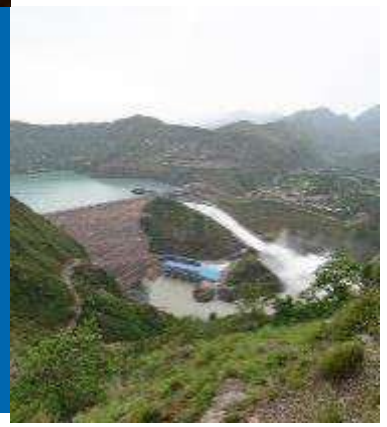
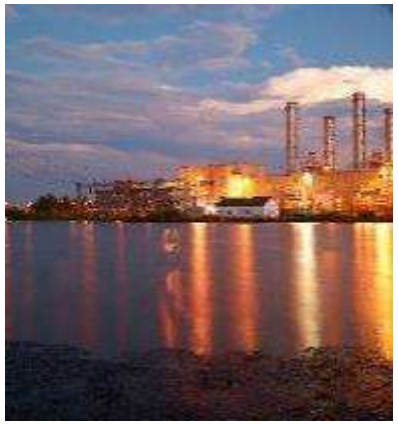


# NTPC Initiative in Greening the Coal


## By Sujay Karmakar

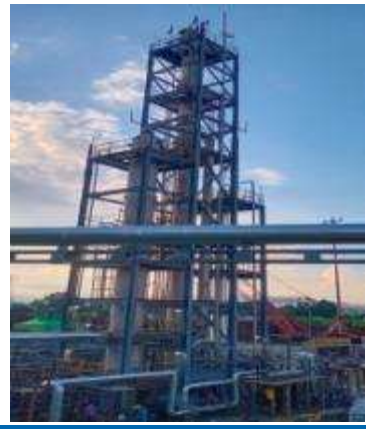
**Chief General Manager- NTPC (NETRA & GC)**


# Outline of the Presentation

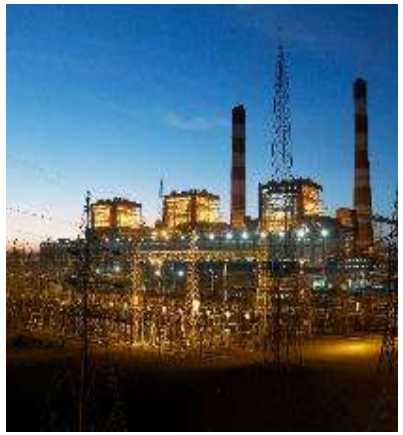
- Introduction to NETRA- R&D Division of NTPC
- India's Commitment to Climate Action Plan
- Clean Energy Transition
- Pathways for Decarbonization of Thermal Generation
- CCUS
- Conclusion





# ABOUT NETRA





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**NTPC ENERGY TECHNOLOGY RESEARCH ALLIANCE**

**R&D DIVISION OF NTPC**

## NETRA VISION

**"Delivering sustainable technology solutions thru applied research and provide advanced scientific services for power sector"**

# NETRA in a Snapshot: Genesis

## Genesis:

Formed in 2009 by merging:

- R&D Centre-Set up in 1981: Testing & Analysis
- Energy Technology: Set up in 2004: Tech. Development

## Credentials:

- **IPR:**
  - ✓ Patents : 79 Nos filed, 55 Nos granted
  - ✓ Copyrights : 30 Nos filed, 25 Nos Granted
- **Governmental Expert Panel:**
  - ✓ NITI Aayog: 7 Nos of committees/panels,
  - ✓ DST: 7 Nos of committees/panels,
  - ✓ CSIR Labs: 2 Nos of 'Research Advisory Council'
- **Certification & Recognition:**
  - ✓ DSIR recognition
  - ✓ Boiler Board certification
  - ✓ 11 Nos of NABL Accredited Laboratories


NETRA Main Building

# NETRA in a Snapshot: NABL Accredited Labs

| NABL Accredited Lab | |
|---|---|
| **SN** | **Lab** |
| 1 | Metallurgy & Material Science Lab |
| 2 | Creep Lab |
| 3 | NDE & Imaging Lab |
| 4 | Corrosion Analysis Lab |
| 5 | Analytical Lab |
| 6 | Water Treatment Tech Lab |
| 7 | Transformer Oil Lab |
| 8 | Tribology & Lub Oil |
| 9 | Coal & Combustion Lab |
| 10 | Environmental Science Lab |
| 11 | Electrical Lab |
| **Advance Process Lab** | |
| 12 | Advance Computing Lab |
| 13 | Computation Fluid Dynamics Lab |
| 14 | Robotics and sensor |
| 15 | Advanced Coal Characterization Lab |


Creep Lab


Metallurgy Lab

# NETRA in a Snapshot: Knowledge Alliance

## Alliances

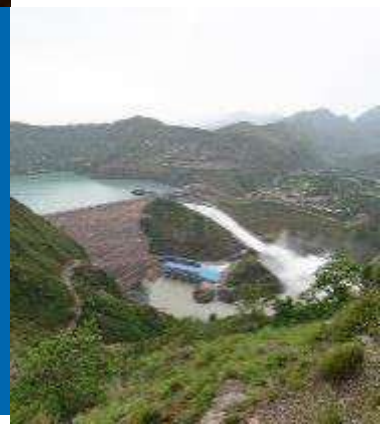
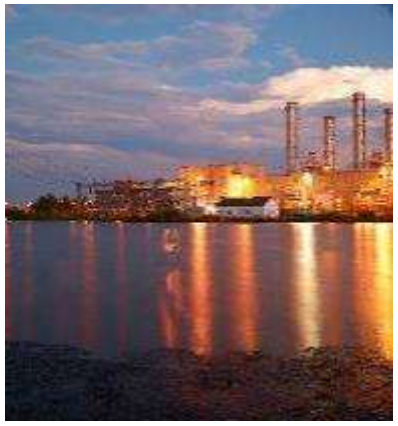
- National Knowledge Alliance: 22
- International Knowledge Alliances: 08
- Collaborations: 09

| INTERNATIONAL ALLIANCES | |
|---|---|
| **DLR Germany** | Solar Thermal Lab |
| **ISE Germany** | Concentrated PV |
| **VGB Germany** | ESP Performance Improvement |
| **Curtin University Australia** | Boiler/Biomass Combustion |
| **NETL USA** | CFD based AI Modeling of Boiler |
| **University of South California, US (*)** | CO2 derived Liquid Fuel |
| **ESB, Ireland (*)** | Green Fertilizer & Fuel |
| (*) MoU in offing | |

