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CIRCULAR ECONOMY IN INDIAN OIL AND GAS INDUSTRY: AN OVERVIEW

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ABSTRACT

Harmonizing industrial development and sustainable growth prompted the Circular Economy (CE) concept. The central aspect of CE lies in the maximization of resources while mitigating pollution in a closed-loop system. This paper narrates an overview of CE strategies employed in the Indian petroleum industry. Bioenergy, Waste Recovery, Green Hydrogen, Carbon Capture, Utilisation, and Storage (CCUS) are some methods employed in the contemporary scenario for India's net-zero emissions.

KEYWORDS: ***Circular economy, closed-loop system, Bioenergy, Carbon Capture Utilisation and Storage (CCUS), Waste Recovery***

1. INTRODUCTION

Reducing, reusing, and recycling is an age-old practice in every household. Why can't this be practised in industries? Circular economy introduces 3 R (Reduce, Reuse, and Recycle) and 6 R (Reuse, Recycle, Redesign, Remanufacture, Reduce, and Recover) at various stages of processing, converting the linear model into a circular one. The biomimicry concept of cradle-to-cradle is brought into practice.

The oil and Gas (O&G) industry is quite notorious for its environmental contribution. By and large, the O&G industry's source is non-renewable and cannot be recycled. However, humankind is dependent on the O&G industry. It forms one of the core industries that contributes immensely to the country's economy. Around 25% of the environmental footprint can be reduced with the implementation of circular economy at distinct stages of upstream and downstream processing. As Godfrey quotes 'Certain countries have sunshine, some have wind, some still have oil and gas, and others have nothing at all. So, each country will have a very different set-up in the way that energy systems will develop in the most optimal way' (Offshore Technologies, 2021). Circularity brings in creative solutions that are locally suitable.

The praxis of circular economy in industries is comparatively new and many initiatives are being taken in various parts of the world. This paper reviews the different circular economy strategies introduced to the O&G industry.

Fig 1: Circular economy (Source: UNIDO)

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1.2. Background

The concept of the circular economy appeared first in 'The Economics of Natural Resources' in 1988, in which it states 'The market works well in stimulating the exploitation of basic resources and in processing and distributing them, but it fails in the efficient disposal of residuals to common property resources' (Allen, 1988). Later, the UN introduced the 17 sustainable goals whereupon SDG 12 titled "Responsible Consumption and Production," focuses on achieving sustainable management, reducing waste generation, and integrating life cycle assessments.

Jerez et al conducted a comprehensive characterisation of petroleum oily sludge. Around 15-50% w/w composition of oily sludge is made of total petroleum hydrocarbon (TPH) and the rest is made of solids and water. The study showed that hydrocarbon components can be recovered by dark fermentation or valorisation. Valuable resources such as benzene, sulphur, phenol, etc. can be recovered by nitrogen/air stripping, high-pressure wet air oxidation process, and liquid-liquid extraction methods respectively (Shailja 2017).

Water management is highly essential in many processes in refineries. Mohammed shows that the Water-Closed-Loop-System (WCLS) incorporating 5Rs (Refuse, Reform, Reduce, Reuse, Recycle) ensued a water consumption of 28.66% and 46.33% in the reuse and recycle scenarios, respectively. Water balance study is an important feature Conventionally, liquid treatment plants within the industry follow biological treatment processes. Microalgae-based wastewater treatments can remove hazardous contaminants without major side effects. It can also further be used to produce biofuels generating energy back to the industry.

Pinto et al. emphasise the economic and environmental evaluation of a cogeneration power unit situated in Brazil. Co-generation is the simultaneous generation of power heat and electricity, and it is a way to optimise efficiency while reducing emissions at the same time. The unit recovered heat from the high temperature of outlet gases during the calcination of coke. The economic assessment showed a positive Net Present Value (NPV), indicating the project was profitable. Overall, it showed a 10% decrease in the dependency on grid electricity. It reduced the capital costs related to on-site power plants and increased operational efficiency by cutting out energy transmission losses and saving energy emissions.

Decommissioning of oil and gas offshore facilities can be used for different purposes. The pipeline can be reused to transport carbon dioxide. Reusing platform components is a popular practice in the United States (Aikaterini, 2017).

2. CIRCULAR ECONOMY STRATEGIES USED IN INDIAN O&G INDUSTRY

India is a net crude importer and has Asia's second-largest refining capacity. Most of these companies are public, owing to their contribution to the UN Sustainable Goals. Indian circularity was largely associated with the recyclability of electronic waste; Therefore, this paper reviews India's take on the circular economy in Indian refineries. The Indian Oil Corporation (IOCL) commissioned decarbonisation plans in August 2022 to achieve net-zero targets by 2046.

