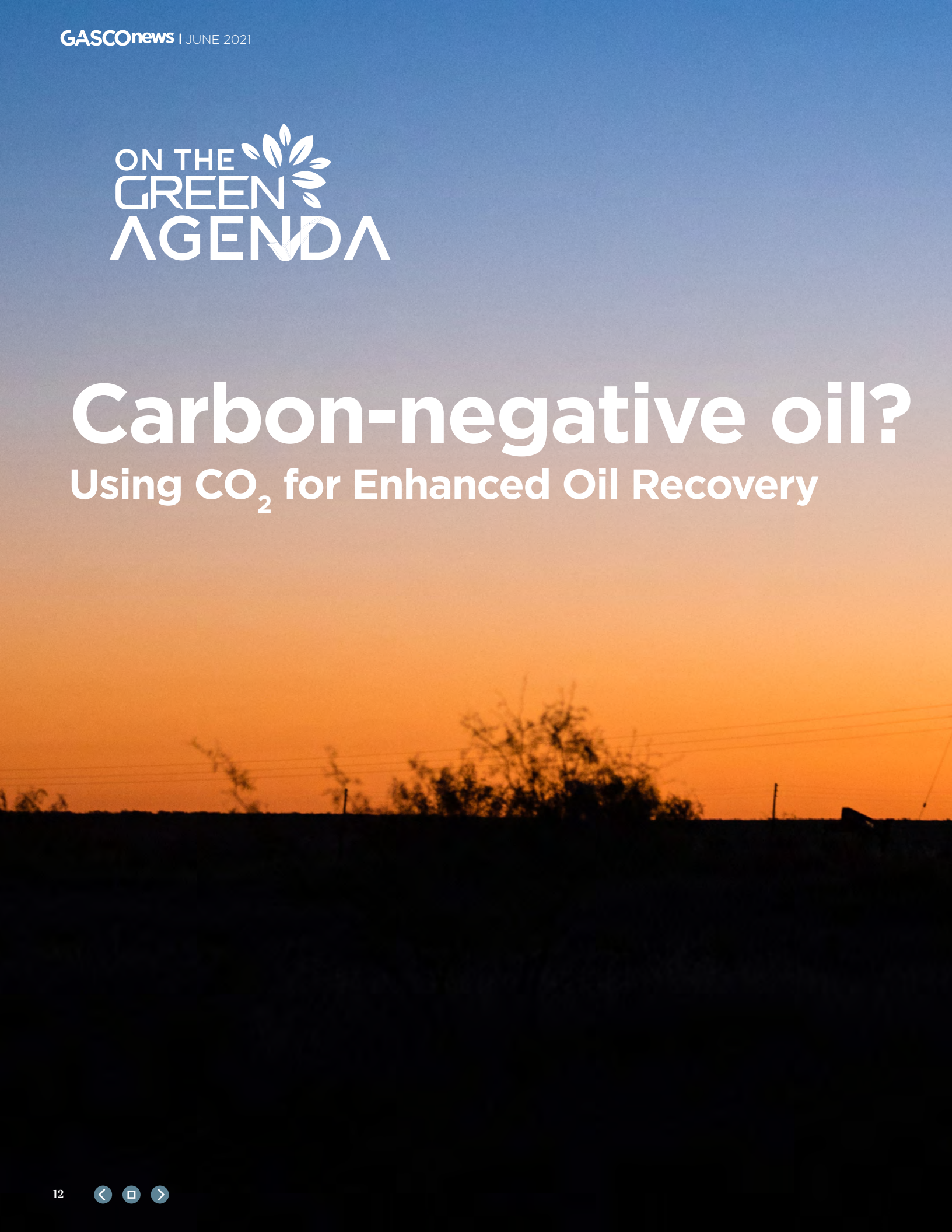
ON THE GREEN AGENDA

Carbon-negative oil?

