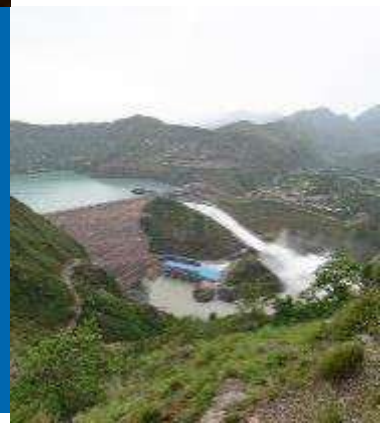
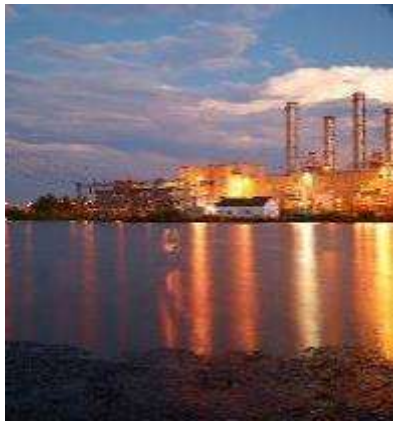


Greening the Coal through CCUS

NTPC Experience of First CO2 to Methanol Plant and Way Forward

Dr Swapnil S Patil
AGM, NETRA

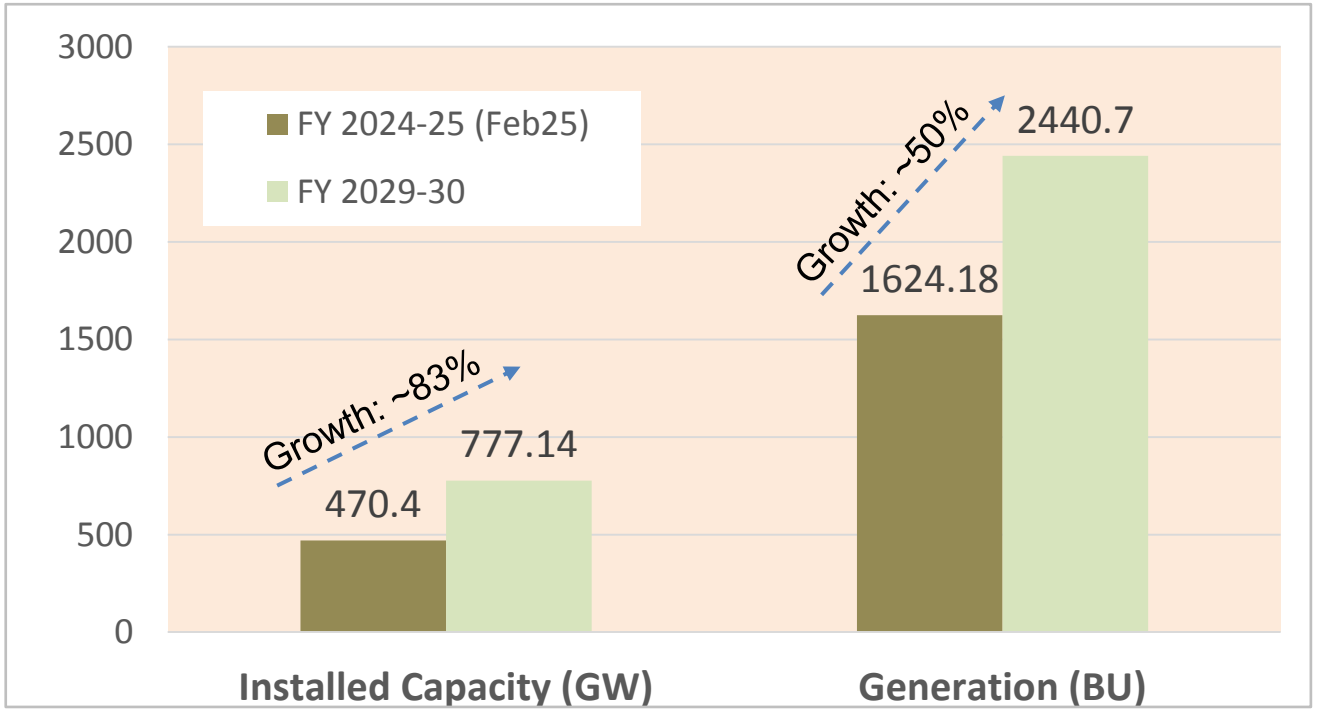




Indian Power Production

Electricity based Economy

Electricity based Economy

- Strong Economic Growth;
- Electric Mobility – Trains, 2W, 3W, 4W-PV, 4W-CV;
- Electric Dwelling – Extensive electrification, Rapid Urbanization, Mobile, Electric Appliances, Cooking



