

# TARGET PRELIMS 2024

## BOOKLET-28; ECONOMY-9

### RENEWABLE ENERGY

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## 2. RENEWABLE ENERGY

- Non-conventional energy sources refer to renewable energy sources which are replenishable at a rate faster than it is consumed i.e. they don't get depleted when used. These sources are also much less hazardous to environment compared to conventional sources of energy.
- **Popular Sources of Non-Conventional Energy Sources are:**
  - i. Solar Energy
  - ii. Wind Energy
  - iii. Tidal Energy
  - iv. Geothermal Energy
  - v. Hydropower
  - vi. Biomass Energy
  - vii. Fuel Cell (Green Hydrogen)

### 1) WHY RENEWABLE ENERGY IS IMPORTANT

- Energy Security and Reduced Import Dependency
- Economic growth:
- Inclusive Development: Electricity in inaccessible areas
- Environmental sustainability:
- Strengthening India's Soft Power and Global Leadership

### 2) STEPS TAKEN BY GOVERNMENT:

- » **Ambitious Targets:** GoI has set a target of achieving 50% of its electricity supply through non-fossil sources by 2030.
- » **Attracting Investment:** FDI upto 100% under automatic route for renewable energy projects including offshore wind energy projects has been allowed.
- » **Promoting Ease of Doing Business:**
  - **Waiving of Inter-State Transmission System (ISTS)** charges for inter-state sale of solar and wind power for projects to be commissioned by 30th June 2025.
  - **Laying of new infrastructure:** New transmission lines and sub station capacity for evacuation of renewable power etc. under Green Energy Corridor scheme for evacuation of renewable energy
- » **Sectoral Initiatives** (Covered separately with each sector)

### A) GREEN ENERGY CORRIDOR:

- **Why in news?**
  - » Cabinet approves Intra-State Transmission System - Green Energy Corridor Phase-II (Jan 2022)
- The GEC project aims at synchronizing electricity produced from renewable sources, such as solar and wind, with conventional power stations in the grid.
  - » The **first component** of the Scheme, **Inter-State GEC** with target capacity of 3,200 circuit kms (ckm) transmission lines and 17,000 MVA capacity substation, was completed in March 2020.
  - » The **second component** - Intra-state GEC has a target capacity of 9700 ckm transmission lines and 22,600 MVA capacity sub-stations.

- It is estimated to be set up with total estimated cost of Rs 12,031 crores.
- The scheme will help in achieving the target of 450 GW of RE capacity by 2030.

### 3) INDIA'S SITUATION

- **India's Situation:**
  - » As of Feb 2023, India's total power generation capacity was 412.21 GW.
    - **Total Renewable Energy Capacity: 168.96 GW** [122 GW without including large hydro]
      - » **Solar Energy:** 64.38 GW
      - » **Wind Energy:** 42.02 GW
      - » **Hydro (large + Small):** 51.79 GW (Small Hydro - Around 5 GW)
      - » **Bio:** 10.77 GW
    - Another **86.62 GW** of green energy capacity is under implementation and 40.89 GW of capacity is under various stages of tendering.
- **Note:** India has already achieved its target of 40% installed electric capacity from non-fossil fuels in Nov 2021 itself.
- **Future Target:** Government aims to achieve 500 GW of installed electricity capacity from non-fossil sources by 2030.

### 4) IMPORTANT INSTITUTIONS

#### A) NODAL MINISTRY: MINISTRY OF NEW AND RENEWABLE ENERGY (MNRE)

- The ministry was established in 1992 as the Ministry of Non-Conventional Energy Sources. It adopted its current name in Oct 2006.
- The broad aim of the ministry is to develop and deploy new and renewable energy for supplementing the energy requirements of the country.
- The **mission** of the ministry is to ensure:
  1. Energy Security
  2. Increase the share of clean energy.
  3. Energy availability and access
  4. Energy Affordability
  5. Energy Equity

#### B) INDIAN RENEWABLE ENERGY DEVELOPMENT AGENCY (IREDA)

- **Why in news?**
  - » The Reserve Bank of India (RBI) has granted an 'Infrastructure Finance Company' status to IREDA in 2023.
  - » **IPO** of IREDA got successfully completed (2023)
- **About IREDA**
  - » IREDA is a mini Ratna (category-1) company under the administrative control of MNRE.
  - » It is a public limited government company established as a Non-Banking Financial Institution in **1987**. It is engaged in promoting, developing and extending financial assistance for setting up projects relating to new and renewable source of energy and energy efficiency/conservation with a **motto: "Energy Forever"**.

## 5) PROBLEM OF STORAGE OF RENEWABLE ENERGY SECTOR

- **Why is storage needed in renewable energy sector?**
  - » **Handling Intermittency and variability problem** of renewable.
  - » **Providing energy in non-solar/wind hours**
- **Various Storage options and their benefits and Limitations**
  - i. **Hydrogen based storage:**
    - It is found feasible for long-term storage (cross seasons)
  - ii. **Lithium-ion batteries:** They are the ideal source for day-today storage.
  - iii. **Pump Storage Plants:**
    - India has a total capacity of about 4.7 GW (out of a worldwide capacity of 149 GW). The CEA estimates that India's storage potential is of 100 GW.
    - **Concerns:**
      - High investment cost
      - Long Gestation Periods
      - Non-remunerative pricing models
      - Lack of adequate sites having the required topography
      - India's expertise in pump storage plants is somewhat a suspect with the Tehri pump storage project yet to be commissioned though construction began in 2011 and was to be complemented in 4.5 hours.
      - There may be environmental concerns associated with this kind of storage.
- In general, we can say that there are two main reasons for lack of storage capacities:
  - » **Cost** of storage technologies is still relatively high.
  - » **Regulatory Framework** for storage is not yet fully developed.
- **Some initiatives to deal with these challenges:**
  - i. **Budget 2023:**
    - Pumped Storage Projects have received a push with a detailed framework to be formulated.
    - 4 GWh Battery Energy Storage Systems supported through Viability Gap Funding (VGF).
  - ii. **National Storage Mission** launched in 2020 and wants to develop 100 GW of storage capacity by 2030.
  - iii. **The Green Energy Corridor:** These are corridors which will be used to transmit electricity from renewable energy projects to load centres. These will also include storage facilities.
  - iv. The **National Battery Manufacturing Policy**, launched in 2020, aims to promote the manufacturing of batteries in India. This will help to reduce the cost of storage technologies.

