CURRENT AFFAIRS PROGRAM PRE-CUM-MAINS 2024 SEP 2023 : BOOKLET-4 RENEWABLE ENERGY

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1. RENEWABLE ENERGY

- **Example Question:**
  - » Discuss the significance of renewable energy in India's sustainable economic development. What are the factors hindering the growth of renewable energy sector in the country? Suggest some measures to deal with these problems. [15 marks, 250 words]
  - » Evaluate the economic and employment opportunities presented by the renewable energy sector in India [10 marks, 150 words]

- **Introduction**
  - » 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)

- **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.

- **Future Target**: Government aims to achieve 500 GW of installed electricity capacity from **non-fossil sources** by 2030.

- **India's NDC and Renewable Energy:**
  - » While the **target was to achieve 40 per cent of the installed electric capacity from non-fossil fuel** sources by 2030 in the initial NDC submitted in 2015, the target has already been achieved.
  - » India is **now striving to achieve the target of 50 per cent cumulative electric power installed capacity** from non-fossil fuel-based energy resources by 2030, in line with **updated NDCs**.

- **Why do we need to invest more in the Renewable Energy Sector?**
  - » **Energy Security and Reduced Import Dependency:** As for fossil fuels, India is mostly dependent on crude oil imports.
  - » **Economic growth:**
    - Reduced cost of energy supply

- Reduced CAD -> Saving Forex
- Opportunity to emerge as a renewable energy hub for the world -> this can become an important source of employment and entrepreneurship.
- Improved export opportunity in the non-conventional energy sector.

» **Inclusive Development: Electricity in inaccessible areas**
- Solar, small hydro, wind energy etc. can easily provide electricity in the region where Grid connected electricity has not reached.

» **Environmental sustainability:**
- **Fighting Climate Change:** Meeting NDCs submitted at COP26 of UNFCCC.
- **Reducing Air Pollution and Water Pollution**

» **Strengthening India's Soft Power and Global Leadership**: India could also handhold other developing nations to explore the path of sustainable development via making best utilization of non-conventional sources of energy.

– **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 subs station capacity for evacuation of renewable power etc. under **Green Energy Corridor scheme** for evacuation of renewable energy

» **Sectoral Initiatives**:
- **National Solar Mission**
  - **Setting up of ultra-mega renewable energy parks** to provide land and transmission to renewable energy developers on a plug and play basis.
  - **Pradhan Mantri Kisan Urja Surakha Evam Utthaan Mahabhiyan** (PM-KUSUM): It is aimed a de-dieselization of the farm sector along with providing energy security and increased income for farmers.
- **National Hydrogen Mission**: It aims to make India a green hydrogen hub, aiding to fulfill its target of production of **five million tonnes of green hydrogen by 2030** along with allied development of renewable energy capaacity.
  - In Aug 2022, India's first indigenously developed **Hydrogen Fuel Cell Bus** developed by KPIT-CSIR was launched.
- **Steps to promote wind Energy**:
  - National Offshore Wind Energy Policy notified in 2015
  - National Wind Solar Hybrid Policy was adopted in 2018
- **Steps to promote bioenergy:**
  - National Policy on Biofuels

- Scheme to support promotion of Biomass based cogeneration in sugar mills and other industries
- Program on Energy from Urban, Industrial and Agricultural Wastes/Residues
- Biogas Power (Off-Grid) Generation and Thermal Application Program (BPGTP)

» **International Collaboration**:
- International Solar Alliance
- Global Biofuel Alliance announced during 2023 G20 Summit in India.

– **Electricity** (Promoting Renewable Energy through Green Energy Open Access) Rules, 2022 notified (June 2022) - It is aimed at ensuring access to affordable, reliable, sustainable and green energy for all.
- **Electricity (Promoting Renewable Energy Through Green Energy Open Access) Amendment Rules, 2023 (Jan 2023)**

– **Problems faced by Renewable Energy Sector**

i. **Mobilization of Finance and investments**: India is a developing country with limited resources and renewable energy sector is a capital-intensive sector.

ii. **Land Acquisition:** Solar and wind Power projects require large land areas, which has in recent years emerged amongst the biggest challenges faced by the sector.
- For e.g., windmills and Solar plants are impacting the habitats of critically endangered the Great Indian Bustard.

