Technical Assistance Report

PUBLIC

Project Number: 55196-001
Knowledge and Support Technical Assistance (KSTA)
October 2023

India: Supporting India's Energy Transition Through Carbon Capture, Utilization, and Storage and Low-Carbon Technologies

Asian Development Bank

CURRENCY EQUIVALENTS
(as of 18 October 2023)

Currency unit	–	Indian rupee/s (₹)
₹1.00	=	$0.01202
$1.00	=	₹83.210

ABBREVIATIONS

ADB	–	Asian Development Bank
CCS	–	carbon capture and storage
CCUS	–	carbon capture, utilization, and storage
CO_2	–	carbon dioxide
DEA	–	Department of Economic Affairs
EOR	–	enhanced oil recovery
GDP	–	gross domestic product
IOCL	–	Indian Oil Corporation Limited
JFPR	–	Japan Fund for Prosperous and Resilient Asia and the Pacific
MOPNG	–	Ministry of Petroleum and Natural Gas
PRC	–	People's Republic of China
SMR	–	steam methane reforming
TA	–	technical assistance

NOTE

In this report, "$" refers to United States dollars.

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KNOWLEDGE AND SUPPORT TECHNICAL ASSISTANCE AT A GLANCE

1. Basic Data

Project Number: 55196-001

Project Name	Supporting India's Energy Transition Through Carbon Capture, Utilization and Storage and Low-Carbon Technologies	**Department/Division**	SG/SG-ENE
Nature of Activity	Capacity Development	**Executing Agency**	Indian Oil Corporation,Limited
Modality	Regular		
Country	India		

2. Sector

Subsector(s)	ADB Financing ($ million)
	Total **0.00**

3. Operational Priorities

- ✓ OP2: Accelerating progress in gender equality
- ✓ OP3: Tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability

Climate Change Information

GHG Reductions (tons per annum)	0
Climate Change impact on the Project	Low
ADB Financing	
Adaptation ($ million)	0.00
Mitigation ($ million)	0.00
Cofinancing	
Adaptation ($ million)	0.00
Mitigation ($ million)	2.00

Sustainable Development Goals

SDG 5.5
SDG 7.a
SDG 13.a

Gender

Some gender elements (SGE) ✓

Poverty Targeting

General Intervention on Poverty ✓

4. Risk Categorization

Complex

5. Safeguard Categorization

Safeguard Policy Statement does not apply

6. Financing

Modality and Sources	Amount ($ million)
ADB	**0.00**
None	0.00
Cofinancing	**2.00**
Japan Fund for Prosperous and Resilient Asia and the Pacific (Full ADB Administration)	2.00
Counterpart	**0.00**
None	0.00
Total	**2.00**

Currency of Financing: US Dollar

I. INTRODUCTION

1. This technical assistance (TA) aims to accelerate decarbonization by promoting carbon capture, utilization, and storage (CCUS) in emitting sectors of India.[1] The TA will undertake feasibility studies for (i) carbon dioxide (CO_2) capture, transport, and utilization for industrial application; (ii) geological storage of CO_2; and (iii) low-carbon production of hydrogen to decrease carbon emissions from refineries in Northeast India until their phase-out. It will also make recommendations on incentive policies and the regulatory framework for CCUS. The TA is closely aligned with the country partnership strategy of the Asian Development Bank (ADB) for India[2] as well as operational priorities 2 and 3 of ADB's Strategy 2030.[3]

II. ISSUES

2. **India's commitment to decarbonize its economy.** India ratified the Paris Agreement and pledged to achieve its nationally determined contributions by 2030. It updated its nationally determined contribution targets in August 2022 to reduce the carbon emissions intensity of its gross domestic product (GDP) by 45% by 2030 over 2005 levels, and to increase the share of non-fossil fuel-based electricity to 50% of its generation capacity mix by 2030. India also expressed its aspiration to achieve net zero by 2070 at the United Nations Climate Change Conference of the Parties (COP26) in 2021. By 2016, India had reduced the emissions intensity of its GDP by 24% over 2005 levels, and increased efforts are required to meet its updated carbon intensity reduction target by 2030.