## 6) DECENTRALIZED RENEWABLE ENERGY/ DISTRIBUTED RENEWABLE ENERGY

- **Decentralized Renewable energy** refers to generation and distribution of renewable energy at a small and localized level, typically closer to the point of consumption. It can be generated via several renewable energy sources, including solar, wind, hydro and bioenergy.
  - » Currently, India has 12 mature technologies powered by DRE. These include high-capacity irrigation pumps, as well as micro-pumps, silk reeling machines, dryers, charkhas, small horticulture processors, small refrigerators/deep freezers, cold storages, vertical fodder growing institutions units, grain milling machines etc.
  - » The DRE technologies include solar run textile manufacturing units, biomass powered cold solar storages and micro solar pumps etc.
- **Key characteristics** include localized generation, distributed energy resource, Off-Grid or Mini-Grid Solutions;
- **Advantages:**
  - » **Environmentally sustainable**
  - » **Energy Security**
  - » **Inclusive Growth**
  - » **Scalability and Flexibility**
  - » **Job Creations**

### 3. SOLAR ENERGY

- **Introduction:**
  - » Though India missed the ambitious target of 100 GW of solar power generation capacity by 2022, we still need to keep working on expanding Solar Energy Capacity.
  - » As per the National Electricity Plan, India aims to reach a target of 185.6 gigawatts of solar capacity by the FY27.
- **Advantages of Solar Energy**
  - » Renewable Energy Advantages
  - » Solar's advantage over other renewable energy
    - Available during office hours
    - Longer life equipment
    - Low running cost
    - India's tropical climate is suitable for solar energy.
    - Less damaging than other renewables
  - » **Solar Energy is becoming more and more competitive.**

### 1) INITIATIVES

#### A) SCHEME FOR DEVELOPMENT OF **SOLAR PARKS AND ULTRA MEGA SOLAR POWER PROJECTS** - CONCEIVED ON THE LINES OF "CHARANKA SOLAR PARK" -> ACT AS FLAGSHIP DEMONSTRATION FACILITY.

- **Goals/Program targets**
  - » It envisaged supporting states in setting up atleast 50 solar parks (capacity 500 MW and above) and Ultra Mega Solar Power Projects targeting over **40,000 MW** of solar power installed capacity within a span of 5 years starting from 2014-15.

- » The scheme envisages supporting the States/UTs in setting up solar parks at various locations in the country.

- **Provisions**

- » The solar parks provide solar power developers with a ***plug and play model***, by facilitating suitable developed land with all clearances, transmission system, water access, road connectivity communication network, etc.
- » All states and UTs are eligible for benefits under the scheme.
- » **Central Financial Assistance**
  - (CFA) of Rs 25 Lakh per solar park for Detailed Project Report Preparation of the Solar Park, conducting surveys etc.
  - Besides this, CFA of up to Rs 20 Lakh per MW or 30% of the project cost, including Grid-connectivity cost, whichever is lower, is also provided on achieving the prescribed milestone in the scheme.
- » **Update: June 2023:** The MNRE has extended the timeline for the 'Development of Solar Parks and Ultra Mega Solar Power Projects' Program to March 31st 2026 (FY26) from the earlier FY24.

**B) PM SURYA GHAR MUFT BIJLI YOJNA (FEB 2024)**

- The finance minister, Nirmala Sitharaman, announced the launch of the 'Rooftop Solar Scheme' or the 'PM Surya Ghar Muft Bijli Yojana' in the 2024-25 budget.
- **Subsequently**, PM Modi launched the 'PM Surya Ghar Muft Bijli Yojna'.
- **Solar panels** are installed in the houses under the scheme to supply power to households and additional money for excess electricity output.
  - The government will provide substantive subsidies directly to people's bank accounts and heavily concessional bank loans to ensure that there is no cost burden on the people.
  - The scheme will help poor middle class to save upto Rs 15,000 to Rs 18,000 annually by getting free solar electricity and selling surplus power to electricity distribution companies.
- **Aim:** Under this initiative government aims to install solar power panels in one crore homes throughout the country.

**C) PRADHAN MANTRI KISAN URJA SURAKSHA EVAM UTTAN MAHAABHIYAN (PM KUSUM)**

- It aims at providing water and energy security to farmers and enhancing their income by making Annadata also a Urjadata. It focuses on creation of **3 things** - (A) Grid Connected Renewable solar power plants; (B) Installation of 20 lakh standalone Solar powered agri pumps; (C) Solarization of 10 lakh grid connected agri pumps.
- **Update:** In 2023, Government approved **expansion of PM KUSUM** with revised target of 49 lakhs pump to be installed/solarized under component B and C of the scheme.

**D) INTERNATIONAL COOEPRATION: INTERNATIONAL SOLAR ALLIANCE**

**E) NEW INNOVATION: FLOATING SOLAR PLANTS**

(for e.g. the 100 MW plant at NTPC Ramagundam commissioned in July 2022) is being set up in various parts of the countries. It brings advantages like no land acquisition requirements, water conservation (less evaporation of water), less dust on power panel etc.



## F) NATIONAL PROGRAM ON HIGH EFFICIENCY SOLAR PV MODULES

- It is a **PLI scheme** which aims to build an ecosystem for manufacturing of high efficiency solar PV modules in India, and thus reduce import dependence in the area of Renewable energy. It will strengthen Atmanirbhar Bharat initiative and generate employment.
- Tranche-II of the PLI scheme was approved by cabinet in Sep 2022

## G) PROMOTING COMPETITION AMONG STATES: SARAL INDEX BY MNRE

## H) SKILL DEVELOPMENT: SURYAMITRA SCHEME

### 4. WIND ENERGY

- **Current Wind Energy Situation in India**
  - » India has made significant progress in the development of wind energy and has emerged as the fourth largest producer in the world with a total capacity of 42 GW as of Feb 2023.
  - » But India did miss the target of achieving 60GW capacity by 2022.
- **Target:**
  - » 140 GW by 2030
- **India's Potential:**
  - » As per National Institute of Wind Energy (NIWE) in Chennai, India has a **much higher wind power potential**. At a **hub height of 120 meters**, the **potential is of 602 GW of onshore and 100 GW of fixed and floating offshore**. A very remarkable fact is that half of the potential is located in wastelands.

