VIEW POINT

BRINGING CIRCULARITY TO OIL AND GAS: TECHNOLOGIES AND STRATEGIES TO MAKE THE TRANSITION

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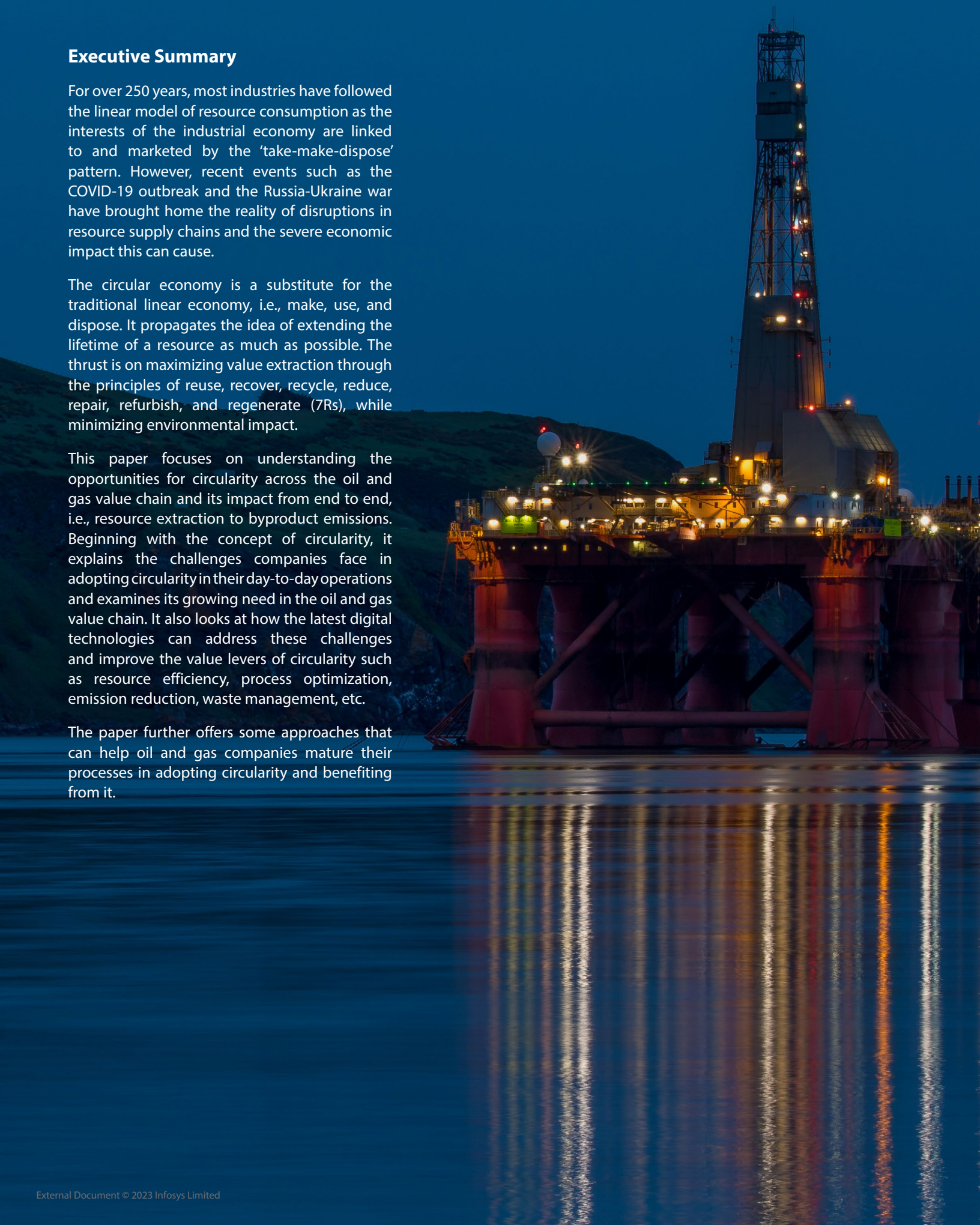
Executive Summary

For over 250 years, most industries have followed the linear model of resource consumption as the interests of the industrial economy are linked to and marketed by the 'take-make-dispose' pattern. However, recent events such as the COVID-19 outbreak and the Russia-Ukraine war have brought home the reality of disruptions in resource supply chains and the severe economic impact this can cause.