3. **Carbon capture, utilization, and storage—a crucial climate change mitigation technology for India.** Along with its projected GDP and population growth over the coming decades, India's energy consumption is expected to continue to rise and to rely on fossil fuels for power generation and industrial sectors well beyond 2030 despite commitments to reduce its carbon intensity.[4] In this light, India will need to explore multiple technologies to reduce carbon emissions, in addition to a growing share of renewable energy and energy efficiency. CCUS is a promising suite of technologies close to commercialization and could abate more than 90% of emissions from hard-to-abate oil refineries, steel plants, and cement industries.

4. **India's experience with carbon capture, utilization, and storage.** Although India has limited experience in this field, the Government of India formally acknowledged CCUS as an emerging technology that could be of interest to the country, especially in abating industrial emissions. Tuticorin Alkali Chemicals and Fertilizer Limited and Carbon Clean have established the world's first commercial CCUS project in Chennai without government aid.[5] The research community has also mapped India's sources of CO_2 and matched these with storage sites.[6] The Energy and Resources Institute carried out a scoping study of carbon capture and storage (CCS)

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[1] The TA first appeared in the business opportunities section of the Asian Development Bank (ADB) website on 10 June 2022.

[2] ADB. 2023. *Country Partnership Strategy: India, 2023–2027—Catalyze Robust, Climate-Resilient, and Inclusive Growth.* Manila.

[3] ADB. 2018. *Strategy 2030: Achieving a Prosperous, Inclusive, Resilient, and Sustainable Asia and the Pacific*. Manila.

[4] BP. 2020. *Three Scenarios: Rapid, Net Zero and Business-as-Usual.* In BP. 2020. *Energy Outlook: 2020 Edition.* pp. 10–17.

[5] Edie. 2021. *Inside the World's First Fully Commercial Carbon Capture and Utilisation Plant*. News. 14 January.

[6] A. Garg et al. 2017. *Cost-Effective Architecture of Carbon Capture and Storage (CCS) Grid in India*. International Journal of Greenhouse Gas Control. 66. pp. 129–146.

for the Global CCS Institute in 2013.[7] Apart from these, India's experience with CCUS is confined to technology research, project preparatory efforts, and pilot or small-scale CCU facilities.

5. **Regulatory and policy setting to incentivize carbon capture, utilization, and storage**. Unlike other low-carbon technologies, such as solar and wind energy and energy efficiency, CCUS is not supported by fiscal and other policy measures in India for large-scale deployment and replication. However, the government is considering establishing an incentive policy framework for CCUS technology as part of its broader energy transition agenda. It is also considering establishing a domestic carbon trading system that would give further impetus to deep decarbonizing technologies such as CCUS. Although major economies have shown a growing commitment to reduce carbon emissions, in the absence of carbon taxes and a carbon emissions trading system in India, it is necessary to identify commercial applications to use the captured CO_2 (also known as CO_2 recycling).[8] The demand for CO_2 in India mainly comes from CO_2 use in industrial applications as well as enhanced oil recovery (not supported under this project).[9] The government expressed renewed interest in identifying potential geological sites for CO_2 permanent underground storage as part of its overall strategy toward decarbonization, despite the lack of commercial returns from CCUS because of the absence of carbon pricing in the India market. Information on potential storage sites for CO_2 in India is limited, and no regulatory framework is in place for geological storage of CO_2.

6. **Capacity building on carbon capture, utilization, and storage in India.** Technical capacity in CCUS technology is still limited because of the lack of CCUS projects in the country. The TA will provide valuable CCUS experience to India and its key sector players. Refineries and the petrochemical industry are a major source of CO_2 emissions in India and provide low-cost opportunities for the demonstration of CO_2 capture technologies and their scale-up because of the presence of concentrated CO_2 streams from gas turbine units or hydrogen-making facilities. The petrochemical industry provides opportunities for the reuse of captured CO_2 in industrial applications, resulting in avoided emissions.

7. **Decarbonizing India's government-owned corporations.** The Indian Oil Corporation Limited (IOCL) is the country's largest government-owned oil corporation, under the supervision of the Ministry of Petroleum and Natural Gas (MOPNG). IOCL focuses on downstream activities, including refining, transporting, and marketing petroleum products across the country. In line with the government's goal to decarbonize its economy, IOCL is keen to lower its refineries' emissions.

