India's Net-Zero Mission: Can CCUS Make a Difference?

Presented by

Vikram Vishal

Convenor, DST-National Centre of Excellence in CCUS
Professor, Earth Sciences, Indian Institute of Technology Bombay, Mumbai
Founder and Director, UrjanovaC Pvt Ltd
Visiting Professor, Massachusetts Institute of Technology, USA

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DST-National Centre of Excellence in CCUS

(Estd. 2021)

सत्यमेव जयते
Department of Science and Technology
Ministry of Science and Technology
Government of India

- Nanofluid amine based solutions
- Modified membrane based CO_2 separation
- Aqueous solution-based CO_2 capture

Carbon Capture

- CO_2 valorization
- Methanol production
- High value organics
- CO/CH_4 generation

CO_2 utilization

- Country-wide capacity assessment
- Source-sink matching
- Enhanced oil recovery
- Enhanced CBM recovery

CO_2 sequestration

- CO_2 transportation
- Life-cycle analysis
- Bioenergy based CCS
- Techno-economic analysis
- Environmental Impact Assessment

Cross-cutting systems

2

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- Environmental Assessment

Cross-cutting systems

Baker Hughes, TATA, ONGC, NTPC, WACKER, SAIL, National Peroxide Limited, HIRA, slb, TATA STEEL, SYRMA SGS, Coal India, Dalmia, KONGSBERG, HSBC, JINDAL STEEL & POWER, AM/NS INDIA, HALLIBURTON

XPRIZE CARBON REMOVAL | MUSK FOUNDATION, XCarb™, OPENAIR

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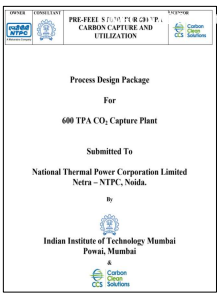
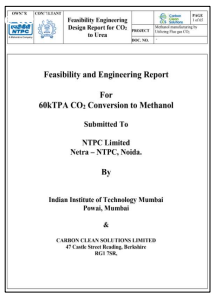
India's first CO_2 Capture from Power plant: IITB-NTPC study

1. Pre-Feasibility studies for 60,000 tonnes per annum CO_2 capture
2. Feasibility and engineering for CO_2 conversion to green chemicals
3. Feasibility for large scale CO_2 capture for enhanced oil recovery


PRE-FEED STUDY REPORT: CARBON CAPTURE AND UTILIZATION

Process Design Package
For
600 TPA CO_2 Capture Plant
Submitted To
National Thermal Power Corporation Limited
Netra – NTPC, Noida.
By
Indian Institute of Technology Mumbai
Powai, Mumbai
&
Carbon Clean CCS Solutions


Feasibility Engineering Design Report for CO_2 to Urea

Feasibility and Engineering Report
For
60kTPA CO_2 Conversion to Methanol
Submitted To
NTPC Limited
Netra – NTPC, Noida.
By
Indian Institute of Technology Mumbai
Powai, Mumbai
&
CARBON CLEAN SOLUTIONS LIMITED


NTPC Energy Technology Research Alliance

PROJECT PROPOSAL

1. PROJECT TITLE : Feasibility and Engineering Design for Zero Carbon Emissions - CO_2 capture from coal fired plant and its utilisation into green products

2. PROJECT INITIATOR : Prof. Vikram Vishal, IIT Bombay

Business Standard

NTPC starts capturing CO2 from flue gas stream at Vindhyachal plant

The power major has also forayed into a variety of business areas, ir cells, e-mobility and waste-to-energy

Topics
NTPC | Carbon dioxide | thermal power plants

Press Trust of India | New Delhi
Last Updated at August 20, 2022 00:40 IST

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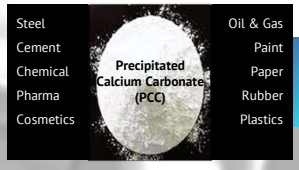
UrjanovaC – A Clean Energy and Net-Zero Solutions Company