The circular economy is a substitute for the traditional linear economy, i.e., make, use, and dispose. It propagates the idea of extending the lifetime of a resource as much as possible. The thrust is on maximizing value extraction through the principles of reuse, recover, recycle, reduce, repair, refurbish, and regenerate (7Rs), while minimizing environmental impact.

This paper focuses on understanding the opportunities for circularity across the oil and gas value chain and its impact from end to end, i.e., resource extraction to byproduct emissions. Beginning with the concept of circularity, it explains the challenges companies face in adopting circularity in their day-to-day operations and examines its growing need in the oil and gas value chain. It also looks at how the latest digital technologies can address these challenges and improve the value levers of circularity such as resource efficiency, process optimization, emission reduction, waste management, etc.

The paper further offers some approaches that can help oil and gas companies mature their processes in adopting circularity and benefiting from it.



Introduction

The COVID-19 pandemic, prolonged geopolitical tensions, the Russia-Ukraine conflict, and severe climate changes have made businesses realize how supply chain disruptions, volatile energy and commodity prices, and inflation can affect their margins and overall operations. Now, industry leaders want to build resilient and sustainable businesses that support business continuity and profitability. Several studies [1] show that on the road ahead there will be calls for more localization or diversification of resource sources.

Beyond the supply-side uncertainties, consumers today are leaning towards more ecofriendly products. Hence, global capital markets are backing companies that are making significant environment, social, governance (ESG) investments. Global ESG assets, i.e., companies that are environmentally sustainable and socially responsible, follow high governance standards, and have excellent financial performance may surpass US $53 trillion by 2025, a third of global AUM (assets under management) [2,3]. In the future, organizations with environmentally sustainable operations will have more access to capital at a reduced cost. They will also be able to expand to new markets and grab a greater market share.

As per the Circularity Gap Report 2022 [3 ,4], only 8.6% of the global economy is circular. In the last six years (2015-2021), the global economy consumed an additional 0.5 trillion tons of virgin materials, namely minerals, ores, fossil fuels, and biomass. In the last 50 years, the global use of materials has nearly quadrupled (increased four times) from 28.6 billion tons in 1972 to 100 billion tons as of 2019 – outpacing population growth. However, 90% of all material extracted or used is wasted [3,]. Ultimately, waste is attributed to common environmental problems such as biodiversity loss, global warming, air pollution, and the plastic soup.

On its part, the oil and gas (O&G) sector is responsible for approximately 10% of greenhouse gas (GHG) emissions including the 4% contributed by fugitive emissions from oil and gas production alone. With the carbon tax rate estimated to reach US $150 per ton by 2030[4,9], this will amount to 10-15% of the operating expense of the oil and gas industry. If enterprises persist in the business-as-usual model, the world will certainly deviate from the 1.5°C pathway. This will cause irreparable environmental damage apart from irreversible depletion of non-renewable virgin material reserves, further exacerbating the resource cost and availability challenge.

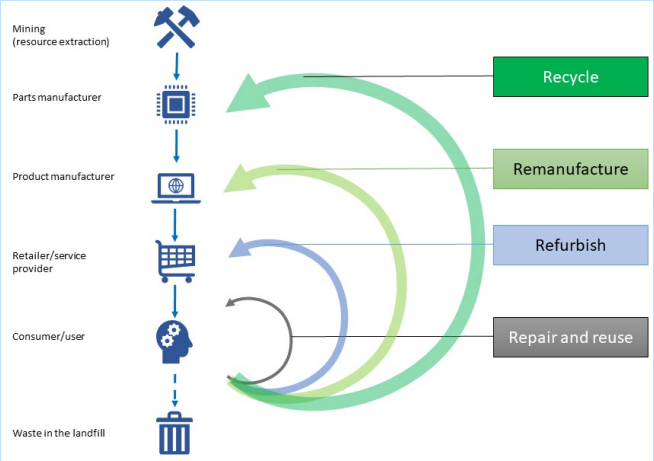
One concept that can address these challenges is 'the circular economy'. The circular economy can help countries and businesses become more resilient and protect their economic interests against volatile or rising input costs. It also helps reduce emissions and waste, thereby making it sustainably profitable and ecologically safe to do business. Unfortunately, despite its many advantages, circularity has not been widely adopted. This indicates the presence of several barriers that hinder businesses and countries from applying circular economy principles.