### 2) NATIONAL WIND MISSION (NWM): LAUNCHED IN 2015 AS PART OF NAPCC

- **Aims and Objective**
  - » To achieve the target of 60 GW by 2022 with an investment of 10 lakh crore (target was missed)
  - » Make India a global leader in wind power, by creating conditions conducive for its diffusion across the country in a time bound manner

### 3) OFFSHORE WIND ENERGY

- **What is offshore wind energy?**
  - » It refers to deployment of wind farms inside the water bodies. They utilize the sea wind to generate electricity. These wind farms either use **fixed foundation turbines** or **floating wind turbines**.



- **A fixed foundation turbine** is built on shallow water, whereas a **floating wind turbine** is built in deeper waters where its foundation is anchored in sea-bed. Floating wind farms are still in infancy.
- **Target:** MNRE has set a target of installing 30GW by 2030.
- **India's offshore wind energy potential:**
  - » **MNRE:** India can generate 127 GW of offshore wind energy with its 7,600 km of coastline. Other sources mention it to be (World Bank Report - 195 GW (112 fixed and 83 floating));
- **Advantages of offshore wind energy parks:**
  - » Renewable Energy
  - » No land acquisition and land scarcity issues
  - » Offshore wind turbines are more efficient compared to onshore ones (wind speed over water bodies is high and is consistent in direction)
- **Steps Taken**
  1. In **June 2022**, MNRE has decided to **bid out offshore wind energy blocks**.
  2. **A Revised Strategy for development of offshore wind energy projects** has been issued in Sep 2023.
    - It indicates a bidding trajectory for installation of 37 GW capacity of offshore wind energy.
  3. The **offshore wind energy lease rules, 2023**: To regulate the allocation of offshore wind sea blocks to developers have been notified.
  4. **National Offshore Wind Energy Policy, 2015**
    - Nodal Ministry MNRE has been authorized for use of offshore areas within EEZ of the country
    - **National Institute of Wind Energy (NIWE)** has been authorized as Nodal agency for development of offshore wind energy in the country and to carry out allocation of offshore wind energy blocks, coordination and allied functions with related ministries and agencies.
    - National Targets for offshore wind energy capacity has been set at 5 GW by 2022 and 30 GW by 2030.

## 5. BIOFUELS

- **Introduction**
  - » Biofuel is a fuel that is produced through contemporary biological processes, such as agriculture and anaerobic digestion, rather than fuel produced by geological processes such as those involved in the formation of fossil fuels.
  - » They are made from recently grown biomass (plant or animal matter). They are **renewable** because the source is continuously replenished.
    - E.g. Biogas, bioethanol, biodiesel etc.
  - » **Biogas** is the biofuel produced through anaerobic digestion of organic waste.

- » **Bioethanol** is an alcohol made by fermentation, mostly from carbohydrates produced in sugar or starch crops such as corn, sugarcane, or sweet sorghum.
  - **Cellulosic biomass**, derived from non-food sources, such as trees and grasses, is also being developed as a feedstock for ethanol production.
  - **Ethanol** can be used as a fuel for vehicles in its pure form, but it is usually used as a gasoline additive to increase octane and improve vehicle emission.

- **Generations of Biofuel (3 important)**

- i. **1G Biofuel:** They are produced directly from food crops such as wheat, sugar, vegetable oil and even animal fat etc.
  - Advantages includes known simple tech, cost competitiveness with fossil fuels etc.
  - Criticisms include food vs fuel debate etc.
  - They are also known as conventional biofuels. Most common first generation bio fuels include:
    - **Biodiesel:** Extraction of vegetable oils (both edible and non-edible), with or without esterification, from seeds of plants like soybean, rape (canola) and sunflower.
    - **Bio-Ethanol:** Fermentation of simple sugar from sugar crops (sugarcane) or starch crops (corn, wheat etc).
      - It accounts for around 2/3rd of total biofuel production in the country.
    - **Bio-Gas:** Anaerobic fermentation of organic waste and crop residue as energy crops.
- ii. **2G Biofuels:** Produced from non-food organic crops such as wood, organic waste, food crop waste and specific biomass crops. It includes use of non-food-crops technologies like **jatropha**-based fuels.
  - The advantages include use of wasteland, less impact on food security.
  - There are some limitations including high capital cost, advanced conversion technologies etc.
  - One well known second-generation technology is Lignocellulosic processing which uses forest material.
- iii. **3G Biofuels:** The source is based on improvements in the production of biomass.
  - They are produced from micro-organisms like algae
  - Algae act as low cost, high-energy and entirely renewable feedstock. It has impressive diversity and higher yield. Advantages include the ease of generating the biomass anywhere where sunlight and carbon is present.
  - Third generation biofuel has the potential to be more sustainable and have a lower environmental impact than first and second generation biofuels.
  - Some limitations include still developing tech, high technology cost, some poisonous algae etc.
- iv. **4th and 5th Generation Biofuels**
  - A. **Fourth Generation:**
    - It takes the advantage of biotechnology to engineer special crops such as algae (sometimes called oilgae) for biomass production. The aim is to engineer

microorganisms to produce biofuels more efficiently, with higher yields, and with lower environmental impacts.

#### B. 5th Generation Biofuels

- They are known as **electrofuels**. They are produced from microbial synthesis using renewable energy sources. In this process, micro-organisms use electricity as an energy source to convert carbondioxide into liquid fuels, such as ethanol or butanol.

