**.

Component C: Solarization of Grid-Connected Pumps

- **Target: Solarizing 15 lakh grid-connected agricultural pumps**.
- **Usage:** Farmers can use the **solar power for irrigation** and sell **excess energy** to DISCOMs at **pre-fixed tariffs**.

OBJECTIVES:

- Enable farmers to **set up solar power generation** on arid lands and sell surplus electricity to the grid.
- Enhance **farmers' income** by allowing them to trade excess solar energy.

SIGNIFICANCE OF THE SCHEME:

1. **Enhancing Energy Access:**
   - Encourages farmers to sell surplus solar power to the state, thereby **supplementing their income**.
   - Expands **rural electricity access**, ensuring a **reliable energy source** for agricultural and allied activities.
2. **Climate Change Mitigation:**
   - Promotes **sustainable irrigation** by reducing reliance on **polluting diesel pumps**.
   - Encourages **efficient groundwater utilization** by incentivizing farmers to save energy.
   - Expected to reduce **carbon emissions by 32 million tonnes of CO2 annually**.
3. **Employment Generation & Rural Empowerment:**
   - Creates job opportunities in the **installation, maintenance, and operation** of solar projects.
   - Strengthens **energy security** by enabling decentralized power generation.

CHALLENGES IN IMPLEMENTATION:

1. **Financial and Logistical Constraints:**
   - High **initial investment costs** may limit access to solar power solutions for small farmers.
   - Domestic **availability of solar equipment**, especially pumps, remains a concern.
2. **Water Table Depletion:**
   - Power subsidies encourage **excessive groundwater extraction**, leading to a declining water table.
   - Upgrading to **higher-capacity pumps** in case of falling water tables requires additional **solar panels**, increasing costs.
3. **Regulatory and Technical Challenges:**
   - **Regulatory restrictions** may hinder seamless integration of **solar power with the grid**.
   - Decentralized solar projects pose **grid stability** and **technical integration issues**.

CHAPTER 2: NATIONAL SOLAR MISSION: PROGRESS, CHALLENGES, AND THE PATH FOR RENEWABLE ENERGY BY 2030

The **National Solar Mission (NSM),** launched in **2010** as part of India's **National Action Plan on Climate Change,** aims to establish India as a global leader in solar energy.

- With ambitious targets set for solar power generation, the mission has made significant strides but faces numerous challenges that must be addressed to achieve its goals by 2030.

PROGRESS OF THE NATIONAL SOLAR MISSION

- **Increase in Installed Capacity**: India's solar power capacity has seen remarkable growth. As of December 2023, India's total renewable energy capacity stood at approximately **180 GW**, with solar energy contributing about **70 GW**. The initial target of **20 GW** by 2022 was surpassed, and the nation is now working towards achieving **500 GW of non-fossil fuel capacity** by 2030 as part of a broader renewable energy strategy.
- **Development of Solar Parks**: The establishment of solar parks has been a cornerstone of the NSM. These parks facilitate large-scale solar power generation and have attracted substantial investments. Notable projects include the **Bhadla Solar Park in Rajasthan (2.25 GW),** one of the largest in the world, and the **Rewa Ultra Mega Solar Park (750 MW) in Madhya Pradesh.**
- **Growth of Rooftop Solar Installations**: Rooftop solar installations have gained traction due to government incentives and subsidies. This decentralization of solar power generation helps alleviate stress on the national grid and promotes energy independence at the household and commercial levels.
- **Technological Advancements**: The mission has spurred innovation in solar technologies, leading to improved efficiency and reduced costs. India is now one of the largest manufacturers of solar panels globally, contributing to both domestic needs and export markets. Advances in **solar panel efficiency, perovskite solar cells, and bifacial modules** are enhancing power generation capabilities.

- **International Collaboration**: India's commitment to global solar initiatives is evident through its leadership in the **International Solar Alliance (ISA)**, aimed at promoting solar energy worldwide and facilitating technology transfer among member countries.

CHALLENGES FACED BY THE NATIONAL SOLAR MISSION

- **Land Acquisition Issues**: Acquiring land for solar projects remains a significant barrier. The process is often hampered by regulatory complexities and local opposition, particularly in densely populated and agricultural regions.
- **Financial Constraint**: High initial capital costs for solar installations pose a challenge, especially for small-scale projects. While government subsidies exist, financing mechanisms such as **viability gap funding (VGF), green bonds, and interest subvention schemes** need further strengthening.
- **Policy and Regulatory Uncertainty**: Inconsistent policies and regulatory frameworks create uncertainty for investors. Frequent changes in tariffs, import duties on solar panels, and delays in power purchase agreements (PPAs) affect project timelines and financial viability.
- **Grid Integration Challenges**: Integrating intermittent solar power into the national grid requires **advanced grid management systems** and energy storage solutions. Battery storage technologies, **pumped hydro storage**, and **hybrid solar-wind projects** are being explored but require further scaling.
- **Skilled Workforce Shortage**: The lack of trained professionals in the renewable energy sector hampers growth. **Vocational training programs and skill development initiatives** are essential to build a workforce capable of supporting the growing solar industry.

