PLUTUS IAS

CURRENT AFFAIRS

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ATOMIC CLOCKS AND INDIA

THIS ARTICLE COVERS 'DAILY CURRENT AFFAIRS' AND THE TOPIC DETAILS OF "ATOMIC CLOCKS AND INDIA". THIS TOPIC IS RELEVANT IN THE "SCIENCE & TECHNOLOGY" SECTION OF THE UPSC CSE EXAM.

WHY IN THE NEWS?

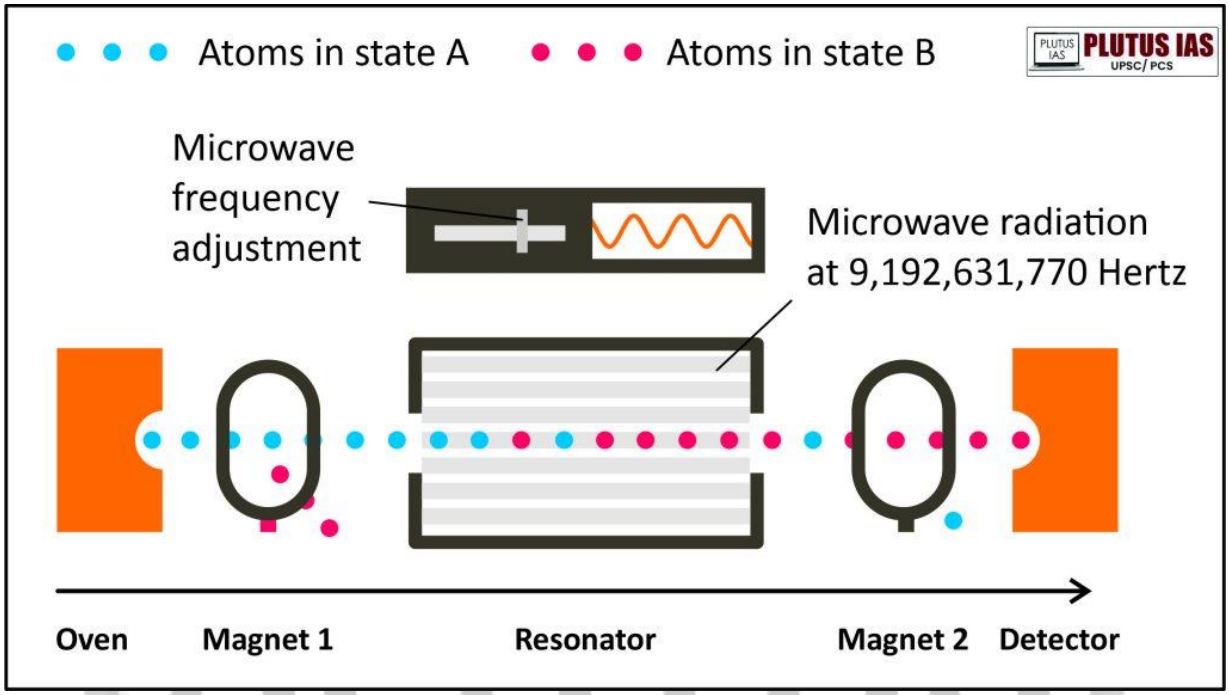
India is strategically distributing atomic clocks nationwide to synchronise the time displayed on digital devices such as watches, smartphones, and laptops with Indian Standard Time. This initiative, initiated over twenty years ago following the Kargil war, aims to ensure accuracy and reliability in timekeeping across the country.

ABOUT ATOMIC CLOCKS

- Atomic clocks are advanced timekeeping devices that utilise the natural vibrations of atoms to measure time with exceptional accuracy.
- These clocks rely on the oscillations of atoms, usually caesium or rubidium, which serve as highly stable timekeeping references.
- By detecting the frequency of these atomic vibrations, atomic clocks can maintain timekeeping precision to within a few billionths of a second per day.
- The atomic clock was developed by Louise Essen in 1955. Presently, India has operational atomic clocks located in Ahmedabad and Faridabad.

HOW DO ATOMIC CLOCKS WORK?

1. Atomic clocks operate by employing a specific type of atom known as **"caesium atoms."** Caesium atoms are **highly stable and exhibit a precise frequency at which their electrons oscillate.** This frequency serves as the fundamental reference for timekeeping in the atomic clock.
2. In the process of measuring time using caesium atoms, **an atomic clock utilises a component called a "microwave cavity."** This cavity functions as a chamber containing caesium vapour. A microwave signal is introduced into the cavity, prompting the caesium atoms to undergo vibration.
3. During this vibration, the caesium atoms emit radiation characterised by a highly specific frequency. **A detector within the atomic clock then captures this emitted radiation and compares it against a predetermined standard frequency.** Any disparity between these frequencies is utilised to make adjustments to the clock's timekeeping mechanism.