**Note:** 4th Generation and 5th Generation Biofuels are in the early stage of development.

#### - Current Capabilities:

- **As of Feb 2023**, India has a biofuel power generation capacity of 10.77 GW.
- According to International Energy Agency (IEA), India is expected to overtake China to become third largest producer of ethanol by 2023.
  - **Note:** USA is the largest ethanol producer in the world accounting for 46% of global production and 2nd largest in biodiesel production accounting for 19% of the production.

#### - Targets:

- **National Biofuel Policy, 2018** (as amended in 2021): Country wide blending target of 20% ethanol by 2025 and 5% biodiesel by 2030.

#### • Advantages of Biofuels

- Renewable and Energy Security**
- Fighting Pollution:**
- Lesser impact on climate change.**
- Can Promote sustainable agriculture:**
- Increase farmer's income**
- Sanitation**
- Reduces Import Dependency and saving foreign exchange**

#### • Some Criticisms:

- **Land Use**
- **Food Security Issues**
- **Water Challenges**

#### - Steps taken by government to support biofuels.

- National Policy on Biofuels, 2018**
- Pradhan Mantri Ji-Van Yojana (PMJY)**
- Oil CPSEs are setting up 2G ethanol bio-refineries** in the country at Panipat (Haryana), Bathinda (Punjab), Numaligarh (Assam), Bargarh (Odisha) and one demonstration project at Panipat..
- EBP and associated steps**
- National Bio-Energy Program (FY 2021-22 to 2025-26):**
  - It comprises of the following schemes:
    - Waste to Energy Programme** (*Program on Energy from Urban, Industrial, and Agricultural Wastes/ Residues*) to support setting up of large biogas, BioCNG, and Power Plants (excluding MSW to Power projects)

2. **Biomass Programme** (*Scheme to support manufacturing of Briquettes & Pellets and Promotion of Biomass (non-bagasse) based congregation in Industries*) to support setting up of pellets and briquettes for use in power generation and non-bagasse-based power generation projects.
  3. **Biogas Programme** to support setting up family and medium Biogas in rural areas.
- vi. **Biogas Promotion**
- vii. **Advisory to carmakers to introduce flexible fuel engines in Vehicles:**
- viii. **International Collaboration:** For e.g. the Global Biofuel Alliance (GBA) is one of the top priorities under India's G20 presidency.
- Brazil, India and the USA, as leading biofuel producers and consumers of the world have agreed to work together towards the development of this alliance along with other interested countries.
  - This alliance will work towards facilitating cooperation and intensifying the use of sustainable biofuels, including in the transportation sector.

## 1) ETHANOL BLENDING

- **What is Ethanol Blending?**
  - Process of mixing ethanol with Petrol is called Ethanol blending. The mixture is called as Ethanol Fuel/ Gasohol which is considered as a quasi-renewable energy.
  - In India, the practice of blending ethanol was started in 2001. Ethanol blending was first time mentioned in the Auto Fuel Policy of 2003.
  - **Benefits of Ethanol Blending**
    - Reduces vehicular emissions especially CO (Carbon Monoxides) emissions.
    - It is cheaper than petrol as it is easier to manufacture.
    - It reduces our import dependency.
      - Trade balance, foreign exchange etc.
    - Ethanol has higher octane rating than ethanol-free petrol
    - In case of India Ethanol production can generate higher sugarcane prices for farmers.
  - **Ethanol Blended Petrol (EBP) Program** was launched by the Government in **2003**, and was aimed at **promoting 5% blending of molasses-based ethanol** with petrol, to promote the use of alternative and environment friendly fuels, to reduce import dependency for energy requirements and to increase value addition to Sugar industry enabling them to clear cane price arrears of farmers.
  - **Target for Ethanol blending of Petrol was 10% by 2022 and 20% by 2030.**
  - **Allowing conversion of surplus stock of rice with FCI and Maize to Ethanol.**
    - In June 2021, central government allocated 78,000 tonnes of rice from FCI for ethanol production.
  - **Cabinet** keeps on reviewing the prices for procurement of ethanol by Public sector Oil Marketing Companies, to ensure better prices for farmers.

## 2) NATIONAL POLICY ON BIOFUELS

- **Why in news?**
  - » Cabinet approves amendments to National Policy on Biofuels to make India energy independent by 2047. (May 2022)
- **Aims**
  - » Reduce India's oil import dependency.
  - » Provide better income opportunities to farmers by helping them dispose of their surplus stock in economic manner.
- **Key Highlights**
  - » **Aim (as amended in 2021):** Country wide blending target of 20% ethanol by 2025 and 5% biodiesel by 2030
  - » **Categorization of Biofuels to enable extension of appropriate financial and fiscal incentives under each category.**
    1. **Basic Biofuels** viz. First Generation (1G) bioethanol and biodiesel
    2. **Advanced Biofuels** - Second Generation (2G) Ethanol, Municipal Solid Waste to drop-in fuels, Third Generation (3G biofuels), bio-CNG etc.
  - » **Expands the scope of raw material for ethanol production.**
    - Allowing use of sugarcane juice, sugar containing materials like Sugar Beet, Sweet Sorghum, starch containing materials like Corn, Cassava, Damaged Food grains like wheat, broken rice, Rotten Potatoes unfit for human consumption for ethanol production.
  - » **Allows use of surplus food grains for production of ethanol** for blending with petrol
  - » **A VGF for 2G Ethanol bio-refineries** of Rs 5,000 crore in 6 years in addition to additional tax incentives, higher purchase price as compared to 1G biofuels.
  - » The new policy encourages setting up of supply chain mechanisms for biodiesel production from non-edible oilseeds, used cooking oil, short gestation crops.
  - » **Specifies the role of all the concerned ministries/ Departments** with respect to biofuels
- **2022 Amendment:**
  - » Advance the deadline to reach the blending target of 20% bioethanol in petrol, from 2030 to 2025-26.
    - It will promote the production of biofuels in the country, under the Make in India program, by units located in SEZs/Export Oriented Units (EOUs).
  - » Make additional feedstocks eligible for the production of biofuels.