2.1. Bioenergy

India majorly (32%) produces energy from biomass. In 2014, the Indian government initiated the Ethanol Blended Petrol (EBP) programme. The programme has increased the supply of ethanol from 7% to 10% within a year. Under the "Pradhan Mantri JI-VAN Yojana" Scheme, funding is provided for twelve integrated bio-ethanol projects (MNRE 2022). Additionally, 7% biodiesel is blended with High-Speed Diesel (HSD) by Bharat Petroleum Corporation Limited (BPCL). Another innovative turn Reliance Industries Limited (RIL) has taken is the production of biofuel from microalgae.

India generates the second-largest agricultural waste in the world (Rahul 2022). First Generation (1G) Ethanol production is extracted from sugar molasses and grains (rice, maize). However, taking feed from agricultural waste can be viable and resolves problems such as water footprint and air pollution, and does not compete with food production. In 2G Ethanol, agricultural waste and extra biomass are combined with gasoline (Rachita, 2022). Nevertheless, with technological advancement 1G and 2G ethanol can be produced in the same mill (Daniele 2022). Biodiesel is made from the conventional method of transesterification of vegetable oils and animal fats.

RIL has demonstrated the 'Algae-to-Oil (A2O)' technology that uses algae and sunlight to create bio-crude oil from carbon dioxide waste from the refinery (Forbes 2020).

2.2. Carbon Capture, Utilisation and Storage (CCUS)

Carbon Storage and Capture (CCS) in petroleum refineries takes the CO_2 emissions created during an oil refining process and injects it back into coal mines for enhanced extraction of oil, gas, and other minerals. India does not have operational CCS and cleaning technologies but has joined ventures with international

organisations into carbon capture and sequestration (Rohit 2022). IOCL's largest carbon dioxide capture from Steam Methane Reforming (SMR) will be employed to enhance oil recovery from wells (Sanjib, 2022).

About 90% of carbon dioxide produced within the refineries can be captured (Carbon Clean, 2021). Carbon capture, transport, and storage are the three stages of the carbon capture and sequestration (CCS) process. The first two steps are linked yet distinct. CO_2 from industrial and power plant sources is first isolated, concentrated, compressed, and transported through pipes. The second phase involves injecting subterranean geologic formations with CO_2 in a dense, fluid condition known as supercritical. The three methods of capturing carbon include - Precombustion capture, Post-combustion, and Oxyfuel combustion.

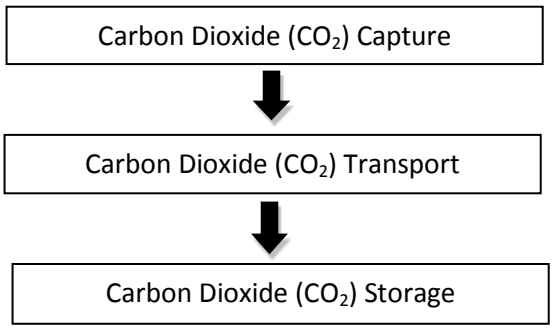

Fig 2: Three Stages of Carbon Capture and Sequestration (CCS).

2.3. Waste Recovery

A circular economy provides a blueprint for doing business that is in line with resource constraints. It can manage the disposal of hazardous waste as well as the recovery of resources. Waste in petroleum refineries is disposed of as wastewater, flare gases, and solid waste. Recovery can be either direct or external. Direct recovery happens within the site, normally due to economic feasibility, such as heat recovery, water reuse, catalyst regeneration, hydrogen recovery, and hydrocarbon recovery. External recycling is not directly recovered by the refinery in the case of ammonia, hydrogen sulphide, phenol, sodium hydrosulphide, etc (William 1982).
Flare Gas Recovery Systems (FGRS) are designed to recover and reuse gases and pollutants, like sulphur dioxide and methane/LPG, which typically would be consumed during flaring. BPCL has commissioned its 20 T/D FGRS to mitigate emissions (BPCL, 2022). Light hydrocarbons from flue gases are processed using centrifugal and rotatory compressors.

2.4. Green Hydrogen

Hydrogen that is extracted from fossil fuels is called grey hydrogen; the common form currently used. As derived from carbon, hydrocracking results in high carbon footprint release. Many countries, including India, have taken the initiative to produce green hydrogen to solve this problem. In contrast, green is produced through electrolysis and releases hydrogen and oxygen. As per India's Hydrogen Policy, by 2035 Indian refineries are to replace their fuel usage (30%) with green hydrogen. IOCL has stated its commitment to setting up green hydrogen plants.

Green hydrogen is the cleanest form of energy and contributes immensely to the decarbonisation of refineries. This renewable source can help in India's clean energy transition. Replacing a non-renewable source with renewable transits linear to a circular economy.

3. SUMMARY

India's O&G sector is moving towards an integrated energy sector. Different strategies of circular economy are described. Investigations on bioenergy, waste recovery, green hydrogen, carbon capture and storage are outlined. Detailed exploration and research on the above topics would result in a promising future for India's net-zero emission goal.

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