Using CO_2 for Enhanced Oil Recovery



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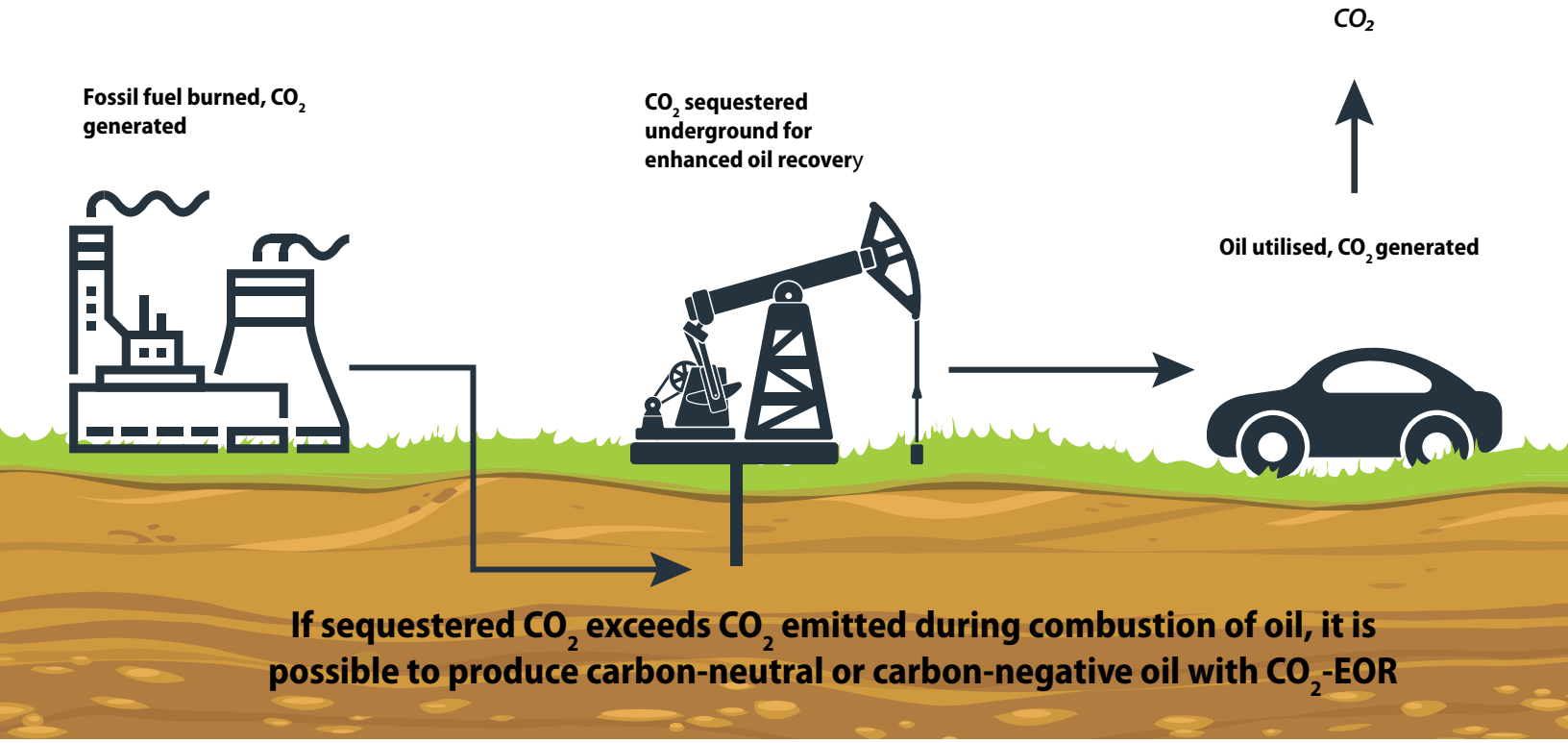

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Every roadmap to a net-zero carbon future assigns a key role to carbon capture, utilisation and storage (CCUS) technologies. CCUS has both environmental and economic merit, since captured CO_2 can be traded as a commodity or put to productive industrial use.

Of all the captured CO_2 currently utilised around the world, approximately one third goes into Enhanced Oil Recovery (EOR).[1] This end-use of CO_2, known as CO_2-EOR, can be quite valuable to the global energy transition, as it enables some last-lap oil production while simultaneously sequestering CO_2 permanently underground. In certain enabling environments, this strategy could even support production of carbon-negative oil.