## 3) PRADHAN MANTRI JI-VAN (JAIV INDHAN VATAVARAN ANUKOOL FASAL AWASHESH NIVARAN) YOJANA

- **Ministry of Petroleum and Natural Gas**

- **Key Highlights**

- » The Yojana provides **financial support (VGF)** to Integrated Bioethanol Plant using **Lignocellulosic biomass** and other renewable feedstock.
- » Under the yojana, **12 commercial scale** and **10 demonstration scale Second Generation (2G)** ethanol projects will be provided with VGF support in two phases:
  - **Phase-I (2018-19 to 2022-23)**: wherein six commercial projects and five demonstration projects will be supported.
  - **Phase-II (2020-21 to 2023-24)**: wherein remaining six commercial projects and five demonstration projects will be supported.
- » **Financial Outlay**: 1969.50 crore for the period from 2018-19 to 2023-24.
- » The ethanol produced by the scheme will be mandatorily supplied to OMCs to further enhance the blending percentage under EBP program.
- » **Centre for High Technology (CHT), a technical body under the aegis of MoP&NG**, will be the **implementation Agency** for the scheme. The Project developers interested in availing benefits of the scheme, shall be submitting their proposal for review by Scientific Advisory Committee (SAC) of MoP&NG. Projects recommended by SAC shall be approved by Steering Committee of MoP&NG under the chairmanship of Secretary, MoP&NG

- **Significance**

- **Incentivize 2G Ethanol Sector** by setting up commercial and demonstration projects
- **Increased R&D** in the sector.

#### 4) WORLD BIOFUEL DAY: 10TH OF AUG

- The day is observed to show the importance of fossil fuels.
- **History:**
  - It is celebrated in remembrance of Sir Rudolf Diesel, who created diesel engine.
    - On Aug 8, 1893, he successfully used peanut oil to run a mechanical engine for the first time. With this, he was able to foresee the possibility that fossil fuels could be replaced by vegetable oil as a practical source of energy in the coming century.
  - the day is marked by the inventor of the diesel engine, Sri Rudolf Diesel who was the first one to predict the chance of vegetable oil being replaced by fossil fuels.
- **2022 theme: 'Biofuels for Sustainability and Rural Income'**.
- **2023 theme: No official theme was announced - the day was celebrated with 2022 theme only.**

#### 5) E-100 PILOT PROJECTS:

- **Launched at Pune City by Public Sector OMCs on 5th June 2021**
- **To facilitate sale of E-100 fuel.**

- MoP&NG vide its order dated March 22, 2021 has amended the Motor Spirit and High Speed Diesel (Regulation of Supply, Distribution and Prevention of Malpractices) Order, 2005 by permitting the direct sale of Bio-Ethanol (E100) by an oil company for use as standalone fuel or blending with motor spirit, for compatible automobiles to all consumers, in accordance with the standards specified by the Bureau of India Standards (BIS).

## 6) BIOGAS PRODUCTION OF FAT-RICH SLUDGE

- Researchers at **CSIR-CFTRI Mysore** have developed a novel high performance bioreactor system integrated with sustainable pre-treatment process for enabling anaerobic digestion of complex fat-rich sludge from dairy industry. It has further been integrated with membrane bioreactor based-wastewater treatment to enable zero liquid discharge in the dairy industry.
- It can also be applied for anaerobic digestion of complex solid waste containing Fats and oils and can be coupled with wastewater treatment to enable Zero liquid discharge.
- Dairy and food industry** are likely industries that can take up the technology. The technology will also be applicable for any biodegradable waste sludge and food waste from any food industry as well as food industry wastewaters.

## 7) NATIONAL BIOENERGY PROGRAM

- Why in news?**
  - MNRE notifies National Bio-Energy Program (Nov 2022)
- Details**
  - MNRE has continued the National Bio-Energy Program for the period **FY2021-22 to 2025-26**. The program has been recommended for implementation in two phases.
  - Phase-1** of the program has been approved with a budget outlay of Rs 858 crores.
  - The NBP** will comprise of following sub schemes:
    - Waste to Energy Program:** (*Programme on Energy from Urban, Industrial and Agricultural Wastes /Residues*) to support setting up of large Biogas, BioCNG and Power plants (excluding MSW to Power projects). IREDA will be implementing agency for the program.
    - Biomass Programme:** (*Scheme to Support Manufacturing of Briquettes & Pellets and Promotion of Biomass (non-bagasse) based cogeneration in Industries*) to support setting up of pellets and briquettes for use in power generation and non-bagasse based power generation project.
    - Biogas Programme:** To support setting up of family and medium size biogas in rural areas.

## 8) BIOGAS

- Why in news?**



- Budget 2023-24 had announced setting up of 500 biogas plant across the country under the Gobardhan Scheme. Of these 75 plants were to be set up in urban areas.
    - Ministry of Housing and Urban Affairs, 42 plants with a total capacity of 6,213 tonnes per day (TPD) at a cost of Rs 1,082 crore had been approved and the remaining proposal would be cleared soon (April 2023)
- The biogas plants can generate biogas from organic substances like cattle dung, night soil, and biomass from the Kitchen, garden, farms and other such bio-degradable material. This biogas is generated through a process called anaerobic digestion (AD).
- **Advantages of Biogas:**
  - **Renewable and Sustainable** (+ plus other related advantages -> energy security, reduced import dependency etc.)
  - **Reduction in Greenhouse emission:**
  - **Waste Management:** Organic waste gets converted into energy and leads to environmental cleanliness.
  - **Versatility:** Biogas can be used for cooking, heating, transportation etc.
  - **Rural Development and Employment** - Energy source in rural areas leads to these advantages
- **Key challenges:**
  - Level of waste segregation still leaves a lot to desire.
  - Maintenance of biogas plants and other equipment have remained an issue.
- **Steps taken to Promote Bio-gas.**
  1. **Gobar Dhan Yojana** (announced in Budget 2018-19)
    - Galvanizing Organic Bio Agro Resources - Dhan (GOBAR-Dhan) focuses on managing and converting cattle dung and solid waste in farms to compost, bio gas and bio CNG. The scheme aims to collect waste and solid waste from farmers to sell to entrepreneurs, who thereafter produce manure, biogas, and bio-CNG from the waste. Thus, the scheme connect farmers to buyers.
    - Government has also announced an online trading platform to connect to buyers of agri-waste facilitating the GOBAR-dhan scheme.
    - Ministry: Ministry of Jal Shakti
  2. **Unified Registration Portal for GOBARdhan (June 2023)**
    - Ministry of Jal Shakti has launched the Unified Registration Portal for GOBARdhan. It will act a one stop repository to access investment and participation in Biogas/CBG sector at Pan India level and more importantly streamline the process of setting up CBG/Biogas plants in India.
  3. **National Biogas and Manure Management Program (NBMMP)** aims to set up family type biogas plants.
    - By MNRE.
    - It is a central sector scheme with an aim to setting up family type biogas plants for providing biogas as clean cooking fuel and a source of lighting primarily set up for rural and semi-urban households.