| NATIONAL ALLIANCES | |
|---|---|
| IISc, Bangalore | Carbonated Aggregate |
| CSIR – IIP | Methanol Catalyst |
| CSIR – CGCRI | Fiber Optic Sensor for APH FG temp. |
| CSIR – NML | Creep Damage Assess. of High Temp. Headers & Pipe |
| CSIR – SERC | Structure & Corrosion Assessment |
| IGCAR | A-USC |
| NCCBM | Fly Ash to Sand, RCC Structure-Audit and Survey |
| CIPET | Floating Solar |
| GSI | Prep. of DPR for Geo Thermal Resource Assessment |
| IIT B | Solar, Robotics, MEMS, Corrosion, CO2 Capture Amine |
| IIT K | Power Sys., Smart grid, Sensors, |
| IIT D | Simulation & Modeling, AI, CFD, Solar PV |
| IIT Gh | Metal Hydride based H2 Compressor, CO2 Capture Amine |
| MIDHANI | Development of erosion resistant component |
| IOCL | Micro-Algae based CO2 utilization |
| CPRI | Drop Tube Reactor, Fly ash bricks |
| EEC | ESP performance improvement using CFD Modeling |
| IOCL | Micro-Algae based CO2 utilization |
| C-DAC Pune | Computational hardware |
| Jadavpur Univ | Transformer health assessment |
| RGIPT | Hydrogen generation |



# Focus Area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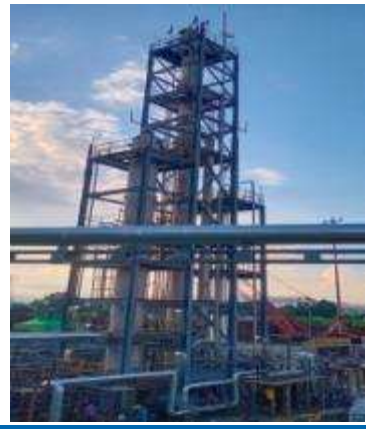
# Focus Area – In the New Paradigm

## Focus Area:

In the new paradigm

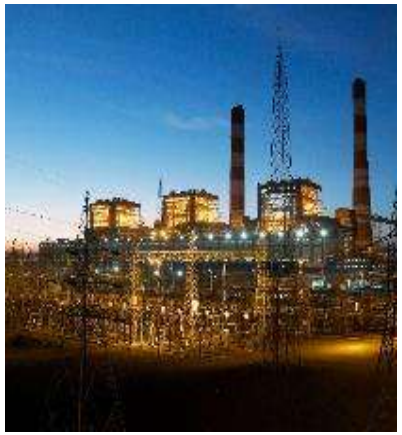

1. Carbon Capture, Utilization & Storage (CCUS)
2. Coal Gasification based Synthetic Fuel & Chemical
3. Energy Storage
4. Green Hydrogen
5. Advanced Scientific Services





# INDIA'S COMMITMENT TO CLIMATE ACTION PLAN





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# Low Carbon Transition - Indian Perspective

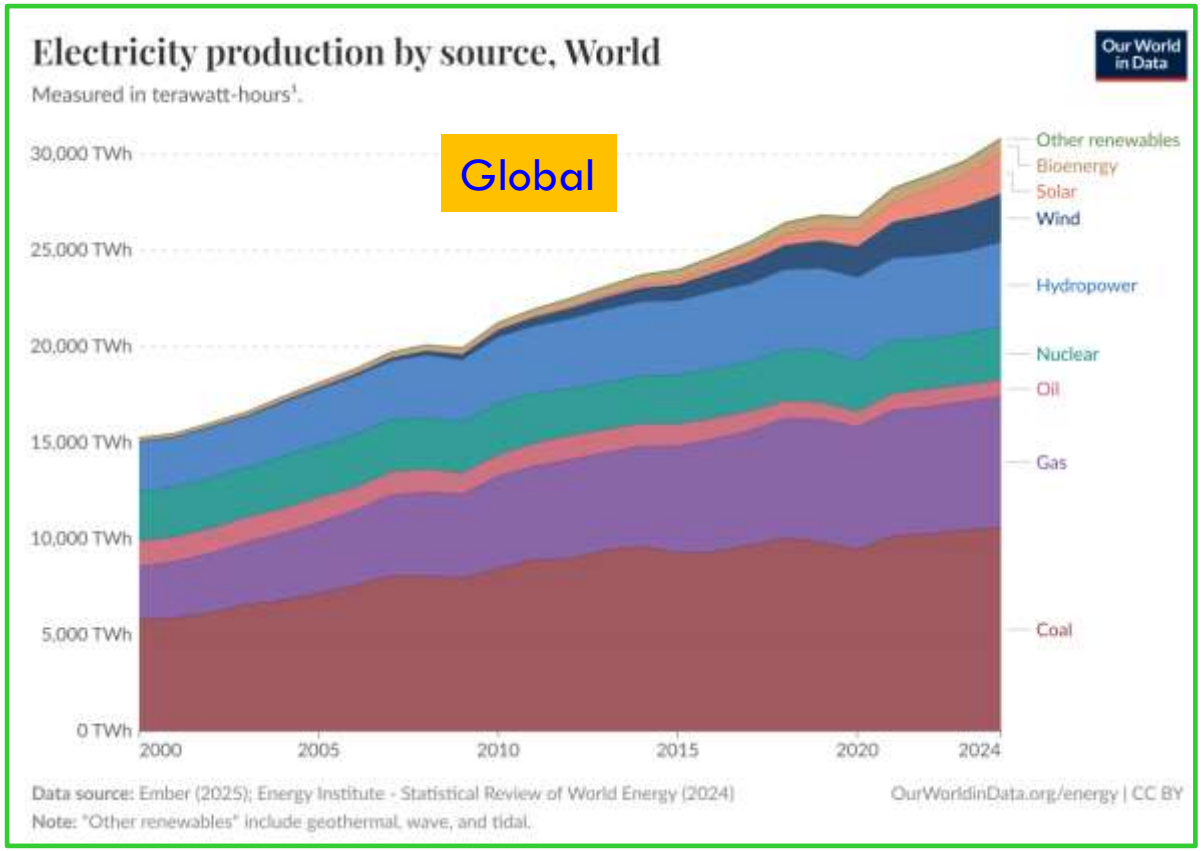
- **Vision given by honorable PM in COP 26 in Glasgow**
  - Precise and Quantified Target for Decarbonization
  - Progressive decarbonization to reach net zero by 2070
- **NDC setting quantifiable targets for Climate Action Plan till 2030**
  - Reduce carbon intensity of our GDP by 45% wrt 2005 level.
  - ~50 % of installed electricity capacity from non fossil fuel sources
- **Policy Enablers for Industrial decarbonization: Few examples**
  - National Biomass Mission:
  - National Green Hydrogen Mission
  - National CCUS Mission
  - National Coal Gasification Mission