What is Circular Economy?

The circular economy is an alternative to the traditional linear economy (i.e., make, use, and dispose). It maximizes resource value extraction and utilization through recycle and reuse, thereby reducing the carbon footprint.

The fundamental concept of circularity lies in decoupling economic activity from resource consumption by creating closed-loop cycles in which waste is minimized or eliminated and resources are reused. To put it simply, the emphasis is to minimize or halt the leakage that goes to landfills at the end of a product's useful life by incorporating levers such as utilization maximization, product life extension, and replacing virgin material with recycled material [5].

Figure 1A – Depiction of a circular economy based on Stahel and Reday,1981



Loop 1- Reuse
Loop 2- Repair
Loop 3- Reconditioning
Loop 4- Recycling [6]

Advantages of adopting a circular business model

- Decarbonize the value chain
- Become resilient against supply chain disruption and other externalities
- Protect the bottom-line against volatile input costs
- Increase competitiveness
- Improve brand value and positioning through premium products- product premiumization
- Improve ESG ratings, thereby boosting investor confidence
- Adhere to governmental regulations and compliance requirements

As per the Ellen MacArthur Foundation, the four principles of circular economy are [5]:

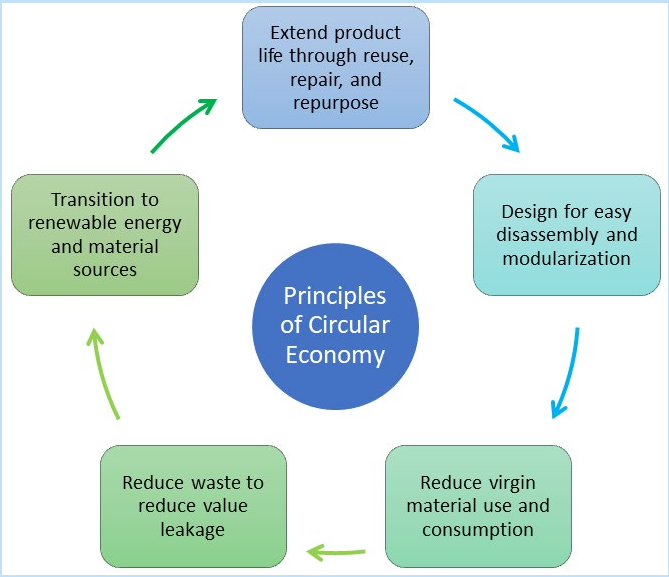


Figure 1B – Principles of a circular economy

The UN has called for urgent action by industries globally to address various sustainable development challenges. The circular economy has been presented as a key solution to address most of the pressing issues in production, consumption, and disposal. Simultaneously, it offers a promising way to achieve multiple Sustainable Development Goals (SDGs) [8].

Figure 1C – UN SDGs supported by circularity

Organizational Barriers to Adopting Circularity

The adoption of a circular economy is viewed as a major step in the fight against climate change and toward sustainability. However, organizations struggle with several barriers to enabling circular operations:

Lack of management awareness: Despite circularity being a trending topic, most business leaders lack awareness of its adoption, implementation methods, and return on investment (RoI). Circularity comes with a steep initial cost and requires making structural changes in value chain, which leads to low stakeholder buy-in.

Organizational and cultural change: Adopting circularity causes changes in the entire value chain from procurement to sales, which can be a significant disruption for established suppliers and partners. It may also require creating new business processes or updating existing ones to cater to the circularity principles. All of this involves high capex, meticulous planning, and uniform agreement from multiple stakeholders.

Economic viability of the circular business model (CBM): It is essential to perform the necessary due diligence before adopting the CBM. Organizations must evaluate the technical and economic feasibility of circular solutions to ensure a successful implementation.