WAY FORWARD

To meet its ambitious target of fulfilling **50%** of its energy needs from renewable sources by **2030**, India must adopt a multi-faceted approach:

- **Strengthening Policy Frameworks:** Establishing stable and transparent policies that encourage long-term investments in renewable energy.
- **Enhancing Infrastructure:** Investing significantly in **smart grids, advanced energy storage, and transmission infrastructure** to accommodate increased renewable capacity.
- **Promoting Public-Private Partnerships:** Encouraging collaboration between government entities and private companies to mobilize resources effectively.
- **Redirecting Subsidies:** Shifting financial support from fossil fuels to renewables will enhance cost competitiveness and drive adoption.
- **Investing in R&D:** Continuous innovation in solar technology, including **high-efficiency solar cells, energy storage solutions, and grid management systems,** will be crucial for improving efficiency and reducing costs.

CONCLUSION:

In conclusion, while India's National Solar Mission has made impressive progress since its inception, overcoming existing challenges will be vital for achieving its renewable energy targets by 2030. A concerted effort involving **policy reform, financial investment, infrastructure development, and workforce training** will pave the way for a sustainable energy future in India.

Table 1 : Salient features of PM-KUSUM

Aspect	PM-KUSUM
Coverage	All India
Year of Initiation	March 2019
Architecture/ Institutional set-up	• **Two tier** • **National Level:** Screening Committee under the chairmanship of Secretary, MNRE • **State level:** State Implementing Agency (SIA)

Planning	• SIA assesses the demand of solar pumps and submits the proposal to MNRE. • MNRE after the approval from Screening Committee sanctions and allocates the number of pumps to SIA • SIA installs pumps through empaneled vendors, and monitors the progress till at least five years
Nodal Department	• **National level**: MNRE • **State level**: DISCOMS/ State specific Renewable Energy Development Agency/ Agriculture department/Any other department identified by the state government
Beneficiaries	• Individual farmers/SHGs/JLGs forming groups of farmers/Co-operatives/ Panchayats/FPO, WUA.
Financial assistance (Subsidy)	**Component B&C:** • 60 per cent of the benchmark or tender cost whichever is less, in all states except North Eastern states, J&K, Himachal Pradesh, Uttarakhand, Lakshadweep and A&N Islands where subsidy assistance is 80 per cent. • In case the state government provides top up subsidy, farmers' share can be reduced. • Priority is given to marginal and small farmers, and those with micro-irrigation system
Ceiling	• Central Financial Assistance (CFA) is restricted to 7.5 Hp pumps. However, more than 7.5 Hp pumps may be allowed without CFA. • CFA is available for pumps up to 15 Hp capacity in J&K, Ladakh, Uttarakhand, Himachal Pradesh, and the A&N and Lakshadweep Islands, as well as for cluster/ community irrigation projects in high water table areas.
Funding pattern	**Component B&C:** • 100 per cent central government assistance for all UTs • 50:50: Central & state government sharing for all other states (60 per cent subsidy of benchmark cost) • 62.5: 37.5: Central & state government sharing for all other states in NE & Himalayan states, Lakshadweep and A&N Islands (80 per cent subsidy of benchmark cost) • Farmers share: 20 per cent in special category states and 40 per cent in other states. • Bank finance may be available upto 10 per cent to 30 per cent of farmers' share.
Installation and maintenance	• Empaneled vendors are responsible for design, supply, installation and commissioning of solar agricultural pumps under the close real-time monitoring of SIA. • Annual maintenance charges for a period of 5 years, including insurance coverage for the installed system against natural calamity and theft.
Convergence possibility	• The guidelines of PM-KUSUM encourage convergence with PDMC. New solar pumps shall not be installed in dark zones. Existing pumps in dark zones can be replaced with solar provided they use micro-irrigation techniques to save water.

CONCLUSION:

PM-KUSUM has the potential to **revolutionize rural energy access**, promote **sustainable agriculture**, and mitigate **climate change**. However, addressing **financial, regulatory, and technical challenges** is essential for the scheme's **effective implementation and long-term success**.

CHAPTER 3: PERFORM, ACHIEVE, AND TRADE (PAT) SCHEME

INTRODUCTION

India's economic growth, under the and initiatives, is closely linked to energy consumption.

- ✦ However, rising energy demand, climate change, and pollution necessitate a shift towards energy efficiency and renewable energy sources.

- The scheme, under the , aims to reduce energy consumption in industrial sectors through energy-saving targets and trading of .

INDIA'S ENERGY SCENARIO AND CHALLENGES

- India aims to reduce energy intensity by **45% by 2030** (compared to 2005 levels) and achieve **net-zero emissions by 2070**.
- Energy-intensive industries like steel, cement, fertilisers, and power generation require efficiency improvements.
- Transitioning to **energy-efficient technologies** (e.g., LEDs, efficient industrial processes) is crucial to managing growing energy demand while mitigating pollution and climate risks.