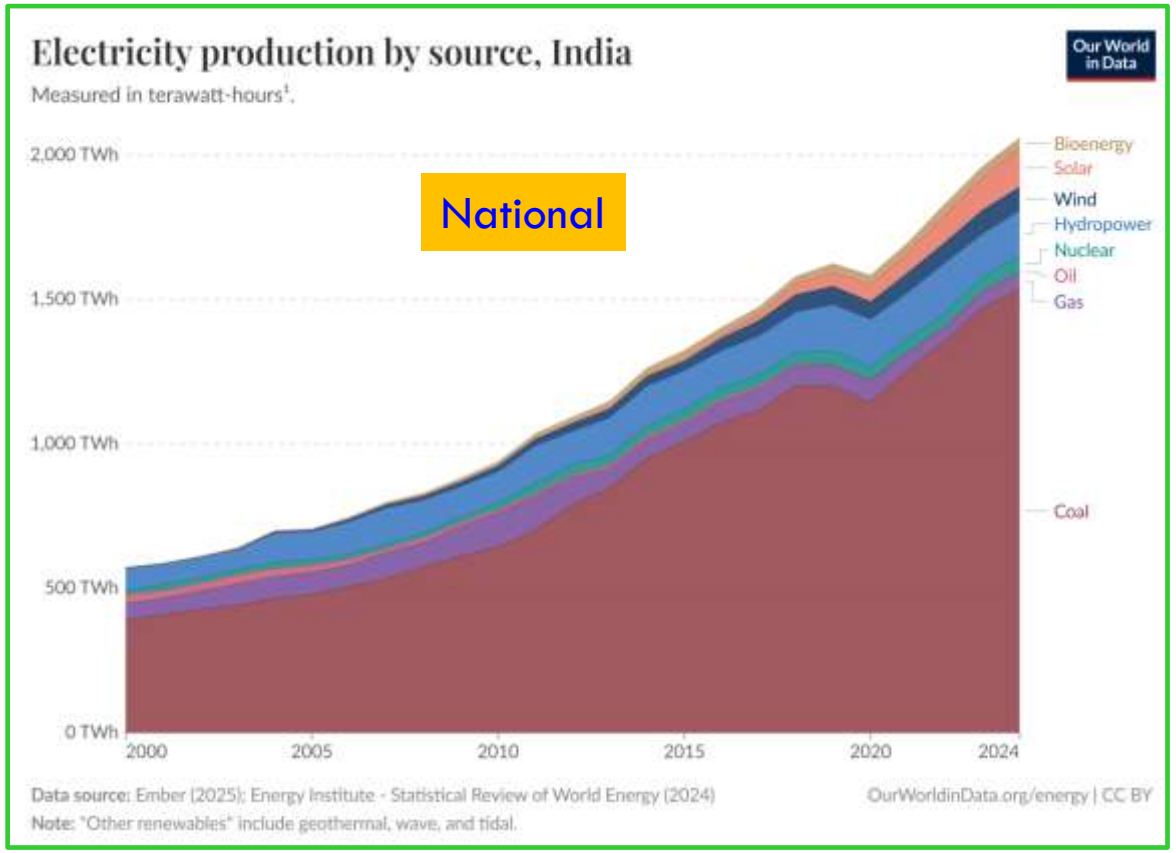
# Transition towards a Clean & Secure Energy

## Indian Scenario

# Low Carbon Transition - Indian Perspective

## COAL IN GENERATION MIX




**Even with 50 % Installed capacity on Non Fossil, Country still rely on Generation from Coal**

# Low Carbon Transition - Indian Perspective

## ECONOMIC & ENERGY SECURITY

**1. PRIMARY ENERGY SOURCE:**

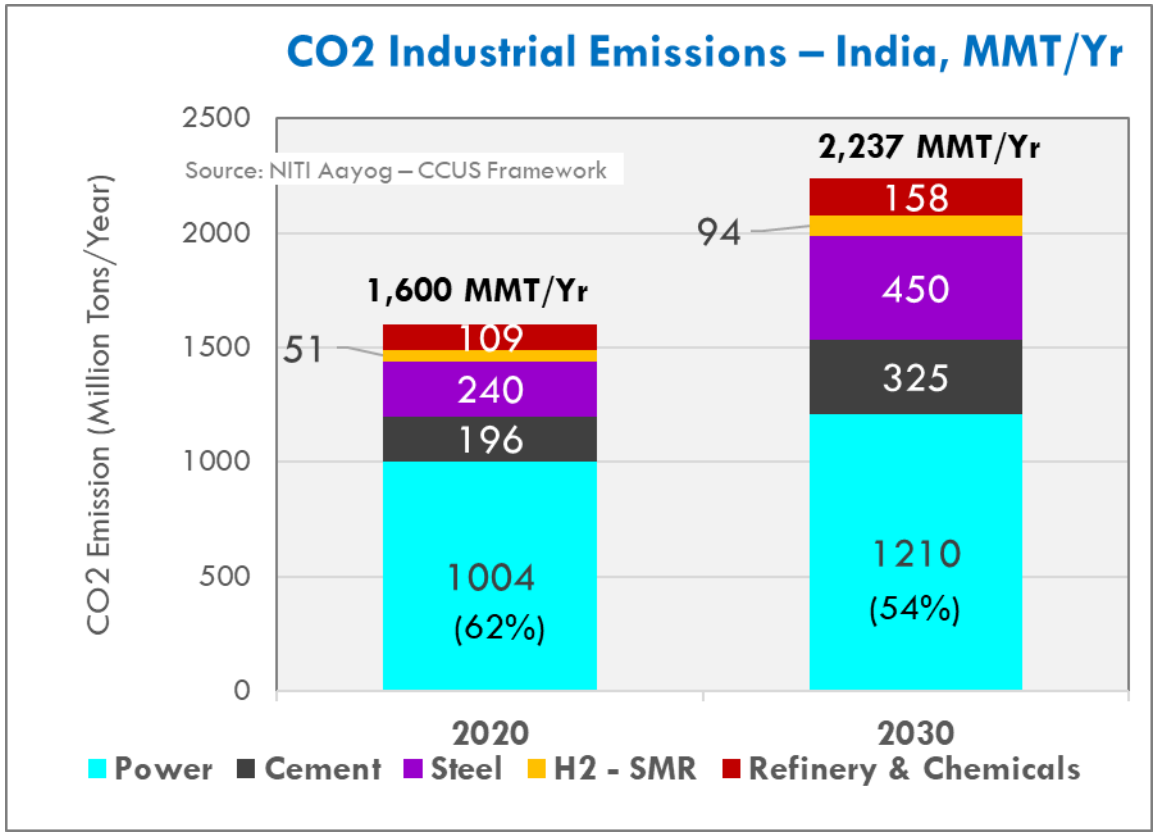
- India has 149/319 Billion Tons of 'Proven/Total Coal Reserve' (Ministry of Coal),
- Bulk (129/149) of it is 'Non-coking' variant – Used only in Power Plant (GOI-MOC),
- India does not have meaningful oil and gas reserve – bulk of it is imported. (Geo political Risk)

**2. ECONOMY:** Economy of many Indian States are critically dependent on coal mining. (i) Jharkhand: 91%, (ii) MP: 73%, (iii) Chhattisgarh: 66%, (TERI: Coal Transition in India)