## 9) BIO CNG (ALSO KNOWN AS COMPRESSED BIOGAS)

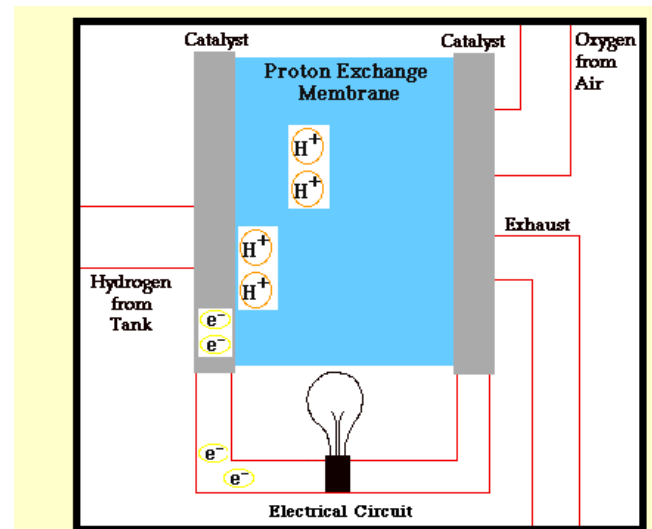
- **BioCNG**, also known as biomethane, is a renewable and clean-burning transformation fuel produced by upgrading biogas to natural gas quality. It's essentially purified biogas, made from organic materials like: Agriculture waste, food waste, and Sewage Sludge.
- It is an upgraded version of biogas (the dung-based version of which serves as cooking fuel in many villages in India).
- **How Bio-CNG is produced?**
  - » **Pre-Treatment:** The waste is passed through a filter to remove hard material like Coconut shells and pieces of wood.
  - » **Shredding:** the waste is shredded in a hammer mill and made into a slurry with water.
  - » **Hydrolysis:** The slurry is kept in the pre-digester tank in aerobic conditions for one-two days to attract microbes - the process is called **hydrolysis**.
  - » **Methanogenesis:** After hydrolysis the slurry is transferred to anaerobic digester where it is retained for 20-25 days. It is during methanogenesis that biogas is generated. This gas contains 65% methane, while the rest is Hydrogen Sulphide, carbondioxide, and water vapour.
  - » **Purification:** The above gas is passed through a wet and dry scrubber to remove hydrogen Sulphide and CO<sub>2</sub>. Methane, purified upto 95% is obtained here which is then compressed at high pressure in cylinders and send to filling stations. This highly purified methane is similar in chemical properties to CNG derived from petroleum sources and can thus be used in vehicles.
- **Advantages:**
  - » **Renewable**
  - » **Swatch Bharat**
  - » **Fighting Air Pollution:**
  - » **Strengthening Rural Economy, organic farming -> More income to farmers and More jobs in rural areas**
  - » **Decentralized energy** as it is produced closest to the point of consumption.
  - » **No Intermittency** like solar and wind as CBG could be produced at all hours.
- **Limitation:**
  - » **Maintenance cost** of Bio-CNG based vehicles is higher.
  - » Further, users have complained that calorific value of Bio-CNG is lower than CNG as it contains moisture.
  - » **Biogas plants** are also sometimes seen as methane bombs as any emission of leak from digester or pipelines can contribute to climate change significantly.
- **Government Initiatives:**
  - » **SATAT (Sustainable Alternative Towards Affordable Transport) Initiative:**
    - Launched in 2018, it aims to promote production and use of Bio-CNG (Compressed Bio-GAS) in India. Under it, government sets up compressed Bio Gas (CBG) production plants and make available CBG in the market for use in automotive sector.
  - » **National Bio-Energy Program (FY 2021-22 to 2025-26)**

- » **Compressed Biogas (CBG) Blending Obligation (CBO)** - Government has announced a phased compulsory blending obligation of CBG in CNG and PNG segments of the City Gas Distribution (CGD) sector in Oct 2023.
  - **CBO** is voluntary till 2025 and mandatory obligation will start from FY26.
    - It shall be 1% (FY26), 3% (FY27) and 4% (FY28) respectively.
    - It shall be 5% for FY29 onwards.
- » Asia's largest compressed bio gas plant was inaugurated in Sangrur by Union Minister Hardeep S. Puri.

