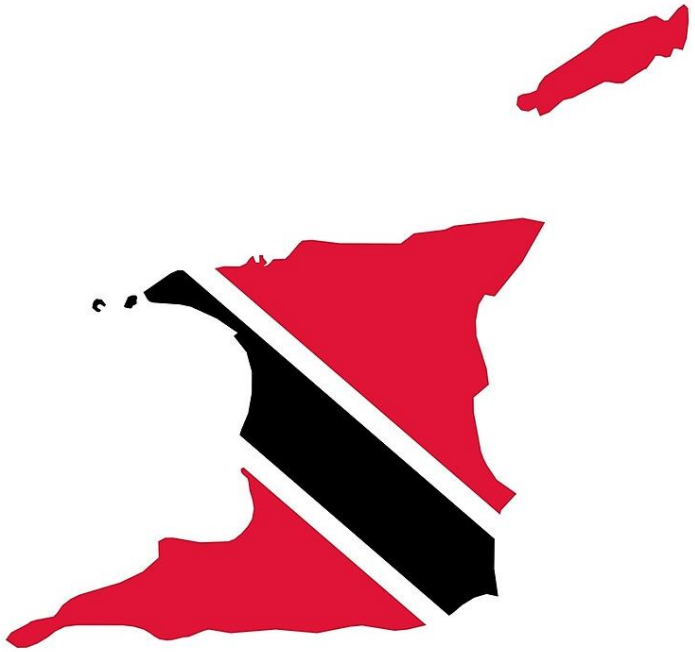
Government of the Republic of Trinidad and Tobago
Ministry of Energy and Energy Industries