**3. EMPLOYMENT:** Coal mining generates large quantum of employment – estimated 355,000 to 500,000 Nos – across various skillset (TERI: Coal Transition in India)

**4. FINANCIAL INVESTMENT:** Total investment made in coal power plants are in excess of 10 Trillion INR – this is a significant investment - needs to be handled carefully

## ENVIRONMENTAL

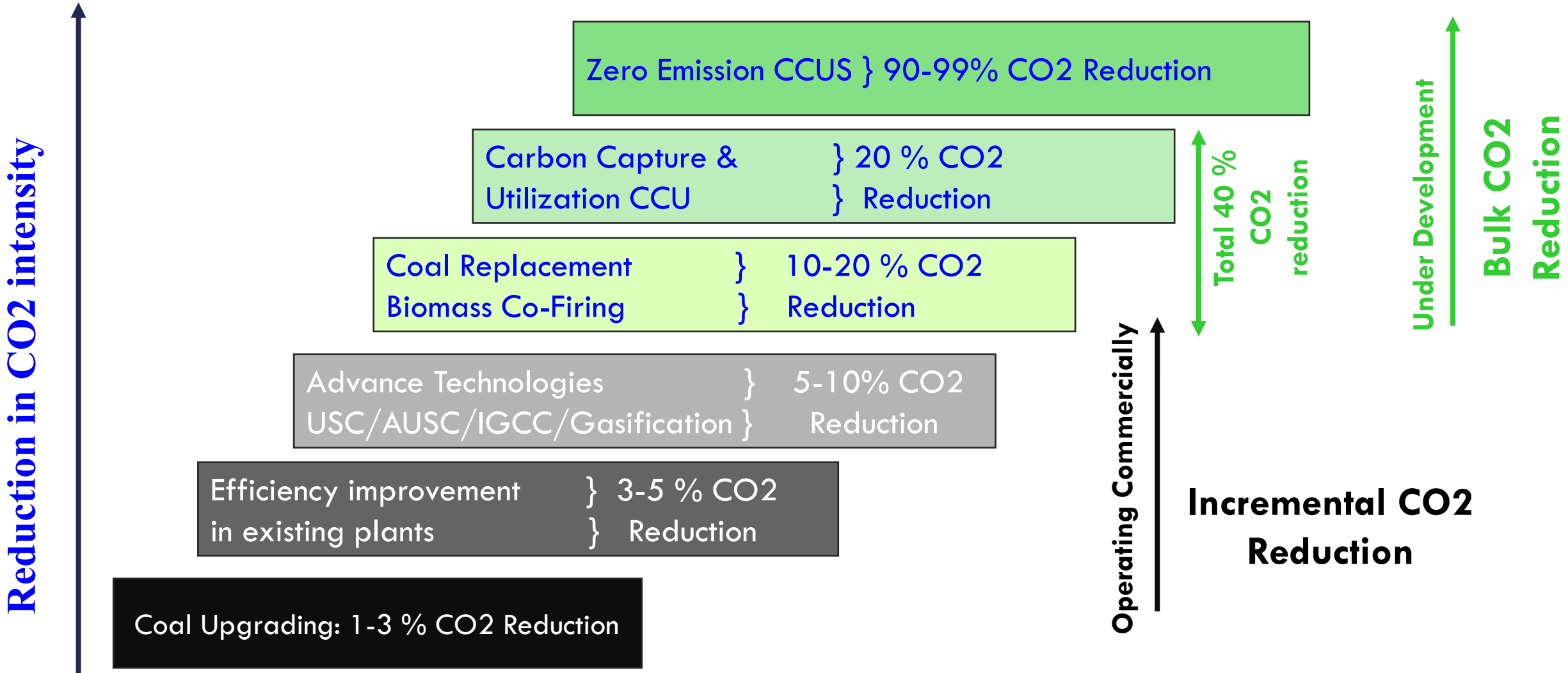


To meet economic demand coal generation has to be increased even with record RE injection

- Coal is here to stay till Energy Storage becomes feasible and affordable
- Strategy Required for decoupling of economic growth from GHG emission

**Decarbonization of Coal Generation**

# Strategy for Decarbonization of Thermal Plant



# Greening the Coal
# Biomass Cofiring

# $CO_2$ Emission Reduction from Biomass Co-Firing in Thermal Plants

## R&D to Commercial Operation

**Biomass Co-firing**

Biomass pellets in power plant as fuel

**Biomass Co-firing R&D**

**Carried out in NETRA**

- Detailed Characterization
- Biomass combustion
- Ash formation
- Effect of high VM in Biomass
- Effect of high alkali compound
- Combustion trial in NETRA
- Combustion trial at NTPC Dadri

- **Total Biomass fired : ~ 15.92 lakh MT (till date)**
- **Approx. 16 lakh MT $CO_2$ reduced**
- Provision for 20% Bio-mass cofiring in new power plants

Each % Biomass co-firing proportionately reduces $CO_2$ emissions

**Biomass**

| Year | Co-fired |
|---|---|
| 19-20 | 3903 |
| 20-21 | 24389 |
| 21-22 | 38953 |
| 22-23 | 23856 |
| 23-24 | 165700 |
| 24-25 | 703466 |
| 25-26 | 632334 |
| Total | 15,92,601 |

# Greening the Coal

## Carbon Capture, Utilization & Storage

# CCUS Technologies: 15 years of R&D Initiatives & Pilots

## CO2 Capture Technology & Pilot Plants

| Physical Route | Chemical Route | Biological Route |
|---|---|---|
| Pressure Swing Adsorption | Modified Amine | Micro Algae |
| 1 No of Pilot Plant (Collaborative R&D Project of NETRA with 4 Institutes – CSMCRI, NEERI, IITB & IIP) | 2 Nos of Pilot Plant (Collaborative R&D Project with IIT Guwahati & IIT Bombay) | 1 No of Pilot Plant (Collaborative R&D Project of NETRA with IOCL) |

Completed

***Gave us Confidence and data for scaling to Demonstration Plant***

# Cost effective CO2 Utilization Technology

## Our Thought Process back in 2015-16

- Now we have 1.
- What are the value-added products from utilizing CO2 ??
- What are best combinations of 2 & 3 for best utilization of CO2 ??