iii. **Intermittent Nature of Renewable, Lack of energy storage, and wastage (15-20%)**
- This makes grid integration difficult.
- The absence of storage facilities leads to wastage to the tune of 15-20% of electricity generated.

iv. **Poor Manufacturing Ecosystem** in the country leads to import dependency for wind mills and solar power panels.

v. **Lack of Skilled Manpower:** India still has not been able to attract youth towards this sector. Moreover, the opportunity to train in the sector is also negligible

vi. The **financial conditions of our distribution companies (discoms)** is another hindrance.
- The additional solar and wind capacity will come from private sector and developers would be discouraged if they are not assured of market and timely payments.

vii. **International Trade Rules**
- WTO trade rules have sometimes hindered our local manufacturing.

– **What further needs to be done?**

» **For increasing Finance**
1. More government investment
2. Creating mandates for provident funds to invest in infrastructure and environmentally sustainable projects.
3. Increasing the priority sector lending limit for bank loans under solar energy from a meagre Rs 15 crore.
4. Mobilizing retail savings by way of tax exemption on the lines of Section 80CCF
5. Promote Green Bonds.

» Standardizing the definition of green to be able to target government efforts in the direction.

» Promoting more R&D on Green sector

» Promoting local manufacturing

- » Dealing with **intermittency and wastage** (due to variability and lack of storage facilities)
  - Focus more research towards storage technology -> use tax incentives and VGF.
  - Promoting use of smart grid, net metering and storage devices.
  - Redesign power markets to reflect the new feed for flexible supply and demand
  - **Options available for storage**: Hydrogen based storage, lithium ion batteries, and pump storage plants.
    - Hydrogen based storage is used for long term
    - Lithium-ion batteries are suitable for day-to-day storage
- » **Dealing with Land Acquisition Issues:**
  1. **Minimising total land-use requirements** for renewable energy by promoting offshore wind, rooftop solar and solar on water bodies
  2. **Identification and assessment of land for renewable generation** by limiting undue regional concentration and developing environmental and social standards for rating potential sites.
  3. **Attention on Indian agri-voltaics sector** — securing benefits to farmers and incentivising agri voltaics uptake where crops, soils and conditions are suitable and yields can be maintained or improved.
- » **Ensure Greater Synergy among all the concerned stakeholders** through a participatory approach and awareness generation, can further help to fasten the pace of shift towards renewable sources of energy.
- » **International Cooperation**:
  - Renewable Energy Technology should be declared as a global public good, including removing of IPR barriers to technology transfer.
  - Improve global access to supply chains for renewable energy technologies, components and raw material.

- **Conclusion1:** Time is not on our side and our climate is changing before our eyes. We need a complete transformation of the global energy system.

- **Conclusion2**: By addressing these challenges and implementing these measures, India can further accelerate its transition to renewable energy, promoting sustainable economic development while reducing its environmental footprint.

2. PROBLEM OF STORAGE IN RENEWABLE ENERGY

- **Introduction**:
  - » India is emerging as a renewable energy powerhouse with a target of 450 GW of installed RE capacity by 2030. However, the country faces a major challenge in the form of lack of storage capacity.

- **Why is storage needed in renewable energy sector?**
  - » **Handling Intermittency and variability problem** of renewable due to sudden cloud cover and decreased wind velocity.
  - » **Providing energy in non-solar/wind hours**

- India's doesn't feel the pinch right now because we have more than 200 GW of coal based capacity which is managing the show by backing renewables in case of variability. So, decarbonization will be difficult without finding an alternative.

- **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.
     - **Concerns**: Though the cost of batteries have declined by 80% over the last decade, it is still quite expensive as the levelized cost of battery is about Rs 8 to Rs 10 per unit.

  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.