PAT SCHEME: DESIGN AND IMPLEMENTATION

- **Objective:** Improve energy efficiency in high-energy-consuming industries by setting specific energy consumption (SEC) reduction targets.
- **Implementation:**
  - **Designated Consumers (DCs):** Identified industrial plants mandated to participate.
  - **Baseline Calculation:** Accredited energy auditors assess SEC for each DC.
  - **Energy-Saving Targets:** Assigned based on industry benchmarks.
  - **Energy Efficiency Measures:** DCs implement recommended improvements, ranging from low-cost interventions to high-investment structural changes.
  - **Trading Mechanism:**
    - DCs achieving savings beyond targets receive .
    - These can be sold to underperforming DCs, allowing flexibility in compliance.

SECTOR-SPECIFIC CHALLENGES AND SOLUTIONS

- **Iron & Steel Industry:** Variability in raw materials (iron ore, coal), energy-intensive processes.
  - Solutions: Improved coal quality, waste heat recovery, increased scrap utilisation.
- **Other Sectors:** Variability in technology, process efficiency, and resource availability impact energy efficiency goals.

IMPACT AND ACHIEVEMENTS

- **PAT Cycle I (2012-15):** 8.67 million tonnes of oil equivalent (MTOE) saved (target: 6.86 MTOE), reducing **31 million tonnes of CO_2** emissions.
- **Subsequent PAT cycles:** Expanded to new sectors, achieving cumulative savings of **over 14 MTOE** in Cycle II (2016-19).
- **Flexibility and Market Approach:** The trading of ESCerts allows industries to optimise energy efficiency investments.

CONCLUSION

The PAT scheme has proven to be an effective mechanism in reducing India's industrial energy consumption while aligning with global climate commitments. By integrating technical, financial, and market-based solutions, PAT fosters sustainable industrial growth and contributes significantly to India's energy efficiency and carbon reduction goals.

CHAPTER 4: SMART CITIES MISSION (SCM) AND THE ROLE OF ENERGY EFFICIENCY IN URBAN DEVELOPMENT

INTRODUCTION

India's **Smart Cities Mission (SCM)**, launched in **2015**, aims to integrate **technology and infrastructure** to improve urban living standards. Given that cities contribute **50-60% of global greenhouse gas (GHG) emissions**, energy efficiency has become a key pillar of sustainable urbanization.

ENERGY EFFICIENCY IN URBAN DEVELOPMENT

- **Rising Energy Demand**: Urbanization has made India the **third-largest energy consumer**, with **80% of its energy** coming from conventional sources like **coal**, which contributes **70% of emissions**.
- **Government Initiatives**: India's **Nationally Determined Contributions (NDCs)** and **Long-Term Low-Emissions Development Strategy (LT-LEDS)** focus on **energy-efficient and climate-resilient** urban infrastructure.

KEY SECTORS FOR ENERGY EFFICIENCY IN SMART CITIES

- **Energy-Efficient Buildings**:
  1. Buildings account for **over one-third** of India's total energy consumption.
  2. Retrofitting **HVAC, lighting, and water supply** can **reduce energy demand**.
  3. Green building standards such as **GRIHA** and **LEED** promote sustainable construction.
- **Energy-Efficient Water Management**:
  1. The **Climate Smart Cities Assessment Framework (CSCAF)** promotes energy-efficient **water supply networks**.
  2. **SCADA automation, solar energy integration, and hydraulic modeling** can improve efficiency.
- **Energy-Efficient Waste Management**:
  1. Urban waste is growing at **5% annually**, requiring **sensor-based waste collection, AI-driven waste processing**, and **waste-to-energy conversion**.

- **Energy-Efficient Transportation**:
  1. The transport sector contributes **14% of CO_2 emissions**.
  2. **Electric vehicles (EVs), AI-driven traffic management, and multimodal transport networks** can help reduce the energy footprint.

POLICY AND REGULATORY FRAMEWORK

- The transition from **Energy Conservation Act (2001)** to more **consumer-oriented policies** reflects a shift towards sustainability.
- **NAPCC (National Action Plan on Climate Change)** and **NMEEE (National Mission on Enhanced Energy Efficiency)** should be integrated into urban planning.

WAY FORWARD

- **Stakeholder Collaboration**: Coordination among **think tanks, academia, businesses, and local governance** can enhance policy impact.
- **Technological Advancements**: Adoption of **smart grids, AI-driven energy systems, IoT-enabled sensors, and blockchain energy trading** can revolutionize energy efficiency.
- **Decentralized Energy Governance**: Strengthening **urban local bodies** can lead to better energy management.