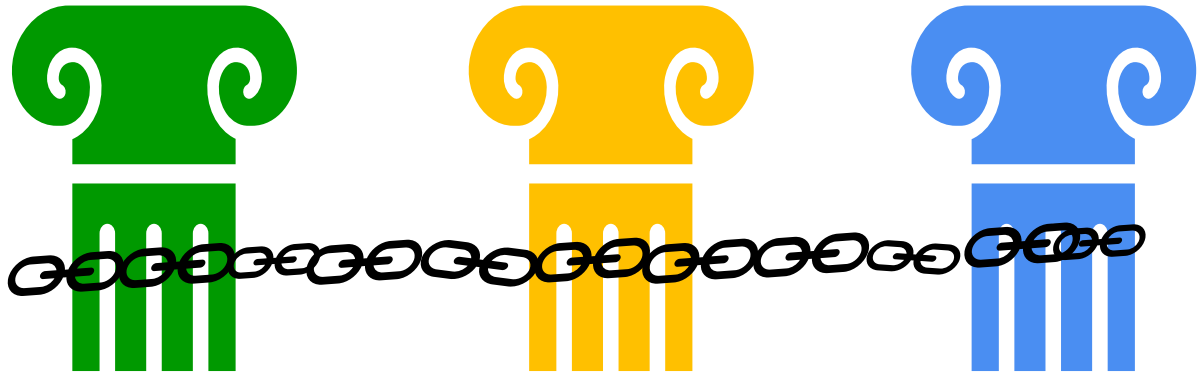
**1** Cost Effective CO2 Capture

**2** Options 1,2,3

**3** Value added Product for bulk consumption

# Low Carbon Transition - Strategy

## LOW CARBON TRANSITION
## THE INDIAN MODEL

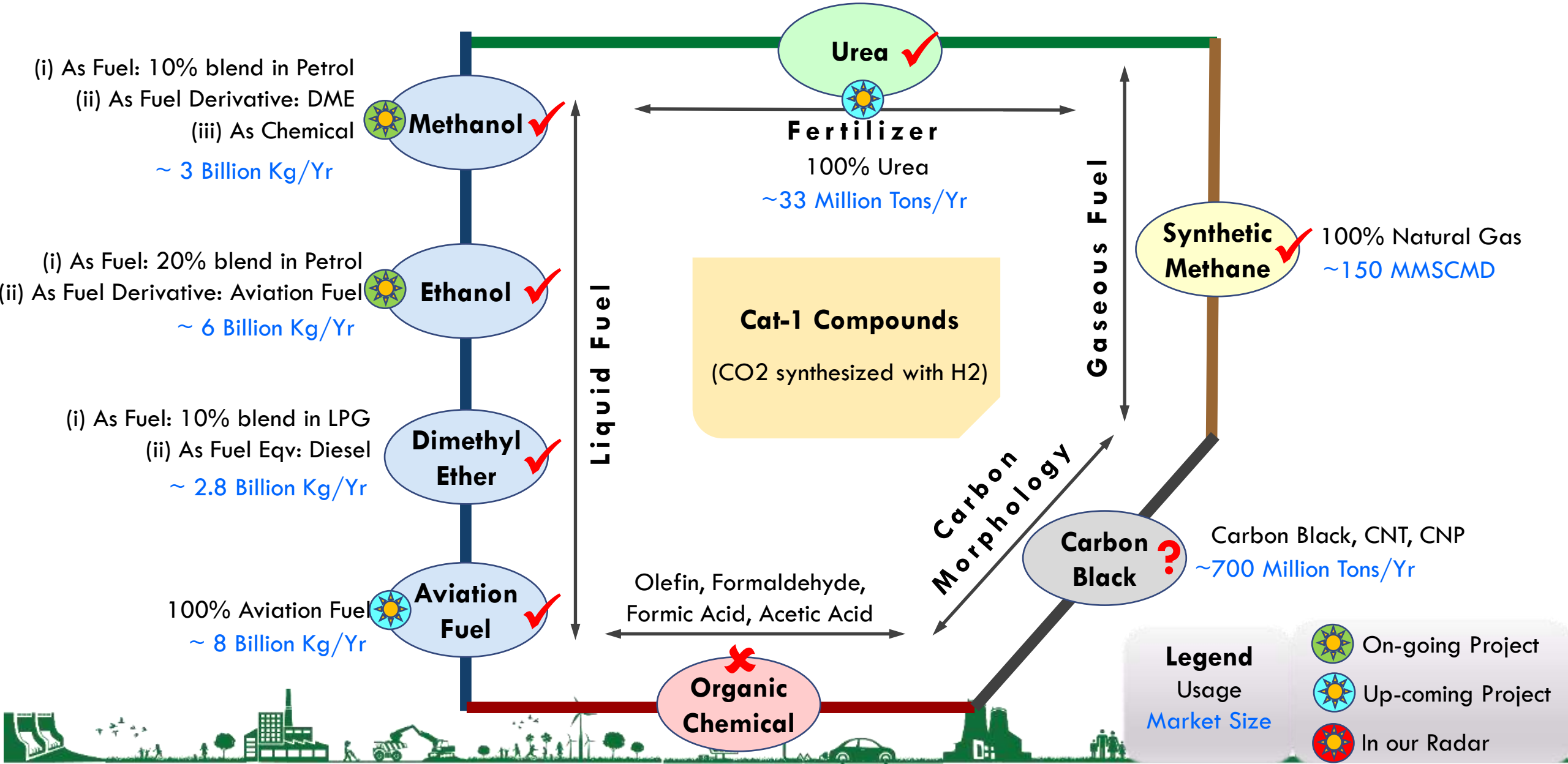


Renewables | Green Hydrogen | Carbon Capture & Utilization

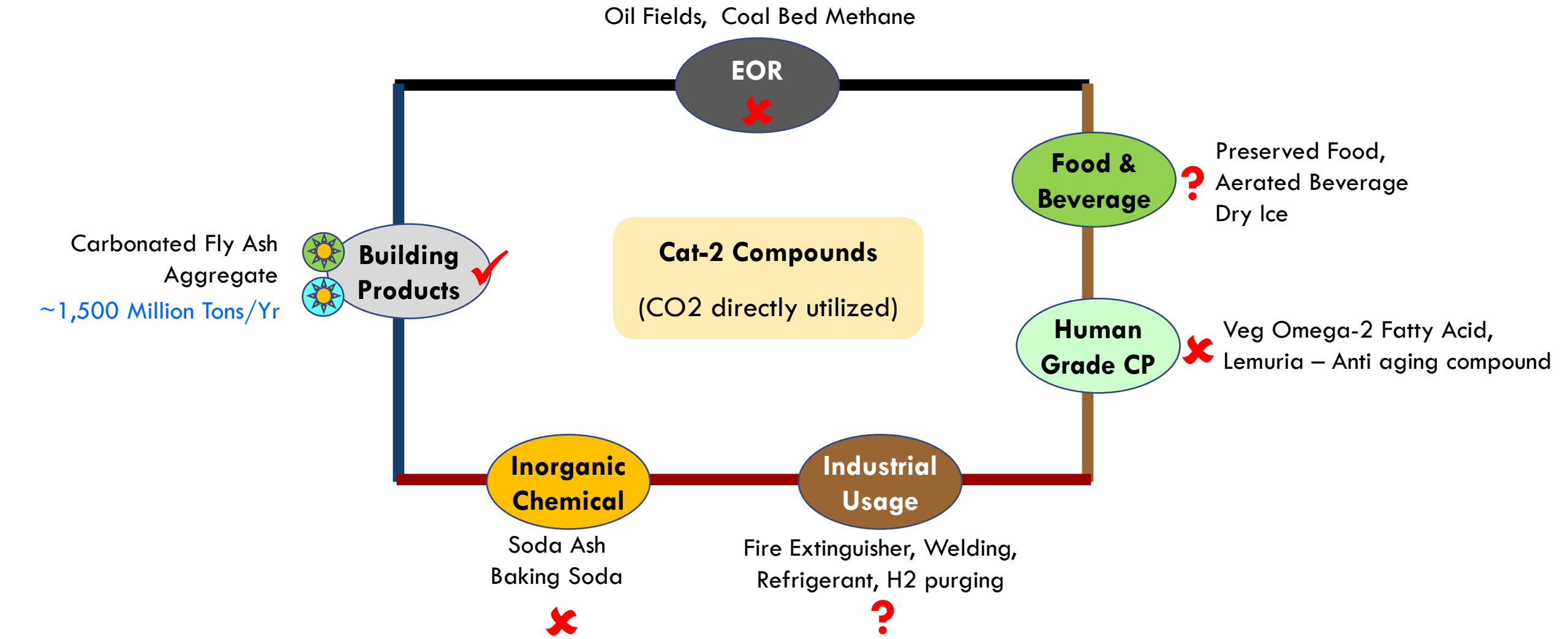
**Inter-linking of 3-Green Pillars**
(Renewables, Green Hydrogen & Carbon Capture and Utilization)