- These are steps in the right direction, however, more efforts needs to be put to expand the capacities in parallel with the expansion of the renewable energy.
  i. **More R&D in battery storage** to reduce the cost: Government should increase the financial incentive and subsidies to development and adopt more advanced energy storage technologies.

ii. **Grid Modernization**: To accommodate energy storage and intermittent renewable energy sources effectively. Implement smart grid technologies to enhance grid flexibility.
iii. **Finalize a regulatory framework** which would help investors to develop and deploy storage projects.
iv. **Public Private Partnerships** - It can be used to develop and deploy storage projects.
v. **Demand Side measures** to reduce the need of storage e.g. smart metering, smart grid, energy efficiency etc.
vi. **Skill Development (Human Resource Creation)**: To develop workforce capable of designing, installing and maintaining energy storage systems.
vii. **International Collaboration** bilaterally and multilaterally to leverage best practices and sharing knowledge on energy storage solutions.

- **Conclusion**: These steps have the potential to increase the storage capacity for renewable energy sector and to help to make renewable energy a more reliable and affordable source of electricity.

3. DECENTRALIZED (DISTRIBUTED) RENEWABLE ENERGY

- **Example Question:**
  - "Decentralized renewable energy play a vital role in transitioning towards a more sustainable and resilient energy future, particularly in areas where centralized grid infrastructure is inadequate on non-existent" Critically Analyze [10 marks, 150 words]

- **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**: DRE doesn't lead to environmental damages which are caused by large scale hydropower plants, large scale solar parks etc.
  - **Energy Security**: Technologies like rooftop solar, micro hydel power plants etc. can lead to sustainable energy production and thus can ensure long term energy security.
  - **Inclusive Growth**: DRE can ensure energy supply and thus other associated services in remote, under-developed regions.
  - **Scalability and Flexibility**: DRE can be scaled gradually depending on the local needs.
  - **Job Creations**: DRE will stimulate local job opportunities in manufacturing sector, installation, operations etc.
    - As per MNRE, DRE has a market potential of Rs 4 lakh in rural and peri-urban communities in India.

- **Challenges and way forward**

» **Repairing** remained a challenge: Enough human resource and contact with manufacturers is still poor, especially in remote areas.
  - Skill development can not only improve the repair services but can also provide increased job opportunities.

» **Increasing Affordability** - For a lot of people, affordability is a major concern and increased access to loans/government incentives is crucial for accessing the DREs.
  - At the same time, development of DRE industries in India, more R&D, etc. would be important for reducing the cost of the technology.

» **Policy supports** especially at state level: In India state level policy schemes are incapable of effectively supporting DRE technologies, especially when it comes to enabling affordable financing for entrepreneurs and end-users.

» **International Cooperation** across sectors for an equitable exchange of knowledge and resources is essential for scaling DRE technologies.

– **Conclusion:**
» DRE can play a vital role in transitioning towards a more sustainable and resilient energy future, particularly in areas where centralized grid infrastructure is inadequate or non-existent.

4. SOLAR

– **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**
  - (climate change, pollution, Energy Security, Economic Opportunities, Inclusive growth, cost competitiveness, reduce import deficiency etc.)

» **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 then other renewables
    - A new study by WWF and IRENA found that wind and solar power are significantly less damaging than other renewable pathways.

» **Solar Energy is becoming more and more competitive**

– **Government Efforts to promote Solar Energy**
i. **Jawaharlal Nehru National Solar Mission (JNNSM)** - aimed at achieving 100 GW of solar power by 2022 (60 GW through large and medium scale solar power projects and 40 GW of rooftop solar)

ii. **Pradhan Mantri Kisan Urja Suraksha Evan Uttham Mahabhiyan (PM Kusum)** 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** - Grid Connected Renewable solar power plants; Installation of 20 lakh standalone Solar powered agri pumps; Solarization of 10 lakh grid connected agri pumps.

iii. **Steps to ensure easy finance for Solar energy.**
- **Increased government spending**: For e.g., the Budget 2023 allocated Rs 10,222 crore to MNRE which is 45% higher than the previous allocation.
  - 'Off-Grid' solar projects have seen an increase in allocation to **360 crore** which is 6 times higher than last year.
- **Financial Incentives:** Generation based incentives (GBIs), capital and interest subsidies, viability gap funding, concessional finance, fiscal incentives etc for providing financial support for various schemes have been initiated.
- New **tax-free solar bonds**.
- Making roof top solar as part of housing loan by banks/NHB.

iv. **International Cooperation:** International Solar Alliance, One World One Grid etc.

v. **New Innovations: Floating Solar Power Plant** (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.

