Ammonia as a Automotive Fuel

For Prelims: Ammonia, **Battery Electric Vehicles**, Energy Density of Ammonia, **Haber-Bosch process**, **Green Hydrogen/ Green Ammonia Policy**.

For Mains: Advantages and Challenges Related to Ammonia as a Fuel, Scientific Innovations & Discoveries, Conservation

Why in News?

Recently, an **internal combustion engine** powered by **ammonia** is gaining traction in the **automotive industry.**

- This unique approach is sparking interest as it **explores alternative propulsion technologies** while not completely departing from **traditional Internal Combustion Engine (ICE) systems** or transitioning to Battery Electric Vehicles **(BEVs).**

What are ICE Systems and BEV Systems?

- **Internal Combustion Engine (ICE) Systems:**
  - ICE vehicles use traditional engines that burn fossil fuels (e.g., petrol or diesel) to generate power.
    - **Fuel is mixed with air, ignited,** and the resulting explosion drives the vehicle's wheels.
  - They are commonly found in cars, trucks, and motorcycles.
  - They emit exhaust gases and contribute to air pollution and greenhouse gas emissions.
- **Battery Electric Vehicles (BEVs):**
  - **BEVs** are electric vehicles that rely **solely on rechargeable batteries to power an electric motor.**
    - They must be charged using electricity from the grid, which can be generated from various sources, including renewable energy.
  - They produce **zero tailpipe emissions** and are considered environmentally friendly.

What are the Current Major Applications of Ammonia?

- **About:**
  - **Ammonia** is a chemical compound with the formula NH3. It is a colorless gas with a pungent odor and is widely used in various **industrial, agricultural, and household applications.**
- **Major Application:**
  - **Agriculture:** Key component in the **production of ammonia-based** fertilizers, such as ammonium nitrate and urea, which are essential for crop growth.

- **Chemical Industry**: Fundamental ingredient in the production of substances like **nitric acid, ammonium sulfate, and various nitrogen-based compounds.**
    - It plays a crucial role in the manufacturing of synthetic fibers as well, like nylon
- **Manufacturing**: As a **refrigerant in industrial refrigeration systems** and air conditioning.
    - Also, ammonia is used in the manufacture of dyes and as a **pH regulator in dyeing processes.**
- **Household:** An ingredient **in household cleaning products,** including glass and surface cleaners.

What are the Advantages of Using Ammonia as a Fuel?

- **High Energy Density:** Ammonia has a **high** energy density**,** which means it **can store and release a significant amount of energy,** making it suitable for long term applications.
    - Ammonia has **9 times the energy density of** lithium-ion batteries and 3 times that of compressed hydrogen.
- **Low Carbon Emissions**: Ammonia has the potential to **produce** near-zero carbon dioxide (CO_2) emissions **during combustion,** making it an environmentally friendly choice, especially when compared to fossil fuels.
- Bridge Fuel: Ammonia can serve as a bridge fuel, helping reduce dependence on traditional fossil fuels and offering a **transitional buffer toward** cleaner energy **sources**.
    - Also, using ammonia can enhance a **nation's energy security by diversifying the energy mix** and reducing reliance on a single energy source.

What are the Major Challenges Associated with Using Ammonia as a Fuel?

- **Environmental Impact:** Ammonia as a fuel holds the promise of near-zero CO2 emissions during combustion.
    - But current ammonia engines still emit exhaust gases, including unburned **ammonia and** Nitrogen oxides (NOx) that pose risks to environment and health.
        - Nitrogen in the atmosphere usually results in **more tropospheric ozone, respiratory illnesses, and acid rain.**
- **Production Challenges:** The production of ammonia typically relies on the **Haber-Bosch process**, which consumes a significant amount of energy and relies on fossil fuels.
    - Green ammonia **production**, which involves using renewable energy and sustainable sources of hydrogen, is still in the early stages of development and **faces cost and scalability challenges.**
- **Toxicity**: Ammonia is highly toxic, posing health risks to humans and the environment if not managed properly.
    - Also, due to its **toxicity and corrosiveness**, accidents or mishandling could have severe consequences.
- **Fuel Quality Standards:** Developing and implementing **consistent quality standards for ammonia as a fuel can be complex,** especially when ammonia is produced from various sources or with varying levels of impurities.

Note

The **Ministry of Power, Government of India** has notified the Green Hydrogen/ Green Ammonia Policy **in February 2022,** which provides various incentives and support measures for the manufacturers of green hydrogen and **green ammonia using renewable power.**

Way Forward

- **Improved Engine Technology:** There is a need to invest in **research and development to create more efficient and cleaner ammonia engines.**

    - This includes optimizing combustion processes and designing engines that can handle ammonia fuel with minimal (NOx) emissions.
    - **Practical advancements** in engine design can **make ammonia a more viable option.**
- **Safety Training:** Implementing comprehensive training programs for workers involved in the ammonia industry. **Proper handling, safety protocols, and emergency response training** can reduce the risks associated with ammonia's toxicity.
- **Market Incentives:** Creating market incentives, such as tax credits or subsidies, to encourage the adoption of ammonia as a fuel, particularly in sectors where its use can have a significant positive impact, **like** maritime transport.
- **Ammonia Hybrids:** Developing hybrid systems that **combine ammonia with other renewable energy sources,** such as solar and wind power.
    - Ammonia can then be used as a fuel during **periods of low renewable energy generation.**

UPSC Civil Services Examination, Previous Year Question

Q1. Consider the following statements: (2019)

1. Agricultural soils release nitrogen oxides into the environment.
2. Cattle release ammonia into the environment.
3. Poultry industry releases reactive nitrogen compounds into the environment.

Which of the statements given above is/are correct?

(a) 1 and 3 only
(b) 2 and 3 only
(c) 2 only
(d) 1, 2 and 3

Ans: (d)

Q.2 With reference to chemical fertilizers in India, consider the following statements: (2020)

1. At present, the retail price of chemical fertilizers is market-driven and not administered by the Government.
2. Ammonia, which is an input of urea, is produced from natural gas.
3. Sulphur, which is a raw material for phosphoric acid fertilizer, is a by-product of oil refineries.

Which of the statements given above is/are correct?

(a) 1 only
(b) 2 and 3 only
(c) 2 only
(d) 1, 2 and 3

Ans: (b)