CARBON CAPTURE, UTILIZATION & STORAGE

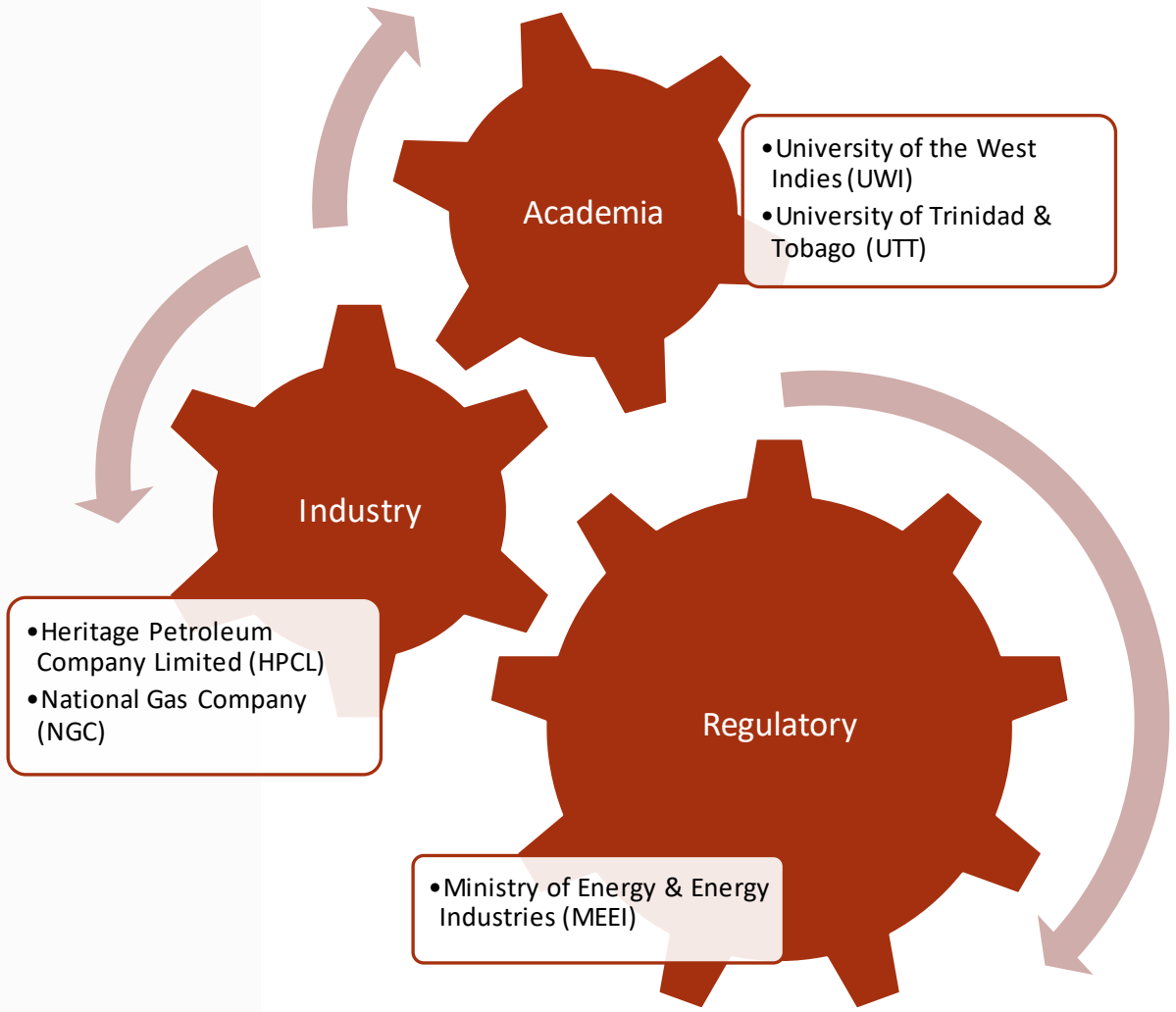
A TRINIDAD & TOBAGO UPDATE



TRINIDAD & TOBAGO ENERGY CONFERENCE
JANUARY 23-25, 2023

Current CCUS Work

- Steering Committee Appointed
  - Carbon Capture and Carbon Dioxide Enhanced Oil Recovery
    - CO_2 EOR – HPCL/MEEI
      - Identification of Reservoirs for CO_2 EOR
        - Feasibility Study Underway
    - Carbon Atlas – UWI/UTT
      - Identification of Reservoirs for CO_2 Storage
        - First Draft of Report Completed
    - Methane Reduction - NGC
      - Strategies to Reduce Methane Emissions
        - Analysis ongoing
    - Policy/Legal – MEEI
      - Framework and Legislation Required
        - Completed First Draft Legal Policy Paper on CCS
        - Sent to 27 Companies for review
        - Team presently compiling and reviewing feedback from Stakeholders towards revising Policy Paper



Government of the Republic of Trinidad and Tobago
Ministry of Energy and Energy Industries
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Carbon Capture & CO2 EOR Steering Committee Composition

- Penelope Bradshaw-Niles, Permanent Secretary (Ag.), MEEI [CHAIR]
- Himalaya Boodoosingh, Snr. Manager HSE, NGC
- Arlene Chow, CEO, Heritage Petroleum Company
- Andrew Jupiter, Coordinator Dept. of Pet. Eng., UWI
- Kishan Kumarsingh, Head Multilateral Environmental Agreements Unit, MoPD

MANDATE

"to manage the implementation of a Large-Scale CO2 EOR Project to increase Trinidad and Tobago's oil revenue *and to address the reduction of carbon dioxide emissions*."

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Terms of Reference

Large Scale CO2 EOR Project

- "It is envisaged that the project would involve the use of CO2 from the Atlantic LNG facility for EOR in the oil fields of Heritage in Point Fortin central area"

- "The initial focus of the Committee would be the identification of suitable reservoirs in the Heritage producing areas such as Point Fortin, Guapo, Gran Ravine and Forest Reserve; Heritage would have the lead and be responsible for the implementation of the project"

Research & Technical Studies

- "The technical studies required to advance the work of the Steering Committee be funded by the Ministry of Energy and Energy Industries from the Research and Development Funds contributed under the Production Sharing Contracts"

- "Research and technical studies to be conducted, where available, through UWI, St. Augustine, and/or the UTT"

High Level Organization

STEERING COMMITTEE:
Penelope Bradshaw-Niles – MEEI chair
Arlene Chow - Heritage
Prof Andrew Jupiter - UWI
Kishan Kumarsingh - MoPD
Himalaya Boodoosingh - NGC

GHG/EOR Coordinator:
Yatindranath Keith Bally

- Technical Support : **Lorez deVignes**
- Data management
- HSE - **Sadiyah Forde**

Lorna Mohammed- Singh - Heritage

Workgroup 1- SPA*

Technical/Subsurface

Heritage & MEEI
- 5 Geoscientists
- 1 Res. Eng.
- 2 Pet. Engs
- 1 Chem. Eng.