Operates with variable CO_2 sources

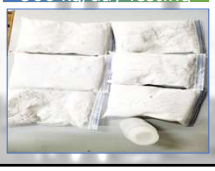
CO_2

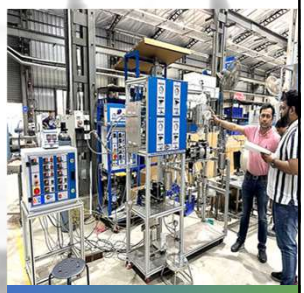
Low-cost Sustainable Modular



Market Ready product

300 kg/day Testing





1 TPD Pilot

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UrjanovaC – A Clean Energy and Net-Zero Solutions Company

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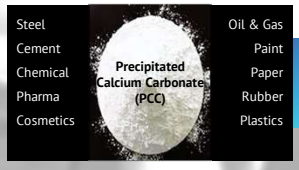
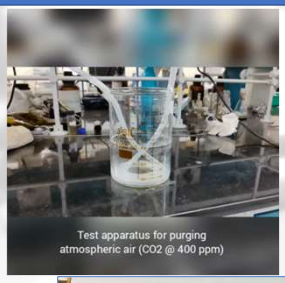
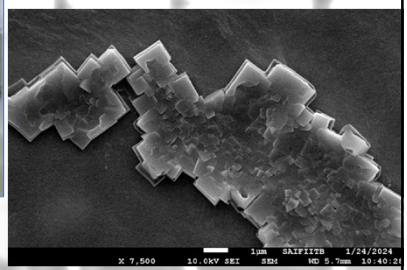


Market Ready product

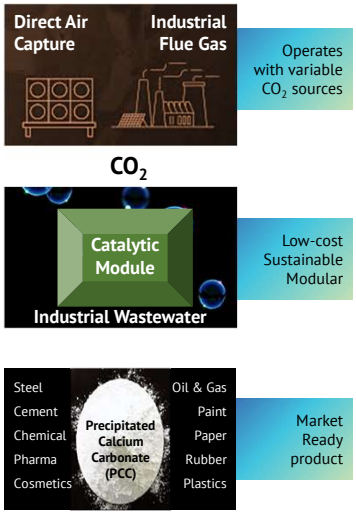




6

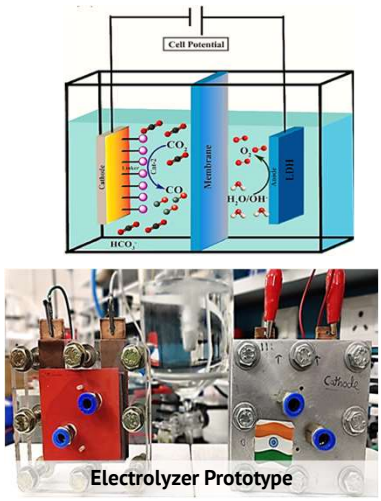
Steel sector decarbonization efforts led by IIT Bombay

Steel Slag to $CaCO_3$ using captured CO_2



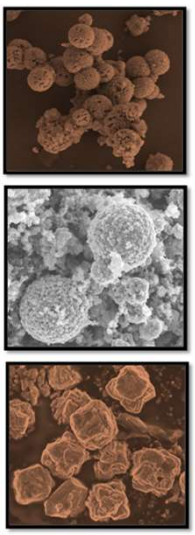
Indian Patent No : 538214
Dutta and Vishal

Sustainable and Low energy CO_2 to CO conversion



Indian Patent No. 435947
Dutta, Vishal et al.

Metal nanoparticle-based electrocatalyst



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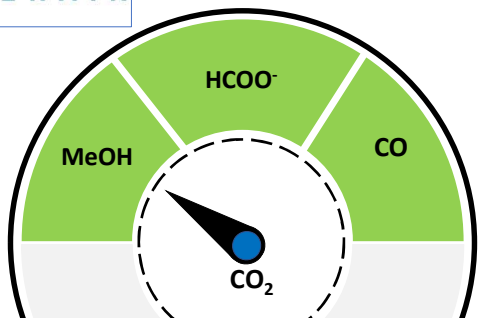
CO_2 conversion: Producing Commercially Viable Products

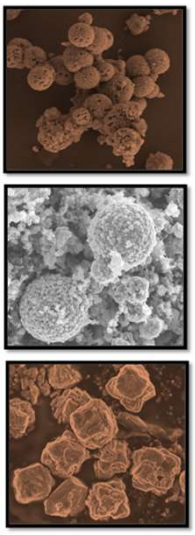
OPENAIR



- Producing combinations of CO, Methanol, and Formate
- Works in aqueous bicarbonate solution
- Tunable reactivity for product formation

Is it really possible to convert all the captured CO_2?

