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THE HINDU
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Daily News Analysis

The Hindu Important News Articles & Editorial For UPSC CSE

Tuesday, 18 Feb, 2025

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Page 07 : Prelims Fact

Scientists in China reported that the EAST reactor sustained a plasma at 100 million degrees Celsius for 1,066 seconds on January 20, 2025.

- This was a major milestone in the quest for nuclear fusion, surpassing its previous record of 403 seconds in 2023.

Experimental Advanced Superconducting Tokamak (EAST):

- **Location and Operation:** EAST is located in Hefei, China, and is operated by the Hefei Institutes of Physical Science, Chinese Academy of Sciences.
- **Purpose:** It serves as an experimental nuclear fusion reactor to test and refine technologies for the ITER megaproject.
- **Design Features:** EAST is the world's only tokamak reactor with both toroidal and poloidal superconducting magnetic fields, ensuring better plasma confinement.
- **Temperature Milestones:** On January 20, 2025, it sustained a plasma at 100 million°C for 1,066 seconds, setting a new world record.
- **Fusion Process:** It uses magnetic confinement to hold deuterium-tritium plasma and facilitate fusion reactions.
- **Challenges:** EAST has not yet achieved ignition, meaning It does not generate more energy than it consumes.
- **Significance:** Its advancements contribute to the global effort in achieving commercial nuclear fusion, a potential clean energy source.

China's EAST reactor keeps the fire of magnetic fusion burning

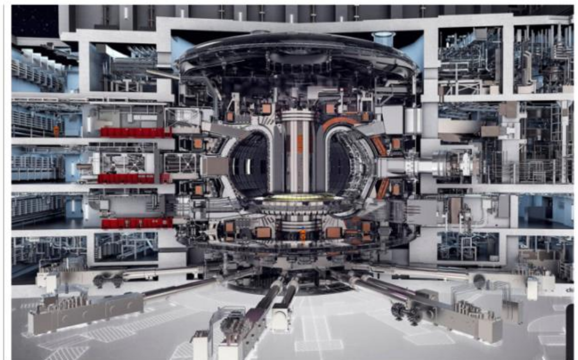
EAST is a testbed reactor for ITER, an international megaproject in which six countries are working together to build a tokamak to sustain nuclear fusion. EAST's successes are important for ITER's future because the latter has come under criticism for its delayed timelines and cost overruns

Shamim Haque Mondal

On January 20, Chinese scientists reported that they were able to maintain a plasma at a temperature of 100 million degrees C for about 1,066 seconds in a nuclear fusion reactor called the Experimental Advanced Superconducting Tokamak (EAST).

In 1938, physicists Otto Hahn and Fritz Strassmann found that energy is produced when the nucleus of an atom breaks apart, a process that Lise Meitner and Otto Frisch explained a year later as a process called "fission." Only four years later, physicists used this principle to build and operate the world's first reactor with a sustainable nuclear fission reaction.

By this time physicists also knew that energy is also produced when two atomic nuclei fuse together, a process called fusion. Nuclear fission produces harmful radioactive waste whereas nuclear fusion doesn't. This is why developing a nuclear fusion reactor has become an important technological goal for a world keenly interested in new sources of clean energy.



An exploded view of the ITER nuclear-fusion facility. A human figure in orange is shown just below the image's centre for scale. The tokamak is visible at the centre, with the D-shaped cross-section. OAK RIDGE NATIONAL LABORATORY

The tritium problem

The problem is the amount of energy required to start and sustain a fusion reaction. A nuclear fission reaction can be kicked off by shooting neutrons of suitable energy at the atoms of unstable nuclei like uranium. For fusion to occur, however, the nuclei need to be exposed to a temperature of at least 100 million degrees C.

The lightest nucleus in nature is of hydrogen, consisting of a single proton. An isotope of hydrogen called deuterium has one proton and one neutron in its nucleus. The nucleus of another isotope called tritium has one proton and two neutrons. Deuterium-deuterium fusion requires a higher temperature to begin than deuterium-tritium fusion. This is because the extra neutron in the tritium nucleus helps overcome the repulsion of like-charges between the protons.

The fusion of a deuterium and a tritium nucleus creates a non-radioactive helium-4 nucleus, a neutron, and 17.6 MeV of energy, which is significant. The neutron can be directed to a blanket of materials surrounding the reactor that capture it and release more heat.

While deuterium is abundant in seawater, there are no natural deposits of tritium and it is very hard to produce. At present it is mostly created as a by-product in heavy-water fission reactors in Canada, India, and South Korea.

The temperature problem

Yet another challenge for nuclear fusion is the temperature. For two nuclei to fuse, two things need to happen: the like-charges in the nuclei (due to the protons) need to be overcome, then the particles need to come within around 1 femtometre (fm) of each other so they can bond with each other using the strong nuclear force.

This force is the strongest fundamental force in nature and is responsible for keeping protons and neutrons together in the nuclei of atoms. But on the flip side, it only acts across very short distances: 1 fm is roughly one-fourth the width of a carbon nucleus. This is why the nuclei need to be heated to such high temperatures: to give them enough energy to overcome their repulsion and get so close to each other.