## 6. HYDROGEN FUEL

### 1) HYDROGEN FUEL CELLS

- **Introduction**
  - » Hydrogen is the simplest fuel. A fuel cell combines hydrogen and oxygen to produce electricity, heat and water.
- **Fuel Cell**
  - » A fuel cell is a device that **converts chemical potential energy (energy stored in the molecular bonds) into electrical energy**.
    - A Proton Exchange Membrane (PEM) cell uses hydrogen ( $H_2$ ), and Oxygen ( $O_2$ ) as fuel.
    - The products of the reaction are water, electricity and heat.
- **Key Elements of a fuel cell**
  - » **The anode**, the negative electrode of the fuel cell, conducts the electrons that are fed from the hydrogen molecule so that they can be used in the external circuit.
  - » **The Cathode**, the positive post of the fuel cell, has channels etched into that distribute the oxygen to all surface of the catalyst. It also conducts electrons back from the external circuit to the catalyst, where they can recombine with hydrogen ion and oxygen to form water.
  - » The **electrolyte** is a **proton exchange membrane**. This specially treated material, which looks something like ordinary kitchen plastic wrap, only conducts positively charged ions. The **membrane blocks electrons**.
  - » **The catalyst** is a special material that facilitates the reaction of oxygen & hydrogen. It is usually made up of platinum nano particles very thinly coated onto carbon paper or clothe.
- **How does a fuel cell work**



- » Hydrogen from a tank onboard the vehicle, enters into anode side of the fuel cell.
- » Oxygen pulled from air enters from cathode side
- **As the hydrogen molecule encounters the membrane, a catalyst forces it to split into electron and proton**
  - » The proton moves through fuel cell stack and the electron follows an external circuit, delivering current to the electric motor and other vehicle components.
  - » At cathode side, the proton and electron join again, and they combine with oxygen to form the vehicle's only tailpipe emission, water.
- **Advantages of Hydrogen Fuel Cell**
  - » Fuel cell **avoids the "thermal bottleneck"** (a consequence of 2nd law of thermodynamics) and are thus inherently **more efficient than combustion engines**, which must first convert chemical potential energy into heat, and then mechanical energy.
  - » Hydrogen is high in energy.
  - » Fuel cells **don't have any moving part** and thus are more reliable than traditional engines.
  - » **No pollution** (Only steam (H<sub>2</sub>O) emitted as by product)
  - » **No Greenhouse gas and Climate Change** (since no GHG are produced as biproducts)
  - » **Ends dependency of Li-Ion batteries** (Please note for Lithium we are almost completely import dependent)
- **Limitation**
  - » Complex and difficult to build
  - » Still mostly in research phase
  - » Extracting hydrogen is difficult and expensive - **catalyst used is Platinum**- which is very expensive.

## 2) FUEL-CELL ELECTRIC VEHICLES (FCEVS)

- FCEV combine hydrogen and oxygen to produce electricity which runs the motor.
  - E.g.s of cars using FCEV: Toyota's Mirai, Honda's Clarity, and Hyundai's Nexo.
- Since they are powered entirely by electricity, FCEVs are considered EVs, but unlike BEVs, their range and refueling processes are comparable to conventional cars and trucks.
  - The **major difference** between a BEV and a refueling time of just five minutes, compared to 30-45 mins charging for a BEV.
  - Also, consumers get five times better energy storage per unit volume and weight, which frees up a lot of space for other things, while allowing the rider to go farther.
- India's first indigenously developed Hydrogen Fuel Cell (HFC) technology bus was unveiled in Aug 2023, with the fuel cell - which uses hydrogen and air to generate electricity onboard to power the bus - being developed jointly by CSIR and Pune based automotive software company KPIT Ltd (Aug 2023)

## 3) TYPES OF ELECTRIC VEHICLES: EV/BEV, HEV, PHEV, FCEV

- **Electric Vehicles:** The standard EV is also known as **Battery powered EV (BEV):**

- They don't have an internal combustion engine and instead of an petrol/diesel, these vehicles run solely on battery power. These can be charged at home or commercial charging stations.
- **Hybrid Electric Vehicles (HEVs):** They run on both Internal Combustion Engines and electric motor that uses energy stored in a battery. However, unlike other Evs, HEV cars battery is charged by regenerative braking.
  - **Micro (or mild) Hybrid** uses both battery and electric motor to make the car run. Though they can't run solely on electric power, they maximize fuel economy by shutting off the internal combustion engine during complete stops.
- **Plug-in Hybrid Electric Vehicles (PHEV):** They expand the concept of HEVs. They have both an internal combustion engine and a battery powered electric motor. This allows the battery to store enough power to feed the electric motor and in turn decrease the gas usage by as much as 60%. They can travel around 60 kms on electric power, rather than 2-3 kms with a standard HEVs.
- **FCEV:** already discussed above.

#### 4) HYDROGEN ENERGY

- **Hydrogen Energy** is a clean and efficient form of energy derived from Hydrogen (H<sub>2</sub>). It has the potential to replace fossil fuels.
  - » Hydrogen can be produced from variety of sources including water, natural gas, and biomass.
  - » There are two main ways to produce Hydrogen:
    1. **Steam Reforming:** This process uses heat and steam to break down natural gas into hydrogen and carbon mono-oxide.
    2. **Electrolysis:** This process uses electricity to split water molecules into hydrogen and oxygen.
  - » **Cost of producing hydrogen** varies depending on the various methods used.
- It can be used in two primary ways:
  - » **Direct Burning** to produce heat and water
  - » **Fuel Cell Route** to directly produce electricity.
- **Advantages of Hydrogen Fuel:**
  - » **Abundance:** It is the most abundant element in the Universe.
  - » **Energy Density** -> High
  - » **Can contribute in achieving Net Zero by 2050**
  - » **No Pollution** (only releases water)
  - » **Leading options for storing energy from renewables**
  - » **Advantages of Hydrogen Vehicles (Fuel cell Stack) over other Electric Vehicles (Lithium-ion batteries)**
    - A fuel cell electric vehicle can be refueled in just 5 minutes. EV takes 30-45 minutes for charging.
    - Energy storage per unit volume and weight is higher in fuel cells than other types of electric vehicles.
    - EV battery materials are controlled by a few larger players. Scaled up hydrogen fuel cell will bring countries on equal footing.
    - EV batteries (like Lithium ion batteries) have still not been found viable for heavy vehicles like trucks.

- **Some limitations of Hydrogen fuel**
  - » **Hydrogen** molecule is not available in abundance on earth and is found in combination with other elements.
  - » Hydrogen technology is "**yet to be scaled up**". Tesla CEO Elon Musk has called fuel cell technology "mind-bogglingly stupid".
  - » **Lack of fueling station infrastructure**
    - There are fewer than 500 operational hydrogen stations in the world today, mostly in Europe.
  - » **Safety is a concern**
    - Hydrogen is pressurized and stored in a cryogenic engine. Some companies like Toyota and Hyundai have said that safety and reliability of hydrogen fuel tanks is similar to that of standard CNG engines.