vi. **Other steps to promote solar sector.**
- **Amendments to Electricity Act and Tariff Policy**
  - For strong enforcement for Renewable Purchase Obligations and for providing Renewable Generation Obligations (RGO).
- Evacuation of renewable energy through **Green Energy Corridor project**.
- Amendment to building by laws for mandatory provision of roof top solar for new construction or higher floor area ratio.
- Infrastructure status to Solar projects.
- Provision of rooftop solar and 10% renewable energy as mandatory under mission statements and guidelines for development of **smart cities**.

vii. **Promoting Domestic Manufacturing of Solar PV cells and various components**

1. **National Programme 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.

viii. **Promoting Competition among States**: SARAL index by MNRE ranks states in terms of their efforts to incentivize rooftop solar.

ix. **Skill Development:** Focus on skill development of workforce: "Surya Mitra Scheme" launched in May 2015. To create 50,000 trained personnel within a period of five years

– **Some Problems faced by Solar Energy Sector**

i. General Problems faced by renewable energy sectors like finance, technology, human resource, land, Global Trade Rules etc.

ii. **Substandard Equipment and Lack of Accountability**: For e.g. in Assam, under DDUGJY, Solar kit was distributed to ensure rural electrification, but when problems occurred either in the panel or the batteries, even within the contract period, the replacements haven't happened.

iii. **Poor Performance of Rooftop Solar Power Projects**

» A parliamentary panel (March 2023) has attributed **low installation of solar rooftop and wind energy** projects as key reasons for the shortfall in achieving India's renewable energy capacity target of 175 GW by 2022.

» **Key Reasons**

a. **Residential Roof top policy** wasn't very effective. Government's policy was primarily focused on industrial rooftop.

b. Lack of cooperation from state electricity utilities and distribution companies across India as it could hurt their finances.

c. **India still doesn't have uniform policies around net metering.**

d. **Lack of awareness amongst public**

- For e.g., not many people are aware that with their home loans they can get loans for solar rooftops too.
- Further, people are not aware of the financial incentives and attractive return on investment that taking up rooftop solar power solutions can achieve.

iv. **Import Dependency:**

» Much of India's solar PV manufacturing uses imported components with parts mostly sourced from China. In the Budget announced in Feb 2022, government has announced a Basic Customs Duty of 40% on modules and 25% on solar cell imports from 1st April.

v. **Intermittency -> Lack of energy storage facilities**.

– **Some Limitations of expanding Renewable Energy:**

i. **Land Acquisition -> Ecological and biodiversity losses**: Even dry regions support native vegetation such as grass, herbs and shrubs. They are diverse, ranging from woodland savannas, scrubland and grasslands, to rocky outcrops, ravines and dunes. They have some protected species like black buck and Great Indian Bustard.

ii. **Loss of Ecological services -** like sequestering of more carbon than if trees were planted on them. Grazing based livelihoods also support millions in India.

iii. **Displacement**: In Kutch, communities displaced from their traditional grazing lands by renewable energy projects have been protesting these projects.

iv. **Emerging E-Waste Challenge:** As per a report by International Renewable Energy Agency (IREA), India could be generating more than 4 million tonnes of photovoltaic waste by 2050.

- Currently, India is recovering about 20% of the photovoltaic waste, rest is dealt with informally. This waste gets accumulated at landfills which in turn cause leaching of toxic metals in soil and water.

– **Way Forwards**

i. **Increased focus on Rooftop Solar**: Development of positive retail led ecosystem to promote rooftop solar.

» **Improved policy of rooftop solar** - Increased focus on awareness generation.

» **Prioritize smart grid and net metering.**

» **Incentivize discoms** by providing them with performance linked incentives.
» **Improving Tender Process** under DDUGJY: Tender process should be based on a '**Quality Cost Based System**', a well-accepted methodology for vendor selection globally which evaluates bidders based on technical and quality scores before looking at cost.
» **More focus on creating skilled workforce**: Government tenders for solar rooftops should have clause for training locals in maintenance by teaching them the required skill sets and generating job opportunities for them.

ii. **Agri-Voltaics** - Deploying solar panel in a manner which allows agriculture below it.
» **Advantages:** Reduces evapo-transpiration and saves water; cooling effect of plants improves the efficiency of the solar power panels.

iii. **Ensure effective implementation of Social Impact Assessment and Environmental Impact Assessment** in large scale projects.

iv. **Deal with photovoltaic waste:**
» **Formulate and implement provisions specific to photovoltaics waste treatment** (rather than clubbing it with e-waste). This should also include EPR.
» Pan India sensitization drive about photovoltaic waste.
» More R&D in development of better recycling mechanisms.

v. Other steps discussed under Renewable Energy Section above.