Not adopting circularity across the value-chain: Many organizations misinterpret circularity as recycling. It is very important to apply circularity principles in every possible part of the value chain of the organization and embed these within every step from design to disposal.

Low maturity of circularity technologies: Products and components manufactured from different composite or blended raw materials need advanced recycling processes. But, due to unavailability of relevant recycling technologies, such materials end up in a landfill. Until cost-effective advance recycling technology is available at scale, environment-friendly alternatives should be explored and utilized.

Lack of facilities: It is often not commercially viable for small and medium enterprises (SMEs) to set up recycling facilities for all types of components. Thus, even if SMEs are inclined towards adopting circularity, it may not be practical. Further, there is a dearth of common facilities or industrial parks at scale that can help such players recycle their goods.

Lack of participation of the ecosystem:

- Customers: Consumers should imbibe the mindset of using recycled products. When implementing the circular economy, it is vital that organizations parallelly raise awareness among their customers to participate in this change. Similarly, it is advantageous to target consumers who prefer recycled products and are aware of the benefits. They can also be ambassadors for circular products.
- Original equipment manufacturer (OEM) partners: Ecosystem partners are critical to the successful implementation of circularity. OEMs, vendors, distributors, and other value chain partners should find value in participating in the circular value chain. In case there are no direct benefits, organizations should find ways to incentivize them.

Not measuring your circularity: Any initiative that is implemented must be measured. Unless organizations establish defined metrics and KPIs and measure these diligently, it is not possible to track the progress of the initiative and implement corrective measures in time.