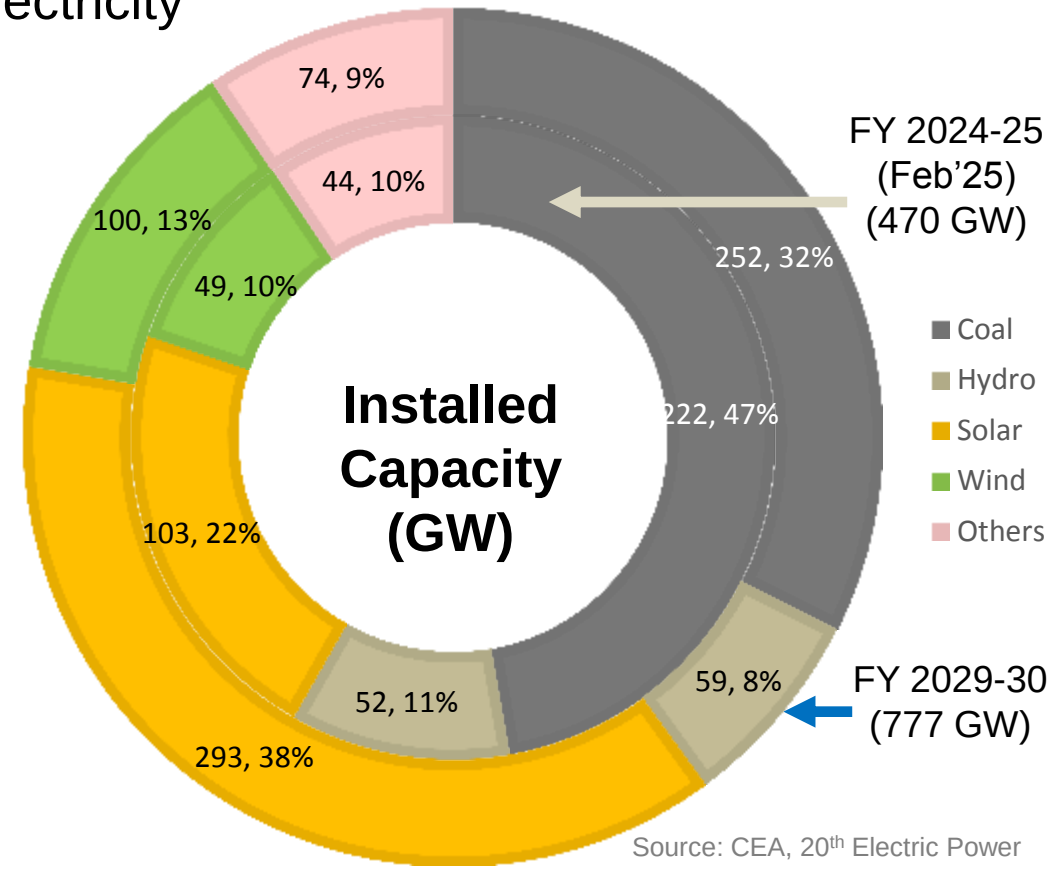
Source: CEA, 20th Electric Power Survey

Future of Energy is Electricity – in India

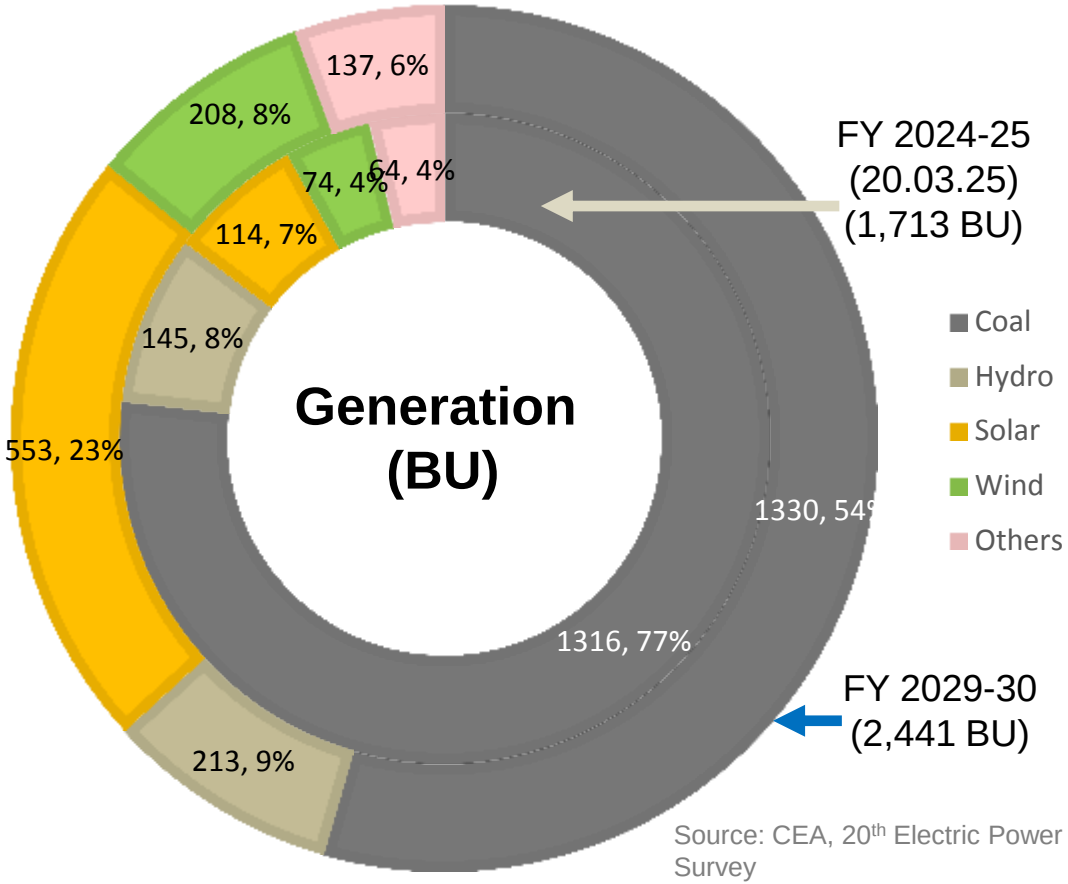
Indian Power Sector – The Perspective

Electricity based Economy

Coal Power Plant shall remain the ‘Mainstay’ of electricity



Source: CEA, 20th Electric Power Survey



Source: CEA, 20th Electric Power Survey

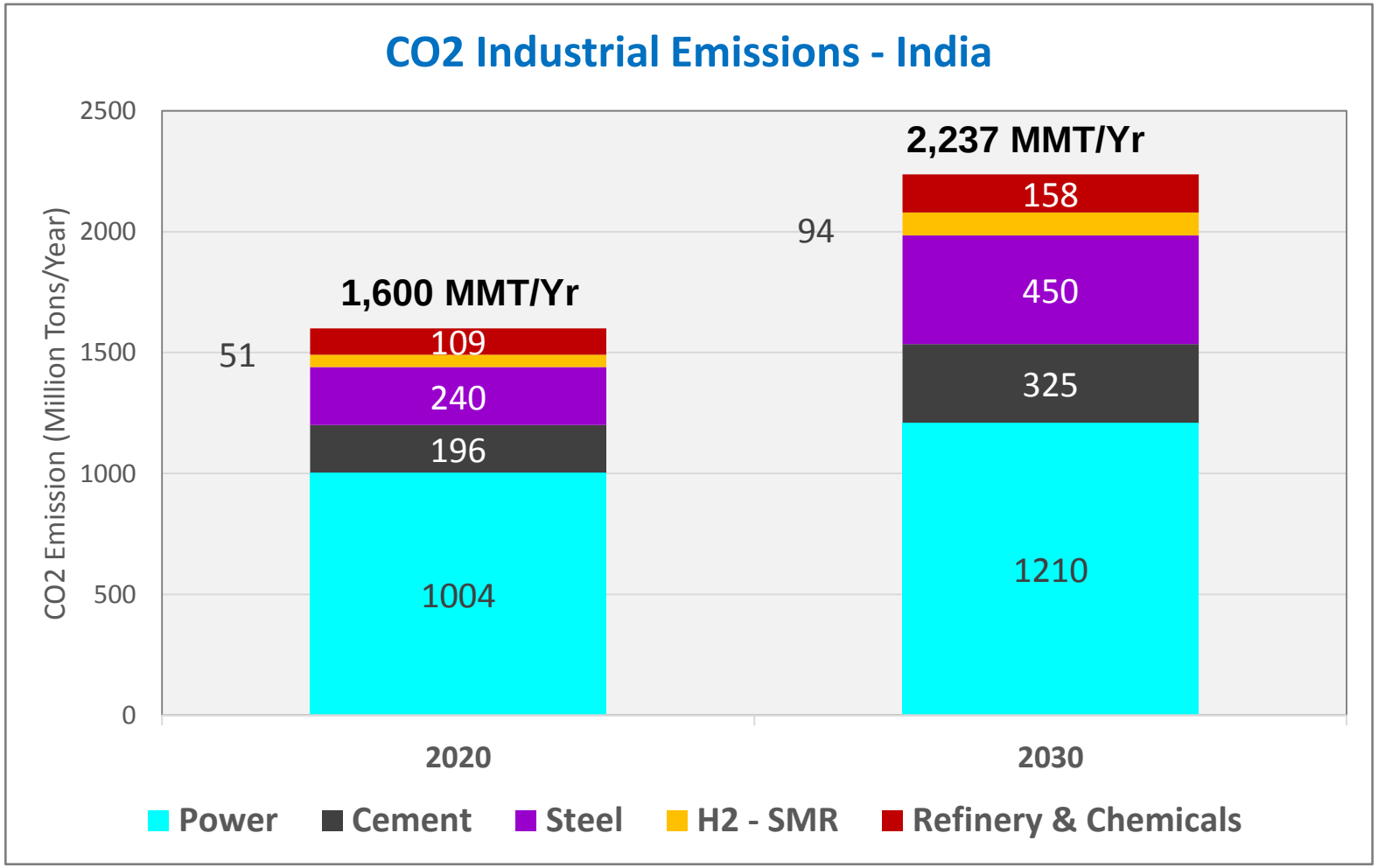
In absolute numbers, Coal Power Plants are expected to hold their position - both in terms of ‘Installed Capacity’ & ‘Power Generation’

Indian Scenario - CO2 Emissions by Sector

Electricity based Economy

CCUS shall be critical for 'Clean Energy Transition'

- CO2 emissions from Coal Power Plants are significant ~62% in 2020 & ~54% in 2030,
- In order to sustain Coal Power Plant, its CO2 intensity needs to be reduced



