Carbon Capture and Utilization

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INDIA’S Strategies in climate change abatement
India’s initiative towards Global Climate Change

India’s “Nationally Determined Contributions Towards Climate Justice”

- Oct 2016-India ratified Paris Climate agreement
- Supports global initiative to reduce temperature by $1.5^0$ to $2^0$ C
- Voluntary reduction of emission intensity to 33-35% by 2030 w.r.t 2005
- Plans to have 40% of total installed electric power from non-fossil
- To create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030
**India’s Renewable Expansion Targets**

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>2015</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Energy</td>
<td>23.76GW</td>
<td>60GW</td>
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<tr>
<td>Solar Energy</td>
<td>4060MW</td>
<td>100GW</td>
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<tr>
<td>Bio mass energy</td>
<td>4.4GW</td>
<td>10GW</td>
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<tr>
<td>Hydro Power (Small+ Large hydro)</td>
<td>46GW</td>
<td>.....*</td>
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<td></td>
<td>(4.1+41.99 GW)</td>
<td>(Aim to utilize the vast potential of 100GW)</td>
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<tr>
<td>Nuclear Power</td>
<td>4300MW</td>
<td>63GW( By 2032)</td>
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*Aim is to achieve 175 GW renewable Energy capacity*

Green Energy Corridors projects worth INR 380 billion to ensure evacuation of renewable energy
NTPC – India’s Maharatna

- 53000+ MW capacity in Operation
- 20000+ MW under Construction
- 21 Coal, 7-Gas, 1-hydro, 1-Wind, 9-JV
- 10 coal mine blocks awarded by GOI
- 22,000 plus committed workforce
NTPC’s Expansion Targets

• NTPC to be a 130 GW company by 2032 with diversified fuel mix and a 600 BU company in terms of generation.
• Coal would continue as predominant fuel with 65% share of coal based capacity in the portfolio.
• Non-fossil fuel based capacity would achieve a share of 30% and Thermal based generating capacity share would be 70%.
• Share of RE (including hydro) would be 28%
• NTPC targets a market share of 25% in ancillary services and storage
• NTPC aims to achieve 10% of the estimated market share for supply of electricity in E-mobility business
Major sources of CO₂ Emissions

- Burning of fossil fuels
- Power Plants
- Transportation
- Industrial Processes
Carbon Management in Energy Sector

- Strategies
  - Reduce
  - Replace
  - Reuse

- Technologies
  - Clean Coal Technologies
  - Renewable Technologies
  - Carbon capture & Utilisation Technologies
NETRA’s Focus Area – Climate change and Environment

Carbon → Capture → Utilization
Different methodologies: Challenges and opportunities

**Adsorption**
- TRL 5/6 level, Industry validation still needs to be done.
- The cost economics is yet to be assessed

**Cryogenic**
- Not viable

**Membrane**
- TRL level 5, Industry evaluation not done.
- International collaboration for new material development, lowering of cost, high selectivity and high temperature operation is desirable for quantum jump.

**Absorption**
- This technology has been demonstrated at TRL 9 – Commercial operation
- However, in regeneration of absorbent material the energy consumption is high
- Development of efficient absorbents, their regeneration, life and capacity.
- Enzyme (biomimetic) assisted solvent mediated CO₂ capture to reduce CAPEX & OPEX.
- In order to increase the efficiency of absorption, there is a requirement for Hybrid model of two technologies.

**Biological**
- Requires huge resources, such as land, water, etc
- Conversion into biofuel is techno economically not viable
- Alternate routes are being explored.
NETRA’ activities – Climate change and Environment

**Carbon Capture Technologies**

- **Absorption Method – IIT Guwahati**
  Development of Energy Efficient Modified Amine process for CO2 separation

- **Adsorption Method – IIP-Dehradun**
  DPR for a pilot scale up of PVSA process for CO2 separation at NTPC plant

**Biological Method**

- **Feasibility study and Engineering report preparation with IITB to establish 10MW equivalent Flue gas CO2 capture plant through a cost effective and environmental friendly absorption technology and utilize the captured CO2 in the production of Soda ash or Urea or Methanol**

- **NETRA Initiatives**
  Feasibility study and Engineering report preparation with IITB to establish 10MW equivalent Flue gas CO2 capture plant through a cost effective and environmental friendly absorption technology and utilize the captured CO2 in the production of Soda ash or Urea or Methanol

  NETRA is in talks with ONGC in establishing carbon capture plant at NTPC-Jhanor Gandhar Plant and utilizing CO2 in enhance Oil recovery in ONGC’s Jhanor’s field

- **Biological fixation – IOCL, Faridabad**
  Flue Gas CO2 fixation through Algae and utilisation through conversion into bio methane at NTPC Faridabad
NTPC-NETRA initiatives in Carbon Capture and utilisation
Demonstration of Zero Carbon Emission power plant

NETRA initiated a project with IIT B for the preparation of Feasibility and Engineering report of CO₂ capture from coal fired power plant and its utilization into green chemicals