ADOPTING CIRCULAR ECONOMY IN O&G

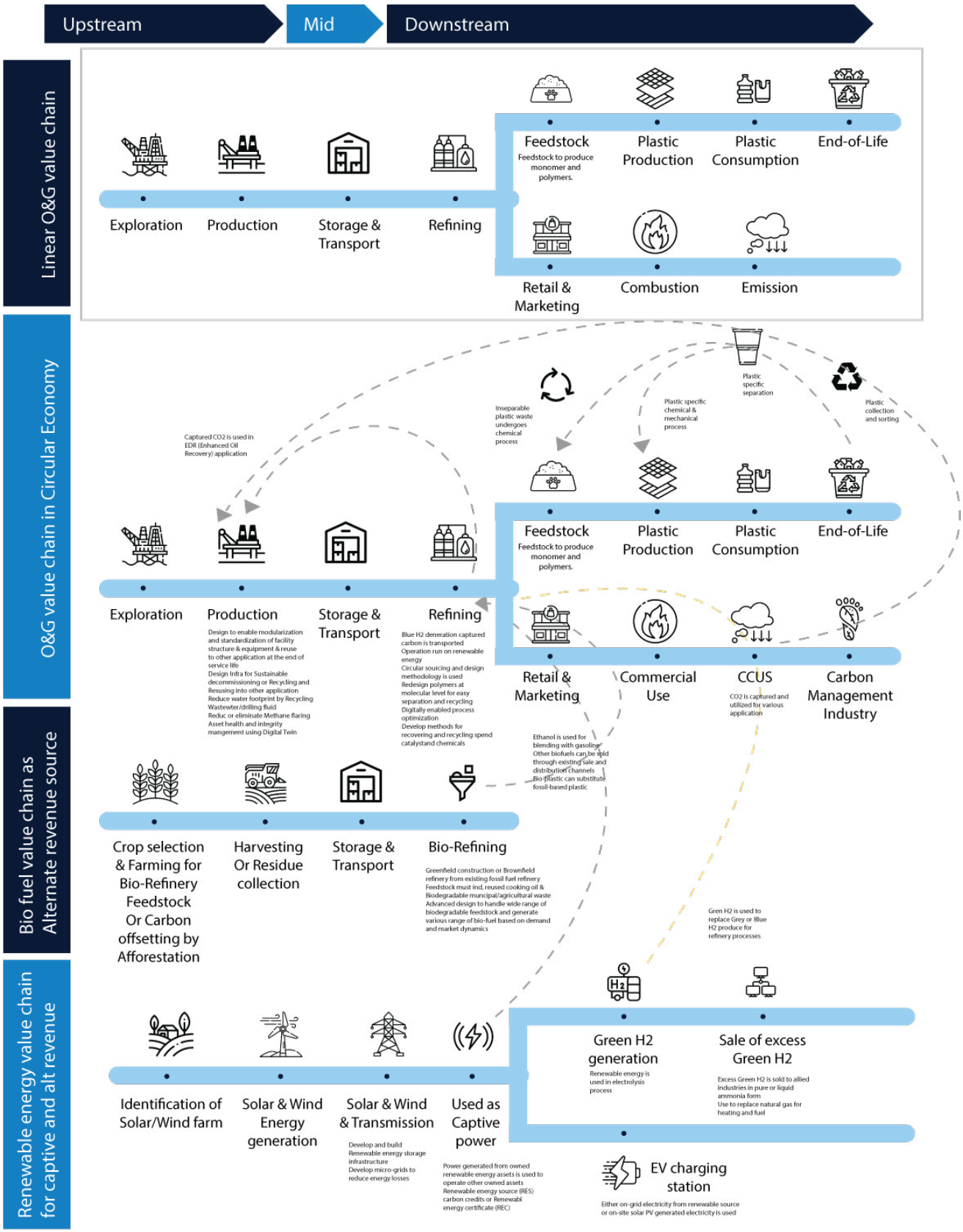


Figure 2 – An indicative circular business model with an integrated value chain for different revenue streams in the oil and gas sector

How Oil and Gas Companies can Adopt Circularity

While oil and gas companies undoubtedly require regulatory, government, and infrastructure support, they must do what they can to prepare their organizations and the larger ecosystem to adopt circularity. They need a combination of strategic planning, feasibility assessments, and a metrics-driven approach. The approach includes:

Introducing circular operations – Opportunity areas within the O&G value chain

Let us look at the avenues where O&G companies can integrate/adopt a circular business model within their value chains[10,11,12,13]. As seen in Figure 2, multiple activities in the value chain loop back into the early stages of production or refining. These are some of the avenues that can be utilized to create a circular business model. Along with exploring the different areas of the value chain where circularity can be adopted, it is also important to know what strategic steps, metrics, and technologies O&G organizations can adopt for the circular business model[15,16].

Strategies for O&G companies to become circular

- Diversify the product mix and revenue streams by increasing the share of bio-based or renewable products in the portfolio.
- Transition to renewable energy sources and regenerative water usage.
- Design for Recycling (DFR) and extended product life. This means not merely producing recyclable or durable products but also using equipment, plant, and structures that are designed for recycling and have an extended life.
- Form business alliances and partnerships with OEMs that support circular business model. Given the huge business potential that O&G sector offers to its OEMs, it can leverage its soft power to push the circular business model among its suppliers and vendors by either incentivizing them to adopt CBM or giving preference to circular vendors.
- Actively reduce carbon footprint by investing in carbon offsetting projects.