There are different reactor designs to achieve nuclear fusion by meeting these conditions. One set of designs involves the use of a tokamak – a donut-shaped vessel where the nuclei are confined, like in a cage, and made to fuse.

A magnetic cage

Inside the vessel, a deuterium gas is exposed to about 20 million degrees C, when matter exists in the plasma state. The charged particles are stripped from their respective atoms and float around freely. Next, the particles are exposed to a very strong magnetic field that acts like an invisible net, trapping the particles along the field lines. This method is called magnetic confinement.

Engineers prefer to use electromagnets – special materials that generate a magnetic field when a current is passed through wires coiled around them – to create these fields because the field strength only depends on the amount of current in the wires. These wires are also superconducting: they can carry electric current with zero resistance if they are cooled to a very low temperature, which is achieved by blanketing them with liquid nitrogen or helium.

Inside EAST, both toroidal and poloidal magnetic fields are generated by superconducting electromagnets. It is currently the world's only tokamak with this feature. Toroidal magnetic fields flow around the donut-shaped reactor while poloidal fields flow through its centre. Together, they keep the particles within from drifting into the vessel's walls and collapsing the plasma. Instead they move in a spiral pattern through the vessel, with opportunities to collide with each other and fuse.

The poloidal field also induces an electric current in the plasma. When parts of the plasma resist the flow of this current, heat is produced, adding to the energy required to achieve fusion.

Series of records

Through the years, EAST has been setting a series of records and validating the technologies used to achieve them. It was the first tokamak to sustain a plasma in high-confinement mode at around 50 million degrees C for more than 60 seconds in 2016 and for more than 100 seconds in 2017. In 2023, EAST achieved the world's first steady-state high-confinement plasma for 403 seconds – a world record that it broke on January 20, 2025, by sustaining a plasma for 1,066 seconds. For this achievement, operators provided twice the thermal power to EAST as they did for the 2023 feat, allowing the plasma to remain stable for longer.

At present, EAST isn't producing electricity. In fact, it is yet to reach a milestone called ignition: meaning it doesn't produce enough heat for more fusion reactions to occur, a.k.a. become self-sustaining. To produce usable electricity, a tokamak needs to maintain millions of degrees C for at least a few hours.

A nuclear fission reaction can be kicked off by shooting neutrons of suitable energy at the atoms of unstable nuclei like uranium. For fusion to occur, however, the nuclei need to be exposed to a temperature of at least 100 million degrees C

EAST is a testbed reactor for ITER, an international megaproject in which six countries around the world, including India, and the European Union are working together to build a tokamak that will sustain nuclear fusion that releases more energy than that required to sustain the plasma.

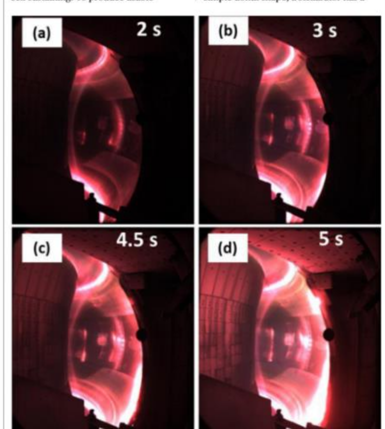
A need for alternatives

Crucially, EAST's successes are important for ITER's future because the latter has come under criticism for its delayed timelines and cost overruns. With a bill already upwards of euro 18 billion, ITER has been called the most expensive science experiment in history – at a time in which the high cost of doing cutting-edge science has put off many governments from pursuing it.

Some research groups have also been trying to achieve nuclear fusion using methods that require fewer (but still considerable) resources. For example, one alternative to achieving magnetic confinement is a device called a stellarator. Whereas a tokamak has a simple donut shape, a stellarator has a more twisting design that is harder to build and operate. But its advantage is that it does away with the need for a poloidal magnetic field to achieve a twisting magnetic field inside the vessel. Instead it achieves the desired field configuration using a more complicated architecture of external magnets.

Other designs do away with magnetic confinement altogether. In one technique, for example, a pellet of deuterium and tritium is hit with laser beams of extreme power.

Whereas a deuterium nucleus has one proton and one neutron, a tritium nucleus has one proton and two neutrons. When the beams strike the pellet, the energy causes the nuclei to compress and fuse, releasing more energy. The heat from the reactions could then be diverted to a pool of water, generating steam that moves a turbine and produces electricity.



A fast visible wavelength camera's images of plasma inside the EAST Tokamak at various times.
DOI:10.1088/1741-4326/AA626C

In the light of lasers

In 2008, scientists at the Lawrence Livermore National Laboratory in the US began a project called 'Laser Inertial Fusion Energy' (LIFE) to test this idea. While they were able to develop lasers with the requisite power, the fusion output was found to be much lower than they had predicted. The project was cancelled in 2013 after it became clear it couldn't achieve ignition.