5. WIND

1) 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.

- **Recent Steps taken by Government.**
i. **National Wind Mission (NWM)** - launched in 2015 as part of NAPCC -> To achieve the target of 60 GW by 2022 with an investment of 10 lakh crore.
ii. Scheme for Procurement of Blended Wind Power from 2500 MW ISTS connected projects.
▫ The objective of the Scheme is to provide a framework for procurement of electricity from 2500 MW ISTS Grid Connected Wind Power Projects with up to 20% blending with Solar PV Power through a transparent process of bidding.

- **Why did India miss its wind energy target?**
    - **Inconsistent policy environments** also discourage investment in the sector.
        - For e.g. In 2016, the government **decided to withdraw 50 percent of accelerated depreciation benefi**t to industry from 2017.
    - **Legacy challenges** - infrastructure and transmission bottlenecks, financial conditions of discoms etc.
    - **Moving from feed in tariff system to e-reverse auction in 2017**.
        - Competitive bidding at low tariffs led to wind energy exploitation only remaining feasible in Gujarat and TN. In these two states plant Load Factor (PLF) is higher due to high wind speed.
        - The **overemphasis** on low tariff meant that tariff caps set for centrally sponsored auctioned projects are often too low to make the projects bankable or economically viable.
        - In 2022, MNRE has said that it would be doing away with the practice of reverse auction. This is expected to bring some relief to the wind energy sector.
    - **Cost Escalation**: Due to increased commodity prices
    - **Competition**: especially from cheaper photovoltaic power
    - **Reduced Policy Attention**: Government's policy focus has been on solar energy and wind energy has been reduced to playing a second fiddle, despite the fact that it was an early mover in the renewable energy sector.
    - **Land Acquisition** is emerging as another major issue.

- **What Further needs to be done?**
    i. **Clear, well-defined policy**
        - Perhaps the keenly awaited Renewable Energy Law that has been in the making for quite some time now.
        - This would bring policy clarity and remove uncertainties in the sector.
    ii. **Repowering -** i.e., upgrading the capacity of the existing wind turbines to produce more energy**:** It can increase productivity and spur socio-economic benefits.
    iii. **Work on solving legacy challenges.**
        - Strengthening transmission infrastructure, DISCOMS and Changing State land policies to simplify land acquisition.
    iv. **Develop Offshore wind roadmaps:**
        - The offshore wind measurement campaign can yield LiDAR data to identify bankable offshore wind zones.
        - Promote engagement among decision-makers at the federal, state and local levels of government, civil society organizations, and local stakeholder communities to align offshore wind development strategies and promote **a collective understanding of offshore wind's socioeconomic benefits**.
    v. **Creating Export Potential for wind energy equipment**
        - Develop a technology exchange program and align Indian manufacturing based with global wind supply chain to create export-oriented opportunities.
        - Including these components in FTAs
    vi. **Focus on modular and micro-wind turbines**: These can produce electricity at low wind speeds (5-6 kmph).
        - These micro-turbines could be fixed on terrace like a TV aerial; on street and highway lights; agricultural pumps; traffic signals etc.
        - It will reduce the land acquisition problem and would be suitable for regions which get continuous slow wind speed.

2) 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 seabed. Floating wind farms are still in infancy.

- **Target:** MNRE has set a target of installing 5GW of offshore capacity by 2022 and 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. **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.
  2. In **June 2022**, MNRE has decided to **bid out offshore wind energy blocks**.

- **Challenges:**
  1. **General challenges of wind energy** as discussed above.
  2. **Technological and Engineering challenges**: High sea breeze, corrosive saltwater and challenging seabed conditions require technological and engineering advancements.
  3. **Local substructure manufacturers, installations vessels and trained workers** are lacking in India. Offshore wind turbines require stronger structures and foundations than onshore wind farms. This can cause higher infrastructure cost.
  4. **Maintenance** of offshore wind farms are more costly due to problems like cyclones.
  5. **Grid Infrastructure and Integration** will be challenges as the power generated at sea has to be transmitted to the onshore grid.
  6. **Environmental concerns**: Environmentalists are worried that noise from offshore wind farms could impact fish habitats.

