Despite the potential of CCTs, its mainstreaming faces several challenges, such as:

- **Costly and energy-intensive**: These technologies are costly and energy intensive. Therefore, they may have considerable impact on the global competitiveness of adopting countries.
- **Doubts over effectiveness of CCUS technologies**: Besides concerns related to indefinite and safe storage at CCUS facilities, there is no concrete evidence that storing carbon underground does not have an effect on the ozone layer and the environment.
- **Could shift attention from renewable energy**: The increasing emphasis on CCTs is perceived as shifting of policy makers' attention from renewable energy investments, which is seen as the most potent measure to address carbon emission in comparison to CCTs.
- **May encourage unsustainable coal mining practices**: As more CCTs are developed, power companies will be encouraged to construct more coal-fired power plants which will encourage more exploitation and mining of coal, and undermine global initiatives to reduce coal consumption.

As the world needs to focus on sustainable development with increasing demand of energy, there is a need to focus on clean energy by forging global partnerships in the field of R&D, funding, regulatory framework and balancing CCTs with renewable energy.

6. Explain the significance of the recently acquired capability of Hypersonic cruise-vehicle technology by India. (150 words) 10

Approach:

- Briefly explain the Hypersonic cruise vehicle technology and its current relevance.
- Explain its significance for India.
- Conclude accordingly.

Answer:

Hypersonic cruise vehicle technology is the one where the system moves with a velocity at or above **5 Mach.** It uses a Scramjet **(Supersonic Combustion Ramjet)** engine, which efficiently operates at hypersonic speeds and allows supersonic combustion. This technology has **applications in** Re-entry vehicle, Short range Ballistic Missile, Hypersonic Cruise missiles, hypersonic aircraft, Inter-continental ballistic missile, boost-glide vehicles, etc. Recently India successfully launched a **Hypersonic Technology Demonstrator Vehicle** with a hypersonic speed of Mach 6.

Significance of Hypersonic Cruise Vehicle Technology for India:

- **Reduces the overall fuel needed for satellite missions:** Nearly 70% of the propellant (fuel-oxidiser combination) used by existing launch vehicles consists of oxidiser. While **scramjet uses atmospheric oxygen as oxidizer,** which would considerably reduce the overall propellant required to place the satellite in orbit.
- **Potential for reusing launch vehicles:** Air breathing propulsion systems enable a **powered return cruise flight** for launch vehicles, thus making them reusable. The possibility of reusing the launch vehicle will significantly **reduce the cost** of launching the satellites.
- **Testing of ancillary technologies:** The successful launch also proved the efficacy of many other critical technologies (apart from the scramjet engine) such as **aerodynamic configuration** of hypersonic manoeuvres and separation mechanism at hypersonic velocities.
- **Self-reliant major power:** Only a few countries such as the USA, Russia, China in the world have hypersonic technology. In this context, the indigenous development of Hypersonic cruise vehicle technology is a step towards Sashakt and Atmanirbhar Bharat.
- **Faster and long range cruise missiles**: Hypersonic missiles are considered as a 'new class' of military threat as they can **penetrate most missile defences**, and reduce the timelines for a countermeasure. There are **currently no credible detectors and interceptors** to successfully shoot down hypersonic missiles.
    - Also, a hypersonic missile is a "**quick reaction missile**", which can be **used to intercept incoming missiles** in the outer atmosphere or in the inner atmosphere.
- **Faster air transportation:** They may provide **tactical advantages** in certain operational scenarios. For instance, Hypersonic transport aircraft would allow the army to move troops far