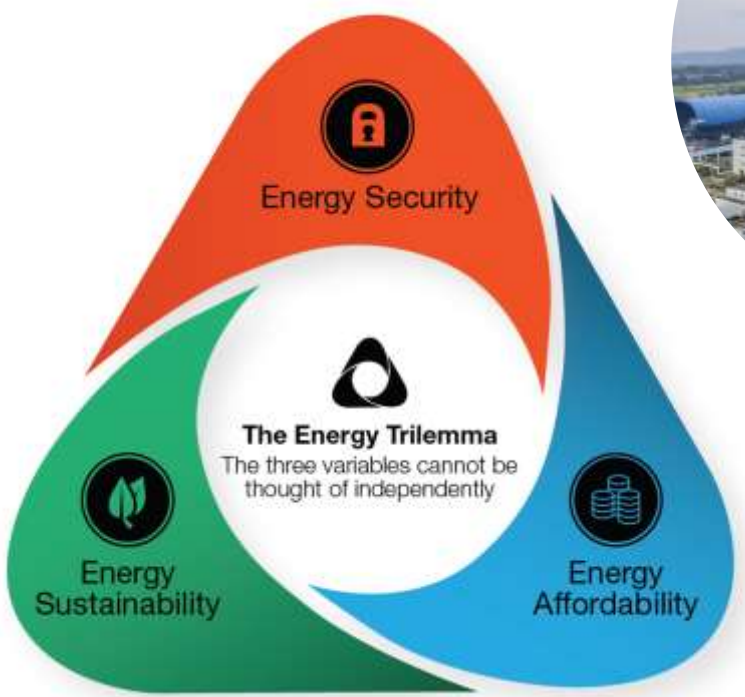
Source: NITI Aayog – CCUS Framework

Key Takeaway

CCUS shall be important – in Indian context

Hydrogen shall play a 'critical' role to support CCUS

In Quest of Blue Coal Generation



Subcritical Coal Power Station

938 g/kWh

Blue Coal Pathway

Green Power Declared by EU

Combined Cycle Gas Turbine

490 g/kWh

Sp. CO2 emissions

Low Carbon Transition - Indian Perspective

LOW CARBON TRANSITION - INDIAN MODEL

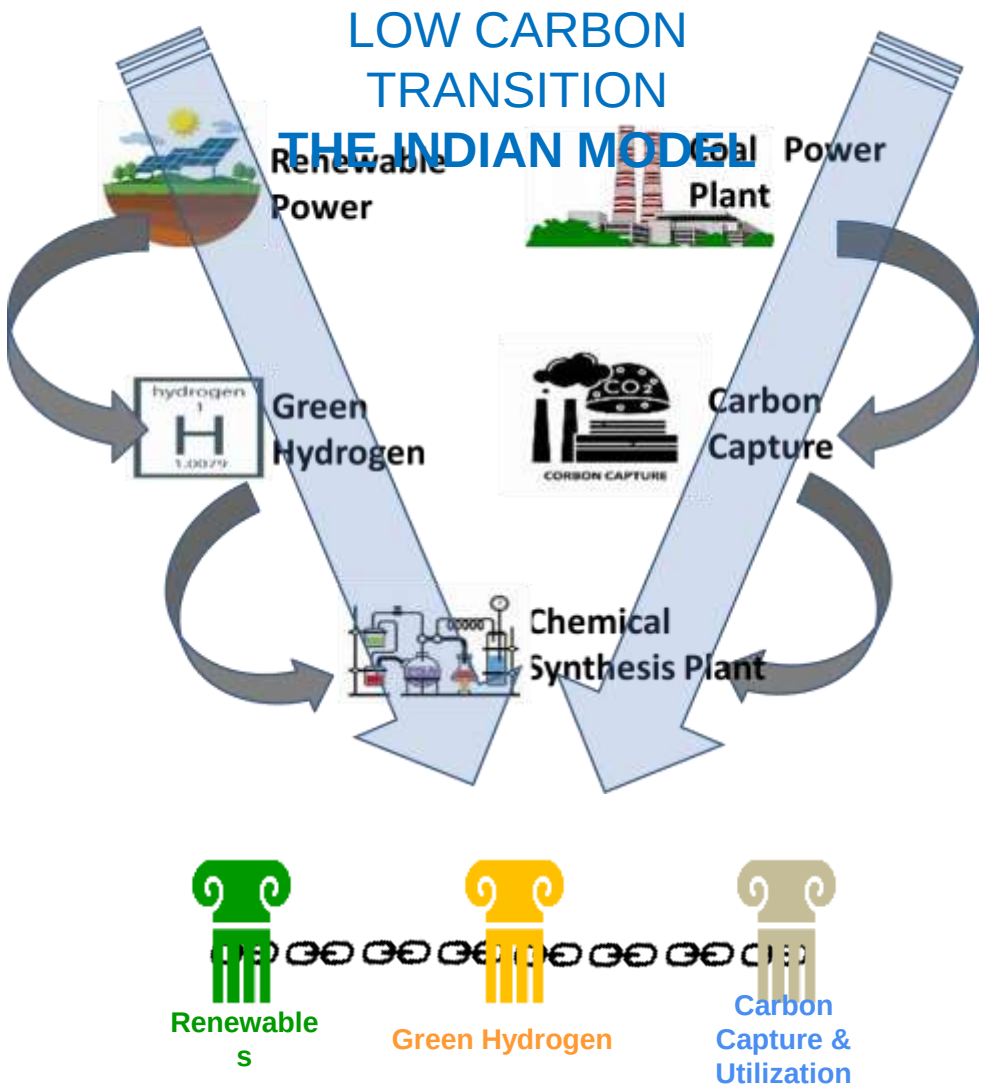
- Every country needs to find its own unique path
- Our Model in based on **inter-linking 3-Green Pillars** together i.e (i) Renewables, (ii) Green Hydrogen & (iii) Carbon Capture and Utilization

KEY BENEFITS

- 'Low Carbon Intensity' Coal Power Plants
- Following can be saved: (i) Employment in Coal Sector, (ii) Economy of coal rich states, (iii) Investment in Coal Power Plants,
- Create numerous 'down stream industry' – based on 'Carbon compound'

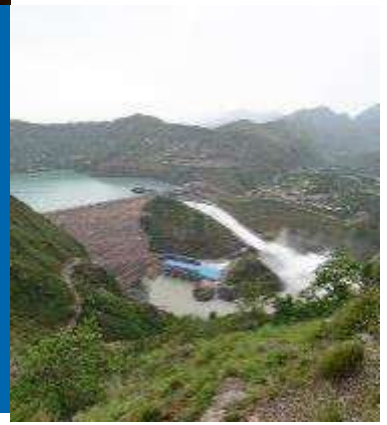
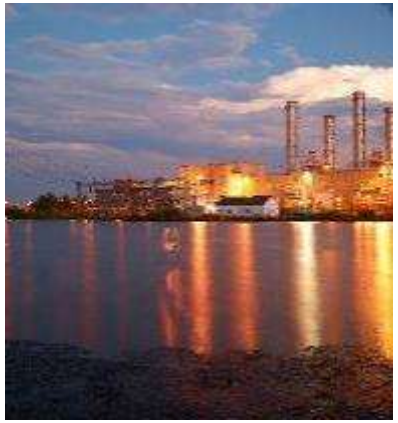
CONTRIBUTE TOWARDS COP-26 COMMITMENTS

(i) 500 GW Non-fossil capacity; (ii) 50% energy from RE; (iii) Carbon intensity < 45%; (iv) 1 billion tons emissions reduction; (v) Net-zero emissions by 2070.

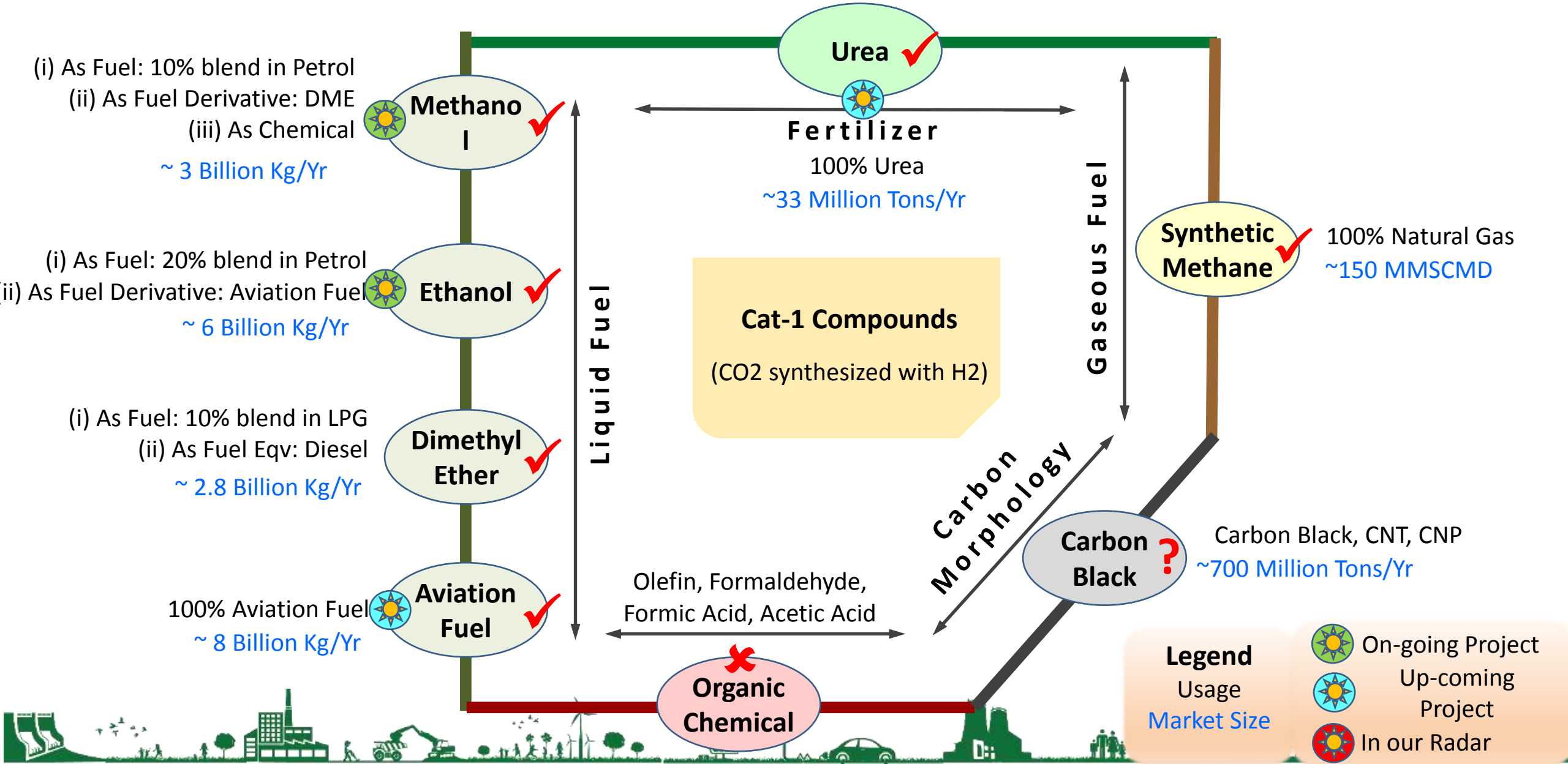




CO2 Capture, Utilization and Storage
CCUS


Carbon Capture & Utilization: **Potential Avenues**



Carbon Capture & Utilization: **Potential Avenues**

Oil Fields, Coal Bed Methane

EOR ✗

Food & Beverage ?

