Carbon Capture Utilization and Storage

Indumathi K, NTPC Ltd
Global Climate Change-A great threat to humanity

- Temperature increase
- Snow cover decrease
- Declining Arctic Sea
- Extreme Events
- Ocean acidification

It is time to do things through United wisdom

Conserving Now, Preserving Future
India’s initiatives towards Global Climate Change

Indian’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
51 GW + Operational capacity

20 GW under Construction (Incl. 1320 MW International Project)

10 coal mine blocks awarded by Government Of India

22,000 plus committed workforce

23 JVs and 5 Subsidiaries in Generation, Services & other Business

NTPC – India’s Powerful Maharatna in energy Sector
NTPC’s share in All India Generation and Capacity

NTPC Share in India’s installed Capacity (31.3.2017) (GW)

- NTPC Group – 50.5 GW
- Rest of India – 276.4 GW

NTPC Share in India’s Generation (FY 16-17) (BU)

- NTPC Group – 277 BU
- Rest of India – 877 BU

NTPC (15.5%)

Others (84.5%)

NTPC (24%)

Others (76%)

NTPC Group – 277 BU
Rest of India – 877 BU
NETRA’s Focus Areas

- Climate Change & Environment
- New & Renewable Energy
- Efficiency & Availability Improvement
- Advanced Scientific Services

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## International Collaborations

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MOU under discussion with GOI
### National Collaborations

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<td>Solar, Robotics, MEMS, Corrosion</td>
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**Conserving Now, Preserving Future**
Major sources of CO$_2$ Emissions

Approx. *87%*-Burning of fossil fuels

Power Plants

Transportation

Industrial Processes

Power plants have greater responsibility and role to play in CO$_2$ abatement
Carbon Management in thermal sector

Strategies
- Reduce
- Replace
- Reuse

Technologies
- Clean Coal Technologies
- Renewable Energy
- Carbon capture & Utilization Technologies

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Reduce strategy: NTPC's Approach towards Clean Coal Utilization
Indigenous development of Advanced USC

Increase in the efficiency of Power plants decreases the utilisation of coal and in turn decreases the CO2 emissions

For the development of Advanced Ultra Super Critical Technology

A Consortium partners: BHEL, Indira Gandhi Centre of Atomic Research (IGCAR), NTPC

- Estimated Cost: Rs. 1554 crores
- Project: 7 years (R&D – 2.5 years; Demonstration plant – 4.5 years)
- The main R&D activity includes material development for with standing high pressure and temperature
- Benefits: 20% reduction in CO2 emission at source, 20% saving in coal consumption compared to a sub-critical plant

Ultra Supercritical technology with Steam temperature up to 600°C is being specified for new 600/800/1000 MW units
20000 MW generation capacity currently under construction is based on SC/USC technology
In line with India Renewable energy plans to become 175 GW in 2022, NTPC framed its Renewable Energy expansion plans.

- **Fossil Coal+Gas**: 70.1%
- **Solar, wind**: 24.6%
- **Hydro**: 3.8%
- **Nuclear**: 1.5%

**2017** 51+ GW

**2032** 130GW

- NTPC has given Green Energy Commitment for 10 GW solar in 5 years. This generation would save around 10 MMT of CO₂ emissions annually.
Reuse Strategy

**Carbon**
- Flue gas 12-14% of CO2

**Capture**
- Urea
- Soda ash
- Methanol

**Utilization**
- Green chemical
Different methodologies: Challenges and opportunities

**Adsorption-Adsorbent like zeolite is used for selective capture of CO2**
- TRL 5/6 level, Industry validation still needs to be done.
- The cost economics is yet to be assessed

**Cryogenic- Low temperature fractional distillation**
- Not viable

**Membrane – Chemically quoted membranes for selective CO2 separation**
- 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 CO$_2$ capture to reduce CAPEX & OPEX.
- In order to increase the efficiency of absorption, there is a requirement for Hybrid model of two technologies.

**Biological-Algae sequestrations**
- 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 PSA process for CO2 separation at NTPC plant

Biological fixation – IOCL, Faridabad
- Flue Gas CO2 fixation through Algae and utilisation through conversion into bio methane at NTPC Faridabad
Development of modified amine to reduce parasitic energy penalty in absorption based CO2 capture

IIT-Guwahati

- Identification of Modified Amine for reducing parasitic energy.
- Indigenously developed technology
- Energy penalty is expected to reduce to 25% as that of conventional MEA

The preparation of Detailed Project Report (DPR) for scale up of NETRA's patented Pressure Swing Adsorption process

IIP-Dehradun

- First of its kind in PSA 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 PSA 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

Current Projects - Carbon Capture Projects
We do not inherit the earth from our ancestors, we borrow it from our children.
1. Project title: DPR for a pilot scale up of PSA process for CO2 separation at NTPC plant (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 CO2 adsorbents and PSA process. The preparation of Detailed Project Report (DPR) has been initiated for scale up of the process.

3. Technical information
   - CO2 is selectively adsorbed in zeolite based material at 4.5 bar pressure at 40°C.
   - CO2 is recovered under vacuum
   - A bench scale test facility is set up at NETRA

4. Benefits:
   - First of its kind in PSA based CO2 capture technology
   - Appr. 75% CO2 recovery & Appr. 90% purity with flue gas containing 10-12% CO2 is expected to be achieved in large scale
   - Availability of first-hand manual for future cost effective installation of PSA unit at NTPC station

Focus Area: Carbon capture utilisation and storage
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 i**
   \[
   \text{CO}_2 \text{ is absorbed in 20-30\% aqueous solution of modified amine at 40-45}^\circ\text{C in an absorber column and recovered at 120-125}^\circ\text{C using low pressure steam in a stripper column. A test facility of 20 liter per minute(lpm) CO2 handling capacity is developed at IIT-G}
   \]

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)
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