The Government of Trinidad and Tobago has identified CO_2-EOR as a strategy for boosting oil revenue while reducing CO_2 emissions.[2]

In February 2021, Cabinet appointed a special Steering Committee, charged with managing the implementation of a local large-scale CO_2-EOR project for Heritage Petroleum's onshore fields. Named among the Committee members was NGC's Senior Manager HSSE, Himalaya Boodoosingh, who shared some insight into the process of CO_2-EOR and its utility in the context of the green agenda.

Understanding EOR

When an oil well is drilled successfully, the crude surfaces with ease at first, due to the pressure of overlying rock. Think of those on-screen scenarios, where early prospectors stumbled across oil in surface pools, or black geysers pitched from wells, launching oil-slicked tycoons-to-be into jubilant celebration. In these depictions, oil rushes naturally to the surface once a reservoir is breached.

As oil leaves the reservoir, however, the internal pressure begins to fall. Before long, specialised equipment and techniques are needed to support continued extraction.

[1] https://www.iea.org/reports/putting-co2-to-use

[2] https://w e-co2-enhanced-oil-recovery-steering-committee-established/

Carbon Negative Oil? Using CO_2 for Enhanced Oil Recovery | CONTINUED

These are called Enhanced Oil Recovery (EOR) mechanisms. Pump jacks are a familiar example of EOR technology - hammer-headed contraptions whose seesaw motion helps lift oil from underground wells. Less visible to us would be offshore EOR methods, which include injection of gas, water or steam into wells to displace oil, boost well pressure, or heat the oil to get it moving.

While EOR is typically considered a strategy to help maximise production and profit from oil, today it represents an avenue to address one of the biggest problems of our time - greenhouse gas (GHG) mitigation. This is because one form of EOR involves injection of carbon dioxide into wells (CO_2-EOR), which in effect sequesters the gas underground. Today, it is widely used across the world, with the International Energy Agency (IEA) reporting that 20% of all oil produced using EOR - some 500,000 barrels a day - is produced using carbon dioxide injection.[3]

Of course, there is an apparent contradiction in the claim that CO_2-EOR can help with GHG mitigation, when it is used to produce oil - a major contributor to global GHG emissions. However, under the right conditions, CO_2-EOR, can in fact, enable production of net carbon-neutral or even carbon-negative oil. Lining up these conditions in the Trinidad and Tobago context is the challenge that has been put to the Cabinet-appointed Steering Committee.

Committee Members

- Chairman - **Mrs. Penelope Bradshaw-Niles,** Permanent Secretary (Ag.), Ministry of Energy and Energy Industries
- **Ms. Arlene Chow** - Chief Executive Officer, Heritage Petroleum Limited
- **Professor Andrew Jupiter** - Head of Department of Petroleum Engineering, The University of the West Indies
- **Mr. Kishan Kumarsingh** - Head Multilateral Agreements Unit, Ministry of Planning and Development
- **Mr Himalaya Boodoosingh** - Senior Manager HSSE, NGC

Why do we want more oil anyway?
One might wonder why our country should invest effort and capital in pumping more oil out of the ground at a time when more and more countries are announcing plans to wean certain productive sectors off oil in the near future. However, it is precisely because of the downward trajectory of oil consumption that Government is pushing to increase production in the short-term.

On an energy equivalency basis, oil is more expensive than natural gas. Based on an average oil price of USD$60 per barrel of oil and USD$3 per mmBTU of gas, the energy contained in a barrel of oil is more than triple the price of the same quantum of gas-derived energy.[4] Even though oil is a higher-priced energy commodity, there are many sectors still reliant on this energy source - for example, the transportation sector. This means that demand is still strong, and an oil producer like Trinidad and Tobago can still earn relatively more from oil than gas per unit of energy.

[3] https://www.iea.org/commentaries/can-co2-eor-really-provide-carbon-negative-oil

[4] Assuming one barrel of oil = 5.8 mmBTU, per reference: https://www.investopedia.com/terms/b/barrelofoilequivalent.asp

Based on an average oil price of **US$60** PER BARREL OF OIL + **US$3** PER MMBTU OF GAS, the energy contained in a barrel of oil is more than triple the price of the same quantum of gas-derived energy.