#### A) NOTE: VARIOUS TYPES OF HYDROGEN:

- The most common element in nature is not found freely. It exists only combined with other elements, and has to be extracted from naturally occurring compounds like water (which is a combination of two hydrogen atoms and one oxygen atom). This process is energy intensive.
  - **Grey Hydrogen**
    - Hydrogen produced from fossil fuels. This constitutes a bulk of hydrogen produced today.
  - **Blue Hydrogen**
    - Hydrogen generated from fossil fuels with carbon capture and storage options
  - **Green Hydrogen**
    - Hydrogen generated entirely from renewable power sources. Here electricity generated from renewable energy is used to split water into hydrogen and oxygen.
    - For e.g. a IIT-Madras team generated hydrogen from seawater using solar energy. (June 2023)

#### 5) NATIONAL HYDROGEN MISSION

- **Ministry:** MNRE
- With a vision to make India an energy independent nation, and to decarbonize critical sectors, the Government approved National Green Hydrogen Mission on Jan 4, 2023 with an initial outlay of Rs 19744 crores upto 2029-30.
- The mission will facilitate demand creation, production, utilization, and export of Green Hydrogen and mobilization of Rs 8 lakh crores of investment by 2030.
- **Likely Outcomes by 2030:**
  1. **Green Hydrogen Production Capacity** of at least 5 MMT (Million Metric Tonne) per annum.
  2. **Reduction in fossil fuel imports** by over Rs 1 lakh crores and creation of over 6 lakh jobs.
  3. **Renewable Energy Capacity Addition** of about 125 GW and abatement of nearly 50 MMT of annual GHG emissions.

- **Interventions:**
  1. Under the **Strategic Interventions of Green Hydrogen Transition (SIGHT) Program**, two distinct financial incentive mechanisms - targeting domestic manufacturing of electrolyzers and production of Green Hydrogen - will be provided under the mission.
  2. **Regions capable of supporting large scale production and/or utilization of hydrogen** to be developed as **Green Hydrogen Hubs**.
- **Policy Framework:**
  1. **Development of an enabling policy framework** to support establishment of **Green Hydrogen Ecosystem**.
  2. **Robust Standards and Regulations Framework**
  3. **Public Private Partnership framework** for R&D (**Strategic Hydrogen Innovation Partnership - SHIP**) will also be facilitated under the mission.
  4. **Skill Development Program**
- **Several Pilot Projects** by PSUs like OIL, NTPC etc. have been initiated for the production of Green Hydrogen.

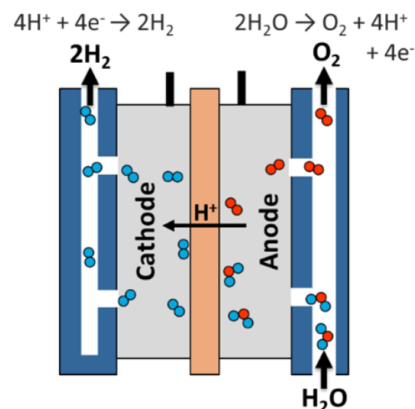
## 6) GOVERNMENT UNVEILS GREEN HYDROGEN STANDARDS (AUG 2023)

- It outlines the **emission threshold for production of hydrogen** that can be classified as 'green'.
  - » Well-to-gate emission of not more than 2 kg CO<sub>2</sub> for per Kg H<sub>2</sub>.
    - The well-to-gate emission include water treatment, electrolysis, gas purification, drying and compression of Hydrogen.
    - The scope of the definition encompasses both electrolysis based and biomass-based hydrogen production methods.
  - » A detailed methodology of measurement, reporting, monitoring, on-site verification and certification of green hydrogen and its derivatives will be specified by the Ministry of new and renewable energy.
  - » Bureau of Energy Efficiency (BEE) under the MoP will be the nodal authority for accreditation of agencies for the monitoring, verification, and certification of green hydrogen production projects.
- **Significance:**
  - » The definition of green hydrogen brings a lot of clarity to the mission of making India a global green hydrogen hub.

## 7) ELECTROLYSERS



- Electrolysers are a critical technology for the production of low-emission hydrogen from renewable or nuclear electricity.
  - » **Note:** Electrolysis is the process of using electricity to split water into hydrogen and oxygen. This reaction takes place in a unit called an Electrolysers.
- **How does it work?**
  - » Like fuel cells, Electrolysers consist of an anode and a cathode separated by electrolyte. Different electrolyzers function in different ways, mainly due to the different type of electrolyte material involved in the ionic species it conducts.
- **The cost of electrolyzers and electricity** (fuel) make up the largest share of the production cost, and thus developing more efficient electrolyzers will give a major boost to green hydrogen generation in India.



## 8) HYDROGEN CNG (H-CNG)

- In Sep 2020, MoRT&H has notified hydrogen-enriched compressed natural gas (CNG) as an automobile fuel.
- In Oct 2020, **Delhi became the first city in India to operate buses running on hydrogen spiked compressed natural gas (H-CNG)** in a six month pilot project.
  - The buses are running on a new technology patented by Indian Oil Cooperation for producing H-CNG - 18% hydrogen in CNG - directly from natural gas without resorting to conventional blending.
- **What is H-CNG?**
  - It is a hydrogen enriched compressed natural gas. The ideal hydrogen concentration is 18%.
    - In **Delhi**, instead of physically blending hydrogen with CNG, hydrogen spiked CNG will be produced using a compact reforming process patented by IOC.
- **Advantages of H-CNG over CNG**
  - **Less Air Pollution**
    - Emits 70% less CO<sub>2</sub>;
    - Reduces total hydrocarbons emissions by around 15% and increases fuel efficiency by 3-4%.
  - **Increases fuel efficiency**
  - **Higher power output**
- **Updates in Sep 2021**
  - **CNG to HCNG model 'Capital intensive'**; Delhi government unlikely to scale up pilot project.