8. **National hydrogen mission.** The Prime Minister of India announced the National Hydrogen Mission on 15 August 2021 to ensure a green and secure energy future for India. While green hydrogen (produced from the electrolysis of water powered from renewable energy) is the preferred option for the country, the cost of green hydrogen is relatively high at present. Most hydrogen in India is produced using steam methane reforming (SMR), which results in significant CO_2 emissions. While green hydrogen offers a cleaner solution in the long run, blue hydrogen (from SMR combined with CCUS) and turquoise hydrogen (from methane pyrolysis) offer cheaper technological alternatives in the short term while producing significantly less greenhouse gas

[7] The Energy and Resources Institute. 2013. *India CCS Scoping Study: Final Report*. New Delhi.

[8] The European Union, Japan, and the People's Republic of China (PRC) have announced net zero carbon emissions targets. The European Union has also announced its intention to apply a border carbon adjustment mechanism to discourage imports from countries with high carbon intensity.

[9] The scope of the TA does not include any support for enhanced oil recovery (EOR) as the ADB Energy Policy (ADB. 2021. *Energy Policy: Supporting Low-Carbon Transition in Asia and the Pacific*. Manila) excludes EOR from ADB support because of concerns about life cycle CO_2 emissions from EOR applications.

emissions than conventional processes (SMR).[10] The early introduction of such technologies would allow the country to gain valuable experience and kick-start its low-carbon economy. Hydrogen is an important input in several industrial sectors, including refinery processes. To decarbonize its operations, IOCL seeks to explore several technologies for cleaner hydrogen production, including green hydrogen and methane pyrolysis.

9. **ADB's value addition.** ADB has more than 10 years of experience in promoting CCUS in Asia through knowledge products, policy formulation, feasibility studies, and front-end engineering designs. In India, ADB has supported pre-feasibility studies for CO_2 utilization in the food industry and CO_2 capture in the cement industry.[11] ADB will share with Indian counterparts the experience it has gained from similar work in the People's Republic of China (PRC) and Indonesia.[12] Lessons learned will be widely disseminated by the TA among Indian research institutes, and recommendations will be made on incentive policies and the regulatory framework for policy makers. Japan has gained valuable experience in CCUS and collaboration with Japanese partners will be sought under this TA. In particular, Japan CCS Co. Ltd. has agreed to participate in knowledge sharing events and offered to receive the IOCL staff for a site visit.

10. **Development partner support on carbon capture, utilization, and storage.** The Government of the United Kingdom is supporting the development of a CCU facility at Dalmia Cement's industrial site in Tamil Nadu, India. In July 2020, India and the United States jointly announced their intent to collaborate on CCUS,[13] and the United States Trade and Development Agency provided grant funding to IOCL for feasibility studies on CCUS deployment at its Gujarat refinery.[14] In September 2020, the Directorate General of Hydrocarbons and Norwegian Energy Partners jointly organized a knowledge sharing event providing an overview of CCUS activities in Norway and discussing potential for collaboration. India and Japan are strengthening their bilateral collaboration in the energy sector, of which CCUS is a key pillar.

III. THE TECHNICAL ASSISTANCE

A. Impact and Outcome

11. The TA is aligned with the following impact: a climate-friendly and clean development path with reduced emissions intensity of GDP by 45% by 2030 from the 2005 level.[15] The TA will have

[10] Methane pyrolysis involves the thermal decomposition of methane into its components—hydrogen (gas) and carbon (solid particles)—and prevents direct CO_2 emissions. (Chemical equation: CH_4 (g) = C(s) + 2 H_2 (g)).

[11] ADB. 2018. *Regional: Integrated High Impact Innovation in Sustainable Energy Technology—Prefeasibility Analysis for Carbon Capture, Utilization and Storage (Subproject 2).*