Metal nanoparticle-based electrocatalyst



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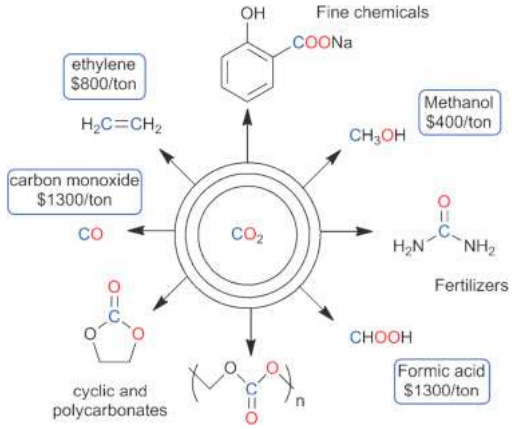
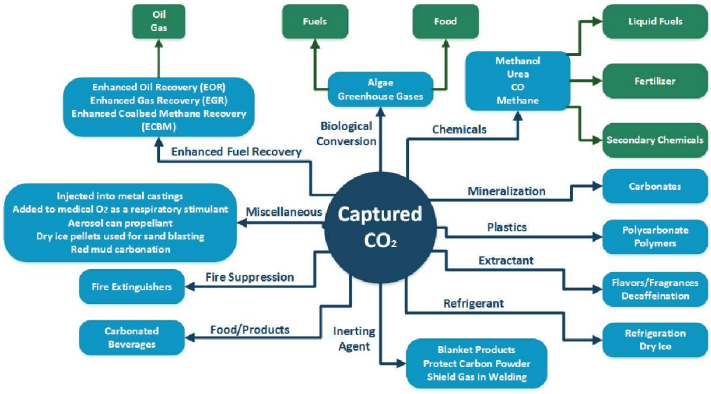
CO_2 utilization strategy

Chemical transformation





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Current Status

Multi-modular retrofittable units convert captured CO_2 to high-value chemicals & can be customized as per industry needs.

300 kg/day Testing Unit

- A 3 TPD pilot ready for commissioning
- TRL - 6 test successfully completed

1 TPD Pilot

GoI Net-Zero Pavilion, IEW-25

For 1 TPD CO_2 Capture:

- Treated flue gas: 500 Nm^3
- Catalyst required: 10.0 kg
- $CaCl_2$ required: 2.5 ton
- NaOH required: 1.0 ton
- $CaCO_3$ produced: 2.25 ton
- Water required: 5000 L
- Catalyst recycling: 10,000 times
- Area requirement: 5 m x 5 m
- Low energy requirement
- System can handle up to 10,000 ppm (1% v/v) NOx
- **Removes SOx and NOx simultaneously**
- **Overall CO_2 capture: > 90%**

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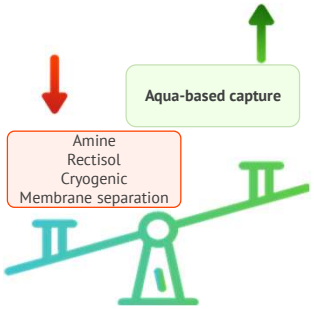
Value Proposition & Competitor Analysis

Capture & conversion of CO_2 in a sustainable, scalable, cost-effective, & energy efficient process.



Sustainable

- Uses salts & water/ wastewater
- Non-hazardous & recyclable
- Low energy requirement - Dual processing tech (capture & conversion in the same unit)
- Low space requirement - ~10x smaller in size for identical CO_2 capture capacity

Scalable

- >200 TPD*
- Abundantly available materials
- Retrofittable
- Modular

Cost-Effective

- Lower than average OPEX
- Lower than average CAPEX

Circular

CO_2 conversion to CO, Formic Acid, Methanol, Ethanol, Precipitated Calcium Carbonate OR can be sequestered

PATENTS			
Title	Year	Country	Status
Combining Direct Air Capture And Soda Ash Plant Processing For Sustainable CO_2 Mitigation	2022	India/ PCT	Granted
Reversible CO_2 /CO Conversion By A Homogeneous Copper Based Molecular Catalyst	2022	India	Granted
Carbon Dioxide Capture And Mineralization	2023	India	Filed

DUE DILIGENCE	
Name	Year
XCarb Competition by ArcelorMittal (winner)	2024
Technip Energies	2024
ONGC Startup Funding Program	2024
Azimuth Capital Management, Canada	2024

*Source: Lab reports, literature; * As per our NTPC study*

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Traction

Demonstrated the effectiveness of our innovation on multiple platforms.