Table 1: Transforming policy environment with direct & indirect contribution to energy efficiency in cities

Policy/Programme	Year	Emphasis
Energy Conservation Act (EC Act)	2001, Amended 2010	Establish energy efficiency standards, promote energy conservation, regulate high energy-use industries.
National Mission on Enhanced Energy Efficiency (NMEEE)	2010	Enhance industrial energy efficiency through Perform, Achieve & Trade (PAT), and financial instruments like Energy Savings Certificates.
National Mission for Sustainable Habitat (NMSH)	2010	Promote sustainable urban development, energy-efficient buildings, and urban waste management.
National Solar Mission (NSM)	2010	Scale up solar power generation with targets for grid-connected and off-grid solar installations.
Perform, Achieve, and Trade (PAT) Scheme	2012	Market-based mechanism for enhancing energy efficiency in industries
National Electric Mobility Mission Plan (NEMMP)	2013	Development and promotion of electric vehicles that contribute to net zero emissions by reducing vehicular pollution
Smart Cities Mission (SCM)	2015	Foster energy-efficient, sustainable urban development with integrated technologies and green infrastructure.
National Smart Grid Mission	2015	Modernises India's power distribution network using smart grids and enables grid decarbonisation for net zero carbon goals.
Unnat Jyoti by Affordable LEDs for All (UJALA)	2015	Encourages the production and use of energy-saving LED lights and appliances. Lowers the amount of electricity used in homes and businesses.
Energy Conservation Building Code (ECBC)	2017 (Updated)	Sets energy efficiency standards for commercial buildings to boost climate resilience in Urban Development.
Draft National Energy Policy (NEP)	2017	Provide universal energy access, reduce fossil fuel dependency, and promote low-carbon development.
Draft National Cooling Action Plan (NCAP)	2018	Manage cooling demand, reduce carbon footprint, and increase energy-efficient cooling technologies.
National Program for Climate Change & Human Health (NPCCHH)	2019	Ensuring environmentally sustainable and climate-resilient health services
Steel Scrap Recycling Policy (SSRP)	2019	Promotes the use of scrap steel in manufacturing to lessen the emissions and effects of mining. Encourages the steel sector to use sustainable manufacturing practices.

CONCLUSION

Energy efficiency is a **cornerstone of smart urbanization**. India must **scale up its energy-efficient initiatives** in **buildings, transport, water, and waste management** to achieve **sustainable, low-carbon, and climate-resilient** urban development.

CHAPTER 5: SCOPE AND OPPORTUNITIES FOR RENEWABLE ENERGY IN RURAL INDIA

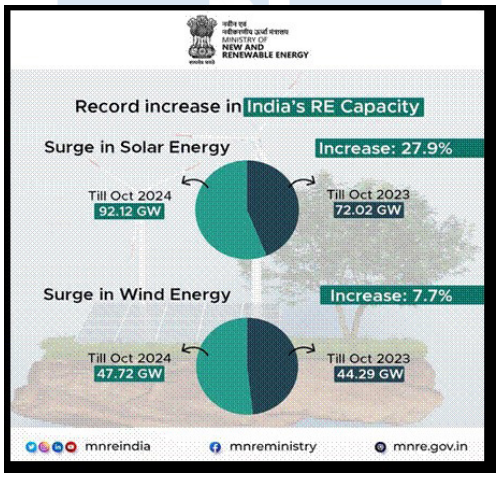
INTRODUCTION

India has witnessed a remarkable growth in its renewable energy capacity, expanding by 165% over the past decade—from 76.38 GW in 2014 to 203.1 GW in 2024.

- Given that rural India constitutes about 67% of the total population and contributes 37% of GDP, renewable energy can play a transformative role in its development. The government has identified energy as a priority sector, allocating Rs 68,769 crores towards its enhancement.

The **Pradhan Mantri Surya Ghar: Muft Bijli Yojana** aims to install rooftop solar plants in one crore households, providing up to 300 units of free electricity per month.

- Additionally, the **National Green Hydrogen Mission** seeks to achieve 5 million metric tonnes of annual green hydrogen production capacity by 2030. These initiatives align with India's commitment to sustainable energy solutions.



NEED FOR RENEWABLE ENERGY IN RURAL INDIA

Despite India's rapid economic growth, rural areas still face significant infrastructure deficits, particularly in electricity access.

- Around 300 million people in rural India lack access to grid-connected power, relying instead on traditional and polluting sources such as kerosene, diesel, and wood-fired chulhas. These not only contribute to environmental degradation but also impose health hazards and economic burdens.

SOLAR POWER: A KEY SOLUTION

Solar energy emerges as a viable alternative due to declining costs and its ability to provide decentralized power solutions. Key advantages include:

- **Decentralized Electrification**: Solar energy enables cost-effective electrification of remote areas where grid extension is not feasible.
- **Multi-purpose Applications**: Solar power benefits productivity, safety, healthcare, clean water access, and livelihoods.
- **Improving Rural Productivity**: Solar lighting can extend working hours and increase household incomes.

- **Solar-Powered Agricultural Pumps**: These enhance irrigation efficiency, reducing dependence on fossil fuel-based pumps that consume nearly 20% of India's installed power capacity.
- **Water Purification**: Solar energy can be harnessed for water treatment, addressing the pressing need for clean drinking water in rural India.