Prof Raffie Hosein – UWI
Dr. David Alexander - UTT

Workgroup 2 - SPA

Carbon Atlas

- UWI
- UTT
- Min of Energy (MEEI)
- Basin Operators

Himalaya Boodoosingh - NGC

Workgroup 3- SPA

GHG Emissions – Methane

- Heritage
- NGC
- MEEI
- ALNG
- Pt Lisas plants

Christian Welsh - MEEI

Workgroup 4- SPA

Legal/Regulatory

- Min of Planning
- MEEI
- EMA

Workgroup 5- SPA

Funding/Commercial

- Min of Planning
- Min of Energy
- Min. of Finance
- Heritage Commercial

* Single Point of Authority

Steering Committee

- 14 General review meetings and 9 company reviews since March 2021

Mar 2022 – GHG Emissions: Methane Workgroup leader appointed.

- May 2022– Committee endorsement to the T&T Green Fund of a non profit company's CCUS initiative

- Workshop held on June 14 2022

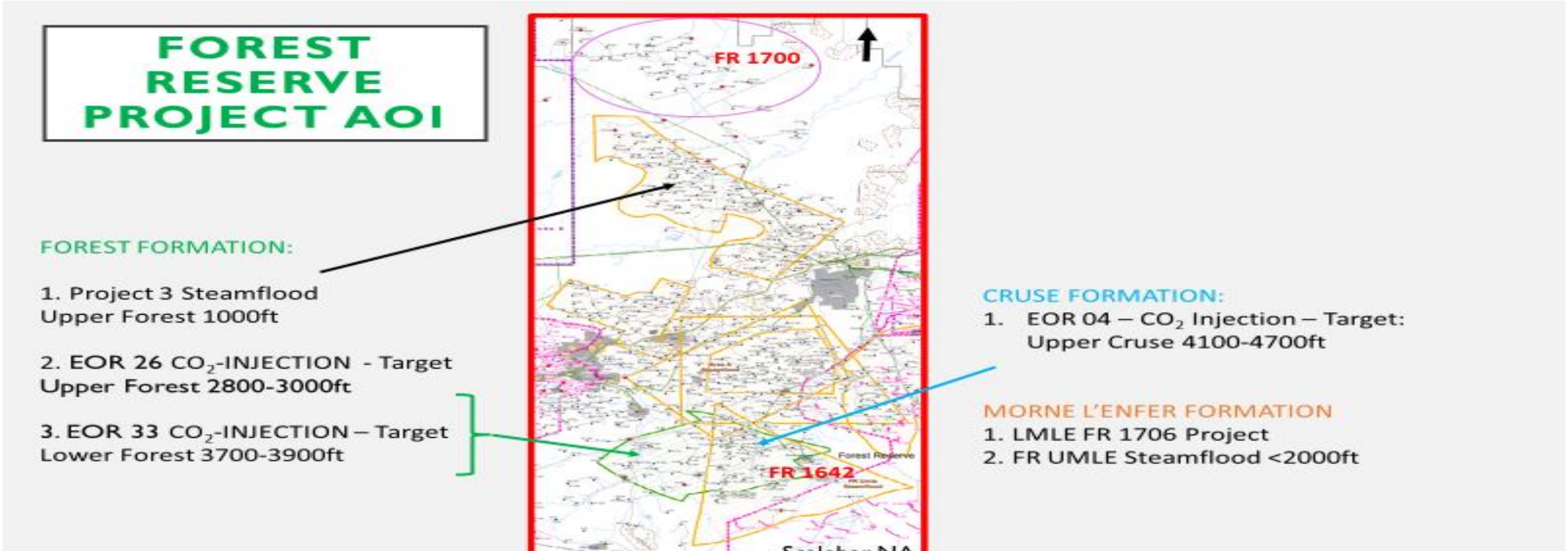
- Workshop format proved beneficial enabling idea generation and open dialogue.
- Participant mix proved useful, add ALNG rep to Steering committee, include transport workstream
- Consensus gained for a phased approach with Phase 1 (P1) Project focused on Forest Reserve.
- Committee agreed on resourcing a Project Implementation Team/Project Manager. As a result approval has been given for a Project Manager in Heritage to commence in January 2023.