Our Partners

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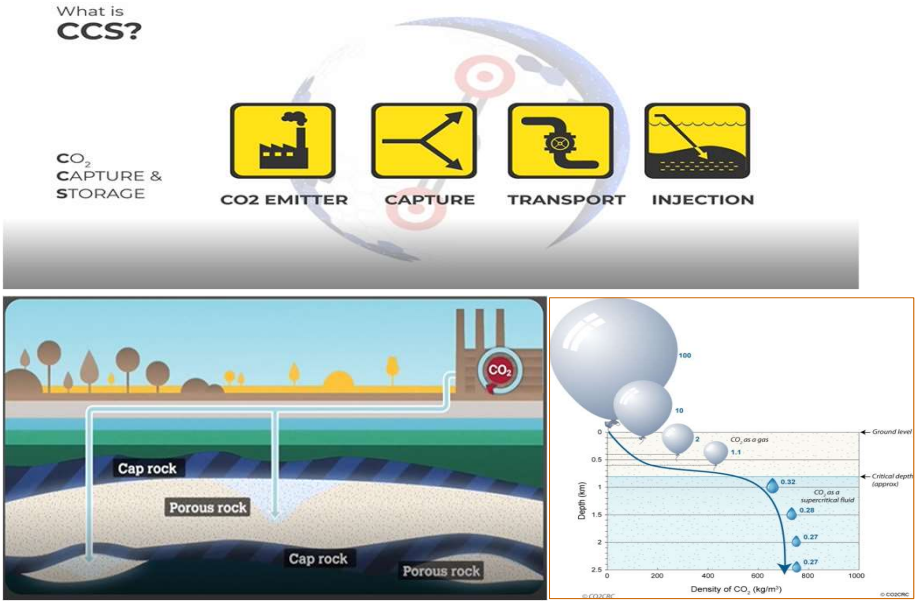
Large scale CO_2 mitigation



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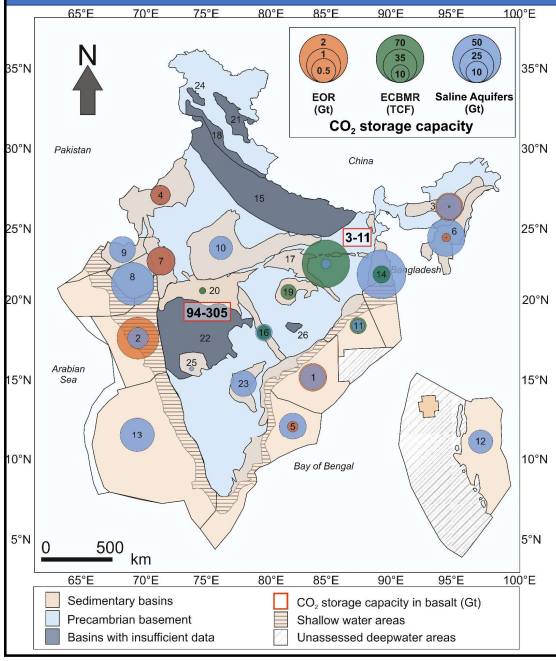
CO_2 Storage Potential in India – DST's Mission Innovation CCS Challenge



- Enhanced oil recovery: 3.4 Gt
- Enhanced coalbed methane recovery: 3.7 Gt
- On-shore/Off-shore saline aquifers: 291 Gt
- Basalt Formations: 97 – 316 Gt

Total: 395 – 614 Gt

Vishal et al., 2021, A systematic capacity assessment and classification of geologic CO_2 storage systems in India. *International Journal of Greenhouse Gas Control,* Vol. *111*, p.103458.