**Every country needs to find its own unique path**

# Carbon Capture & Utilization: **Potential Avenues**

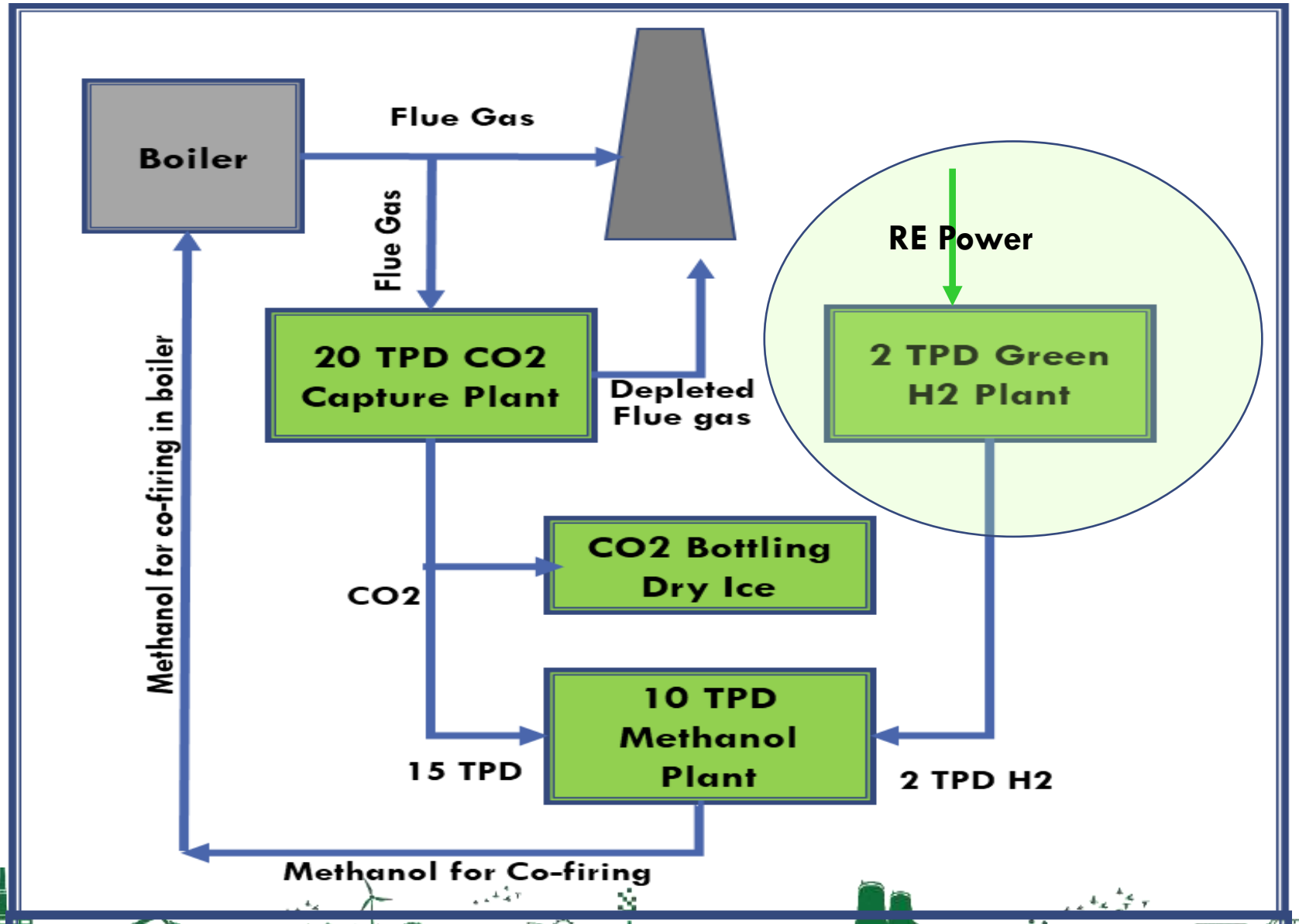


# Carbon Capture & Utilization: **Potential Avenues**



# Carbon Capture, Utilization & Storage Experience Sharing

# 10 TPD CO2 to Methanol (CTM)-Schematic



# CCUS- CO2 to Methanol: Demonstration Plant & Parallel Indigenous R&D

## CO2 to Methanol- From licensing technology to indigenous development

**Methanol-Licensed**

3,300 TPA Plant at NTPC Vindhyachal

**Commissioned**

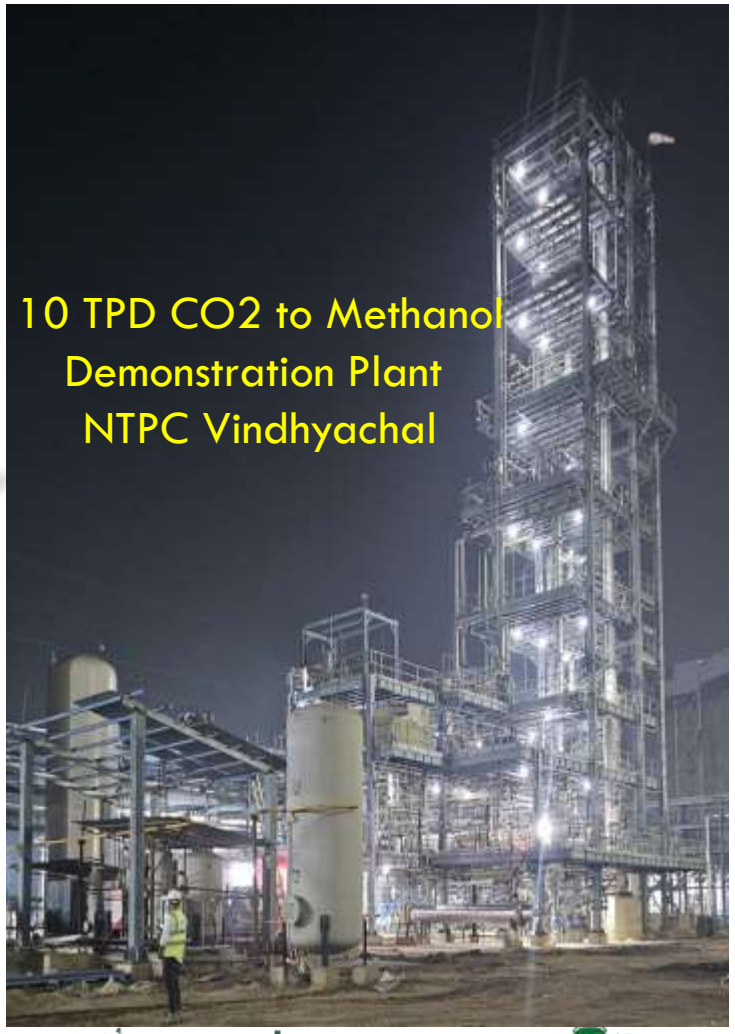
- 20 TPD CO2
- 2 TPD PEM Based H2
- 10 TPD Methanol synthesis
- 'First-Operation' completed on 7th Nov 2024
- Integrated Plant Operation on 3rd June 2025

**Methanol-Indigenous**

Indigenous Catalyst/Reactor Development

**Completed**

- With CSIR-IIP,
- 10 Kg/day Pilot at Netra
- Long term catalyst life testing under progress