But another project at the same institute, called the National Ignition Facility (NIF), achieved the milestone in 2022. At the NIF, a system of 192 high-power lasers delivers 2.05 megajoules (MJ) of energy towards a small cylindrical capsule at the centre of the room. This capsule, called a hohlraum, is made of uranium-238 and plated with gold. It's about 2 mm wide. It contains a thin shell made of a polymer inside which deuterium and tritium atoms are placed in a frozen or gaseous state.

When electromagnetic radiation from the lasers enters the hohlraum, it strikes the inner wall and produces X-rays. Over a short span of time, the nuclei are bombarded by X-rays from all directions inside the hohlraum. Eventually they compress the fuel sample in a symmetric way and heat it up rapidly to around 100 million degrees C. In 2022, the NIF said it had used this technique to produce 3.15 MJ of energy, crossing the breakeven point.

On the other hand, ITER was launched in 2007 and is expected to produce its first plasma only in 2033, and over time also devour the world's meagre tritium reserves. The desperate need for sources of clean energy means achieving nuclear fusion may just be a matter of time, especially if governments continue to trust the scientists working on the required technologies. But which technology gets it over the line – magnetic, inertial or something else – remains to be seen. Some private sector enterprises are also beginning to enter the mix.

While the NIF has demonstrated a proof-of-concept ignition, EAST is keeping tokamaks in the hunt with its large scale and steady progress.

(Shamim Haque Mondal is a researcher in the Physics Division, State Forensic Science Laboratory, Kolkata. shamimmondal709@gmail.com)

Comparison of Nuclear Fission and Fusion

Nuclear fission and fusion are two different nuclear reactions used to release energy, but they operate through distinct processes. Here's a comparison of the two:

1. Definition

- **Fission:** Fission is the process in which the nucleus of a heavy atom (like uranium-235 or plutonium-239) splits into two smaller nuclei, along with a few neutrons and a large amount of energy.
- **Fusion:** Fusion is the process where two light atomic nuclei, usually isotopes of hydrogen (like deuterium and tritium), combine to form a heavier nucleus, releasing energy in the process.

2. Energy Released

- **Fission:** Fission releases a significant amount of energy per reaction. The energy comes from the binding energy difference before and after the splitting.
- **Fusion:** Fusion releases even more energy per reaction than fission. In fact, fusion is the source of energy in stars, including our Sun.

3. Byproducts

- **Fission:** The byproducts of fission are typically smaller nuclei (fission fragments) that are often radioactive and can pose long-term disposal and environmental challenges.
- **Fusion**: The main byproducts of fusion are usually harmless, such as neutrons and isotopes like helium, which is non-radioactive and safe.

4. Fuel

- **Fission:** Fission typically uses heavy isotopes of elements like uranium-235 or plutonium-239 as fuel. These materials are relatively rare and need to be enriched to increase their fissionability.
- **Fusion:** Fusion typically uses isotopes of hydrogen, such as deuterium and tritium, which are more abundant. Deuterium can be extracted from seawater, making fusion fuel more widely available.

5. Control and Efficiency

- **Fission:** Fission can be controlled relatively easily using control rods (which absorb neutrons) in nuclear reactors. Fission reactions can be sustained at a stable rate for energy production.

- **Fusion:** Fusion reactions are much harder to control because they require extremely high temperatures (millions of degrees) to overcome the repulsion between positively charged nuclei. This has made sustained and controlled fusion energy production difficult to achieve.

6. Safety and Risks

- **Fission:** Fission reactions can be dangerous due to the production of radioactive waste and the potential for catastrophic accidents (e.g., Chernobyl, Fukushima). Additionally, there is the risk of nuclear weapons proliferation.
- **Fusion:** Fusion is considered much safer in terms of radiation risk, as it doesn't produce harmful long-lived radioactive waste. However, the technology to achieve controlled fusion has not yet been fully realized for practical energy production.

7. Technological Challenges

- **Fission:** Fission has been well-developed and is in widespread use for energy production, with nuclear power plants around the world.
- **Fusion:** Fusion, while potentially offering a more sustainable and cleaner energy source, faces many technical hurdles, particularly in maintaining the extreme conditions required for fusion (high temperature and pressure).

8. Waste and Environmental Impact

- **Fission:** The nuclear waste from fission is highly radioactive and must be carefully managed for thousands of years.
- **Fusion:** Fusion produces little to no long-lived radioactive waste, making it a much cleaner alternative if it becomes viable.

9. Current Use

- **Fission:** Fission is widely used in nuclear power plants and is a primary source of low-carbon electricity in many countries.
- **Fusion:** Fusion has not yet been used for practical energy generation, though experimental reactors like ITER (International Thermonuclear Experimental Reactor) are working toward making fusion a reality.

Page 11 : Prelims Fact

On 18 February 2025, we will observe the 139th anniversary of the passing of Ramakrishna Paramahamsa (1886).