- **Way forward to promote offshore wind energy:**

» **MNRE should set up a specific Renewable Purchase obligation (RPO) targets for each state** just like it does for solar.
  - Note: Currently, there are two types of RPOs - Solar and Non-Solar
» **Feed in Tariffs**: Discoms can adopt feed-in tariff (FiT) regulations and make offshore wind power procurement mandatory.
» **Skill Development** - Capacity building programs, vocational training, and educational initiatives should be implemented to develop a skill workforce for offshore wind energy.
» **Infrastructure Building:** Initiatives to promote domestic manufacturing and supply chain management.
» **Environmental Impact Assessment and mitigation** to prevent environmental degradation and protect biodiversity.

6. HYDROGEN ENERGY

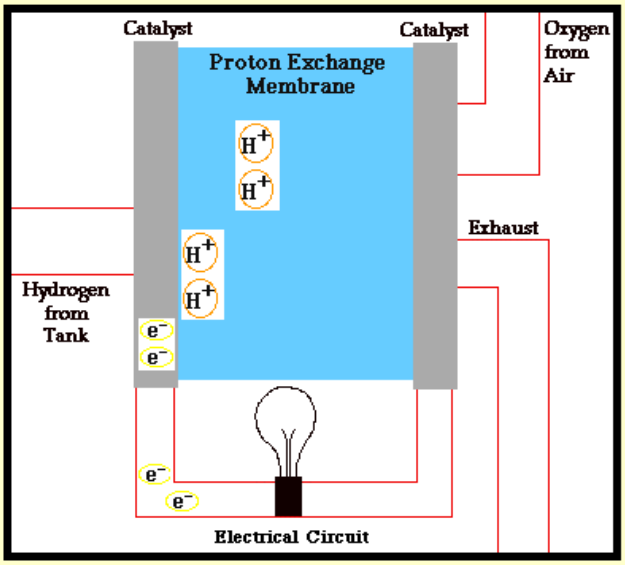
1) HYDROGEN FUEL CELL

– **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_2O) emitted as by product)
  » **No Greenhouse gas and Climate Change** (since no GHG are produced as bi-products)
  » **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.

A) FUEL-CELL ELECTRIC VEHICLES (FCEVS)

» FCEV combine hydrogen and oxygen to produce electricity which runs the motor.
  - E.gs 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)

B) 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.

2) HYDROGEN ENERGY

- **Hydrogen Energy** is a clean and efficient form of energy derived from Hydrogen (H_2). 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 to 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**.

– To get support in **Regulatory Framework** - the MoRTH in 2020 have issued a notification proposing amendments to the Central Motor Vehicle Rules, 1989, to include s**afety evaluation standards for hydrogen fuel cell-based vehicles**.

– **Some limitations of Hydrogen fuel**
» **Hydrogen** molecule is **not available in abundance** on earth and is found in combination with other elements.
  ▪ Thus, **external energy source** is required to isolate hydrogen. If coal or other fossil fuel is used for this extraction, it is called grey hydrogen and has carbon footprint.
» 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.

– **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)

A) NATIONAL GREEN 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.

B) 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_2 for per Kg H_2.
  - 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.

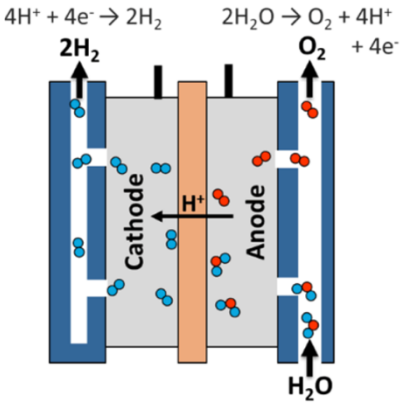
– **Significance**:

» The definition of green hydrogen brings a lot of clarity to the mission of making India a global green hydrogen hub.

C) 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 iconic 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.