[12] ADB. 2019. *PRC: Promoting and Scaling Up Carbon Capture and Storage Demonstration—Feasibility Assessment of a Large-Scale Carbon Capture and Storage Demonstration Project and Development Support to Yanchang Petroleum Group (Subproject 2)*; ADB. 2012. *PRC: Road Map for Carbon Capture and Storage Demonstration and Deployment*; ADB. 2019. *Carbon Dioxide-Enhanced Oil Recovery in Indonesia: An Assessment of its Role in a Carbon Capture and Storage Pathway*. Manila; ADB. 2016. *Indonesia: Pilot Carbon Capture and Storage Activity in the Natural Gas Processing Sector*; ADB. 2019. *Pilot Carbon Capture and Storage Activity in the Natural Gas Processing Sector in Indonesia (Gundih Block Feasibility Design and Costing)*. Consultant's report. Manila (TA 9189-INO); ADB. 2019. *Pilot Carbon Capture and Storage Activity in the Natural Gas Processing Sector in Indonesia (Sukowati Pilot CCUS Enhancement Study)*. Consultant's report. Manila (TA 9189-INO); and ADB. 2010. *Regional: Determining the Potential for Carbon Capture and Storage in Southeast Asia*.

[13] Government of India, Ministry of Science and Technology. 2020. *Ministerial Meeting of Indo–US Strategic Energy Partnership Highlight Major Accomplishments, Prioritizes New Cooperation Areas*. Press release. 18 July.

[14] United States Trade and Development Agency. 2020. *USTDA Supports India's First Refinery Carbon Capture Project*. Press release. 9 September; and G. Sarthak. 2020. *M N Dastur Joins US-Funded Study on Carbon Capture at IOC's Koyali Refinery*. *Energy World.* 26 December.

[15] Government of India. 2022. *India's Updated First Nationally Determined Contribution Under Paris Agreement (2021–2030)*. New Delhi.

the following outcome: feasibility of commercial scale CCUS technology deployment in India established.[16] In so doing, the TA will facilitate India's access to clean carbon capture technology and complement other ongoing ADB-supported CCUS projects that focus on storage and utilization of CO_2. The TA will thus contribute to fostering a more sustainable growth path.

B. Outputs, Methods, and Activities

12. **Output 1: Feasibility of carbon capture and recycling from India Oil Corporation Limited operations in Assam, Northeast India explored.** This output will examine various options of carbon capture technologies at the IOCL refineries in Digboi, Guwahati, and Bongaigaon. The feasibility study will cover a technical assessment and preliminary engineering of carbon capture; assessment of the social and environmental implications of CCUS deployment, including emissions measurement and reporting and verification protocols; economic analysis; and financing options (including from ADB). Various CO_2 utilization options at the three refineries will be studied. Such options include industrial gases for concreting and packaging industry, mineral carbonation, mineralization, methanol production, polyol production, and chemical production.

13. **Output 2: Pre-feasibility of selected geological structures for storage of carbon dioxide in Northeast India explored.**[17] This output will study geological structures[18] around the Digboi, Guwahati, and Bongaigaon sites and assess the viability as CO_2 storage. The output will identify suitable sites (up to four) for a pilot CO_2 storage project. The TA will further select the most promising site and conduct a pre-feasibility study for the selected site. The pre-feasibility study would assess the technical viability of the site as permanent underground storage, technically and economically optimal CO_2 transportation modes from the carbon capture location to the proposed storage site, or an injection point, and the economics of the entire CCS operation after the commission of the infrastructure, including the monitor of stored CO_2 leakage.

14. **Output 3: Low-carbon hydrogen production technologies explored.** This output will review the methane pyrolysis technologies for hydrogen production with respect to cost, environmental impact, and future development. The output will assess the process most suitable for India. A road map to implement a methane pyrolysis pilot or demonstration project at IOCL's operations in Northeast India will be prepared. The roadmap will cover hydrogen production, transportation, storage, and utilization.

15. **Output 4: Knowledge transfer and sharing on carbon capture, utilization, and storage and other decarbonization technologies among key stakeholders promoted.** This output will organize knowledge sharing workshops and trainings with Indian counterparts to strengthen their capacity on CCUS and decarbonization technologies[19]. Results of Outputs 1, 2, and 3 will be materialized as knowledge products and disseminated through knowledge sharing events to various stakeholders, including civil society organizations in and around the project area.[20]

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[16] The design and monitoring framework is in Appendix 1.

[17] This assessment will enable IOCL to gain the required experience for when carbon storage becomes mandatory and/or the government begins to levy a tax on carbon emissions.

[18] Abandoned oil and gas fields where EOR and enhanced gas recovery operations cannot be performed.

[19] Ensuring even capacitation of men and women on CCUS and decarbonization technologies.