THE DAILY QUIZ

Please send in your answers to dailyquiz@thehindu.co.in

A quiz on Ramakrishna Paramahamsa on the Hindu mystic's birth anniversary

V.V. Ramanan

QUESTION 1
What was the birth name of Ramakrishna Paramahamsa and in which year was he born?

QUESTION 2
What important role did Bhairavi Brahmani play in Ramakrishna Paramahamsa's life?

QUESTION 3
Name the wife and spiritual consort of Ramakrishna Paramahamsa who was 17 years younger than him.

QUESTION 4
How do we better know Narendranath Dutta who is considered Ramakrishna's most famous disciple?

QUESTION 5
In which famous temple did Ramakrishna start his career as a priest?

QUESTION 6
What is the Ramakrishna Math's emblem said to symbolise?

QUESTION 7
Which affliction caused the demise of Ramakrishna?

Visual question:
What is the name of the place where the headquarters of the Ramakrishna Mission is located? FILE PHOTO

Questions and Answers to the previous day's daily quiz: 1. The reason the Nobel Prize for ICRC was delayed in 1944. **Ans: The Norwegian Nobel Committee decided that none of the nominations met the criteria outlined in Alfred Nobel's will**
2. This book proved decisive in the formation of the ICRC. **Ans: *A Memory of Solferino***
3. The Assembly is the governing body of the ICRC and all its members must be ____ nationals. **Ans: Swiss**
4. The ICRC has called this event its greatest failure. **Ans: Holocaust at Auschwitz**
5. The ICRC has come under criticism several times in the recent past from the President of this country. **Ans: Ukraine**
Visual: The reason the Ottoman Empire used this symbol instead of the Red Cross. **Ans: They believed that the cross would alienate Muslim soldiers**
Early Birds: ViswanadhaRao Batchu| Anil Warrier| Arvind Tillway

About Ramakrishna Paramahamsa:

- **Birth Name and Year:** Ramakrishna Paramahamsa was born as Gadadhar Chattopadhyay in 1836.
- **Role of Bhairavi Brahmani:** Bhairavi Brahmani was a spiritual teacher who guided Ramakrishna in his spiritual practices and played a significant role in his spiritual awakening.
- **Wife and Spiritual Consort:** His wife and spiritual consort was Sarada Devi, who was 17 years younger than him.
- **Famous Disciple:** Narendranath Dutta, better known as Swami Vivekananda, was one of Ramakrishna's most famous disciples.
- **Temple of Service:** Ramakrishna began his career as a priest at the Dakshineswar Kali Temple in Kolkata.
- **Ramakrishna Math's Emblem:** The emblem symbolizes unity of all religions, highlighting the oneness of God in various faiths.
- **Affliction Leading to Demise:** Ramakrishna passed away due to throat cancer in 1886.

Page 11 : GS 2 : Indian Polity

The concept of constitutional morality has become central to many judicial interpretations.

ISTOCKPHOTO

Constitutional morality: the origins and nuances of the concept

Constitutional morality is a civic culture of respect for constitutional forms and offices, along with the vigilant application of public reason, self-restraint and critique. It requires citizens to understand that the constitution's rules are sacred

Saai Sudharsan Sathiyamoorthy

In the recent past, our constitutional courts have embraced the polysemous concept of "constitutional morality" as a tool to interpret and as a test to adjudicate upon the constitutional validity of statutes. Today, it is seen by some as a bulwark to keep a check on the volatility that is attached to public morality, and to others, as a "dangerous weapon". In its judgments in *Navtej Singh Johar versus Union of India* (2018) and *Joseph Shine versus UOI* (2018), the Supreme Court reinvigorated the ancient concept to frame it as an ideal of justice and a "guide (to) the law."

As such, it is not a surprise that constitutional morality and its meaning(s) have become the cynosure of debates on some of the most pressing issues of our time – the rights of sexual minorities, women's entry into temples, the limits of free speech, and the balance between national security and civil liberties. However, amidst these swirling debates of ownership, it is worth revisiting the origins of this evocative but elusive phrase. British classist George Grote's original conceptualisation of the phrase offers a nuanced and constructive path forward for popular political engagement.

Back to the roots

For Grote, whose *A History of Greece* was as much a reflection of the Victorian passion for –and self-identification with – ancient Greece as it was an attempt to champion Athenian democracy from the condescension of its critics such as the Scotsman John Gillies and William Mitford, the democracy at Athens was "one of the most important and prolific events in all Grecian history" and the result of a "rare and difficult sentiment which we may term a constitutional morality." This rare and difficult sentiment was "a paramount reverence for the forms of the constitution". This involves adherence to both the form and procedure of the constitution to resolve disputes that arise, with the actions of citizens being only subject to the rule of law, unrestrained by the "censure of those very authorities as to all their public acts." Grote claimed that eloquently drafted rules and procedures were insufficient to ensure the longevity of a constitution. It required the instillation of "constitutional morality" – a civic culture of respect for constitutional forms and offices, along with the vigilant application of public reason, self-restraint and critique. Pertinently, it requires the creation of confidence in citizens that the constitution's rules are sacred even to those with different political views, even during heated political debates.