# Carbon Capture, Utilization & Storage
# Scaling up the Technology

# CCUS Technologies: **NTPC Initiatives**

## 1. CCUS – NTPC Initiatives:

NTPC is working on all four (4) verticals of CCUS Technology – (i) CO2 Capture, (ii) CO2 Compression & Pipeline Transportation, (iii) CO2 Utilization and (iv) CO2 Sequestration

### CO2 Capture Hub
(At NTPC Simhadri)

- 1x25 TPD Plant (Under Execution),
- 2x325 TPD Plant (Upcoming),
- 2x650 TPD Plant (Future),

### CO2 Compression & Pipeline Transportation
(From NTPC Simhadri to NTPC Pudimadaka)

- CO2 Transportation in 'Supercritical Phase' (150 Bar, 40C),
- Configuration: (i) 1000 TPD (Upcoming), Distance: ~25 KM,
- **First CO2 Pipeline in India**

### CO2 Utilization
(At NTPC Pudimadaka)

- CO2 to SAF: 1,800 TPA Plant,
- CO2 to Green Urea – 50,000 TPA Plant,
- CO2 to Green Methanol (Planned),
- **First CO2 to Methanol, SAF, Urea Plants, globally**

# Green Chemical Hub at Pudimadaka
## An Artistic view

# CCUS with Waste Utilization
# Carbonated Bricks with Flyash
# Demo Plant

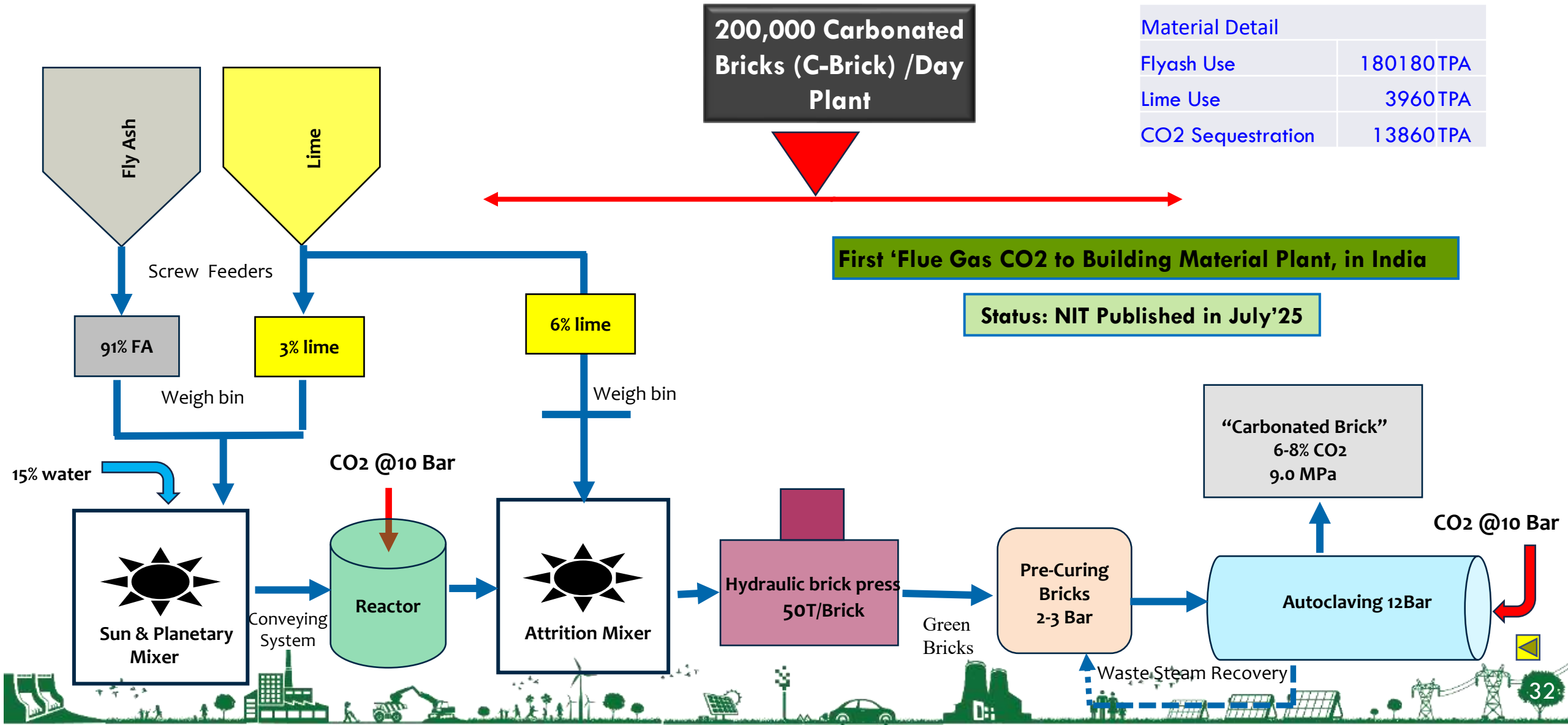
# CCUS Technology Demonstration: 2 Lakhs/day Carbonated Brick Plant at NTPC Ramagundam