Preserved Food,
Aerated Beverage
Dry Ice

Carbonated Fly Ash
Aggregate
~1,500 Million Tons/Yr

Building Products ✓

Cat-2 Compounds

(CO2 directly utilized)

Human Grade CP ✗

Veg Omega-2 Fatty Acid,
Lemuria – Anti aging
compound

Inorganic Chemical

Soda Ash
Baking Soda

✗

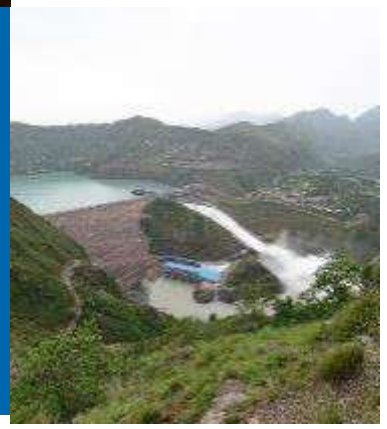
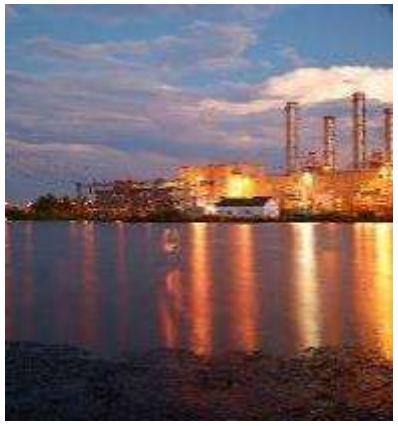
Industrial Usage

Fire Extinguisher, Welding,
Refrigerant, H2 purging

?

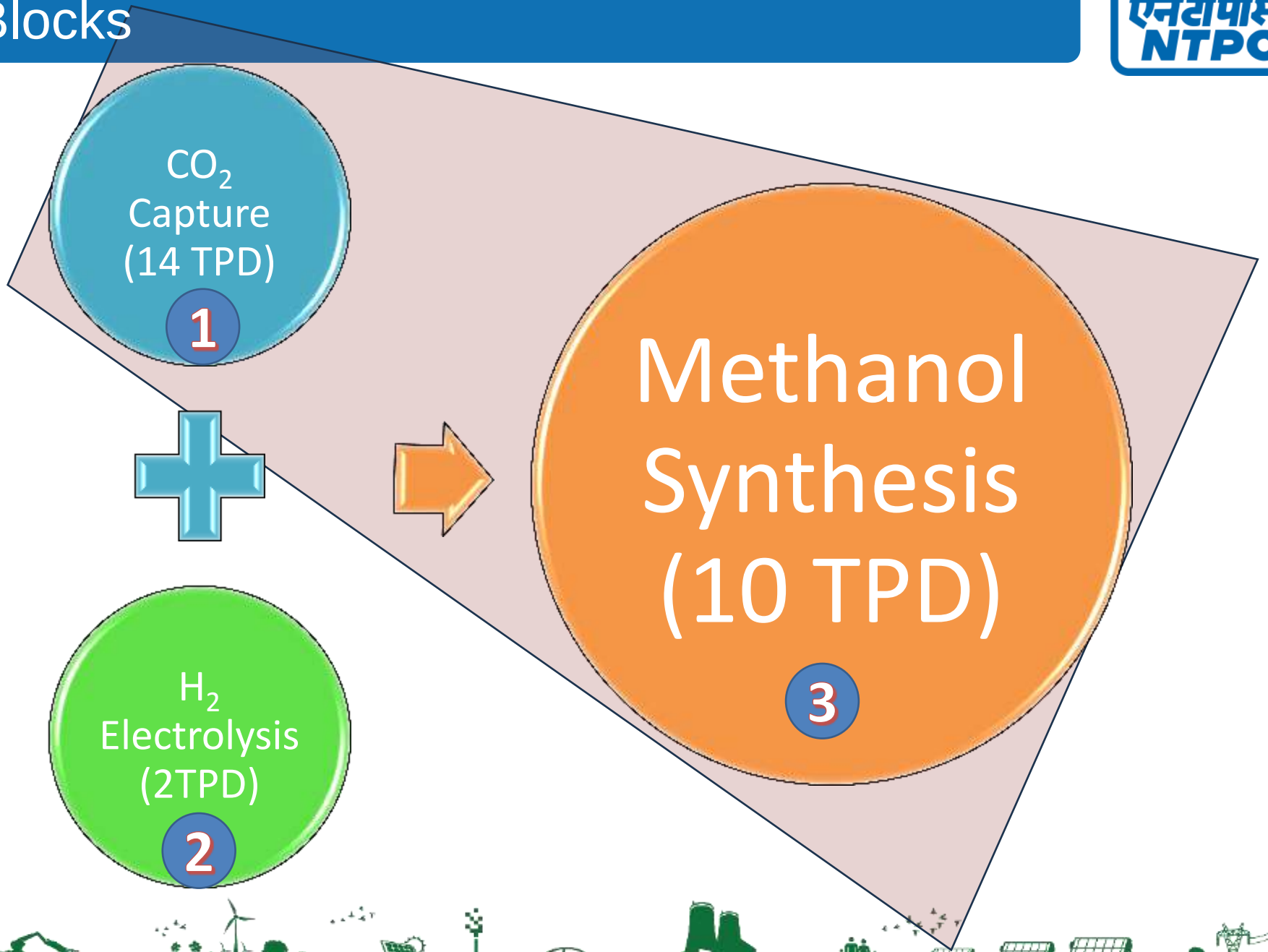


10 TPD CO2 To Methanol PaInt


Follow us on: /ntpc1 /ntpcltd1 /ntpclimited /Company/ntpc /ntpclimited

Basic Building Blocks



CO2 Capture for Different Types of Thermal Power Plants

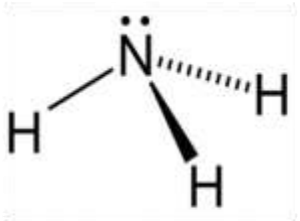
Pre-Combustion

Oxy-Combustion

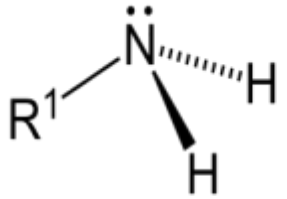
Post-Combustion

CO_2 Capture methods

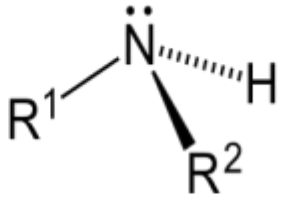
- **Post-Combustion applicable to coal power plants**
- **Low concentration of CO_2 in flue gas**