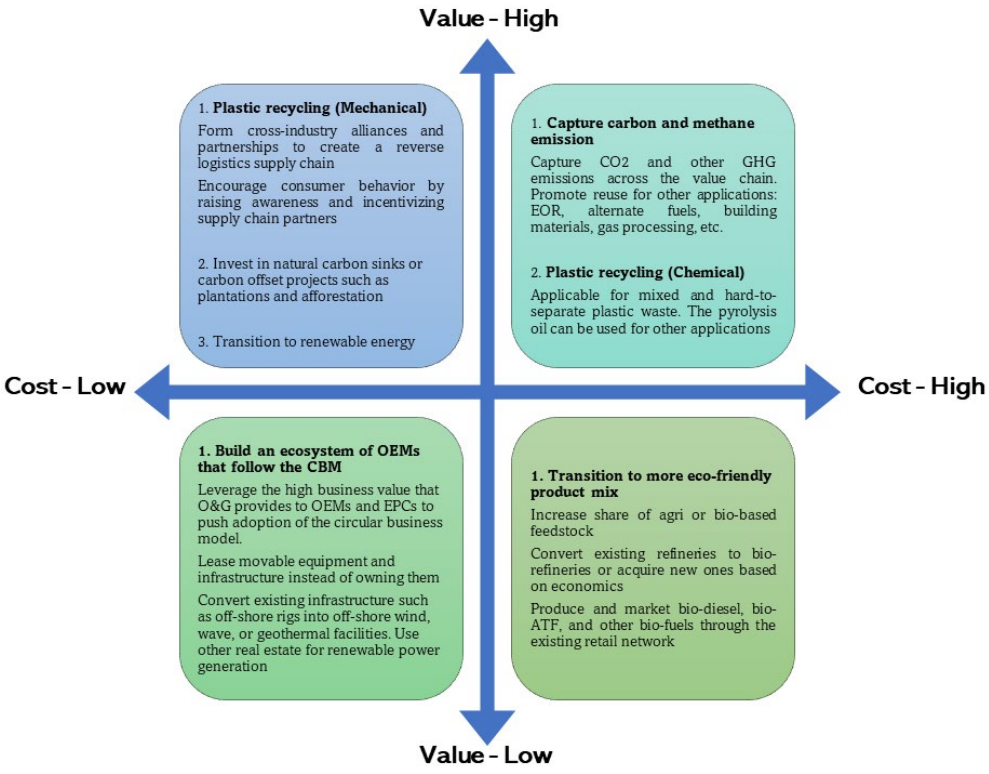
Assessing the feasibility of circularity strategies: A value versus cost matrix

Based on Figure 2 and the above strategies, one can determine the feasibility of any circularity strategy through a careful assessment of value versus cost. To start with, organizations can design a cost-value matrix for the O&G value chain, as described below:

- The value can be high or low, and is computed in terms of brand value, competitive advantage, and savings gained from using intrinsic value of material and energy.
- Costs are in terms of capex (capital expenditure) and opex (operational expenditure). It includes new infrastructure for developing and operating the reverse supply chain for accessing, segregating, and processing the product for re-use, refurbishment, or recycling.

This matrix helps organizations assess the costs spent and value derived on every circular business use case. Further, it will help them identify which strategy to adopt for which use case and how to prioritize the different initiatives. Organizations should also consider their supply chain maturity, risk appetite, and readiness before choosing their desired strategy[18].

Figure 3 – An example of cost versus value benefit analysis of potential circularity use cases in the oil and gas industry