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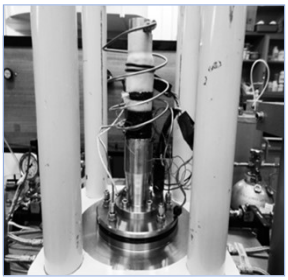
Multi-Scale Investigation: Regional to Core to Pore Scale

Collection of samples/data



Create sub-surface in lab

Mercury Intrusion Porosimeter

Core Saturator

Low Pressure Gas Adsorption setup

Gas Permeameter

Deformation Test

Pulse Decay Permeameter

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Multi-Scale Investigation: Regional to Core to Pore Scale

High pressure, high temperature, multi-phase flow-storage-deformation studies including the dynamic breakthrough

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Multi-Scale Investigation: Regional to Core to Pore Scale

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Multi-Scale Investigation: Regional to Core to Pore Scale

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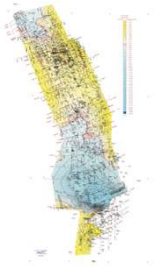
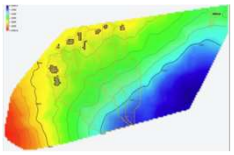
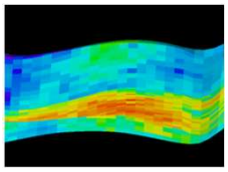
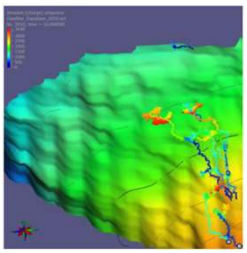
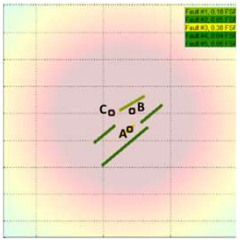
CO_2 storage site feasibility assessment

Screening | **Selection** | **Feasibility**

Regional Data Audit → **Site Identification** → **Site Characterisation** → **Site Characterisation and Injection Planning** → **Containment and risk assessment**

Published Data
National Repositories

Regional Models

Static Models
Geological Scenarios

Dynamic Modelling
Capacity assessment
Plume migration
Storage mechanisms

Coupled Reservoir & Geomechanical Modelling
Caprock and reservoir integrity
Fault Slip Potential

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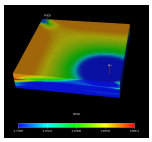
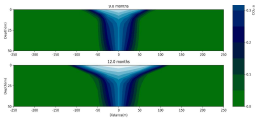
Detailed Assessment of CO_2 storage potential

DST NCoE-CCU
(DGH/SLB/Halliburton)

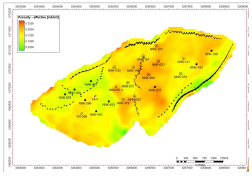
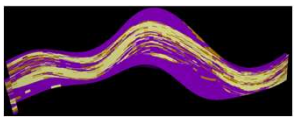
Screening, storage & migration modelling for CO_2 enhanced oil recovery in a mature oilfield in India

India Centric Site Screening Criteria Developed

MoPNG – CoE-OGE
(Oil India Limited/ BPRL)

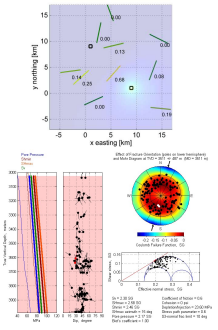
Estimation of CO_2 storage potential in select hydrocarbon fields of North East India

An integrated risk-assessment framework being developed

ONGC

Assessment of CO_2 storage potential, risk and life cycle analysis in select fields of ONGC



Inhouse Assessment Tool for Life-Cycle of CO_2 emissions

Geological Survey of India
(Carbfix, Virginia Tech, PNNL)

Assessment of suitability of four lower formations of Sahyadri Group, Deccan Volcanic Province for CO_2 sequestration.

Early evidences of mineral carbonation in basalts

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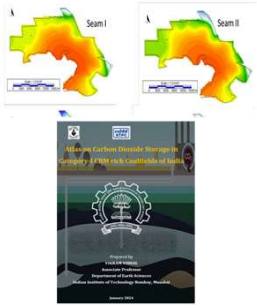
Detailed Assessment of CO_2 storage potential

MoP-NITI-NTPC

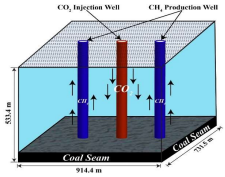
A pre-feasibility assessment of CO_2 storage in Category-I CBM rich coalfields of India



Geological CO_2 Storage Atlas for coal developed

Min of Coal/ Coal India Limited

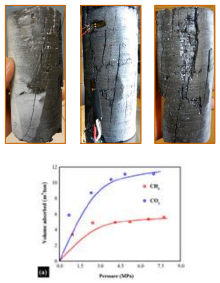
Reservoir characterization and numerical modeling of coal reservoir for CO_2 enhanced CBM recovery.