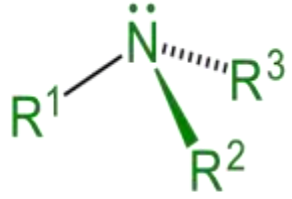
Ammonia



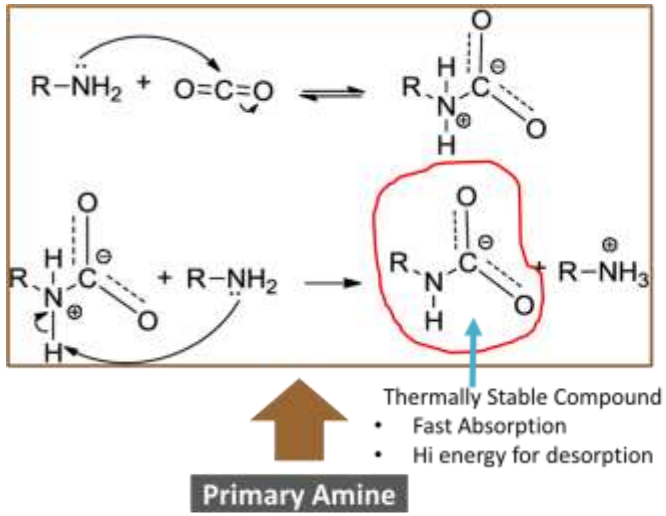
Primary Amine

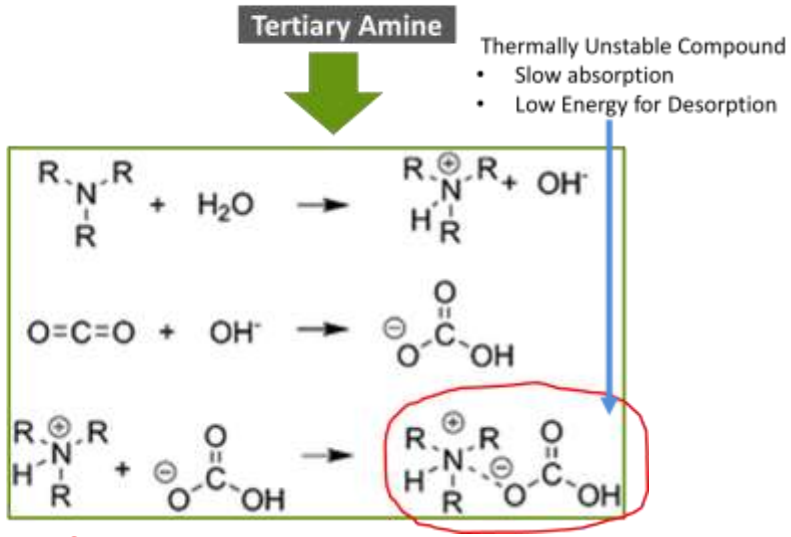


Secondary Amine



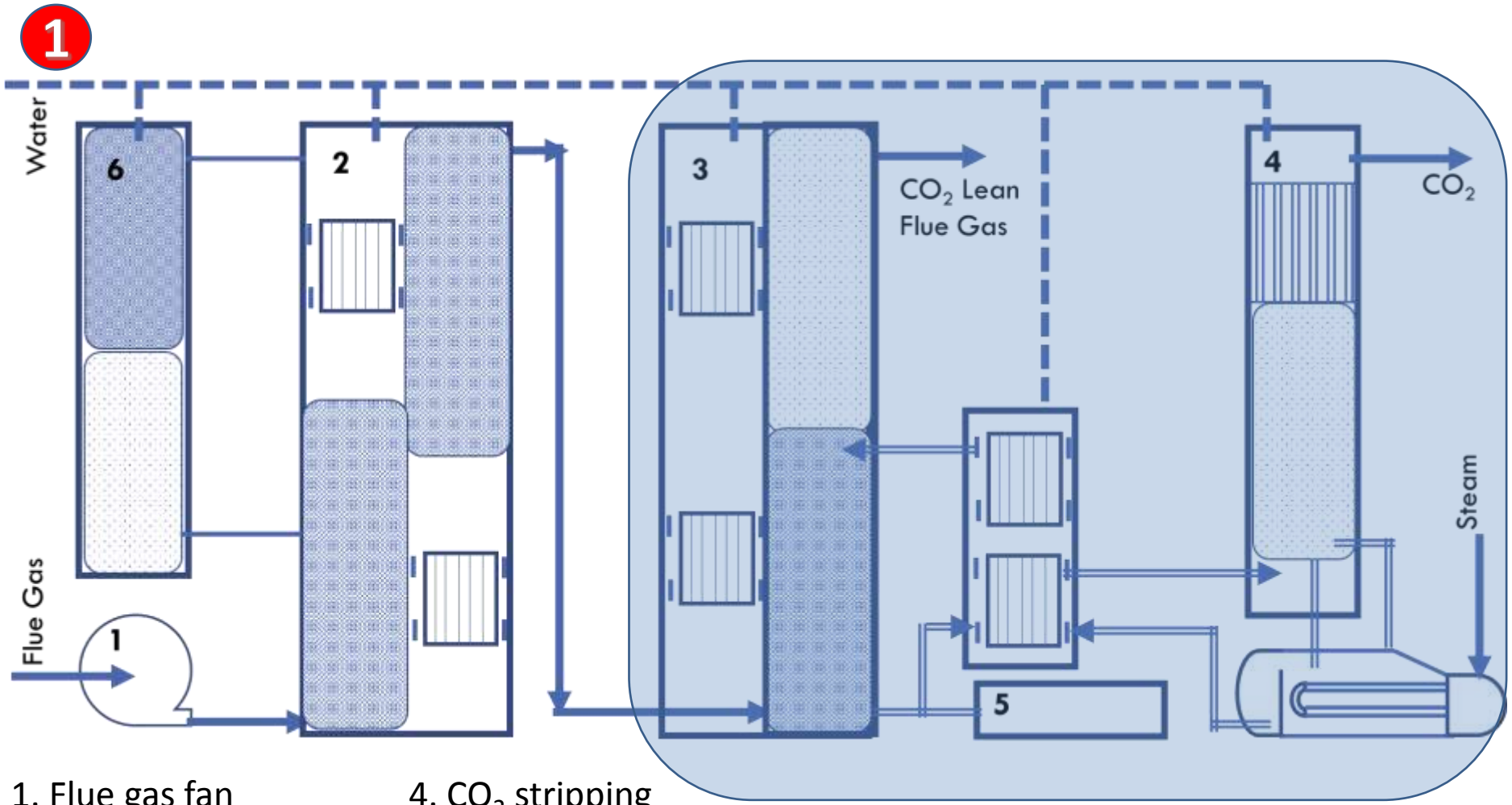
Tertiary Amine

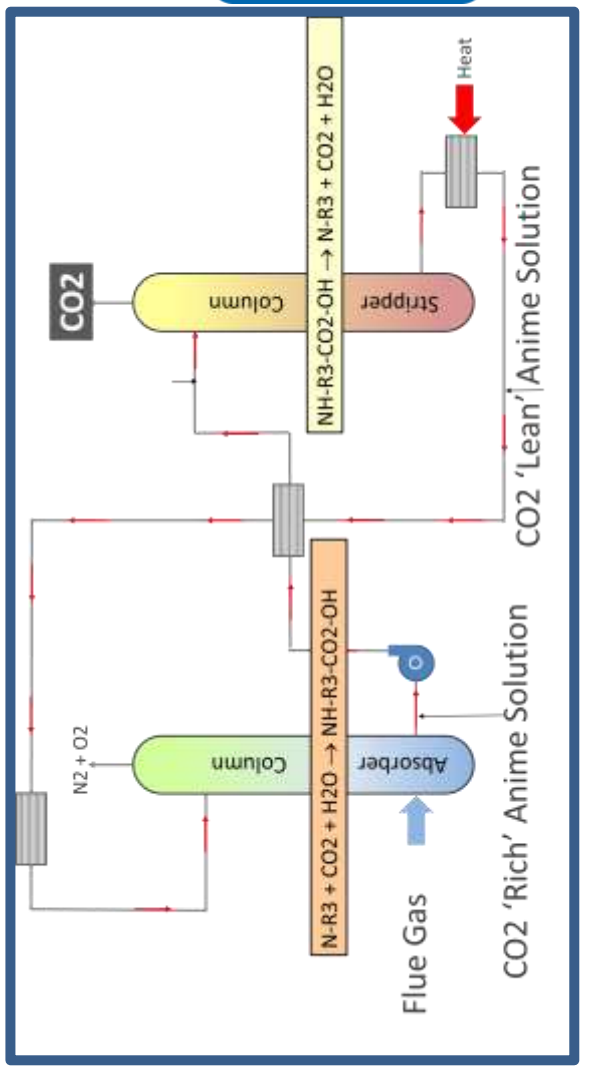




Blend of Modified Ethanol Amines is used for CO2 capture

CO2 Capture: Process Flow Diagram



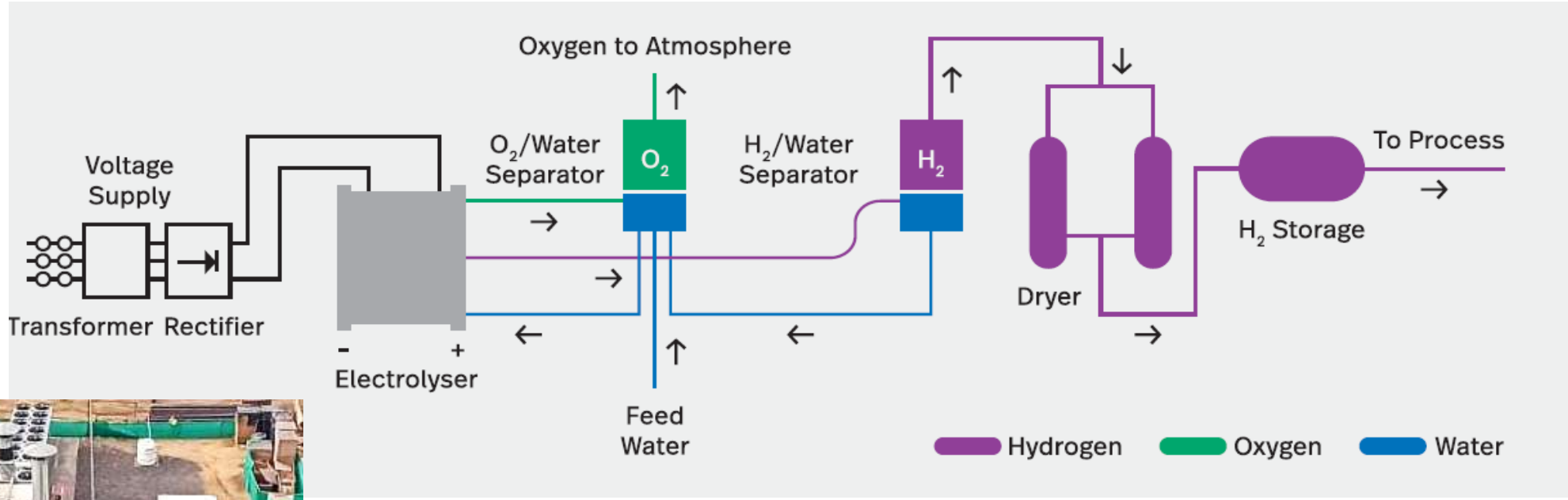


1. Flue gas fan
2. Flue gas pretreatment
3. CO_2 absorption
4. CO_2 stripping
5. Package: Absorption solution recovery
6. Package of pretreatment reagent : Scrubbing agent solution, Caustic solution