CO2 EOR WORKING GROUP

- CO_2 EOR (Study of Heritage Western Land Fields for EOR via CO_2 Injection):
- The Single Point of Authority (SPA) is Mrs. Lorna Mohammed-Singh. This Working Group commenced their activities on 1 December 2021. This Working Group update includes:
- Completed Literature Review
- Finalising the Inventory report of the 17 Western Land Fields (Heritage)
- Continue and select a fault block to map within the Forest Reserve (FR) AOI

CO2 Project for Development

- The red outlined box highlights the Forest Reserve field that was selected for the CO2 EOR project (this selection was done by the CO2 EOR Working Group). This area is currently being further evaluated to determine a suitable fault block for CO2 injection within the Forest Reserve Field. The selected polygons are past EOR projects and show the Formations of interest which have all been successful.
- This Project area is known to have past and current successful EOR projects.



CARBON ATLAS

- This Working Group is done jointly by the University of West Indies (UWI) and the University of Trinidad and Tobago (UTT).
- The SPA for the UWI is Professor Raffie Hosein and the SPA for the UTT is Dr. David Alexander.
- This Working Group commenced their activities on 1 November and1 December 2021.
- Funding by MEEI for Land fields and Gulf of Paria
- Receives Monthly reports
- Funding by BP and Shell for other areas

KEY FINDINGS WITH THE DATA USED (UWI)

The preliminary findings for the Forest Reserve and Palo Seco fields are as follows:

- The estimated deterministic theoretical storage capacity examined in this study is approximately 9.55 Mt of CO_2.
- The Forest Reserve field was found to have a deterministic theoretical storage capacity of 6.26 Mt of CO_2. The estimated capacities are: 0.287 Mt in the Lower Forest A sand, 0.356 Mt in the Lower Forest B & C, and 4.821 Mt in the Cruse sands. In comparison, the Palo Seco field potentially stores 3.28 Mt of CO_2.
- The estimated capacities are: 2.35 Mt in the Cruse sand, 0.78 Mt in the Forest sand and 0.151 Mt in the LMLE sands. Commingled production of oil and water in these sands rendered it difficult to quantify storage for individual sand units. However, in both the Forest Reserve and the Palo Seco fields, the Cruse sands were found to be the most ideal candidates for CO_2 storage accounting for 88% of the total calculated storage capacity in the Forest Reserve field and 72% in the Palo Seco field.
- Recommendations to further investigate the potential onshore CO_2 storage should be considered as these values represent a conservative storage due to insufficient map coverage over the reservoirs and production data, as well as, a lack of logs for accurate petrophysical analyses.

KEY PRELIMINARY FINDINGS WITH THE DATA USED (UTT):

KEY PRELIMINARY FINDINGS WITH THE DATA USED (UTT):

- The estimated theoretical capacity of geological storage in the Southern Basin, offshore depleted oil fields examined in this study is around 90.221 Mt of CO_2, representing approximately 90% of the total estimated capacity.
- The largest storage capacity offshore is currently presented in the North Soldado accounting for approximately 50% of total offshore storage. The estimated capacities are: 29.968 Mt for Main Soldado Field, 2.157 Mt for East Field, 8.371 Mt for West Soldado, 3.435Mt Southwest Soldado Field and 46.29 Mt North Soldado Field.
- Of all the Soldado oil fields assessed, the storage capacity computed for the North field area stands out as being significantly large, relative to all other fields. T
- he estimated theoretical capacity of geological storage in the Southern Basin, onshore depleted oil fields examined in this study is around 10.925 Mt of CO_2, representing about 9% of the total estimated capacity of fields examined. The largest storage capacity onshore is currently presented in the Point Fortin Field accounting for more than 57% of total onshore storage.