GOVERNMENT INITIATIVES FOR RENEWABLE ENERGY PROMOTION

The Government of India has launched several initiatives to enhance renewable energy capacity, including:

- **100% FDI in Renewable Energy**: Permitted under the automatic route to attract global investment.
- **National Green Hydrogen Mission (2023)**: Targets 5 MMT of annual green hydrogen production by 2030.
- **Waiver of Inter-State Transmission Charges**: Encourages inter-state sale of renewable power.
- **Ultra Mega Renewable Energy Parks**: Provides land and transmission infrastructure for large-scale RE projects.
- **PM-KUSUM Scheme**: Supports solar-powered agriculture and energy security.
- **PM Surya Ghar: Muft Bijli Yojana**: Plans to install rooftop solar in one crore households with a financial outlay of Rs 75,021 crore until FY27.
- **Green Energy Corridor Scheme**: Expanding transmission lines for renewable energy evacuation.
- **Project Development Cell**: Established to attract private investment.
- **Offshore Wind Energy Development**: Plans to install 1 GW offshore wind energy capacity along Gujarat and Tamil Nadu coasts.
- **Standard Bidding Guidelines**: Streamlining tariff-based competitive bidding for solar and wind power projects.

CHALLENGES IN RENEWABLE ENERGY DEPLOYMENT

Despite significant progress, India's RE sector faces various challenges:

- **High Land Acquisition Costs**: Finding suitable land, converting its use, and obtaining necessary clearances remain time-consuming.
- **Trust Deficit in Solar Power Solutions**: Despite government incentives, consumer skepticism about performance persists.
- **Lower Efficiency of Domestic Solar Panels**: Indian solar panels often lag behind international competitors in efficiency.
- **Environmental Challenges**: Dust accumulation on solar PV cells reduces efficiency, impacting energy generation.
- **Intermittency Issues**: Renewable sources depend on weather conditions, causing fluctuations in power generation.
- **Grid Balancing Constraints**: Sudden surges or drops in renewable generation can strain grid stability.
- **Impact on Wildlife**: Wind turbines pose risks to birds and bats, particularly during migration seasons.
- **High Water Requirement for Hydrogen Production**: Large-scale hydrogen production demands significant water resources.
- **DISCOM Limitations**: Power Purchase Agreements for thermal energy limit DISCOMs' ability to procure solar power.
- **Economic Viability of Nuclear Power**: Small modular reactors are expected to be expensive and may not be commercially viable before 2030.

CONCLUSION

Renewable energy, especially solar, can drive rural India's growth and sustainability. Addressing manufacturing, grid, and consumer challenges through policy, investment, and technology will ensure inclusive development and global leadership.

CHAPTER 6: GREEN HYDROGEN: INDIA'S PATH TO A SUSTAINABLE ENERGY FUTURE

INTRODUCTION

India's National Green Hydrogen Mission (NGHM) aims to establish the country as a global hub for Green Hydrogen production, usage, and export.

- The mission advances India's energy self-sufficiency by promoting clean energy solutions and reducing dependence on fossil fuels.
- The mission targets a production capacity of at least **5 Million Metric Tonnes (MMT) of Green Hydrogen annually by 2030**, with potential growth to **10 MMT per year** as export markets expand. It is expected to decarbonize key industrial sectors and lay the groundwork for emerging sectors such as steel, shipping, energy storage, and long-haul mobility.
- These initiatives are projected to avert around **50 MMT of CO2 emissions annually**, significantly contributing to India's Net Zero goals.
- Government interventions and a phased approach aim to accelerate the development of Green Hydrogen technologies, reduce production costs, and create economies of scale.

INDIA'S COMMITMENT TO SUSTAINABLE DEVELOPMENT

India, a recognized global leader in climate action, has surpassed its Paris Agreement targets and now focuses on achieving **energy independence by 2047** and **Net Zero emissions by 2070**.

- Green Hydrogen plays a crucial role in this vision by revolutionizing India's energy landscape and positioning it as a leader in renewable energy production.
- With one of the world's fastest-growing renewable energy sectors, India has abundant resources to meet domestic energy needs and supply Green Hydrogen to global markets.
- The NGHM is a comprehensive initiative designed to build a robust Green Hydrogen ecosystem, addressing opportunities and challenges in this emerging sector.

The Global Transition to Clean Energy

As countries strive to combat climate change, ensure energy security, and drive economic growth, Green Hydrogen is gaining prominence as a clean energy alternative. Produced from renewable sources like solar and wind, it holds vast potential to decarbonize hard-to-abate sectors such as industry, transport, and power generation while creating sustainable economic and employment opportunities.

Through the NGHM, India contributes to global sustainability while advancing its own energy security and economic development.

ADVANCING ENERGY INDEPENDENCE AND SUSTAINABLE DEVELOPMENT

With India's **energy demand projected to grow by 25% by 2030**, over **40% of its primary energy needs** are currently met through imports. Transitioning to Green Hydrogen can significantly reduce fossil fuel dependence and improve energy self-sufficiency. It can replace fossil fuels in industries such as:

- **Petroleum refining**
- **Steel production**
- **Fertilizers**
- **Long-haul transport** (including automobiles and ships)

GLOBAL OPPORTUNITIES

Growing global demand for Green Hydrogen, coupled with disruptions in fossil fuel supply chains, presents a significant opportunity for India to capitalize on its renewable energy resources.