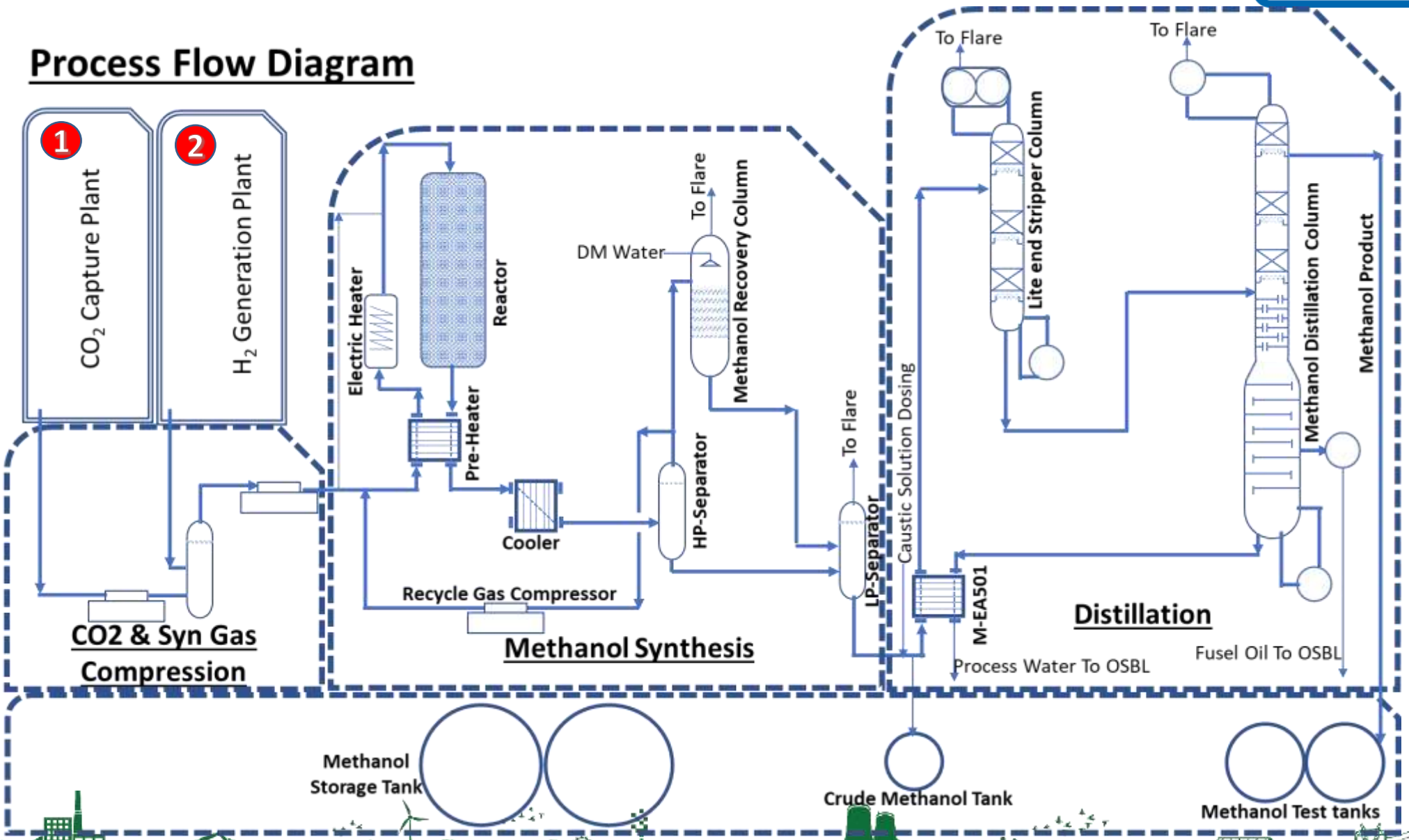
CO2 Capture: Plant

Hydrogen Electrolyzer

2



Methanol Synthesis Process(10 TPD): Process Flow Diagram



Methanol Synthesis Process(10 TPD): Plant

Methanol Synthesis Technologies: R&D Initiatives

CCUS R&D Initiatives – CO2 Utilization:

CO2 to Methanol Catalyst

Indigenous heterogenous catalyst developed with Indian Institute of Petroleum

Catalyst (As Synthesized)

Catalyst Pellets (5% Graphite binder)

- CO2 Conversion: 12.8%
- Reaction Parameter: 50 Bar, 240 C

Pilot Plant (10Kg/Day) at NETRA

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 (Relocated from NTPC Lara),
- 2x325 TPD Plant (Upcoming),
- 2x650 TPD Plant (Future),

- **1 x 20 TPD Plant at NTPC Vindhyachal (Commissioned in Aug'23)**

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

- CO2 Transportation in 'Supercritical Phase' (60- 150 Bar, 40C),
- Configuration: (i) 2x325 TPD (Upcoming), (ii) 2x650 TPD (Future)
- Distance: ~25 KM,
- **First CO2 Pipeline in India**

CO2 Utilization
(At NTPC Pudimadaka)

- CO2 to Sustainable Aviation Plant – 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**

- **10 TPD CO2 to Methanol at NTPC Vindhyachal commissioned**

CCUS – NTPC Initiatives

1. CO2 to Methanol

Green Methanol

3,300 TPA Plant at NTPC Vindhyachal

In Commissioning

- 'First Operation' completed,
- Integrated Plant commissioning in April'25

Indigenous Catalyst Development

Completed

- With CSIR-IIP,
- 10 KgPD Pilot at NETRA

100,000 TPA Plant at NTPC Pudimadaka

Planned

CO2 Capture Plant (20 TPD)

CO2 to Methanol Plant (10 TPD)

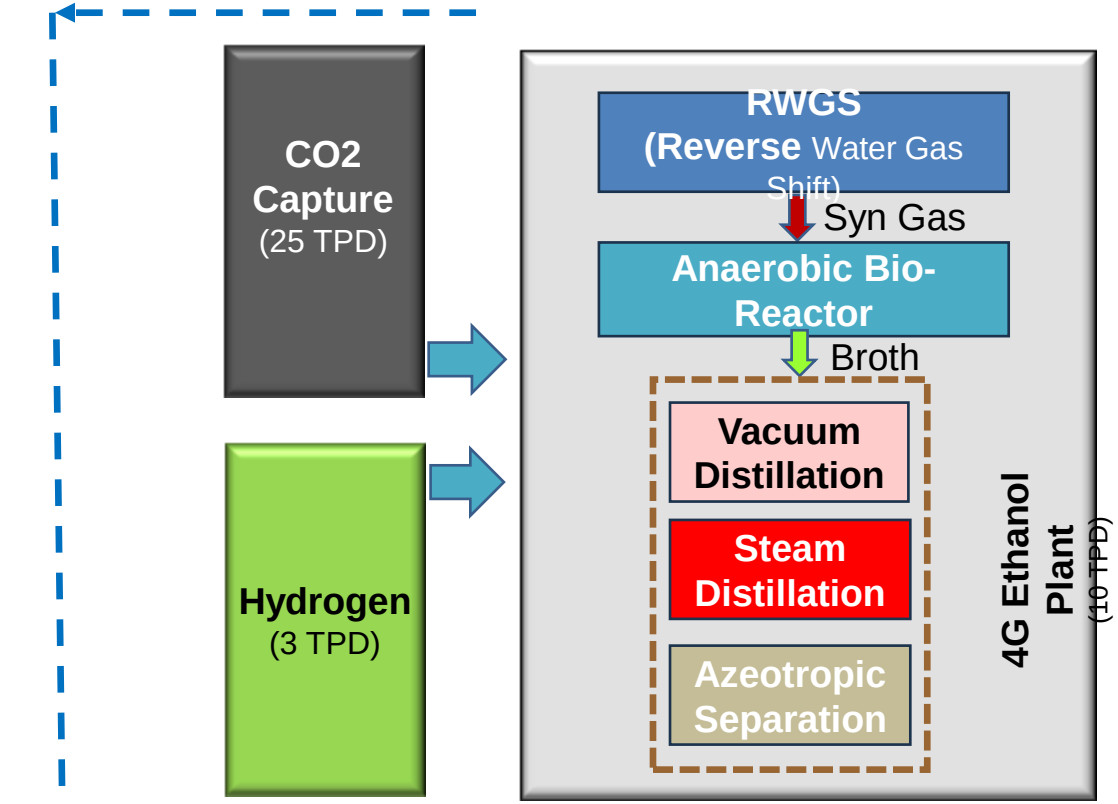
Flue Gas CO2 to SAF: 1800 TPA Plant at (Re located from NTPC Lara)

2. CO2 to Gen-4 Ethanol:

Gen-4 Ethanol

3,300 TPA Plant at NTPC Pudimadaka

Under Execution



3,300 TPA 4G-Ethanol Plant
(Being relocated from NTPC Lara to NTPC Pudimadaka)

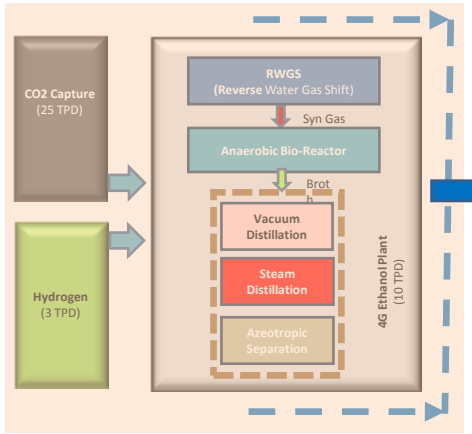
Flue Gas CO2 to SAF: 1800 TPA Plant at (Re located from NTPC Lara)