SOME DIFFERENT TYPES OF ATOMIC CLOCKS ARE:

1. **Cesium Atomic Clocks:** The most widely used type, caesium atomic clocks, measure the frequency of transitions in the cesium-133 atom, typically using a microwave resonance method. These clocks are highly accurate and serve as the primary standard for defining the second in the International System of Units (SI).
2. **Rubidium Atomic Clocks:** Rubidium atomic clocks operate similarly to caesium clocks but use rubidium atoms as the reference instead. They are generally smaller, less expensive, and more portable than caesium clocks, making them suitable for applications where size and cost are important factors.
3. **Hydrogen Maser Clocks:** Hydrogen maser clocks are even more precise than caesium clocks. They rely on the hyperfine transition of hydrogen atoms and operate at much higher frequencies, resulting in superior short-term stability and accuracy. These clocks are commonly used in scientific research, satellite navigation systems, and space missions.
4. **Optical Atomic Clocks:** Optical atomic clocks use optical transitions in atoms, such as those of strontium or ytterbium, to achieve even higher precision than traditional atomic clocks. By operating at optical frequencies, they can potentially redefine the second with even greater accuracy. Research in this field is ongoing, with optical clocks showing promise for future applications in areas like fundamental physics research and global positioning systems.

WHAT IS THE RATIONALE BEHIND INDIA GOING FOR ATOMIC CLOCKS?

India started efforts to develop atomic clocks in response to the denial of Global Positioning System (GPS) information during the Kargil War. The establishment of independent timekeeping capabilities is necessary for defence, cybersecurity, and online transactions.

- **National Security and Self-Reliance:** Currently, India relies on foreign atomic clocks, particularly those in the US, for critical infrastructure like the Indian Regional Navigation Satellite System (NavIC). Developing its own atomic clocks allows India to control its

timekeeping infrastructure, reducing dependence on external sources. This is vital during potential conflicts where access to foreign signals could be restricted.

- **Enhanced Accuracy and Reliability:** Atomic clocks offer unmatched precision compared to conventional methods. By deploying them across the nation, India can synchronise all digital devices with Indian Standard Time (IST), ensuring a unified and highly accurate time reference. This translates to improved performance in various sectors:

1. **Telecommunications:** Precise timing is essential for the smooth operation of communication networks, minimising errors and ensuring seamless data transfer.
2. **Financial Systems:** Timestamping financial transactions with atomic clock accuracy minimises errors and safeguards against fraud in high-frequency trading.
3. **Navigation Services:** India's NavIC system can benefit from the enhanced timing provided by domestic atomic clocks, leading to more reliable positioning data.
4. **Cyber security:** In India's burgeoning digital economy, atomic clocks ensure the accuracy of timestamps for transactions, preventing fraud, ensuring data integrity, and bolstering cybersecurity measures.

- **"One Nation, One Time":** With a network of atomic clocks, India can achieve a unified and precise time standard across the country. This fosters a sense of national coherence and simplifies time-related activities for citizens and businesses alike.'
- **Critical Infrastructure and Power Grids:** Atomic clocks play a vital role in synchronising critical infrastructure, including power grids, transportation systems, and emergency services.

PRELIMS PRACTISE QUESTIONS

Q1. With reference to the Indian Regional Navigation Satellite System (IRNSS), consider the following statements: (UPSC-2018)

1. IRNSS has three satellites in geostationary and four satellites in geosynchronous orbits.
2. IRNSS covers the entire India and about 5500 sq. Km beyond its borders.
3. India will have its own satellite navigation system with full global coverage by the middle of 2019.

Which of the statements given above is/are correct?

(a) 1 only
(b) 1 and 2 only
(c) 2 and 3 only
(d) None

Answer: A

Q2. What is the primary function of a microwave cavity in atomic clocks?

(a) Generating atomic vibrations
(b) Trapping caesium atoms
(c) Emitting radiation
(d) Comparing frequencies

Answer: B

MAINS PRACTISE QUESTION

Q1. Evaluate the effectiveness of atomic clocks in enhancing the resilience of critical infrastructure against cyber attacks, considering their role in maintaining synchronisation for telecommunications networks, power grids, and financial systems.

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SOLAR PHOTOVOLTAIC CELL MANUFACTURING IN INDIA

THIS ARTICLE COVERS 'DAILY CURRENT AFFAIRS' AND THE TOPIC DETAILS OF "RECENT IMPORT RESTRICTIONS ON SOLAR PV CELL". THIS TOPIC IS RELEVANT IN THE "SCIENCE AND TECHNOLOGY" SECTION OF THE UPSC CSE EXAM.

WHY IN THE NEWS?