ON THE GREEN AGENDA

AT PRESENT, THE LNG BUSINESS IS ONE OF THE BIGGEST LOCAL CONTRIBUTORS TO CO_2, RELEASING OVER **5 MILLION TONNES OF CARBON DIOXIDE** IN 2019 ALONE.

So, if we have the oil, and it is still worth a lot, it makes economic sense to extract and market it.

That said, the window of opportunity to do so is closing, as environmental pressures are moving markets away from fossil fuels which produce high GHG emissions. Oil-based sectors are seeking to decarbonise, which means switching to cleaner energy sources. When demand falls, so will prices. To maximise the price we can get for our oil, we need to sell it quickly.

Enter CO_2-EOR

Trinidad and Tobago has been producing oil for more than a century, and basins are mature. The lighter crude has been depleted, but there are still considerable quantities of heavier crude that we can extract. The higher density however means more effort - or EOR - is required to get it out of the ground.

Of course, the increasing urgency of bringing GHG emissions down means that additional oil production cannot be undertaken without consideration of its environmental impact. CO_2-EOR is the best available option to produce oil with minimal net output of carbon dioxide. This type of EOR is, however, quite costly, and if Trinidad and Tobago's state oil company is to make use of the technique, it would need to apply for funding from external agencies. The problem is that funding is more readily disbursed to projects that are seeking to reduce GHG emissions, rather than projects that will ultimately increase emissions. In order to secure funding for CO_2-EOR, the country therefore needs to prove that the output would be net carbon-neutral or carbon-negative oil. That is, it must demonstrate that the production of oil using CO_2 injection would result in minimal or zero increase in atmospheric GHG levels. Ideally, it should ***reduce*** levels by sequestering more CO_2 than would be emitted through combustion of the oil produced in the CO_2-EOR process. This is where the Cabinet-appointed Steering Committee comes in.

The task of the Steering Committee

The initial role of the Committee is to help identify Heritage fields in the Point Fortin central area that would be suitable for CO_2-EOR, and help conceptualise a carbon-neutral/negative project to capture CO_2 and transport it to the fields for well injection. To do so, the Committee must answer certain questions.

For instance, where will the required CO_2 input come from? At present, the LNG business is one of the biggest local contributors to CO_2, releasing over 5 million tonnes of carbon dioxide in 2019 alone.[5] Past CO_2-EOR projects in Trinidad — executed in the Forest Reserve and Oropouche fields between 1975 and 2000 – lifted 4 million barrels of oil using approximately 1.26 million tonnes of CO_2.[6] Extrapolating from this data, 16 million barrels of oil could theoretically be lifted using CO_2 from the LNG business alone (although factors such as reservoir age, capacity and oil viscosity would ultimately impact that figure).

Here's the catch. The CO_2 emitted from combustion during LNG production requires special equipment and processing to capture and make it fit-for-use in CO_2-EOR applications. It would also require investment in compression and transportation infrastructure. Nevertheless, the option remains a viable one if the economics favour progression.

[5] Atlantic Sustainability Report 2019: https://issuu.com/iugodigital/docs/atlantic_sustainability_report_2019_for_web