3. CO2 to Sustainable Aviation Fuel

Sustainable Aviation Fuel

1,800 TPA Plant at NTPC Pudimadaka

Up Coming



Hydrogen
(3 Kg/Hr)

Anhydrous Ethanol
(10 TPD)
(Purification & production of anhydrous ethanol)

Ethanol to Ethylene
(6 TPD)
(Dehydration of Ethanol to Ethylene)

Ethylene Oligomerization
(6 TPD)
(Polymerization of Ethylene)

Olefin Hydrogenation
(6 TPD)
(Hydrogenation of Unsaturated polymer)

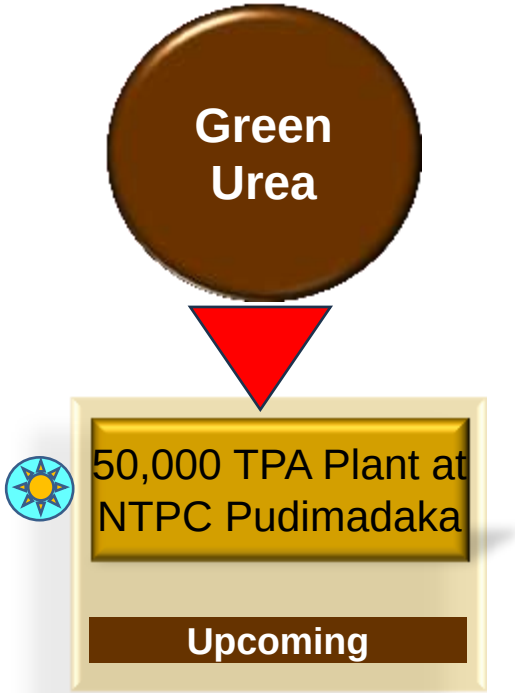
Fractionation
(6 TPD)
(Separation of SAF & RD)

1800 TPA SAF

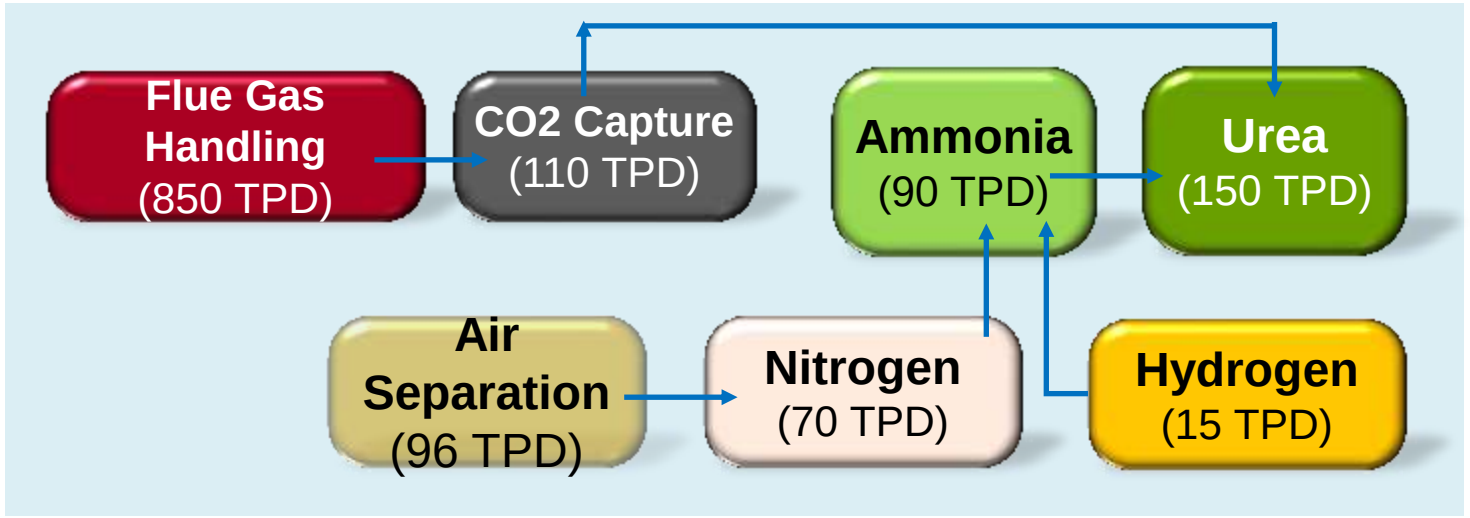
1,800 TPA SAF Plant

CO2 to Green Urea: 50,000 TPA Plant at NTPC

4. CO2 to Green Urea



Building Blocks



First 'Flue Gas CO2 to Green Urea Plant, globally

Green Chemical Hub: Pudimadaka

Project Location : Pudimadaka, Visakhapatnam, AP

Land Size : 1200 + 400 Acre (□1,006 Cr.)

Road : NH 16 (20km), SH 154 (50m)

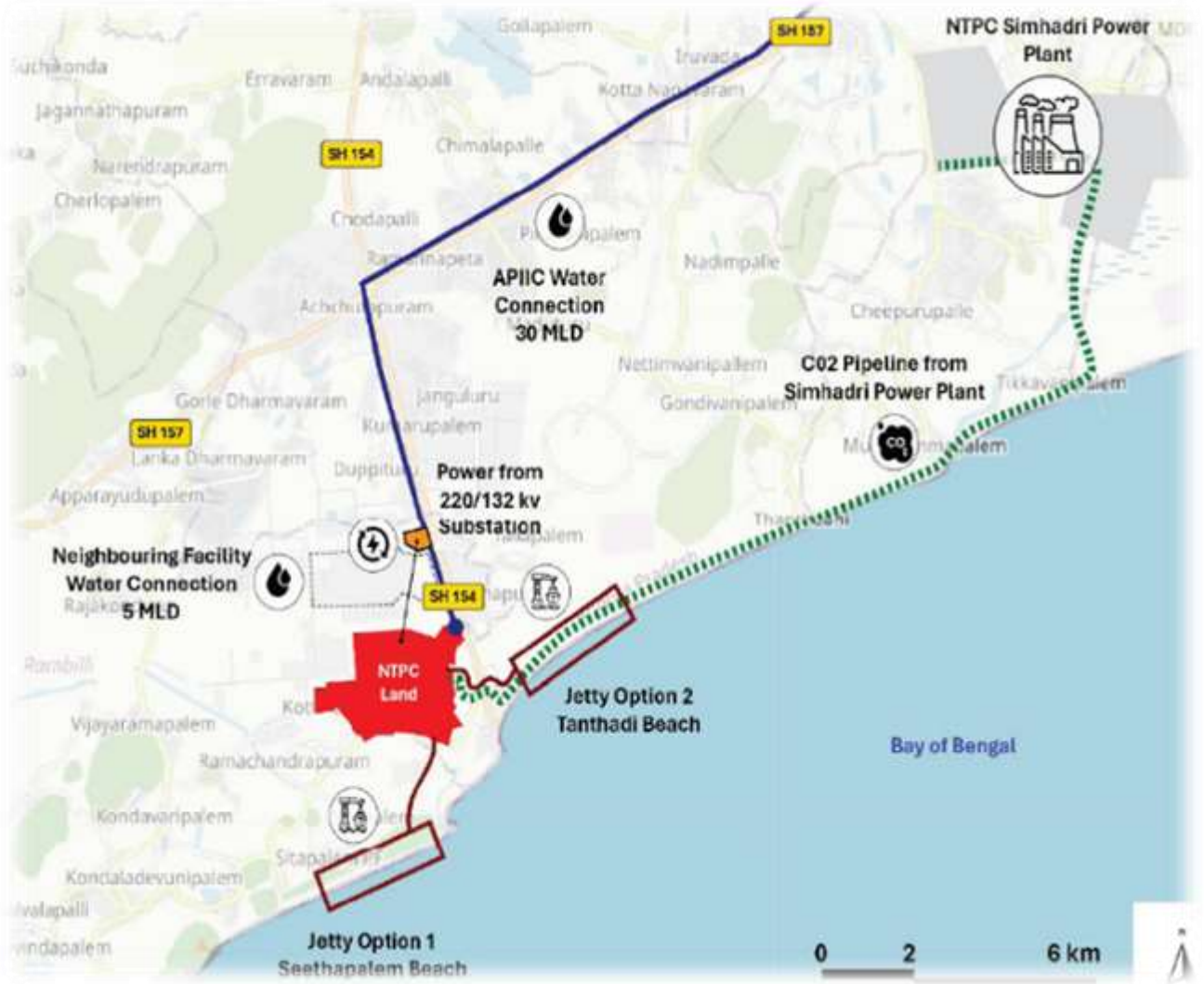
Seaport : Gangavaram (36km), Visakhapatnam (46km)

Airport : Visakhapatnam (44km)