It is this civic culture that Dr. Ambedkar spoke of during his famous invocation of the concept in his speech 'The Draft Constitution', delivered on November 4, 1948. Dr. Ambedkar believed that democracy in India would have to learn the ideal of constitutional morality, as it was not a "natural sentiment" to a polity and had to be "established and diffused" so as to ensure a free and peaceable democracy.

However, Dr. Ambedkar, who had mainly invoked Grote to stress on the necessity of providing for even minor administrative details in the Constitution, knew that the birth of such constitutional morality was a rarity in history. He knew that it was "perfectly possible to pervert the Constitution, without changing its form by merely changing the form of the administration and to make it inconsistent and opposed to the spirit of the Constitution."

For him, self-restraint was a prerequisite for preserving freedom under a properly constituted government.

Commitment with critique

This interpretation of constitutional morality emphasises on the fact that adherence to the Constitution must be non-transactional and that it cannot be based on an expectation that it would result in outcomes that reflect the value judgments or beliefs of a particular group of citizens. In other words, it demands the acceptance of a result that is vastly different from what these citizens had envisioned. The framework's genius lies in how it navigates between competing imperatives. It demands respect for constitutional forms while enabling critique of their operation. It requires following established processes while allowing those processes to be questioned and reformed.

Most crucially, it sees the Constitution not as demanding blind devotion but as a framework for managing differences through agreed-upon procedures. This is in stark contrast to the ideal of Jürgen Habermas' constitutional patriotism, which designates political allegiance as solidarity born of the norms and values of the constitution. While the former stresses on the liberalising effect of moderate cultural nationalism, the latter often pushes forward a form of singular-identity democracy purportedly constructed on the principles espoused in the constitution.

Constitutional morality's emphasis on process is especially important given the present rhetoric. It shows how we can maintain constitutional commitment without descending into fundamentalism. It points toward a more mature constitutionalism that balances reverence and reform, stability and change. One should not forget the fact that the founding fathers also saw the promulgation of the constitution as allegiance to constitutional form.

Saai Sudharsan Sathiyamoorthy is advocate, Madras High Court.

- It highlights the balance between respect for constitutional forms and the need for reform.

Embracing Constitutional Morality in Courts

- Constitutional courts have recently adopted the concept of "constitutional morality" to interpret and assess the validity of laws.
- Some see it as a check on the changing nature of public morality, while others view it as a "dangerous weapon."
- The Supreme Court has emphasized constitutional morality as a guiding principle in cases related to sexual minorities' rights, women's entry into temples, free speech, and the balance between national security and civil liberties.

Historical Origin of Constitutional Morality

- The term was originally conceptualized by a British scholar George Grote who focused on the importance of adhering to both the forms and procedures of a constitution.
- He argued that the constitution's survival depends not just on written rules but also on citizens' respect for these rules, regardless of political differences.
- A civic culture that honors constitutional forms is necessary for a constitution's long-term effectiveness in resolving conflicts and disputes.

Dr. Ambedkar's Perspective on Constitutional Morality

- In his speech on the Draft Constitution, Dr. Ambedkar emphasized that India's democracy would need to cultivate constitutional morality, as it wasn't naturally ingrained in the polity.
- He believed that for a democracy to thrive, constitutional morality must be established and spread.
- He also warned that it was possible to undermine the Constitution by altering administrative practices, which could contradict its spirit.

Balance Between Commitment and Critique

- Constitutional morality emphasizes the importance of following constitutional processes while still allowing for critique and reform.
- It is not about blind loyalty to the Constitution but managing differences through established procedures.
- This approach promotes a mature form of constitutionalism that balances reverence for the Constitution with the ability to adapt and reform it, ensuring a stable yet flexible system of governance.

UPSC Mains Practice Question

Ques : Examine the role of "constitutional morality" in contemporary judicial decision-making, highlighting its implications for rights-based issues and democratic governance in India. **(150 Words /10 marks)**

Page 13 : GS 2 : International Relations

- Germany, once a leader in global trade and export growth, has experienced a significant economic slump over the past five years, marking a remarkable shift in its economy.

Germany's economy is in the dumps. Here are the reasons

Associated Press
FRANKFURT

Germany hasn't seen significant economic growth in five years. It's a stunning turnaround for Europe's biggest economy, which for much of this century had expanded exports and dominated world trade in engineered products like industrial machinery and luxury cars.

So what happened? Here are the reasons for Germany's ongoing economic slump:

Moscow's decision to cut off natural gas supplies to Germany in the wake of Russia's invasion of Ukraine dealt a severe blow. For years, Germany's business model was based on cheap energy fueling production of industrial goods for export.

In 2011, then-Chancellor Angela Merkel decided to hasten the end of nuclear power use in Germany while relying on gas from Russia to bridge the gap as the country moved away from coal generation and toward renewable energy. Russia was then considered to be a reliable energy partner; warnings to the contrary from Poland and the U.S. were dismissed.