KEY PRELIMINARY FINDINGS WITH THE DATA USED (UTT):

Cont'd Preliminary findings

- The estimated capacities for the onshore fields are: 6.355 Mt for Point Fortin Field, 1.24 Mt for Guapo Field, 3.33 Mt for Grand Ravine Field.
- Recommendations to further investigate the potential of CO_2 storage onshore should be considered as these values represent a conservative storage as reservoirs above 800m and unrecorded water and gas production in the early life of these mature reservoirs were not considered.
- Nevertheless, this is not to say that a conservative estimate for carbon dioxide storage potential is unavailing. Simple estimates such as those made at present in this study may be necessary for policy makers and/or industry stakeholders to enhance decision making and secure funding.
- As such, conservative estimates were also made for the capacity of the hydrocarbon formations in the Southern basin of Trinidad for the storage of carbon dioxide – from which the following conclusions can be drawn.
- The total capacity for effective geological storage in the offshore fields within the Southern basin of Trinidad is estimated to be 63.154 Mt of carbon dioxide, of which 50% of this storage potential lies mainly in the North Soldado field. Similarly, the total capacity for effective geological storage in the onshore fields is estimated to be 7.646 Mt.

Table 1: Summary of the theoretical storage capacities for the different fields within this scope of study.

Field Name	Operator Block	Reservoir Unit	Theoretical Storage		Field Recovery Factor (%)
			Deterministic Theoretical SC (Mt)	Probabilistic Theoretical SC P90 (Mt)	
Forest Reserve	-	Lower Forest A	0.287	-	0.245
		Lower Forest B & C	0.356	-	
		Cruse	5.620	4.821	
Palo Seco	WD-1	Middle Cruse	0.475	0.440	0.088
	WD-2	Forest	0.581	0.461	
		Cruse	0.055	-	
	WD-5/6	Lower Forest	0.160	-	
	WD-15	Lower Cruse	0.176	-	
	WD-16	LMLE	0.151	0.149	
		Forest	0.040	0.037	
	PS-1	Cruse	0.887	0.839	
	PS-3	Cruse	0.758	0.693	
Total Onshore SC (Mt)			9.55	7.44	

Table: Summary of the theoretical and effective storage capacities for the different fields within this scope of study.

Field Name		Size (Acres)	Theoretical Storage		Effective Storage		Field Recovery Factor (%)
			Deterministic Theoretical SC (Mt)	Probabilistic Theoretical SC P90 (Mt)	Deterministic Effective SC (Mt)	Probabilistic Effective SC P90 (Mt)	
Offshore Fields							
Soldado Oil Fields	Main Soldado		29.968	28.179	20.977	17.006	
	East Soldado		2.157	1.920	1.509	1.193	
	West Soldado		8.371	6.996	5.859	4.268	
	Southwest Soldado		3.435	N/A	2.404	1.978	
	North Soldado		46.29	47.96	32.405	30.79	
Total Offshore SC (Mt)			90.221	85.055	63.154	55.235	
Onshore Fields							
Point Fortin	Point Fortin West		0.292	0.266	0.204	0.164	
	Point Fortin Central		3.508	2.344	2.454	1.479	
	Point Fortin East		2.555	2.395	1.788	1.470	
Guapo			1.24	1.175	0.87	0.71	
Grand Ravine	WD-3		0.35	0.334	0.24	0.199	
	WD-4		0.55	0.508	0.39	0.308	
	WD-5/6		2.43	2.29	1.70	1.465	
Total Onshore SC (Mt)			10.925	9.312	7.646	5.799	
Total SC for Heritage Fields			101.146	94.367	70.8	61.034	