Seashore : 2km

Water source : Fresh - APIIC Network/Yeluru Canal (15km)
80 MLD Desalination (2km)

Power Supply : 7 GW RE-RTC through CTU Open access



Status:

1. Foundation Stone laid by the Hon'ble Prime Minister on 8th Jan 2025
2. Land Registration is Completed
3. Additional land for captive jetty, desalination, storage- 220 acres (Seethapalem)

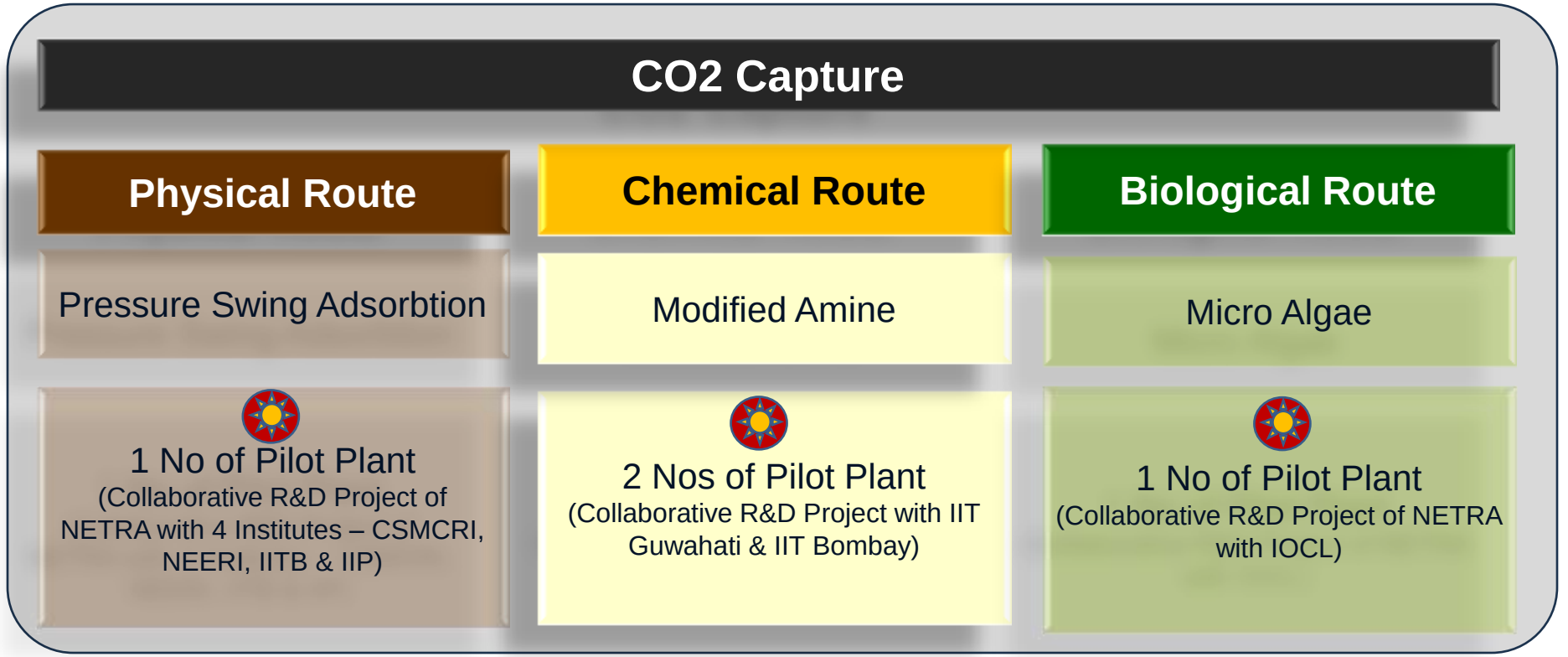
Green Chemical Hub at Pudimadaka

NETRA's Initiatives

CCUS R&D Projects

CCUS Technologies: **R&D Initiatives**

5a. CCUS R&D Initiatives – CO2 Capture:



CCUS Technologies: **R&D Initiatives**

5b. CCUS R&D Initiatives – CO2 Utilization:

CO2 to Building Material-1

- Product: **Carbonated Flyash Aggregate**
- Collaboration: **CBRI, Roorkee**
- Status: **Completed (Dec'23)**

Sintered CO2 Aggregate

100 minutes holding time @ 1150C

'Cold bonded' CO2 Aggregate

100 min holding time @ 1.3 Bar, 120C

CO2 to Building Material-2

- Product: **Carbonated Flyash Brick**
- Collaboration: **SB-NIT, Surat**
- Status: **Ongoing**

CO2 to Building Material-3

- Product: **Mesoporous Carbonated Material**
- Collaboration: **IISc, Bangalore**
- Status: **Ongoing**

CCUS Technologies: **R&D Initiatives**

5c. CCUS R&D Initiatives – CO2 Storage:

CO2 Emissions – The Big Picture:

- CO2 emission from Coal Power Plant in FY 2022-23: ~ 1,000 Million Tons (@ 0.85 KgCO2 /kWh, 1182 BU)
- CO2 emissions reduction to match Gas Plant emissions: ~ 400 Million Tons /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:

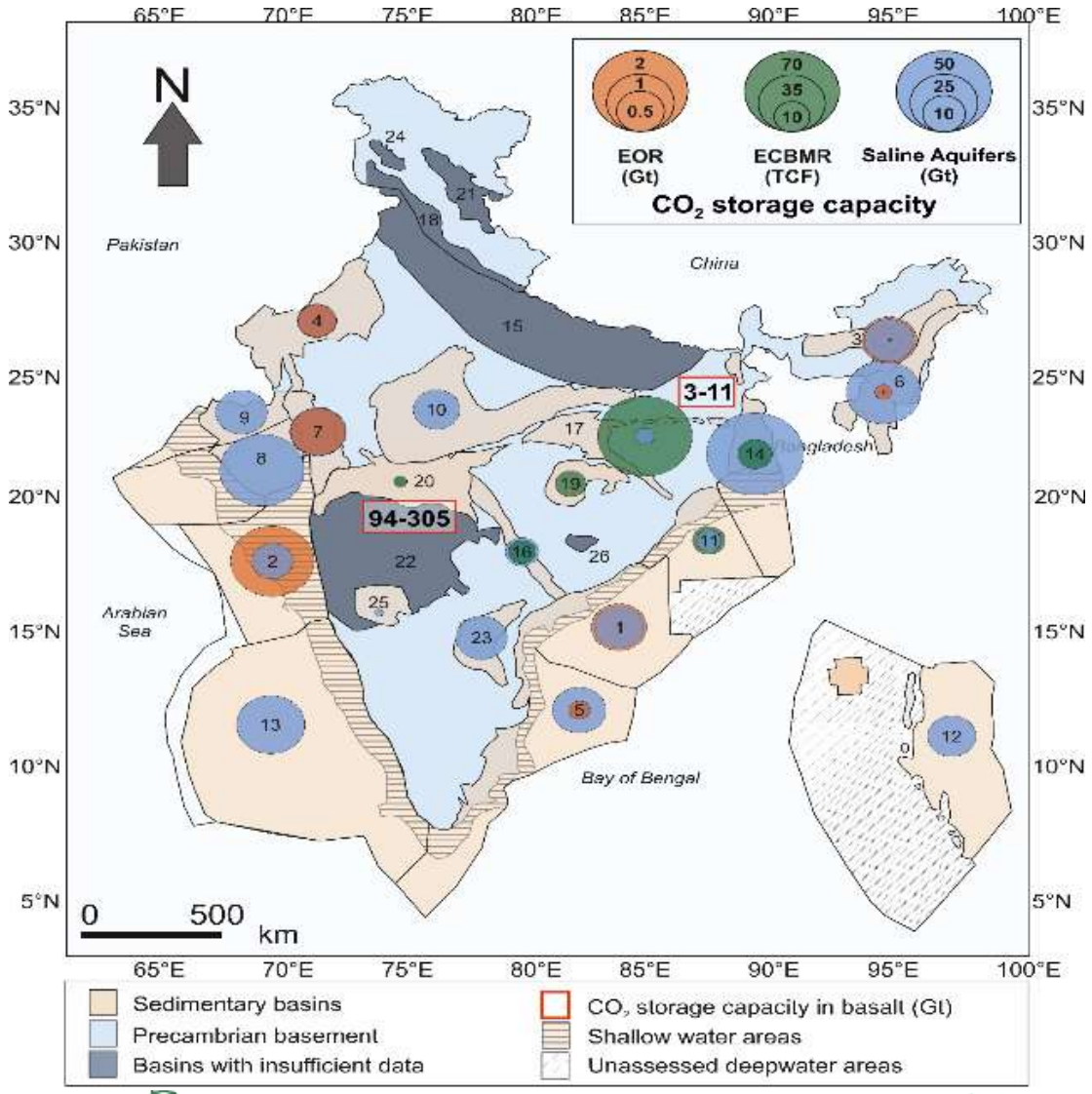
CO2 Storage potential in 'Unusable Cat-1 Coal Seam' of NTPC

- 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

- Work commenced in March'25



Thank You