When Russia discontinued the flow, prices in Germany skyrocketed for gas and for electricity generated from gas, both key costs for energy-intensive industries such as steel, fertilizer, chemicals and glass. Germany had to turn to liquefied natural gas, or LNG, super-cooled and imported by ship from Qatar and the U.S. LNG costs more than pipeline gas.

Red tape: Lengthy approval procedures and paperwork are a drag on Germany's economy. REUTERS

Renewable sources of energy haven't scaled up fast enough to fill the gap. Homeowner and regional resistance to turbines slowed wind energy growth. Infrastructure to transport hydrogen as a replacement fuel for steel furnaces remains mostly on the drawing board.

For years, Germany benefited from China's entry into the global economy– even as other developed countries lost jobs to China. German companies found a massive new market for industrial machinery, chemicals and vehicles. Through the early and mid 2010s, Mercedes-Benz, Volkswagen and BMW reaped fat profits selling into what became the world's largest car market.

Turning tables

At the time, Chinese companies produced items like furniture and consumer electronics that didn't compete with Germany's core strengths. Then, manufacturers in China started making the same things that Germans did. State-subsidized Chinese solar panels wiped out Germany's makers. The government in Beijing has ramped up efforts to promote and subsidize manufacturing for export. The resulting goods–steel, machinery, solar panels, electric vehicles and EV batteries–now compete with German goods on export markets.

Germany, the most auto-centric of the European Union economies, had the most to lose from China's export-oriented industrial policy. In 2020, China was not a net exporter of vehicles; by 2024, it was exporting 5 million a year. Germany's net exports fell by half over the same period, to 1.2 million cars. Chinese factory capacity is estimated at 50 million vehicles a year, roughly half of global demand.

Germany grew complacent during the good times and put off investing in long-term projects such as rail lines and high-speed internet. The government balanced its budget and sometimes ran surpluses off the tax revenue from a booming economy.

German companies are having trouble finding workers with the right skills, from highly trained IT workers to daycare providers, senior care workers and hotel staff members. In a German Chamber of Commerce and Industry survey of 23,000 firms, 43% of companies said they couldn't fill open positions. The response rose to 58% for companies with more than 1,000 workers. And lengthy approval procedures and too much paperwork are a drag on the economy, according to German economists.

Energy Dependence and Crisis

- Germany's economic model relied on inexpensive natural gas, crucial for its industrial production and exports.
- A major shift occurred when the country phased out nuclear power in 2011 and depended on Russian gas as a bridge. When Moscow cut off supplies following the invasion of Ukraine, gas and electricity prices skyrocketed, severely impacting energy-intensive industries like steel, chemicals, and glass manufacturing.

Transition to Renewable Energy

- The move away from nuclear and coal toward renewable energy was not fast enough.
- Resistance to wind turbines from homeowners and local communities delayed the growth of renewable energy sources.
- Infrastructure for alternative fuels, such as hydrogen for industrial use, remains mostly undeveloped, leaving a significant energy gap.

Competition from China

- For years, German industries thrived on exports to a booming Chinese market.

- However, state-subsidized Chinese companies have now entered the same industrial sectors, producing machinery, solar panels, and vehicles.
- This competition has reduced Germany's export dominance and dramatically cut its net vehicle exports.

Delayed Investments and Labor Shortages

- During prosperous times, Germany postponed investments in long-term projects like rail lines and high-speed internet.
- Companies face significant labor shortages, with many reporting difficulties in filling skilled positions.
- Excessive bureaucracy and lengthy approval procedures further hinder economic growth.

UPSC Mains Practice Question

Ques: Analyze the factors contributing to Germany's economic stagnation in recent years. What lessons can India draw from Germany's economic challenges for its own growth trajectory? (150 Words /10 marks)

In News : Matsya-6000

- India's Fourth-Generation Deep-Ocean Submersible, Matsya-6000, successfully completed wet testing, marking a key milestone in ocean exploration capabilities.

About Matsya-6000:

- **Project Overview:** Matsya-6000 is a deep-ocean human submersible developed under India's Deep Ocean Mission by the Ministry of Earth Sciences.
- **Purpose:** It is part of the Samudrayan Project aimed at enhancing ocean exploration capabilities.
- **Design:** The submersible features a 2.1-meter diameter spherical hull designed to carry three people.

Key Features:

- Main ballast system for diving.
- Thrusters for movement in all directions.
- Battery bank for power.
- Syntactic foam for buoyancy.
- Power distribution, control hardware, and underwater navigation systems.

Lighten the pollution burden of thermal power States

In its first updated Nationally Determined Contribution under the Paris Agreement to United Nations Framework Convention on Climate Change (UNFCCC) in August 2022, India has committed to first, adopting a climate-friendly and cleaner path to economic development; second, reducing the emissions intensity of its GDP by 45% by 2030 from the 2005 level, and third, achieving about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030 along with other six commitments. Currently, thermal power has the dominant share in India's electricity basket. Under the new regime, thermal power will also have a 50% share.