[20] These knowledge products may include (i) recent developments in performance improvements and cost curves of carbon capture technologies complementary to current research undertaken by IOCL; (ii) expanding the choice for using CO_2 as feedstock in the manufacturing industry, and ongoing efforts to achieve scale economies; (iii) additional

C. Cost and Financing

16. The TA financing amount is $2.0 million, which will be financed on a grant basis by the Japan Fund for Prosperous and Resilient Asia and the Pacific (JFPR)[21] and administered by ADB. The key expenditure items are listed in Appendix 2. Ineligible expenditures under JFPR financing include (i) academic research, (ii) the purchase of vehicles for project administration,[22] (iii) salaries for civil servants,[23] (iv) scholarships or internships, (v) international travel,[24] and (vi) ineligible expenditures under ADB's Prohibited Investment Activities List.[25] Monitoring and ensuring proper utilization of TA fund will be conducted by ADB. IOCL will provide counterpart support in the form of provision of counterpart staff, data, logistics support, and technical inputs in selected areas.

D. Implementation Arrangements

17. ADB will administer the TA, including monitoring and ensuring proper utilization of TA fund. The Energy Sector Office of ADB's Sectors Group will select, supervise, and evaluate the consultants; procure goods; organize workshops; and provide staff to act as resource persons in the workshop along with the knowledge partners and consultants.

18. IOCL will be the executing and implementing agency. The Government of India's Department of Economic Affairs (DEA) nominated IOCL the executing agency based on IOCL's extensive operations in the oil and gas sector and potential for significant greenhouse gas emissions reduction in its operations.[26] A high-level steering committee will be set up to provide overall guidance and direction for the CCUS work; it will include officials from the MOPNG, NITI Aayog, IOCL, the Directorate General of Hydrocarbons, and other relevant government entities (e.g., the Department of Science and Technology and the Department of Industry).

19. Implementation arrangements are summarized in the table.

Implementation Arrangements

Aspects	Arrangements
Indicative implementation period	November 2023–October 2026
Executing agency	IOCL

up-front planning and effort required for monitoring and verification of CO_2 emissions (following internationally accepted CO_2 accounting methodologies) if carbon credits are to be earned from the CCUS operation; (iv) comparison of current regulations in India with the CCUS-related legal and regulatory environment, including environment, health, and safety, in different parts of the world; (v) methane pyrolysis for hydrogen production; and (vi) long-term CO_2 storage in abandoned oil and gas reservoirs in Northeast India.

[21] The JFPR is a possible funding source subject to the approval of the Government of Japan.

[22] Except when the use of and the need to purchase a vehicle is fully justified and included in the original proposal and approved by the Government of Japan.

[23] This refers to civil servants working under the executing or implementing agencies.

[24] This refers to the travel of executing or implementing agency staff and TA beneficiaries and/or participants, except where the participation of the recipient countries (including civil servants) in international workshops, conferences, mentoring visits, or study tours is fully justified in the original proposal, with a detailed description, objectives, and other relevant information (e.g., the proposed schedule, participants, and budget) and approved by the Government of Japan. The maximum amount for foreign travel is $0.1 million or 10% of the amount of the proposal, whichever is lower.

[25] ADB. 2009. *Safeguard Policy Statement (2009)*. Manila.

[26] IOCL was designated the executing agency since the request was received from the DEA where IOCL is the project proponent. The Government of India's approval of the preliminary project report (PPR) also confirms IOCL as the executing agency, as the PPR was submitted by IOCL and endorsed by the MOPNG and the DEA on behalf of the Government of India.