**200,000 Carbonated Bricks (C-Brick) /Day Plant**

| Material Detail | |
|---|---|
| Flyash Use | 180180 TPA |
| Lime Use | 3960 TPA |
| CO2 Sequestration | 13860 TPA |

**First 'Flue Gas CO2 to Building Material Plant, in India**

**Status: NIT Published in July'25**



# CCUS
# Storing CO2 in Depleted Coal Mines
# Pilot

# CCUS Technologies: R&D Initiatives

## CCUS R&D Initiatives – **CO2 Storage:**

### CO2 Emissions – The Big Picture:

- CO2 emission from Coal Power Plant in FY 2024-25: ~ 1,110 Million Tons (@ 0.85 KgCO2 /kWh, 1336 BU)
- CO2 emissions reduction to match Gas Plant emissions: ~ 400 MT/Yr
- CO2 emissions reduction thru CCUS: ~100-200 Million Tons/Yr
- CO2 utilization in CCU technologies: ~50 Million Tons/Yr
- CCS will be compulsion – if Net Zero is to be achieved

### Project-1:

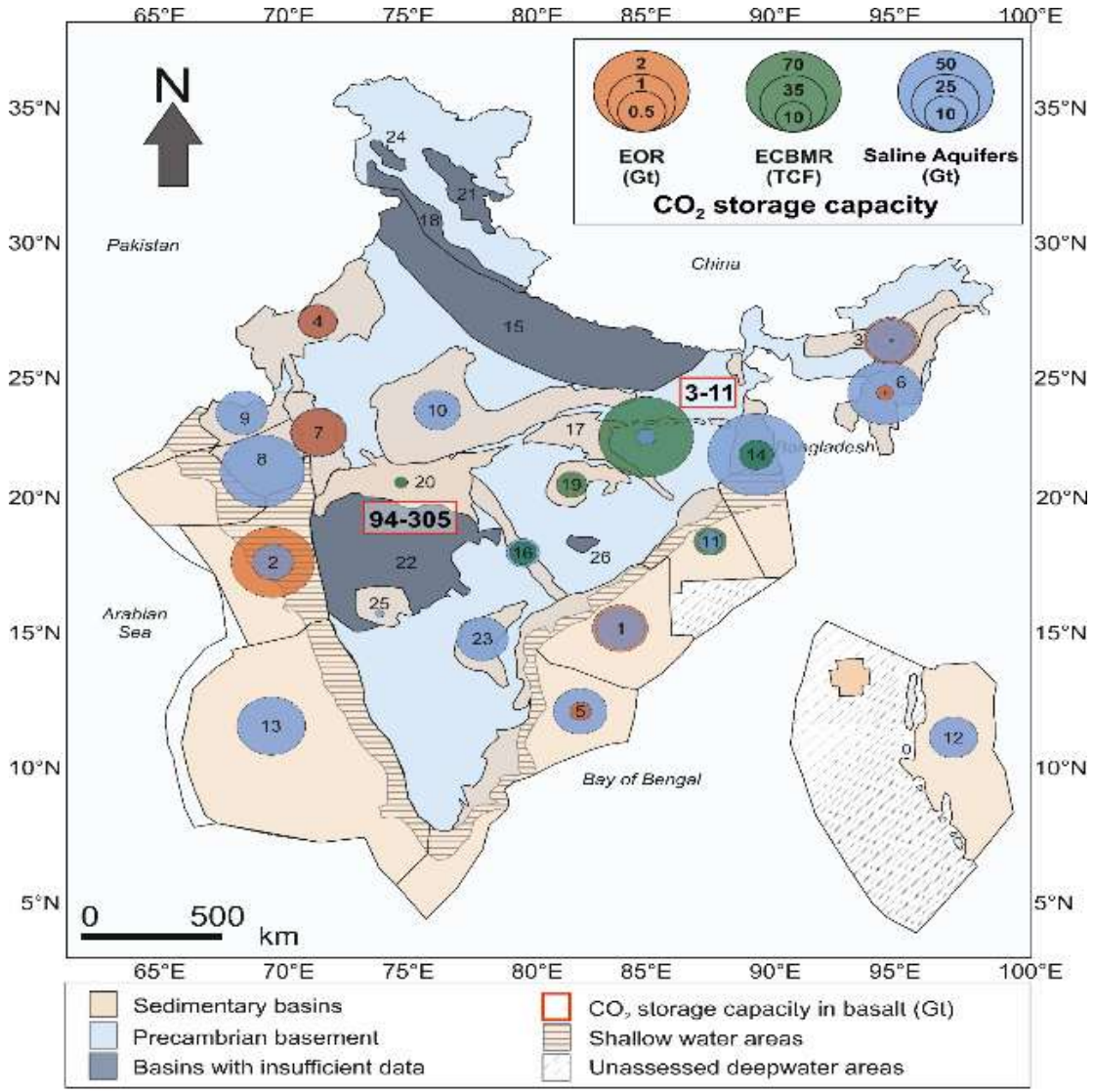
**CO2 Storage potential in 'Unusable Cat-1 Coal Seam' of NTPC**

- First project of its kind, globally
- Collaborative Project with IIT Bombay,
- Completed in Jan'24

### Project-2:

**Drilling of 'CO2 Injection Bore' and detailed Geological Studies**

- Drilling Completed



# CO2 Geological Storage: CO2 Injection borehole at Pakri Barwadih (Ongoing)

**Country's First CO2 Injection Borewell at Pakri Barwadih- Jharkhand.**

Supported by NITI Aayog and based on IIT-Bombay and NETRA R&D Wing of NTPC studies, the site was identified for its high CO2 storage potential (4.3–15.5 million tons).

Two 1200-meter-deep borewell drilled

Lab Analysis:

- Core analysis
- Adsorption Isotherm
- Permeability Studies

Simulations:

- Dual Porosity Model: Fractured coal system
- Geo-Mechanical Coupling: Coal & permeability
- Injection Protocol

Actual Injection & Monitoring


# CONCLUSION

# CONCLUSIONS

- Energy Sector is going through a rapid transition
- India has chosen its path of Just Transition, where important principles are:
  - Energy Security & Sustainability
  - Technology and Innovation
  - Energy Access & Equity
- Coal plays a major role in Indian's Just energy Transition
- NTPC has taken a step forward to work on greening the coal.
- The Nation requires quick capacity development and projects on ground
- Knowledge Sharing & Collaborative Efforts can quicken the transition
- Congratulations to Organisers EEC, IGEF SO, VGBe for organizing the workshop for wider discussion on clean coal utilization
- Thanks and Gratitude for giving us a chance to share our experience

# Thank You