Amarendra Das

is an Associate Professor at the Department of Science and Technology Centre for Policy Research on Energy Transition, National Institute of Science Education and Research (NISER) Bhubaneswar, an autonomous institution under the Department of Atomic Energy, Government of India

Naneshwar Jagat

is a PhD scholar at the School of Humanities and Social Sciences, National Institute of Science Education and Research (NISER) Bhubaneswar

Thermal power producing States need to be well compensated for bearing the burden of pollution while supplying electricity to power consuming States

An agent of emissions

Thermal power production results in a huge amount of carbon emission. The power producing States bear the burden of all this pollution to provide electricity to the consuming States. So, who should pay for the pollution burdens of thermal power plants? This article looks at thermal power production under the central sector and recommended compensation mechanisms for thermal power producing States.

India has a total installed capacity of 4,56,757 MW in which the central sector has 22.9% share, the State sector has 23.7% and the private sector, a 53.4% share. Out of the total electricity generation capacity from thermal power plants (2,37,268.91 MW), private sector power plants have a capacity of 85,899.095 MW (36.20%), the State sector has 75,991.905 MW (32.03%), and the central sector has the capacity of 75377.91 MW (31.77%). Central sector power plants which are located in several States, have 31.77 % of the total electricity generation capacity. NITI Aayog data show that India accounts for 20,794.36 kg of carbon emission from electricity generation.

According to the Ministry of Coal, Government of India (April 1, 2023), the total reserves of coal in India are 378.21 billion tonnes, of which Odisha alone accounts for 94.52 billion tonnes. Around 59.12% of the total energy supply in India is from coal. In India, around 73.08% (11,80,427.19 million units) and 1.48% (23,885.04 million units) of electricity are generated from coal, oil and natural gas, respectively, in 2022-23. Thus, the thermal power sector remains a major contributor to carbon emissions in India.

According to the Central Electricity Authority (CEA), Maharashtra had the highest non-renewable electricity generation capacity (31,510.08 MegaWatt or MW), followed by Uttar Pradesh (26,729.374 MW) and Gujarat (26,073.41 MW) in 2022-23. Rajasthan had the highest renewable electricity generation capacity in India at 22.398.05 MW of installation capacity. Despite having the highest electricity generation capacity, some States consume more than their generation.

Thermal electricity generation by the National Thermal Power Corporation (NTPC) also shows that the States producing the maximum electricity do not consume most of it – Uttar Pradesh, Odisha, and Chhattisgarh only consume 40%, 38.43%, and 29.92%, respectively, of the electricity produced by NTPC in their respective State. Gujarat is the biggest consumer of NTPC produced electricity (4,612 MW) despite the State's meagre generation of 17.7 MW by the NTPC. Gujarat and Maharashtra purchase electricity from different States from what is produced by the central sector and in other sectors.

Thermal electricity-producing States bear a disproportionate pollution burden when compared to the consuming State. Data from the CEA show that Tripura has the highest (96.96%) share of thermal power in the total electricity generation capacity, followed by Bihar (95.57%), Chhattisgarh (94.35%), Jharkhand (92.69%), Delhi (87.96%), West Bengal (87.72%), and Uttar Pradesh (81.84%). Not all the electricity generated in the State is being utilised inside the State. Bihar sold 16,529.62 MW of electricity in 2022-23.

NITI Aayog data show that Chhattisgarh is the highest net seller of electricity among all Indian States with 535.29 MW in 2022-23, followed by Madhya Pradesh (379.19 MW), Himachal Pradesh (153.43 MW), Rajasthan (135.14 MW), Odisha (95.40 MW) and Meghalaya (55.22 MW). These are the States where the central sector produces more thermal electricity and sells to others. Gujarat is the highest importer of electricity (528.17 MW), followed by Haryana (212.63 MW), Maharashtra (187.50 MW), Delhi (162.97 MW), Punjab (160.82 MW), and Tamil Nadu (128.37 MW) in the year 2022-23.

No compensation

India's electricity and environmental regulatory structures do not compensate States that generate electricity from central sector thermal power plants. Therefore, net exporting States of central sector power producers bear the burden of all pollution, and net importing States enjoy clean electricity. Central sector thermal power is mainly produced in coal-rich States such as Jharkhand, Chhattisgarh, and Odisha. Even though coal-rich States produce the maximum thermal electricity, per capita electricity consumption remains substantially lower than other economically better-off States. Thus the coal-rich States face a new form of resource curse.

Under the Corporate Social Responsibility (CSR) scheme, although thermal power-producing companies spend a small amount of funds to develop the periphery, this is far from compensating for environmental damage. The National Clean Energy and Environment Fund was created to promote renewable energy, and to assist States with cleaner technology.

Electricity is a Concurrent subject (Entry 38 of List III of the Seventh Schedule of the Constitution), which allows both the central and State governments to legislate on electricity matters. States are constitutionally permitted to levy taxes on electricity consumption and sale, but not on its generation. Similarly, the central government does not impose any specific tax on electricity production.