Aspects	Arrangements		
Implementing agency	IOCL		
Consultants	To be selected and engaged by ADB		
	Package title	**Selection method**	**Amount**
	Package A. Feasibility Study for CO2 Capture, Transport and Utilization	Firm selection using QCBS (90:10) for international consulting firms	$761,000
	Package B. Review of low-carbon hydrogen production technologies, and Feasibility Study for Hydrogen Production through Methane Pyrolysis	Firm selection using QCBS (90:10) for international consulting firms	$359,000
	Package C. Viability study of permanent underground CO2 storage in Assam and related policy work	Firm selection using QCBS (90:10) for international consulting firms	$217,000
	Package D. Pre-feasibility study for underground CO2 storage, monitoring and related policy work	Firm selection using QCBS (90:10) for international consulting firms	$370,000
	Review Consultant for Package A • CO2 capture expert • CO2 utilization expert	Individual consultants 1.5 person-months	$40,000
	Review Consultant for Package B • Hydrogen Expert	Individual consultants 0.5 person-months	$13,000
	Review Consultant for Packages C and D • CO2 Storage Expert • Drilling Expert	Individual consultants 2.0 person-months	$55,000
	Economic and Financial Review Consultant	Individual consultant 1.5 person-months	$40,000
	Coordination Consultant • International expert • National expert	Individual consultant 6.0 person-months	$102,000
Disbursement	Disbursement of TA resources will follow ADB's *Technical Assistance Disbursement Handbook* (2020, as amended from time to time).		

ADB = Asian Development Bank, IOCL = Indian Oil Corporation Limited, QCBS = quality- and cost-based selection.
Source: Asian Development Bank.

20. **Consulting services.** ADB will engage and supervise four international consulting firms to conduct the proposed studies, three sets of individual consultants for expert independent reviews of these studies to ensure the utmost quality of outputs, one individual consultant to review the economic and financial viability of the study results, and two coordination consultants to facilitate the communication among IOCL, the consultants, and ADB. Among the four firms, Firm-A (48.1 person-months) will work on CO_2 capture, transport, and utilization, including related policy and capacity development. Firm-B (12.7 person-months) will work on hydrogen generation through methane pyrolysis. Firm-C and D will work on CO_2 underground storage, monitoring, and policy-related work. Firm-C (7.9 person-months) will carry out a viability study for the potential of CO_2 underground storage in Assam and recommend site locations, while Firm-D (13.5 person-months) will carry out a pre-feasibility study on permanent CO_2 underground storage for the selected site. ADB will engage consultants following the ADB Procurement Policy (2017, as amended from time to time) and its associated staff instructions.[27]

[27] Terms of Reference for Consultants (accessible from the list of linked documents in Appendix 3).

21. **Knowledge sharing and site visit.** The TA will benefit from knowledge transfer from Japan Carbon Capture and Storage Company Limited (JCCS), a Japanese company with international and thorough experience of designing and operating a carbon capture and storage plant, and carrying out research and development on carbon leakage monitoring, carbon transport, and carbon utilization and recycling. JCCS will mentor IOCL in its deployment of CCUS technologies. JCCS has agreed to participate in workshops under Output 4. JCCS has collaborated with ADB before like the Asia Clean Energy Forum 2020.[28] The TA will also support a site visit by selected IOCL personnel to the JCCS Tomakomai CCUS demonstration unit in Japan, to capitalize on the high-level Japanese expertise in CCUS technologies, considering the financial support of Japan for this project (JFPR). The detailed description, objectives, proposed schedule, participants' eligibility criteria, and budget are in Appendix 3.

22. **Gender.** The capacity building initiatives and trainings under the TA will also aim to develop or strengthen women's leadership skills and potential by increasing their knowledge of innovative low-carbon technologies.

23. **Cofinancier requirements.** The Energy Sector Office of ADB's Sectors Group will conduct the JFPR-financed project's implementation, supervision, and monitoring following ADB's applicable policies, procedures, and guidelines, including on consulting services and procurement, disbursement, social and environmental safeguards, financial management and reporting, and anticorruption and governance. The TA completion report for the JFPR will be submitted following ADB's Project Administration Instruction 6.08.[29] A record of Japanese visibility measures, including all knowledge products produced under the JFPR financing for the TA, will be listed and reported in the completion report.[30] The completion report will be shared with the Embassy of Japan in India and the Japan International Cooperation Agency.

IV. THE PRESIDENT'S DECISION

24. The President, acting under the authority delegated by the Board, has approved the Asian Development Bank administering technical assistance not exceeding the equivalent of $2,000,000 to India to be financed on a grant basis by the Japan Fund for Prosperous and Resilient Asia and the Pacific for Supporting India's Energy Transition Through Carbon Capture, Utilization, and Storage and Low-Carbon Technologies, and hereby reports this action to the Board.

[28] JCCS also participated in ADB webinar 15/16 April 2021 for PRC: "Advanced Training Course/Seminar on Carbon Capture, Utilization and Storage (CCUS) Technology".