Capacity and Regions of CO_2 enhanced CBM recovery provided

Tata Steel Limited

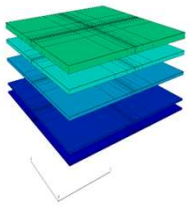
A scoping level assessment of CO_2 storage in coal seams of Jharia group of collieries.



Capacity for CO_2 storage estimated as ~44 Mt

MoSteel/ SAIL / GEECL/ ESSAR

Reduction of Carbon Footprint: CO_2 capture, storage and utilisation from Steel Plant.



An integrated approach for translation of CCUS technologies in steel sector

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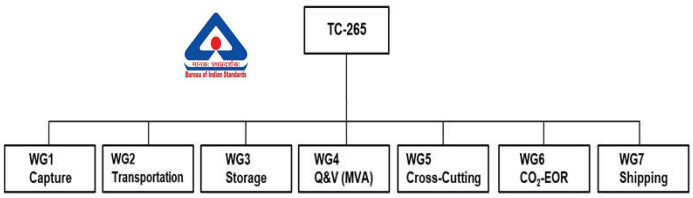
Key Technical Interventions in CCUS Ecosystem in India



Inter-Ministerial Technical Committees for the Implementation of CCUS projects in India, **NITI Aayog**
Committee for the development of Carbon Market Framework, **Ministry of Power**
Mission on Advanced and High Impact Research (MAHIR), **Min of Power and MNRE**
Member, Taskforce on CCUS, **Ministry of Steel**
Taskforce for implementation of CCUS for EOR, **ONGC**
Upstream for Carbon Capture, Utilization and Storage, **Ministry of Petroleum and Natural Gas**
CCUS Roadmap of India, **TIFAC, DST**
High-level Task Force for paving DST's Future Roadmap for accelerating CCUS in India, **DST**
CCUS Technology Gaps and International Collaboration, G-20 Presidency Report, **Ministry of Power/NTPC/Dastur**
CCUS Policies and business models, **International Energy Agency**, France
CCUS handbook for policymakers, **Bureau of Energy Resources**, Govt of USA

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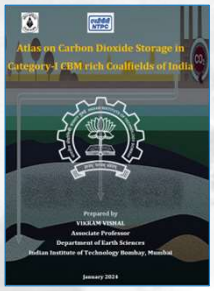
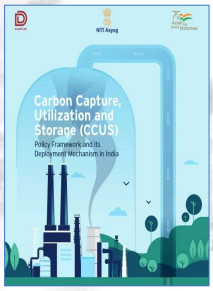
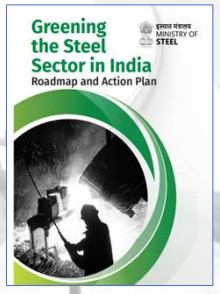
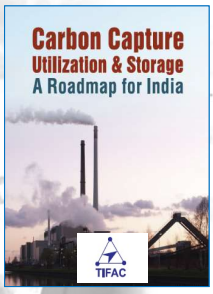
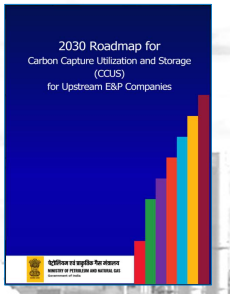
Contributions to CCUS Patents, Atlas, Roadmaps, Research Briefs, Op-Eds and Handbook

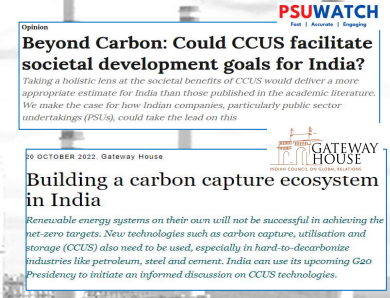












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Thank you for your kind attention

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