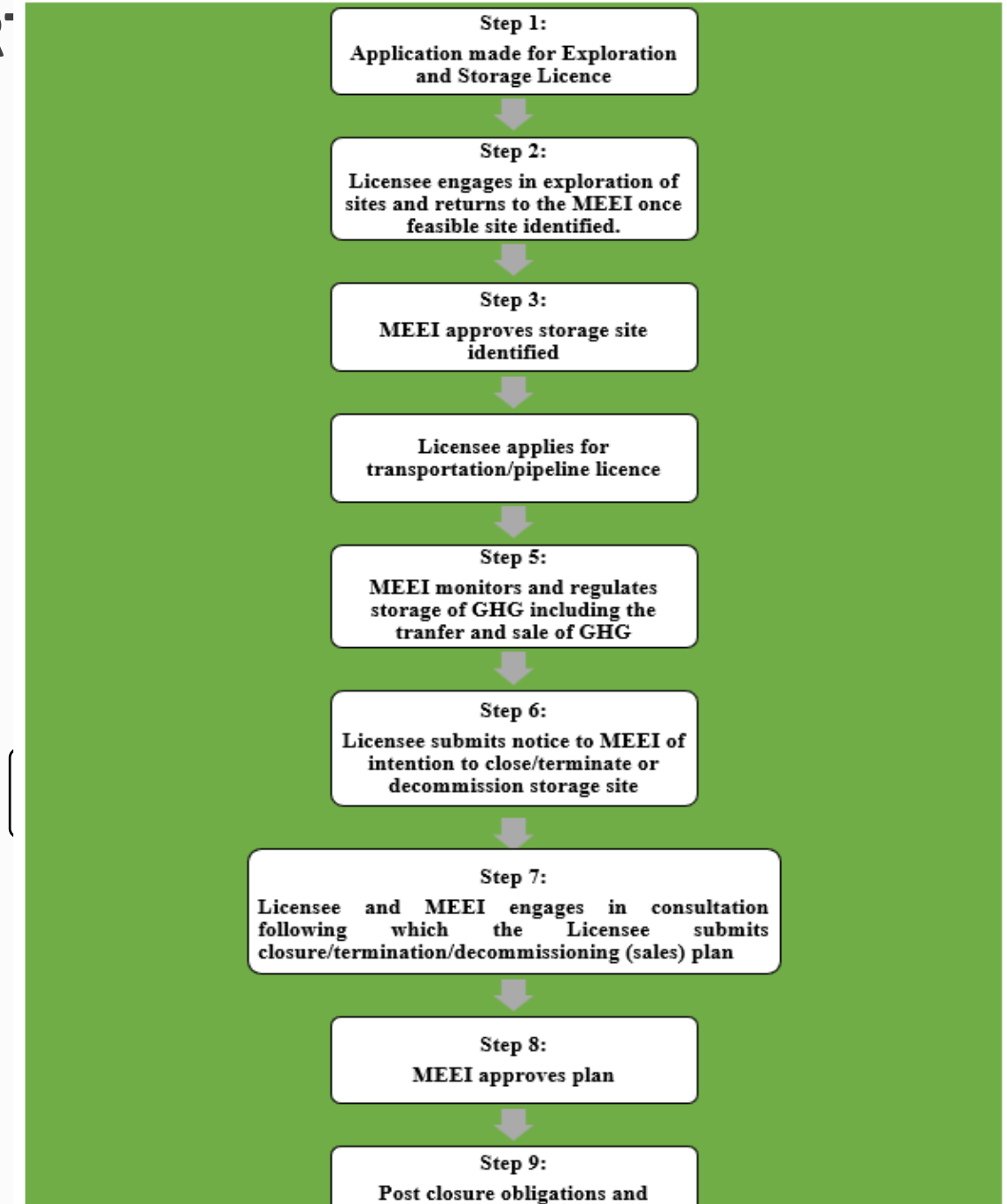
Policy Legal and Regulatory

- Policy, Legal and Regulatory: The SPA is Mr. Christian Welsh. This Working Group commenced their activities on 28 September 2021.
- Completed the first Draft of the legal policy paper on Carbon Capture and Storage (CCS) and CO_2 EOR and currently receiving feedback from the various stakeholders.
- Feedback received from 12 stakeholders

Elements of Draft Policy

- Policy Context
- Process for CCUS Projects
  - Obtaining approval
  - Establishment of a Fund
  - Decommissioning Program
  - Liability post closure liability
- Drafting Instructions
- Requirements to Bring New Legislation Onstream
  - Amendment to other Legislation