[29] ADB. 2019. *Technical Assistance Completion Report. Project Administration Instructions. PAI 6.08.* Manila.

[30] The draft completion report will be shared with the Partner Funds Division of ADB's Sustainable Development and Climate Change Department (SDPF) for comments. The approved completion report will be disclosed on the ADB website and submitted to SDPF for forwarding to the Government of Japan.

DESIGN AND MONITORING FRAMEWORK

Impact the TA is Aligned with A climate-friendly and clean development path with reduced emissions intensity of GDP by 45% by 2030 from the 2005 level (Updated First Nationally Determined Contributions submitted to United Nations Conference on Climate Change)[a]			
Results Chain	**Performance Indicators**	**Data Sources and Reporting Mechanisms**	**Risks and Critical Assumptions**
Outcome Feasibility of commercial scale CCUS technology deployment in India established	**By 2027:** A feasibility report on carbon capture from IOCL's three refineries in Northeast India, CO_2 utilization, and CO_2 storage submitted to IOCL and ADB (2023 baseline: not applicable) (OP3.1.5)	IOCL website, MOPNG website	R: Few or no feasible options for utilizing or storing the captured CO_2, given the cost of capturing, lack of a carbon credit system and lack of demand for CO_2 in industrial applications in Northeast India A: Political will is present to support the demonstration of CCUS and low-carbon technologies in India
Outputs 1. Feasibility of carbon capture and recycling from India Oil Corporation Limited operations in Assam, Northeast India explored	**By 2027:** 1a. A feasibility study of carbon capture technologies from IOCL's three refineries in Northeast India[b] completed and the findings presented to relevant stakeholders (2023 baseline: not applicable) (OP3.1.5)	1a. IOCL annual reports, consultant reports, workshop minutes.	R: Limited or no viable options for CCUS in Northeast India; limited or no viable options that can compete with conventional hydrogen production routes A: Information shared by the relevant authorities and organizations and travel restrictions are lifted
2. Pre-feasibility of selected geological structures for storage of carbon dioxide in Northeast India explored	**By 2027:** 2a. Assessment of selected geological structures for storage of CO_2 in Northeast India[c] completed and the findings presented to relevant stakeholders (2022 baseline: not applicable) (OP3.1.5)	2a. IOCL annual reports, and consultant reports	
3. Low-carbon hydrogen production technologies explored	**By 2027:** 3a. A feasibility study of low-carbon hydrogen production technologies, with an emphasis on	3a. Consultant reports	

Results Chain	Performance Indicators	Data Sources and Reporting Mechanisms	Risks and Critical Assumptions
	methane pyrolysis, completed, and the findings presented to relevant stakeholders (2023 baseline: not applicable) (OP3.1.5)		
4. Knowledge transfer and sharing on carbon capture, utilization, and storage and other decarbonization technologies among key stakeholders promoted	**By 2027:** 4a. At least 2 knowledge products on CCUS and low-carbon technologies published and disseminated (2023 baseline: 0) (OP3.1.2) 4b.At least 70% of participants (of which 30% are women[d]) from five knowledge sharing events report increased knowledge of CO_2 capture, CO_2 utilization, low-carbon hydrogen production, and long-term CO_2 storage in Northeast India (2023 baseline: 0) (OP2.3.1 and OP3.1.2)	4a-b. Workshop minutes, knowledge products, and feedback surveys	

Key Activities with Milestones

1. **Feasibility of carbon capture and recycling from India Oil Corporation Limited operations in Assam, Northeast India explored**

1.1 The consulting firm recruited and mobilized (Q2 2024)
1.2 Carry out technical assessment of CO_2 resource and develop conceptual design for the separation, purification, compression, and transport of captured CO_2 (Q1 2025)
1.3 Carry out economic analysis and prepare cost estimates for the carbon capture project (Q2 2025)
1.4 Assess financing options and develop financing plan, including recommendation on the optimal financing structure (Q3 2025)
1.5 Carry out preliminary environmental analysis and risk assessment (Q4 2025)
1.6 Review regulatory issues and legal framework (Q1 2026)
1.7 Finalize feasibility report and present findings to IOCL (Q3 2026)

2. **Pre-feasibility of selected geological structures for storage of carbon dioxide in Northeast India explored**