In October 2023, the Ministry of Power issued a directive that prohibits State governments from levying additional taxes or duties on electricity generation, clarifying the constitutional boundaries. As a commodity, electricity is exempt from Goods and Services Tax (GST). Services related to electricity transmission or distribution by utilities are also GST-exempt. Therefore, the consuming States receive the electricity duty levied on electricity sales. The electricity-producing States do not get any tax revenue but only the burden of pollution.

A formulation to pursue

Electricity produced and consumed within the State internalises all the benefits and costs. However, when the electricity is produced in one State and consumed in another, it creates a pure negative externality for the producing State. In such a situation, the States producing thermal power under the central sector should be compensated for all the electricity consumed by other States.

This can be done in two ways. States where central sector power plants are located can tax thermal power generation. Otherwise, the Union government can collect and transfer the generation tax to the producing State. The other mechanism would be a compensation mechanism through the Finance Commission of India. The last three Finance Commissions have recommended a formula to transfer funds to States under environmental and climate change concerns. This has been done through grants and horizontal devolution criteria. The Sixteenth Finance Commission should seriously consider India's international climate commitments and develop a fiscal road map to achieve those goals. Whatever the mechanism, thermal power-producing States under the central sector should be compensated adequately for carrying the burden of other States' electricity consumption.

GS Paper 03 **Environment – Environmental pollution and degradation**

PYQ: (UPSC CSE (M) GS-1 2015: **Mumbai, Delhi and Kolkata are the three megacities of the country but the air pollution is a much more serious problem in Delhi as compared to the other two. Why is this so? (200 words/12.5m)**

UPSC Mains Practice Question: **Practice Question: Discuss the environmental and fiscal challenges faced by thermal power-producing States in India. Suggest measures to ensure equitable compensation for pollution burdens. (150 Words /10 marks)**

Context :

- Thermal power-producing States bear pollution burdens while supplying electricity to consuming States.
- They lack compensation, creating environmental and economic disparities.

India's Climate Commitments and Energy Sector Overview

- India, under the Paris Agreement, aims to reduce GDP emissions intensity by 45% by 2030 and achieve 50% installed capacity from non-fossil fuel sources.
- Despite these goals, thermal power still dominates India's electricity sector and is expected to retain a 50% share under the new regime.
- The total installed electricity capacity in India is 4,56,757 MW, with contributions from:
  - Private sector: 53.4%
  - State sector: 23.7%
  - Central sector: 22.9%

Contribution of Thermal Power to India's Electricity

- Coal accounts for 59.12% of India's energy supply, with reserves of 378.21 billion tonnes, of which Odisha holds 94.52 billion tonnes.
- In 2022-23, 73.08% of electricity was generated from coal, oil, and natural gas.
- Thermal power is a major contributor to 20,794.36 kg of carbon emissions from electricity generation.

Producing States vs. Consuming States

- According to the Central Electricity Authority (CEA) Maharashtra has the highest non-renewable electricity generation capacity (31,510.08 MW), followed by Uttar Pradesh and Gujarat.
- Rajasthan leads in renewable electricity generation with 22,398.05 MW.
- States producing the most electricity do not necessarily consume most of it. For example:

Uttar Pradesh consumes only 40% of its NTPC-produced electricity.

- Odisha consumes 38.43% of its NTPC-generated power.
- Chhattisgarh uses only 29.92% of what it generates.
- Gujarat is the biggest consumer of NTPC-produced electricity (4,612 MW) despite generating only 17.7 MW itself.

Disproportionate Pollution Burden on Producing States

- States with the highest thermal power share include:
- Tripura (96.96%), Bihar (95.57%), Chhattisgarh (94.35%), Jharkhand (92.69%), Delhi (87.96%), and West Bengal (87.72%).
- These States produce large amounts of electricity but do not consume all of it.

Electricity Trade Between States

- Chhattisgarh is the highest net seller (535.29 MW), followed by Madhya Pradesh and Himachal Pradesh.
- Gujarat is the largest importer of electricity (528.17 MW), followed by Haryana, Maharashtra, and Delhi.
- While some States benefit from buying electricity, others suffer from pollution caused by thermal power production.

Lack of Compensation for Producing States

- India's laws do not provide compensation to States that generate electricity for others.
- Coal-rich States such as Jharkhand, Chhattisgarh, and Odisha produce maximum thermal electricity but have lower per capita electricity consumption.
- However, States cannot tax electricity generation, while consuming States benefit from taxes on electricity sales.

Potential Compensation Mechanisms

- Taxing Thermal Power Generation
  - Producing States could be allowed to levy a tax on electricity generation.
  - Alternatively, the Union government could collect and distribute such a tax to producing States.
- Compensation through the Finance Commission
  - The Finance Commission has previously recommended environmental grants and devolution of funds.
  - The upcoming Sixteenth Finance Commission should design a fiscal roadmap to support thermal power-producing States.

Conclusion

- By implementing these measures, electricity-producing States can be fairly compensated for the pollution burden they bear while supplying power to others.