Media outlets have extensively covered recent governmental directives aimed at bolstering the domestic manufacturing of solar modules to bolster India's renewable energy sector. These actions are often portrayed as **'import restrictions',** following the Ministry of New and Renewable Energy's (MNRE) March 29 announcement to reinstate its 2021 notification regarding the 'Approved List of Models and Manufacturers of Solar Photovoltaic [PV] Modules', commonly referred to as the ALMM list.

WHAT IS THE ALMM LIST? WHY IS IT BEING REINSTATED?

- The ALMM list comprises **manufacturers eligible for utilization** in various government projects, government-assisted projects, and projects under government schemes and programs.
- However, this notification **was put on hold two years** after its issuance for the past financial year. Although the government did not provide a specific reason for this action, it is believed to have stemmed from concerns raised by renewable power producers.
- These producers had secured sale contracts with the government before the implementation of these rules when solar modules and cells were predominantly imported from China at highly competitive rates. At that time, India's domestic renewable sector was unable to match the sudden surge in demand for solar power production equipment at rates offered by Chinese manufacturers.

The government's decision to reintroduce this regulation is based on the assessment that various measures, such as the **Production Linked Incentive (PLI) scheme, have enhanced the production capacities** of India's domestic sector and improved its price competitiveness to meet local demand. It is important to note that this initiative is aimed at import substitution rather than restricting imports.

STATUS OF SOLAR PV CELLS PRODUCTION IN INDIA

- **India heavily relies on imports** to fulfill its demand for solar cells and modules, primarily sourcing from China and Vietnam. According to data provided by the Minister for New and Renewable Energy in Parliament in February of the previous year, India imported approximately $11.17 billion worth of solar cells and modules over the past five years.
- As of January in the fiscal year 2023-24, data from the Ministry of Commerce's Import-Export division revealed that **China accounted for 53% of India's solar cell imports and 63% of solar PV** module imports. Ratings agency ICRA has estimated that China dominates over 80% of the manufacturing capacity across polysilicon, wafer, cell, and module production.
- In contrast, **India's manufacturing capacity remains relatively low and is mainly concentrated in the final manufacturing stage**. ICRA noted in its November 2023 report that the Production Linked Incentive (PLI) scheme can address this imbalance, with integrated module units expected to emerge in India within the next 2-3 years.

STEPS TAKEN BY INDIA

Over the past five years, India has taken significant steps to reduce its reliance on imports in the solar energy sector.

It all began with the **introduction of the ALMM order** in January 2019, but the issue gained prominence during the COVID-19 pandemic when global supply chains were severely disrupted.

Responding to this challenge, Finance Minister Nirmala Sitharaman unveiled the ₹19,500 crore **PLI scheme in the Union Budget of 2022-23**. The primary objective of this scheme is **to boost domestic manufacturing** across the entire solar supply chain, covering everything from polysilicon to solar modules.

The government also implemented a **high customs duty** of 40% on PV modules and 25% on PV cells. However, these duties were later reduced as the pace of solar capacity additions slowed down. Reuters reported that developers had bid exceptionally low tariffs to secure power purchase contracts, relying heavily on imports of Chinese equipment.

WAY FORWARD:

- **Policy Support**: Implementing policies that provide incentives and support for domestic manufacturing, such as tax breaks, subsidies, and tariff protection. Continuously reviewing and updating regulations to create a conducive environment for investment and growth in the solar PV cells industry.
- **Financial Incentives**: Offering financial incentives such as grants, subsidies, and low-interest loans to encourage investment in solar PV cell manufacturing facilities. This could include the continuation and expansion of schemes like the Production Linked Incentive (PLI) scheme.
- **Research and Development (R&D)**: Investing in R&D to foster innovation and develop indigenous technology for solar PV cell manufacturing. Collaboration between government, academia, and industry can accelerate technological advancements and improve the efficiency and cost-effectiveness of solar PV cells.
- **Infrastructure Development:** Developing infrastructure such as industrial parks and special economic zones dedicated to solar PV cell manufacturing. Providing access to reliable power, water, transportation, and logistics infrastructure can attract investments and support the growth of the industry.
- **Skill Development**: Investing in skill development programs to train a skilled workforce for the solar PV cells industry. Developing specialized training programs and partnerships with educational institutions can ensure a steady supply of qualified professionals and technicians.
- **Market Development**: Promoting domestic demand for solar PV cells through incentives such as net metering, feed-in tariffs, and renewable energy targets. Encouraging the adoption of solar PV systems in residential, commercial, industrial, and utility-scale applications can create a stable market for domestic manufacturers.

FInally, we can learn from China's case, where the Government engaged itself in **hand-holdin approach** to support the Industry by providing Cheap electricity which constitutes almost 40% of the cost. Also, Chinese government policies have prioritized solar PV as a **strategic sector**.

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