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## EDITORIAL ANALYSIS

# From CO<sub>2</sub> to Chemicals: Carbon Capture Is Real, and It Is Not a Licence to Emit

 DOWN TO EARTH

12 July 2026 ·

SCIENCE &amp; TECH ·

GS3

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# From CO<sub>2</sub> to Chemicals: Carbon Capture Is Real, and It Is Not a Licence to Emit

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## THE LIFT LINE

Carbon capture is a mop, and a good one. The trouble begins the moment a country decides that owning a mop is a reason to leave the tap running.

## WHY THIS EDITORIAL MATTERS FOR YOUR EXAM

On July 10, 2026, Adani Enterprises announced a long-term partnership with Dioxycle, a French clean-technology firm, to build what is billed as India's first renewable-powered pilot facility producing formic acid from captured carbon dioxide, using electrically driven chemical manufacturing. It is a pilot, not a plant at scale, and it should be described as such. But it marks a genuine shift: carbon capture and utilisation in India moving from conference slides to steel and concrete. For your exam, this is the entry point into the whole CCUS debate, which sits at the heart of India's net-zero-by-2070 pathway and of every question about hard-to-abate industry.

**GS Paper 3:** conservation and environmental pollution; awareness in the fields of energy and new technology; **indigenisation** (<https://ujjyari.com/vocab/indigenisation/>) of technology; infrastructure and industrial policy; India's commitments on climate change.

For **Prelims**, distinguish the terms carefully. **CCUS** is the umbrella: **capture**, then either **utilisation**, converting CO<sub>2</sub> into a product such as a chemical, a fuel, urea or building aggregate, or **storage**, injecting it into deep saline aquifers or depleted oil and gas reservoirs for permanent sequestration. Utilisation is not automatically **abatement** (<https://ujjyari.com/vocab/abatement/>): if the product is a fuel that is burned, the carbon returns to the atmosphere within weeks, so the durability of storage in the product is what determines the climate benefit. **Formic acid** (HCOOH), used in leather, textiles, rubber, agriculture and as a hydrogen carrier, is a durable-use chemical, which is what makes this pilot interesting. Also hold: India's **net-zero by 2070** pledge announced at COP26; the **Carbon Credit Trading Scheme (CCTS)** notified under the

amended Energy Conservation Act, establishing India's compliance carbon market with the Bureau of Energy Efficiency as administrator, succeeding the PAT scheme; and the **Green Hydrogen Mission**, whose electrolysis-based logic is closely related to the electrochemical route used here.

## BACKGROUND AND CONTEXT

Most of India's emissions can be cut by doing something cheaper: renewables displace coal power, electric vehicles displace petrol, efficiency displaces consumption. A stubborn residue cannot. In steelmaking, carbon is not only the fuel but the chemical reductant that strips oxygen from iron ore. In cement, roughly 60 per cent of emissions come not from the kiln fuel but from calcination, the chemistry of turning limestone into lime, which releases CO<sub>2</sub> no matter what heats the kiln. Refining and some chemicals sit in the same category. These are the hard-to-abate sectors, and for them capture is not one option among several; it is close to the only one that preserves the product.

That is the honest case for CCUS in India, a country that will keep building, and therefore keep making steel and cement, for decades. The Dioxycle route is the electrochemical one: use renewable electricity to drive the reduction of captured CO<sub>2</sub> into a molecule that industry already buys. If the electricity is genuinely additional renewable power, and if the product locks the carbon into durable use, the arithmetic works. Every one of those conditions is an if.

## THE CORE ARGUMENT / ISSUE

### The energy penalty is the central technical fact

Capturing CO<sub>2</sub> from a flue gas at 10 to 15 per cent concentration takes energy, and converting it into a useful molecule takes a great deal more, because CO<sub>2</sub> is a thermodynamically very stable molecule and you are paying to climb back up the hill you burned the fuel to come down. In a conventional amine capture retrofit, the plant's own energy demand can rise by 15 to 30 per cent. If that extra energy comes from the grid and the grid is coal-heavy, a substantial part of the captured carbon is simply re-emitted somewhere else. This is precisely why the "renewable-powered" qualifier in the Adani-Dioxycle announcement is not marketing garnish; it is the load-bearing condition on which the whole climate claim rests.

## Utilisation is only as good as the durability of the product

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| ROUTE                                               | WHAT HAPPENS TO THE CARBON                  | CLIMATE VALUE                              | HONEST VERDICT                                    |
|-----------------------------------------------------|---------------------------------------------|--------------------------------------------|---------------------------------------------------|
| Storage in saline aquifers                          | Locked away for geological time             | High, if monitored for leakage             | Genuine abatement; needs a legal liability regime |
| Enhanced oil recovery                               | Injected to push out more oil               | Often negative in net terms                | Not climate policy; it is oil policy              |
| CO <sub>2</sub> to durable chemicals (formic acid)  | Bound in a product with a long service life | Moderate and real                          | Promising; scale is the open question             |
| CO <sub>2</sub> to building aggregates and concrete | Mineralised, effectively permanent          | High and durable                           | Underrated; deserves policy push                  |
| CO <sub>2</sub> to synthetic fuel                   | Burned again within weeks                   | Near zero, unless it displaces fossil fuel | Useful only as a fuel substitute, not as a sink   |

The table carries the argument. Calling something “utilisation” tells you nothing about whether it helps the climate. Only the residence time of the carbon in the product, and the source of the energy used to make it, do.