- This can position the country as a leading producer and exporter of Green Hydrogen and its derivatives, such as **Green Ammonia and Green Methanol**.

OVERCOMING CHALLENGES

Despite challenges such as high production costs and the lack of harmonized standards, advancements in technology and the declining costs of renewable energy and electrolysers will make Green Hydrogen cost-competitive across various sectors.

OBJECTIVES OF THE NATIONAL GREEN HYDROGEN MISSION (NGHM)

Launched in **January 2023**, the NGHM aims to establish India as a **global hub for Green Hydrogen production, usage, and export**, helping to:

- Decarbonize the economy
- Reduce dependence on fossil fuel imports
- Strengthen India's leadership in Green Hydrogen technology and markets
- Contribute to the global clean energy transition

KEY TARGETS

- **At least 5 MMT of Green Hydrogen production annually by 2030**, with potential growth to **10 MMT**
- Replacement of fossil fuels with Green Hydrogen-based alternatives in sectors like **ammonia production, petroleum refining, and city gas distribution**
- Promotion of **Green Hydrogen-based synthetic fuels**, including Green Ammonia and Green Methanol, in mobility, shipping, and aviation
- Strengthening India's **electrolyser manufacturing** industry

SCALING GREEN HYDROGEN PRODUCTION: LEVERAGING RENEWABLE RESOURCES

India currently consumes **about 5 MMT of Hydrogen annually**, primarily sourced from fossil fuels (**Grey Hydrogen**). However, pilot projects have begun producing Green Hydrogen using **water electrolysis** powered by renewable energy and **biomass-based thermochemical methods**.

The NGHM seeks to scale these technologies by:

- **Reducing costs** associated with electrolysers, renewable energy inputs, and infrastructure
- **Expanding electrolyser manufacturing** to enhance domestic production and reduce imports
- **Exploring decentralized models**, such as **rooftop solar and small hydro plants**, to optimize land and water use
- **Developing hydrogen refueling stations** linked to renewable energy plants

Additionally, for **remote regions and islands**, decentralized Green Hydrogen production can support local energy needs and economic development.

PHASED IMPLEMENTATION: LAYING THE FOUNDATION FOR GROWTH

Phase I (2022-23 to 2025-26)

- Focus on creating demand and boosting **domestic electrolyser manufacturing**
- Introduction of **incentives** to promote indigenization
- Initial deployment in **refineries, fertilizers, and city gas** sectors
- Pilot projects in **steel, long-haul transport, and shipping**
- Development of regulations and standards

Phase II (2026-27 to 2029-30)

- Green Hydrogen expected to become **cost-competitive** in key sectors
- **Commercial-scale projects** in steel, mobility, and shipping
- Pilot projects in **railways and aviation**
- Expansion of **R&D efforts** to drive technological advancements and sector-wide decarbonization

MULTI-MINISTRY COORDINATION FOR SUCCESS

The success of the NGHM requires coordination across multiple ministries and institutions. The key stakeholders include:

- **Ministry of New and Renewable Energy (MNRE)** – Lead agency overseeing policy formulation, incentives, and international collaborations
- **Ministry of Power (MoP)** – Policy support for cost-effective renewable energy production
- **Ministry of Petroleum and Natural Gas (MoPNG)** – Integration of Green Hydrogen in refineries and city gas distribution
- **Ministry of Chemicals and Fertilisers** – Adoption of **Green Ammonia-based fertilizers** to reduce imports
- **Ministry of Road Transport and Highways (MoRTH)** – Promotion of hydrogen adoption in heavy transport
- **Ministry of Steel** – Development of **green steel production** projects
- **Ministry of Ports, Shipping and Waterways (MoPSW)** – Infrastructure development for **hydrogen-powered ships and exports**
- **Ministry of Finance** – Establishment of financial frameworks and incentives

CONCLUSION

The National Green Hydrogen Mission is a pivotal initiative that will transform India's energy sector, making it self-reliant and sustainable. By leveraging its abundant renewable energy resources and fostering technological advancements, India is well-positioned to become a global leader in Green Hydrogen production and export. Through coordinated efforts, phased implementation, and international collaboration, the mission will accelerate India's transition to a low-carbon economy, ensuring a cleaner, greener, and energy-secure future.

CHAPTER 7: BIOFUELS AS A PROMISING SUBSTITUTE FOR HIGH-CARBON ENERGY SOURCES

INTRODUCTION

The rising demand for energy, coupled with the environmental and economic challenges of fossil fuels, has necessitated a shift towards renewable energy sources.

- While wind and solar power have gained prominence in India's renewable energy portfolio, biofuels offer a strategic advantage for sustainable development and energy security.
- The National Policy on Biofuels (NPB) 2018 aims to enhance biofuel production and establish a sustainable ecosystem.

THE NEED FOR ALTERNATIVE ENERGY SOURCES

Conventional energy sources, primarily fossil fuels, are responsible for significant environmental degradation, including climate change, biodiversity loss, and pollution.

- The need for alternative energy sources is pressing, especially in large and developing countries like India, which face challenges such as energy insecurity, climate change, population growth, and poverty.
- Sustainable and clean energy solutions are essential for economic growth, social well-being, and environmental preservation.