CCUS PROJECT FLOW CHAR



Feedback from Stakeholders – issues raised

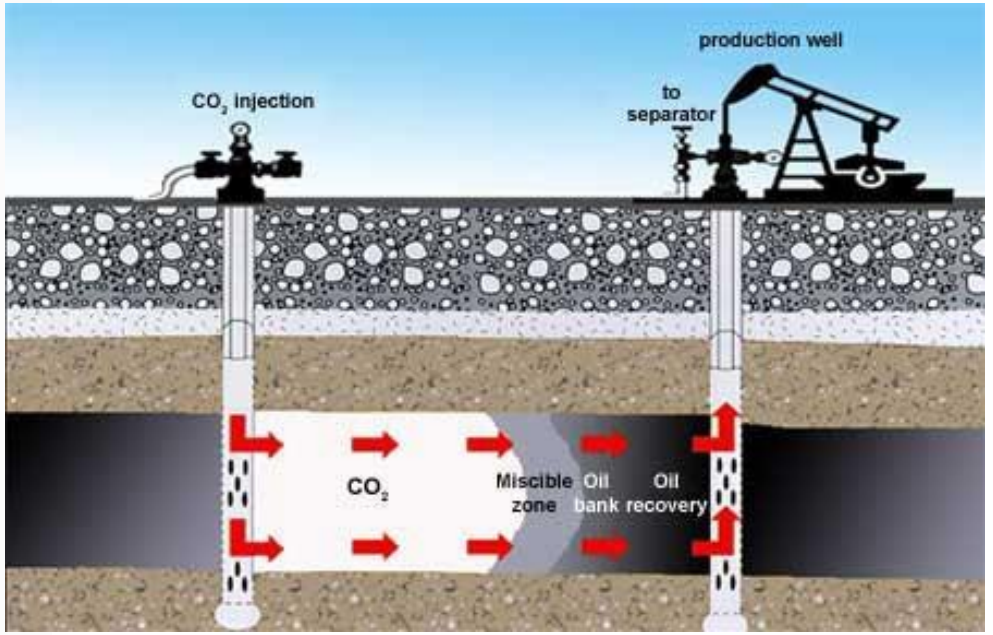
- The Designation of liability for CO2 leakage
- The Particulars as it relates to the sale or commercialization of captured CO2
- The application of the policy to Enhanced Oil Recovery Projects
- Further particulars on the Fund established for post closure monitoring
- Criteria to be used for designating a storage facility and the technical standard

THANK YOU

BACKUP SLIDES

CO_2 EOR – Key Points

- Following primary and secondary production, oil recoveries range from 20-40% (Stalkup 1983).
- Use of CO_2 recognized as the second largest EOR process in the world after the thermal processes (Perera, et al. 2016).
- Screening criteria have been developed to identify potential candidates which correlate reservoir parameters with performance attributes in successful EOR projects.
- CO_2 EOR mechanisms include a combination of solution gas drive, oil swelling, viscosity reduction and the miscible effects (Tunio, et al. 2011).
- Injection of CO_2 into oil reservoirs increases recovery by an additional 4 to 15 % over primary and secondary recovery efforts (US Department of Energy 2010).



Source: Enhanced Hydrocarbon Recovery Corp.

CO_2 EOR in Trinidad & Tobago

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- Current State/Challenges
  - Declining Levels of Primary/Secondary Oil Production
  - High CO_2 Emissions

- CO_2 EOR Provides a Win/Win Solution
  - Improve Oil Production Levels
  - Reduce Net CO_2 Emissions

- Opportunities for Implementing CO_2 EOR
  - Depleted Onshore Oil Reservoirs
  - Existing Production Infrastructure
  - Technical Experience
    - Previously Conducted CO_2 EOR Pilots
      - Six (6) Pilots – All Successful
    - Experience in Pipeline Operations

- Challenges in Implementing CO_2 EOR
  - Timeline to Results
    - Reservoir Analysis and Injection Strategy
    - Pipeline Construction
    - Lag Between Injection and Production Response
  - Capital Intensive
    - Pipeline CAPEX is High
    - Long Payout Period

Additional GHG Reduction Strategies

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- Utility Scale Renewable Energy Power Plant
- Exploring the Hydrogen Economy
- Electric and CNG Vehicle Incentives
- Tax Allowance for Companies Engaged in CCUS
- Solar Park at the Piarco International Airport
- Reduction in Venting and Flaring Operations