It is proposed to establish 10MW equivalent Flue gas CO₂ capture plant through a cost effective and environmental friendly absorption technology and utilize the captured CO₂ in the production of Soda ash or Urea or Methanol

Benefits:
- India's first demonstration cum commercially viable carbon capture plant for Zero Carbon Emission coal fired power plant
- Utilization of the gaseous waste, CO₂ as a precursor for the synthesis of socio-commercially valuable green products, namely Urea and Soda ash
- Commercial success of the green chemicals in the market would open new business avenues of revenues to NTPC
NTPC-IITB CCU Project Scope and Deliverables

- CCU Plant Capacity and CO2 Utilization options
- Select any 4 sites based on high level criterion like ECR., close to port etc.
- Site visits to record, summarize and evaluate following data
  - Flue gas analysis (CO2, Acid Mist, Dust, Moisture, SOx and NOx),
  - Temperature and Pressure (understand DP)
  - Space availability and distance from stack
  - LP Steam and utilities availability
- Discuss and Select the site for CCU
- Engineering and design parameters fixation for the selected site
  - Flue gas conditions, Site Data, Steam Conditions, Cooling Water conditions
  - Space and plot layout
  - Consider impact of utilities cost on opex
- CO2 plant design and engineering and contacting the technology suppliers for CO2 conversion to Soda Ash, Methanol and Urea
- Cost Estimation for CC plant and CU options
- Overall techno-economic analysis for the three CCU options
NETRA initiatives in Carbon Capture and utilisation activities

Carbon Capture Utilisation in Enhanced oil Recovery (EOR) with ONGC

NETRA is in talks with ONGC in establishing carbon capture plant at NTPC-Jhanor Gandhar Plant and utilizing CO2 in enhance Oil recovery in ONGC’s Jhanor’s field.

Benefits:

• Capturing and utilisation of waste flue gas CO₂ through enhanced oil recovery.
• Creating an economic value, which would offset a part of CO₂ capture cost.
• Opening up new business avenues of revenues to NTPC
• Supports NTPC’s corporate social responsibility in addressing Nation’s paramount environmental challenge.
CO2 project with ONGC for EOR

Project details: NETRA is in talks with ONGC in establishing carbon capture plant at NTPC-Jhanor Gandhar Plant and utilizing CO₂ in Enhance Oil Recovery (EOR) in ONGC’s Jhanor’s field

Deliverables:
For enhancing oil production and simultaneous reduction in power plant carbon footprint.

Status:
Preliminary round of discussions and Meetings held at various forums among M/s. ONGC, M/s. NTPC, TIFAC, etc

Carbon capture plant requirement
CO₂ requirement….1500 T/Day
Power requirement….10-15 MW

Areas of concern:
To achieve the CO₂ requirement of 1500 T/Day, all 3 Gas Turbines and Steam Turbines have to be run. The policy advocacy is required for obtaining 3 MMSCMD gas in APM/NAPM mode
Ensuring long term power purchase agreement for 10-15 MW with SLDC by ONGC
**Current Projects - Carbon Capture Projects**

**NETRA** modified amine to reduce parasitic energy penalty in absorption-based CO₂ capture

- **IIT-Guwahati**
  - Identified Modified Amine with 30% reduction in parasitic energy as that of conventional MEA
  - Indigenously developed technology

**Detailed Project Report (DPR) for scale up of NETRA's patented Pressure/Vacuum Swing Adsorption process**

- **IIP-Dehradun**
  - First of its kind in PVSA-based CO₂ capture technology
  - Appr. 75% recovery & 90% CO₂ purity to be achieved in large scale
  - Availability of first-hand manual for future cost-effective installation of PVSA unit at NTPC station

**Flue Gas CO₂ fixation through Algae and utilisation through conversion into bio methane at NTPC Faridabad**

- **IOCL-Faridabad**
  - Demonstration of capture and utilisation of flue gas CO₂
  - Full utilisation of existing bio methanation plant of NTPC-Faridabad
  - In-house generation of kitchen fuel, viz., Biomethane from the waste products of NTPC-Faridabad
1. **Focus Area**: Carbon capture utilisation and storage

(Collaboration: IIP Dehradun)

2. **Objective**: PSA process was optimized at laboratory scale and a bench scale test facility had been fabricated and kept at NETRA. NETRA holds four Joint National & International patents on the CO$_2$ adsorbents and PSA process. The preparation of Detailed Project Report (DPR) has been initiated for scale up of the process.

3. **Technical information**
   - CO$_2$ is selectively adsorbed in zeolite based material at 4.5 bar pressure at 40$^\circ$C.
   - CO$_2$ is recovered under vacuum.
   - A bench scale test facility is set up at NETRA.