Biofuels:

Biofuels are renewable fuels derived from biological sources such as plants, algae, and organic waste. They serve as an alternative to fossil fuels and help reduce carbon emissions. Biofuels are categorized into different generations based on their source and production methods:

TYPES OF BIOFUELS

- **First-Generation Biofuels:**
  1. Derived from food crops like sugarcane, corn, and vegetable oils.
  2. Examples: Ethanol (from sugarcane, corn), Biodiesel (from vegetable oils).
- **Second-Generation Biofuels:**
  1. Produced from non-food biomass like agricultural waste, wood, and algae.
  2. Example: Cellulosic ethanol (from crop residues, wood chips).
- **Third-Generation Biofuels:**
  1. Made from specially cultivated energy sources like algae, which produce high oil yields.
  2. Example: Algal biofuel.
- **Fourth-Generation Biofuels:**
  1. Involves advanced techniques like synthetic biology and carbon capture to enhance fuel production.

Examples of Biofuels

- **Ethanol:** Blended with petrol to reduce emissions.
- **Biodiesel:** Used as an alternative to diesel.
- **Biogas:** Generated from organic waste decomposition.
- **Green Hydrogen:** Produced using bio-based processes.

INDIA'S BIOFUEL INITIATIVES

India's biofuel initiative began in 2003, distinguishing itself by using molasses for bioethanol and non-edible oils for biodiesel. However, challenges such as the cyclic nature of sugar and ethanol production, high costs, and land availability have hindered consistent biofuel development.

- A coherent and long-term policy can drive India's biofuel efforts, ensuring energy security, economic growth, and environmental sustainability.

SOME FACTS ABOUT BIOFUELS

Biofuels	Liquid or gaseous fuels produced from biomass resources and used in place of, or in addition to, diesel, petrol or other fossil fuels for transport, stationary, portable and other applications;
Biomass resources	The biodegradable fraction of products, wastes and residues from agriculture, forestry and related industries as well as the biodegradable fraction of industrial and municipal wastes.
Bio-ethanol	Ethanol produced from biomass such as sugar-containing materials, like sugarcane, sugar beet, sweet sorghum, etc.; starch-containing materials such as corn, cassava, algae, etc.; and cellulosic materials such as bagasse, wood waste, agricultural and forestry residues, etc.
Biodiesel	A methyl or ethyl ester of fatty acids produced from vegetable oils, both edible and non-edible, or animal fat of diesel quality.

STRATEGIC ROLE OF BIOFUELS IN INDIA

The Ministry of Petroleum and Natural Gas has emphasized reducing dependence on fossil fuel imports by promoting alternative fuels. Biofuels, derived from agriculture and forest residues, municipal solid waste, and animal waste, offer multiple benefits:

- **Reduction in fossil fuel imports** leading to foreign exchange savings.
- **Better financial incentives for farmers**, aligning with the goal of doubling farmers' income.
- **Waste management solutions**, supporting the Swachh Bharat Abhiyan.
- **Support for the 'Make in India' campaign** by promoting indigenous energy solutions.
- **Reduction in greenhouse gas emissions**, improving air and water quality.

ENVIRONMENTAL AND SOCIOECONOMIC BENEFITS

Biofuels provide several advantages beyond energy security:

- **Social Benefits**: Biofuels can improve rural livelihoods by creating job opportunities and supporting sustainable agricultural practices.
- **Environmental Benefits**: They help in reducing air pollution and mitigating climate change by lowering carbon emissions compared to fossil fuels.
- **Economic Benefits**: A shift towards biofuels can reduce India's energy import bill, enhance local industry, and stimulate economic growth.

CHALLENGES AND THE WAY FORWARD

Despite their promise, biofuels face significant challenges:

- **Land availability**: Expanding biofuel crop cultivation must not compete with food production.
- **High production costs**: Large-scale production remains expensive compared to fossil fuels.
- **Infrastructure and technology**: Advanced biofuel technologies require substantial investment and development.

To overcome these challenges, India must focus on:

- **Investment in research and development** to improve biofuel efficiency and production.
- **Incentives and subsidies** to make biofuels economically viable.
- **Public-private partnerships** to drive innovation and commercialization.
- **Sustainable land use policies** to balance food security and biofuel production.

CONCLUSION

Biofuels represent a viable alternative to high-carbon energy sources, aligning with India's goals of sustainable development, energy security, and environmental conservation. While challenges persist, a well-structured policy framework, technological advancements, and strategic investments can position biofuels as a cornerstone of India's clean energy future. As the country progresses towards energy self-sufficiency, biofuels will play a crucial role in shaping a sustainable and resilient economy.

CHAPTER 8: PRAGATI: DRIVING INDIA'S DEVELOPMENT WITH PURPOSE

INTRODUCTION

India's governance landscape has witnessed a paradigm shift with the introduction of the **PRAGATI (Pro-Active Governance and Timely Implementation) initiative**.