## Scale is the humbling number

Global CCUS capacity operating today is measured in the low tens of millions of tonnes of CO<sub>2</sub> a year. India’s annual emissions are of the order of three billion tonnes. Even an ambitious build-out of capture in India would address a modest fraction of the total for a long time. The formic acid market itself, worldwide, is small relative to industrial CO<sub>2</sub> flows. This does not make the pilot pointless, because pilots are how costs come down, but it does mean CCUS cannot be a substitute for the boring, unglamorous, decisive work of decarbonising electricity, transport and buildings.

## The moral hazard

The real danger is political, not technical. Once a country can point to a capture facility, the temptation is to treat every new coal plant and every new blast furnace as provisionally acceptable because capture will arrive later. It usually does not, or it arrives at half the promised capture rate. CCUS must therefore be ring-fenced by rule to the sectors that genuinely cannot abate, and it must never be permitted as a justification for new unabated fossil capacity in sectors where clean alternatives already exist.

## HOW TO THINK ABOUT THIS (ANALYTICAL FRAME)

Use a [mitigation](https://ujjayari.com/vocab/mitigation/) hierarchy, and insist on its order: **avoid, reduce, substitute, capture, offset**. Capture sits fourth, not first. Its legitimate role is the residual, what remains after everything cheaper has been done. The test to apply to any CCUS proposal has three questions, and all

three must be answered yes. Is this sector genuinely hard to abate, or is there a cheaper clean alternative being ignored? Is the energy driving the capture and conversion additional and clean, or is it stealing renewable electricity that would otherwise have displaced coal? Is the carbon locked in for a long enough time to matter, or does it return to the atmosphere within a year? The transferable rule: a technology that removes a symptom must be governed so that it does not license the cause.

## THE DIAGRAM IN WORDS

Hard-to-abate emissions (cement calcination, steel reduction, refining) -> flue gas CO<sub>2</sub> -> capture (an energy penalty of roughly 15-30%, which must be paid with clean power or the abatement is fictitious) -> fork: (a) storage in saline aquifers, durable, needs a legal liability and monitoring regime; (b) utilisation, and here the value depends entirely on the product, formic acid and mineralised aggregate lock carbon in for a long life, synthetic fuel returns it in weeks -> the Adani-Dioxycle pilot takes route (b) with renewable-powered electrochemical conversion -> if scaled and if the power is additional, real abatement in a sector with no alternative -> guard rails: mitigation hierarchy enforced, CCUS confined to hard-to-abate sectors, CCTS carbon price making capture economic, no new unabated fossil capacity justified by a promise of future capture

## WAY FORWARD

- 1 **Price the carbon so capture pays for itself.** Operationalise the Carbon Credit Trading Scheme with a meaningful compliance price and tight sectoral intensity targets, because no capture project is viable while emitting remains free.
- 2 **Ring-fence CCUS to the hard-to-abate.** Restrict public support and carbon-market recognition to cement, steel, refining and chemicals, and explicitly bar the use of CCUS promises to justify new unabated coal power.
- 3 **Legislate a storage and liability regime.** India has no framework governing CO<sub>2</sub> injection, pore-space rights, monitoring or long-term liability for leakage. Without one, storage cannot be financed, and a project developer cannot know what it is signing up to.
- 4 **Set a durability standard for utilisation credits.** Award **carbon credits** (<https://ujjayari.com/terms/carbon-credits/>) under CCTS only in proportion to the residence time of the carbon in the product, so that mineralisation and durable chemicals are rewarded and synthetic fuel is not credited as sequestration.
- 5 **Fund the cost curve honestly.** Support pilots, this one included, through **viability gap funding** (<https://ujjayari.com/terms/viability-gap-funding/>) and public procurement of low-carbon cement and steel, while publishing verified capture rates and energy penalties, so that policy is set by measured

performance rather than by press release.

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## PYQ LINKAGE AND PRACTICE

UPSC has asked about India's climate commitments and net-zero pathway, about energy transition and hard-to-abate sectors, and about the role of new technologies in mitigation. This editorial supplies the vocabulary and the sceptical frame that a good answer on CCUS needs.

**Practice question:** “Carbon capture and utilisation is indispensable for India's hard-to-abate sectors and dangerous as a general climate strategy.” Critically examine, with reference to the energy penalty of capture, the durability of utilisation products and India's net-zero-by-2070 commitment. (250 words, 15 marks)

*Sources: Down To Earth* (<https://www.downtoearth.org.in/>), *Adani Enterprises media release, July 10, 2026* (<https://www.adani.com/newsroom/media-releases/adani-dioxycle-partnership-to-advance-low-carbon-chemical-manufacturing>), *Business Standard* (<https://www.business-standard.com/>)

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