- **Some Recent Developments**:
  - **IIT Madras develops a cost-effective way to electrolyze sea water to generate hydrogen**:
    - **Challenges of traditional electrolyzers:**
      - Energy Intensive
      - Use of expensive oxide-polymer separator
      - Wastage of fresh water
    - **IIT Madras team** has addressed all these challenges by developing simple, scalable and cost effective alternatives that are highly efficient in splitting seawater and generating hydrogen.
      - They use **alkaline sea water**.

- They use carbon based support material for the electrodes instead of metals to almost eliminate the possibility of corrosion.
- They have developed a cellulose based separator that is very economic and serves the purpose of allowing hydroxide ions to pass through put prevent oxygen and hydrogen that are generated from crossing over.

D) 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 an 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;
    - 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.

- **Way Forward: Following are the essential actions to ensure the launch of hydrogen economy in India**
  - **Promote Demand**
    - **Identify high demand sectors** like green ammonia, oil-refining, heavy duty transport etc. where initial demand can be catalysed via public incentives.
    - **Pioneer voluntary purchase mechanisms** for green hydrogen embedded products such as green steel or green fertilizers similar to RE100 initiatives, where corporates like Infosys or google pledged to run completely on green energy.
  - **Reduce cost of production of green hydrogen:**
    - **Work towards reducing renewable energy tariffs** -> 70% of the cost of production of green hydrogen is the cost of renewable energy.
    - **Scale:** India should strive to **incentivise the giga-scale production of green hydrogen components**, like electrolysers, to take advantage of the global demand-supply gap and reduce the local green hydrogen prices.

» India should **identify hydrogen production clusters closer to the renewable parks** to utilise near-zero cost excess peak power which can be diverted to hydrogen plants
» **Promote R&D:** Policymakers must facilitate investments in early-stage piloting and the research and development needed to advance the technology for use in India.
» **Focus on Domestic Manufacturing**:
  - Establishing an end-to-end electrolyser manufacturing facility will require more steps than just an PLI scheme. India needs to secure the supply of raw material that are needed for this technology.
» **In the initial phase, Blend Green Hydrogen with Grey Hydrogen** (as grey hydrogen is much cheaper to produce)
» **Plan for large scale refuelling network**
» **Start on pilot basis for gated infrastructure** like airports, ports, warehouses.

– **Conclusion1**
» Scaling up the technology and achieving critical mass remains a big challenge. More vehicles on the road and more supporting infrastructure can lower costs. **India's proposed mission** is seen a step in that direction.

– **Conclusion2:**
» Even before it has reached any scale, green hydrogen has been anointed the flag-bearer of India's low-carbon transition. Hydrogen may be lighter than air, but it will take some heavy lifting to get the ecosystem in place.

7. BIOFUELS

1) BIO-FUEL BASICS

- **Example Questions**
  i. Discuss the key advantages of Biogas. What are the key initiatives by government of India to promote the creation of biogas plants in the country. [10 marks, 150 words]
  ii. '*Promoting biofuels in India is of strategic importance*" Discuss in light of the National Biofuel Policy 2018. [15 marks, 250 words]
  iii. Discuss the 3 generations of biofuels and their advantages and disadvantages. [10 marks, 150 words]
  iv. "National Biofuel Policy is trying to balance India's food security & energy security with farmer's income security". Discuss. [12.5 marks, 200 words]

- **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.
            - **Bioethanol:** 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.
            - **Biogas:** 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 **electro fuels**. 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 2022): Country wide blending target of 20% ethanol by 2025 and 5% biodiesel by 2030

- **Why growth of biofuel sector in India?**
  - The spurt in ethanol production in India is almost entirely policy driven. Initiatives like Ethanol Blending Program, National Biofuel Policy etc. have created conditions for the growth in the sector.