[6] https://www.energy.gov.tt/carbon-capture-utilization-and-storage-ccus/

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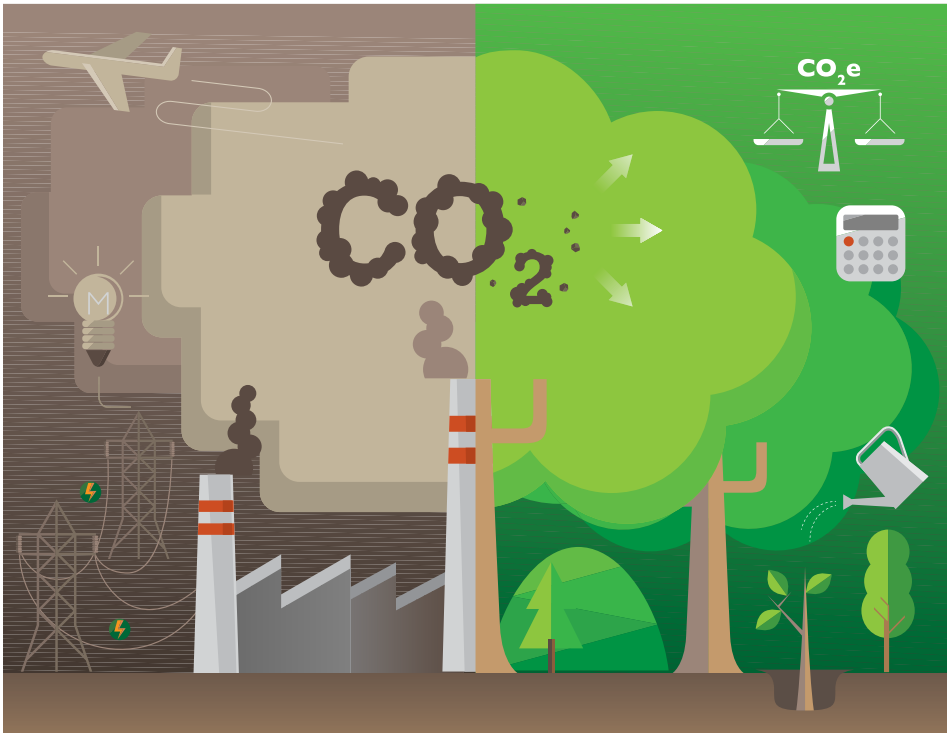
Looking elsewhere, an output of the chemical reactions involved in ammonia production on the Point Lisas Industrial Estate is CO_2. Much of this is vented to the atmosphere, but some is piped to neighbouring plants for use in methanol production. If the same technology used to capture pure CO_2 for sale to methanol producers were to be leveraged to retain what is currently vented, we could have a readily available, fit-for-use gas stream with some preliminary pipeline infrastructure already in place. This option is therefore the first one being explored by the Committee.

The next big question is how do we ensure net carbon neutrality? The IEA estimates that a barrel of oil generates around 500kg of CO_2 with production, processing, transportation and combustion all being factored in.[7] By this math, the 4 million barrels of oil extracted using CO_2-EOR in Trinidad and Tobago pre-2000 would have generated 2 million tonnes of CO_2 — a net positive GHG contribution since only 1.26 million tonnes were sequestered to produce it.

As mentioned before, Trinidad and Tobago would need to conceptualise a net carbon-neutral or negative project to access funding for CO_2-EOR. Part of the Committee's role would therefore be to work with relevant academics and industry stakeholders to determine which wells would be able to store more — or at least equivalent — volumes of carbon dioxide relative to what would result from production of that oil. Other techniques to offset emissions could be added to tilt the scale towards net negative CO_2 output, such as reforestation or afforestation initiatives.

Daunting mathematics aside, carbon-negative oil production is possible, and has been



BALANCING THE EQUATION: PRODUCTION OF CARBON-NEUTRAL OR NEGATIVE OIL MAY REQUIRE SUPPORTING CARBON OFFSET MECHANISMS SUCH AS REFORESTATION OR AFFORESTATION PROJECTS

demonstrated elsewhere in the world. The Steering Committee will be working with US university experts who have the data, and is currently evaluating proposals from both local and international entities seeking joint-venture partnerships to bring the project to fruition.

Where does NGC fit in?

The Steering Committee is expected to present a report to Government within a few months. The hope is that a viable solution can be conceptualised and implemented, to enable the ground-breaking local achievement of carbon-negative oil.

NGC's representation on the Steering Committee makes sense when we consider both the likely source of CO_2 for injection and the mechanism of transportation. NGC will not only bring the perspective of the downstream producer to the conversation, but will also provide expert guidance regarding pipeline construction and operating costs. In addition, participation in this Committee allows NGC to strengthen its contribution to national decarbonisation efforts. This is one of the Company's core strategic objectives moving into the new energy future.

Asked about the importance of the Committee's work, NGC's Senior Manager HSSE, Himalaya Boodoosingh commented: "This exercise underscores the efforts being made by Trinidad and Tobago in support of the UN Sustainable Development Goals. Importantly, it allows us to showcase our ability to tackle complex world problems using local talent and expertise." ■

[7] https://www.iea.org/commentaries/can-co2-eor-really-provide-carbon-negative-oil