4. **Benefits**:
   - First of its kind in PSA based CO$_2$ capture technology.
   - Appr. 75% CO$_2$ recovery & Appr. 90% purity with flue gas containing 10-12% CO$_2$ is expected to be achieved in large scale.
   - Availability of first-hand manual for future cost effective installation of PSA unit at NTPC station.
1. **Project Title Technology:** Development of Energy Efficient Modified Amine process for CO2 separation  
   (Collaboration: IIT Guwahati)

2. **Objective:** Development of modified amine to reduce parasitic energy penalty in absorption based CO2 capture process

3. **Technical information**

   CO₂ is absorbed in 20-30% aqueous solution of modified amine at 40-45°C in an absorber column and recovered at 120-125°C using low pressure steam in a stripper column. A test facility of 20 liter per minute (lpm) CO₂ handling capacity is developed at IIT-G

4. **Benefits:**
   - Identification of Modified Amine for reducing parasitic energy.
   - Indigenously developed technology
   - Scaled up to 20 lpm flow gas capacity test facility
   - Energy penalty is expected to reduce to 25% as that of conventional MEA (4.2 MJ/KgCO2)
Focus Area : Carbon capture utilisation and storage (Current Project)

1. Project Title: Flue Gas CO2 fixation through Algae and utilisation through conversion into bio methane at NTPC Faridabad (Collaboration: IOCL R&D, Faridabad)

2. Objective: At NTPC-Faridabad, in the first phase, Algae cultivation through flue gas CO2 was demonstrated successfully. The phase II, conversion of algae into Bio fuel is found to be techno-economically non viable. As an alternate method, a project on production of bio methane from Algae along with Kitchen waste and Horticulture waste of NTPC-Faridabad is conceived.

3. Technical information: Using IOCL patented technology, the flue gas CO2 can be fixed through high bio mass Algae cultivation and the algae produced can be used for production of Bio methane along with other organic wastes.

4. Benefits:
   - Demonstration of capture and utilisation of flue gas CO2
   - Utilisation of organic wastes of NTPC-Faridabad viz., kitchen waste and horticulture waste.
   - Efficient and full utilisation of the half load running existing bio methanation plant of NTPC-Faridabad
   - In house generation of kitchen fuel, viz., Biomethane from the waste products of NTPC-Faridabad
**International Collaborations**

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<thead>
<tr>
<th>Country</th>
<th>Collaboration Area</th>
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<tbody>
<tr>
<td>Germany</td>
<td>Solar Thermal Lab</td>
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<td>Germany</td>
<td>Concentrated PV</td>
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<tr>
<td>Germany</td>
<td>ESP performance</td>
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<tr>
<td>Australia</td>
<td>Advance Combustion and Gasification Technologies</td>
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<tr>
<td>Australia</td>
<td>Coal characterisation and combustion</td>
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<tr>
<td>USA</td>
<td>Clean Carbon Technologies</td>
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<tr>
<td>Australia</td>
<td>Bulk Ash Utilization</td>
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<tr>
<td>Japan</td>
<td>Waste to Energy</td>
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**Countries:**
- Germany
- Australia
- USA
- Japan
**National Collaborations**

<table>
<thead>
<tr>
<th>Academic Institution</th>
<th>R&amp;D Institution</th>
<th>Industry</th>
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<tbody>
<tr>
<td>IGCAR, Kalpakkam</td>
<td>AUSC</td>
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<tr>
<td>CIPET, Chennai</td>
<td>Floating Solar</td>
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<td>CPRI, Bangalore</td>
<td>Drop Tube Reactor, Fly ash bricks</td>
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<td>ARCI, Hyderabad</td>
<td>Nano coating</td>
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<td>CGCRI, Kolkata</td>
<td>Fiber Optic Sensor for APH FG temp.</td>
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<td>IIP, Dehradun</td>
<td>CO2 Capture</td>
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<td>IIT, Guwahati</td>
<td>CO2 Capture</td>
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<tr>
<td>C-DAC, Pune</td>
<td>Computational hardware</td>
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<td>Jadavpur University, Kolkata</td>
<td>Transformer health assessment</td>
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<td>AMPRI, Bhopal</td>
<td>Ash Utilization</td>
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<td>CBRI, Rookee</td>
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<tr>
<td>IIT B</td>
<td>Solar, Robotics, MEMS, Corrosion, CCUS</td>
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<td>IIT K</td>
<td>Power System Smart Grid, Sensors,</td>
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<tr>
<td>MIDHANI</td>
<td>Development of erosion resistant component</td>
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<td>NCCBM</td>
<td>RCC Structure-Audit and Survey</td>
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<td>EEC</td>
<td>ESP performance improvement using CFD Modeling</td>
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<td>IISc</td>
<td>Process simulation, Flow Battery</td>
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<td>NML</td>
<td>Creep Damage Assess of High Temp Headers &amp; Pipe</td>
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<tr>
<td>IOCL</td>
<td>Micro-Algae based CO2 utilization</td>
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Thank you!
• More than 21 GW under construction.
• Have given Green Energy Commitment for 10 GW solar in 5 years. This generation would save around 10 MMT of CO₂ emissions annually.