- **Advantages of Biofuels**
  i. **Renewable and Energy Security**: Biofuels reduce dependency on imports and thus also reduces India's vulnerabilities to price fluctuations.
  ii. **Fighting Pollution:**
    - Ethanol blended petrol reduces emission of pollutants like carbon monoxide.
    - Biogas is a much better fuel than cow-dung cake. It can also reduce the problems of poor sanitation.
    - Further, bio fuels helps in moving towards newer vehicle emission targets (BS-IV and BS-VI).
  iii. **Reduction in Greenhouse gases**:
    - A report by NITI Aayog quotes potential reduction of GHG emission at the point of use, i.e. from the tailpipe of the vehicle.
  iv. **Lesser impact on climate change**
    - Biogas also reduces the emission of GHGs such as methane and Carbondioxide.
  v. **Can Promote sustainable agriculture:**
    - Government is promoting farmers to move from water intensive crops like wheat and rice to **Maize** which is suitable for biofuel production.
  vi. **Increase farmer's income**

- By providing them another way to use their surplus crops.

vii. **Sanitation**
- Some biofuels like biogas can play an important role in dealing with the problems of open defication and sanitation in rural and semi-urban areas.

viii. **Social impacts**
- Biofuels like biogas can reduce the drudgery of women involved in collecting fuel wood and thus plays a role in women empowerment.

ix. **Reduces Import Dependency** and **saving foreign exchange**

- **Some Criticisms:**
  - **Land Use Change** to grow biofuel crops may have its own negative impact.
    - For e.g. the constant increase in demand from sugarcane based ethanol from Brazil has meant extensive deforestation of rainforests resulting in GHG emissions from Brazilian ethanol use that was about 60% higher than petrol.
  - **Food Security Issues:** The argument that only surplus sugarcane and rice are diverted to fuel production may not hold in the longer term.
  - **Water Challenges** - Sugarcane is a water intensive crop.

- **Steps taken by government to support biofuels**

i. **National Policy on Biofuels, 2018**

ii. **Pradhan Mantri Ji-Van Yojana (PMJY)**

iii. **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..

iv. **EBP** and associated steps

v. **National Bio-Energy Program** (FY 2021-22 to 2025-26):
- It comprises of the following schemes:
  1. **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.

- **Way forward:**

- The proposed expansion of 1G biofuel need to think about broader land use strategies by developing clear and detailed criteria for identifying land suitable for energy crops.
  - Crucial factors like GHG emissions, local pollution, food security, land laws, and resource availability must also be considered.
- For **2G Biofuels** -
  - **Locating the industries near feedstock** availability: It is important to map feedstock location and then plan biofuel production capabilities.
  - **More R&D**: Scope for the schemes **like Pradhan Mantri JI-VAN** Yojana needs to be expanded, and international grants and loans should be redirected towards 2G fuels.
- India also needs to **develop alternative feedstock** for biodiesel production.
  - Millions of tonnes used cooking oil can be channelized here.

- **Conclusion:**
  - Thus, the expansion of the biofuel sector needs to be multipronged and rooted in sustainability.

2) 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.

- **Central Financial Assistance (CFA) for biomass power projects** includes installations from biomass combustion, biomass gasification and bagasse co-generation.

- **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.

3) NATIONAL POLICY ON BIOFUELS

- **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 2022)**: 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**
    1. 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.

- **Analysis: Expected Benefits**
  - The new policy addresses **the supply side issues** that had discouraged the production of bio-fuels within the country.

- **Conclusion**
  - Biofuels in India are of strategic importance as it augurs well with the ongoing initiatives of the Government such as Make in India, Swachh Bharat Abhiyan, Skill Development and offers great opportunities to integrate with ambitious target of doubling farmers' income, import reduction, employment generation, waste to energy creation.

4) BIO-CNG (COMPRESSED BIOGAS)

- 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-digestor 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 digestor 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 CO2. 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:** The energy source is renewable and thus reduces India's import dependency while ensuring **Atmanirbharta and Make in India.**
  - » **Swatch Bharat**: The production of Bio-CNG from biodegradable waste, agricultural residue, cow dung and chicken litter etc. can contribute to sanitation goals.
  - » **Fighting Air Pollution**:
    - Bio-CNG helps deal with air pollution on **three levels** - curtail methane emission, ward-off waste burning and phase out fossil fuel powered vehicles.
    - For e.g. the CBG plant inaugurated in Sangrur, Punjab will soon be processing 300 tons per day of paddy straw and produce 33 tonnes per day of CBG.
  - » **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 digestor 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 Biogas (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)
  - » Asia's largest compressed biogas plant was inaugurated in Sangrur by Union Minister Hardeep S. Puri.