- Launched on **25 March 2015**, PRAGATI embodies the **'Minimum Government, Maximum Governance'** approach, leveraging technology, transparency, and accountability to expedite stalled infrastructure projects and policy implementation.

BACKGROUND

PRAGATI integrates multiple digital platforms like **PARIVESH, PM Gati Shakti, and the Project Management Group (PMG)** to enhance decision-making and implementation efficiency.

- The initiative draws inspiration from **SWAGAT (State-Wide Attention on Grievances by Application of Technology)**, a grievance resolution platform launched in **2003**, evolving it into a broader mechanism for **nation-building, project execution, and grievance redressal**.

KEY ACHIEVEMENTS OF PRAGATI

- **Project Unblocking**: Since its inception, PRAGATI has reviewed **340 stalled projects worth Rs 17.05 lakh crore ($205 billion)**, ensuring their timely execution.
- **Reduced Delays**: Structured monthly reviews and digital interventions have **transformed project delays from 3 to 20 years into completion within months**.
- **Faster Environmental Clearances**: Approval timelines reduced to **70-75 days from 600 days previously**.
- **Forest Clearances**: Approval time reduced to **20-29 days from 300 days**.
- **CPGRAMS Efficiency**: Citizen grievances redressal time reduced from **32 days in 2014 to 20 days by 2023**.
- **Passport Issuance**: Reduced from **16 days in 2014 to 7 days in 2023**.

STRIKING OUTCOMES IN KEY PROJECTS

- **Bogibeel Rail and Road Bridge**: Completed in **3 years** after **two decades of delays**.
- **Jammu-Srinagar Baramulla Rail Link**: Overcoming stagnation, now set for completion by **2025**.
- **Navi Mumbai Airport**: Resolved **15+ years of land acquisition hurdles**, expected launch by **December 2024**.
- **Bengaluru Metro Rail**: Expedited land acquisition facilitated the opening of the **42 km, 40-station** metro network since **2017**.
- **Haridaspur-Paradeep Rail Connection**: Addressed investor-contractual deadlocks, leading to its **inauguration in 2020**.
- **National Highways 8 & 2 (Dahisar-Surat, Varanasi-Aurangabad Sections)**: PRAGATI reviews **accelerated progress**, ensuring project completion.
- **Jal Jeevan Mission**: Increased **tap water access in rural households from 17% in 2019 to 74% in February 2024**.

NATIONAL LEADERSHIP AND GOVERNANCE MODEL

Prime Minister direct oversight of PRAGATI meetings highlights the initiative's strategic importance. His leadership has facilitated:

- **Swift course corrections** for stalled projects.
- **Real-time decision-making** by deploying senior officials on the ground.
- **Enhanced connectivity** by expediting **mobile tower installations in remote areas**.
- **Improved bureaucratic efficiency**, shifting governance from **delays and inefficiencies to real-time execution and transparency**.
- **Cooperative federalism**, ensuring effective **collaboration between the Central and State Governments**.

PRAGATI'S INFLUENCE ON OTHER GOVERNMENT SCHEMES

The **technological success** of PRAGATI has paved the way for **digitization in flagship schemes**, improving their outcomes:

- **Swachh Bharat Mission**: Over **12 crore toilets** constructed, transforming rural sanitation.
- **Jal Jeevan Mission**: **Tap water access increased from 17% (2019) to 74% (2024)**.

- **Saubhagya Scheme**: **Achieved universal household electrification**.
- **Vibrant Villages Programme (VVP)**: **46 remote Northeast villages developed as 'First Villages' of India**.
- **Light House Projects (MoHUA)**: **1,100 houses constructed using digital innovations in just 12 months in a single city**.
- **SVAMITVA Initiative**: Drone-based **land record digitization**, ensuring land security in rural areas.

PRAGATI AS A GLOBAL BENCHMARK FOR GOVERNANCE

PRAGATI has established itself as a **model of governance for developing nations**, demonstrating the transformative power of **digital tools, transparency, and decisive leadership**. Key global benchmarks include:

- **Tech-driven transparency**: Real-time monitoring using **drone feeds, GPS tracking, and digital dashboards**.
- **Combatting corruption**: Reducing red tape, enhancing **efficient resource allocation**.
- **Citizen participation**: A robust **feedback mechanism** integrates public inputs into high-level policy decisions.
- **Infrastructure's GDP impact**: RBI and **NIPFP studies** affirm that **each rupee spent on infrastructure generates a GDP gain of Rs 2.5-3.5**, showcasing PRAGATI's **multiplier effect**.

CONCLUSION

PRAGATI embodies India's commitment to efficient governance by leveraging technology, cooperative federalism, and decisive leadership. It has accelerated project execution and improved public service delivery, showcasing digital leadership as a catalyst for national progress.

UPSC MAINS PRACTICE QUESTIONS

Q1. Discuss the role of biofuels in India's energy security and sustainable development. What are the key challenges in their large-scale adoption, and how can policy interventions address them?

Q2. Discuss the significance of India's Green Hydrogen Mission in achieving energy security and decarbonization goals. Highlight the challenges in its large-scale adoption.

■■■■