2.1 The consulting firm recruited and mobilized (Q2 2024)
2.2 Gather information on geological structures in and close to the Digboi, Guwahati, and Bongaigaon refinery sites in Northeast India (Q1 2025)
2.3 Identify up to four viable candidate sites for the storage pilot project (Q2 2025)

2.4 Review possible modes of CO_2 transport to the proposed injection point and perform an economic analysis for the project (including monitoring of CO_2 leakage) (Q2 2026) **3. Low-carbon hydrogen production technologies explored** 3.1 The consulting firm recruited and mobilized (Q2 2024) 3.2 Review different processes of methane pyrolysis (Q1 2025) 3.3 Prepare feasibility study for a methane pyrolysis pilot project and a road map for its implementation in one of three refineries (Q3 2025) **4. Knowledge transfer and sharing on carbon capture, utilization, and storage and other decarbonization technologies among key stakeholders promoted** 4.1 The consulting firm recruited and mobilized (Q2 2024) 4.2 Prepare knowledge products and conduct six knowledge sharing workshops (Q1 2025–Q2 2026) 4.3 Conduct post-activity evaluation, confirming the success of knowledge sharing activities (Q3 2026) 4.4 Prepare implementation tool kits and conduct TA-wide periodic monitoring briefs and frequent completion reviews (Q3 2024–Q3 2026) **TA Management Activities** Includes reporting, monitoring and evaluation (including primary data collection activities), accounting, and auditing (Q1 2024–Q3 2026)
Inputs Japan Fund for Prosperous and Resilient Asia and the Pacific: $2.0 million Note: The government will provide counterpart support in the form of counterpart staff and other in-kind contributions.

A = assumption; CO_2 = carbon dioxide; CCUS = carbon capture, utilization, and storage; GDP = gross domestic product; IOCL = Indian Oil Corporation Limited; MOPNG = Ministry of Petroleum and Natural Gas; OP = operational priority; Q = quarter; R = risk; TA = technical assistance.

[a] Government of India. 2022. *India's Updated First Nationally Determined Contribution Under Paris Agreement (2021–2030)*. New Delhi.

[b] Including options for the utilization of captured carbon, the preliminary engineering design, social and environmental assessments, carbon credit generation and sale, economic and financial analyses, and financing options analyses.

[c] Including a technical assessment of the geology of the area, its integrity and possibility of leakage, options for transportation and injection of CO_2, preliminary design of above-surface infrastructure, and preliminary environmental and social risk assessment.

[d] Target for women's participation in the five knowledge sharing events will be finalized when baseline data is collected e.g., gender disaggregation of IOCL workforce, etc.

Contribution to Strategy 2030 Operational Priorities:

The expected values and methodological details for all OP indicators to which this TA will contribute results are detailed in Contribution to Strategy 2030 Operational Priorities (accessible from the list of linked documents in Appendix 3).

Source: Asian Development Bank.

COST ESTIMATES AND FINANCING PLAN
($'000)

Item	Amount
Japan Fund for Prosperous and Resilient Asia and the Pacific[a]	
1. Consultants	
a. Remuneration and per diem	
i. International consultants	735.7
ii. National consultants	778.1
b. Out-of-pocket expenditures	
i. International and local travel	259.8
ii. Surveys	40.0
iii. Training, seminars, and conferences	50.0
2. Training, seminars, and conferences[b]	41.6
3. Contingencies	94.8
Total	**2,000.0**

[a] Administered by the Asian Development Bank.
[b] Relevant to the cost for the knowledge sharing and site visit to Japan. Travel cost of resource persons, including ADB staff, can be covered under the item.
Note: The technical assistance (TA) is estimated to cost $2,000,000 which will be contributed from JFPR. In addition, IOCL will provide counterpart support in the form of timely-supply of necessary data, counterpart staff for meeting/discussion, domestic transportation for local movement. In case the other in-kind contributions are identified to be provided during the project implementation, those will be discussed further.
Source: Asian Development Bank Estimates.

LIST OF LINKED DOCUMENTS

http://www.adb.org/Documents/LinkedDocs/?id=55196-001-TAReport

1. Terms of Reference
2. Contribution to Strategy 2030 Operational Priorities
3. International Workshops, Conferences, Mentoring and Study Visits