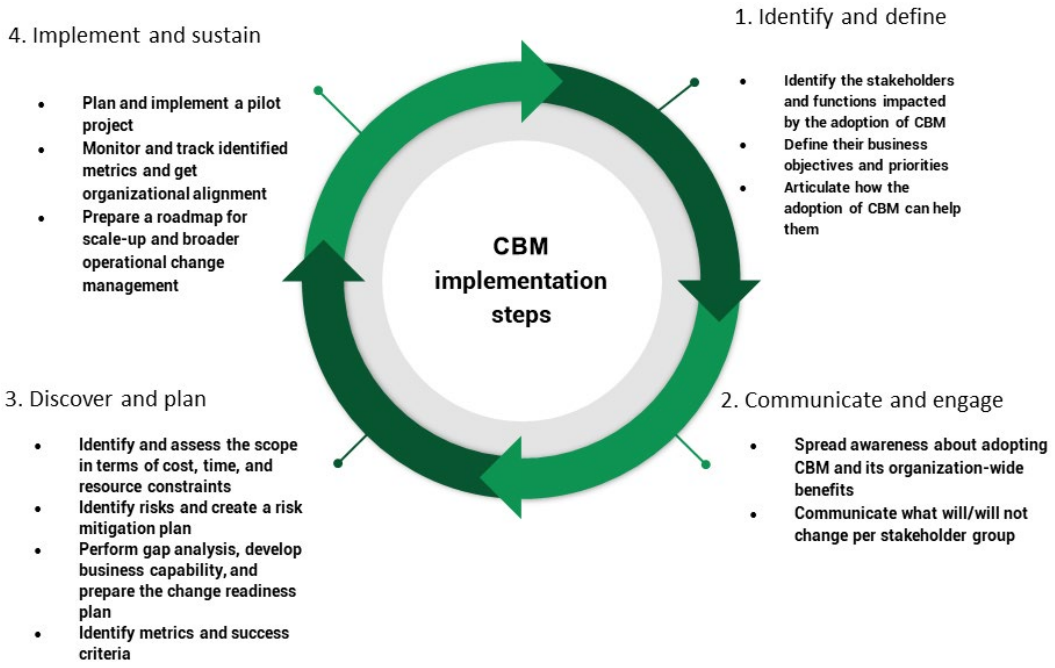


Figure 4 – Steps to implement the circular business model in O&G organizations

Metrics- What's measured, get managed

When implementing new ways of working, it is crucial to define the metrics that will measure the success of the new model. As the saying goes, "What is measured is what gets managed." Oil and gas companies must identify the key metrics to be measured to ensure they are on the right track in their circularity journey.

Metrics allow businesses to:

- Educate and inform shareholders, customers, suppliers, and employees
- Monitor and report on the current and to-be models and evaluate progress along the transformation journey from linear to circular business models
- Identify and chose the most suited circular solutions for individual businesses

Metrics may consist of one or a combination of indicators, methodologies, and tools, and can be standardized or be part of a certification scheme [19]. For every step of the innovation process, different metrics are needed to direct the organization towards new or improved products and services that are beneficial from an economic, social, and environmental viewpoint.

There are commercially available tools, frameworks, and certificates such as CTI, CIRCelligence [21], Circulytics, CirculAbility© [20], Cradle-to-Cradle certified, GRI 306 waste standards, and others. However, these are not tailormade for the oil and gas industry. The O&G value chain is not a typical manufacturing value chain, wherein the product, at the end of its useful life, can be recycled back. Therefore, O&G companies need a unique set of metrics if they are to adopt the circular economy.

Here are some metrics that the O&G industry can use to track their progress:

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Operational Metrics

- Percentage of renewable energy (consumption): Share of renewable energy in the annual total power consumption
- Percentage of green hydrogen and blue hydrogen (consumed): Share of green and blue hydrogen out of total hydrogen consumed
- Percentage of water circularity: Share of water recycled out of the total water consumed
- Percentage of recycled plastic polymer : Share of recycled plastic inflow out of the total plastic plymer produced.

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Financial Metrics

- Share of revenue from clean fuel and renewable energy: Revenue generated from the sale of clean fuel and renewable energy (like solar PV, on-shore and off-shore wind, geothermal) out of the total revenue generated
- Share of revenue from biofuels: Revenue generated from the sale of biofuels (like ethanol, methanol, biodiesel, SAF (sustainable aviation fuel), and waste-to-fuel out of total revenue generated

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<td colspan="2">GHG emission per US $ Million revenue : Net CO2eq (CO2 equivalent) GHG emissions (Scope 1 + Scope 2 + Scope 3) divided by the revenue. This can also be calculated as the net amount of greenhouse gases (GHG) emitted to generate US $1 Million in revenue.</td>
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- Percentage of gas flaring: Volume of gas flared or vented out of the total gas produced or sold
- Percentage of flaring efficiency: The flaring efficiency should be maintained at more than 90%
- Percentage of recycled plastic polymer: Share of recycled plastic inflow out of the total plastic polymer produced
- Net carbon offset: Carbon offset achieved through plantation, reforestation, CCUS (carbon capture, utilization, and storage), or buying carbon credits
- Net carbon avoidance: Carbon avoidance achieved by consuming renewable energy and employing renewable energy-powered operations and transportation

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Capex Metrics

- Percentage of assets made out of recycled material: Ton of assets made using recycled material out of the tons of material used in operations
- Percentage of approved vendors/OEMs that follow the circular business model: Share of approved vendors or OEMs among the organization's approved list that follow the circular business model

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Table 1 – Tentative metrics for monitoring the progress of circularity implementation in an O&G organization

Based on the value versus cost matrix, the best use cases are selected. Based on the selected/agreed metrics, the organization's/business unit's progress is measured and monitored over a period of time. The data of all metrics as well as data from upstream and downstream trade partners must be shared across the value chain. Additionally, for most of the metrics, third party support is needed through tools[22,23].

The Role of Technology in Enabling a Circular Economy

Clearly, metrics require material and energy data across the value chain. In fact, one of the main challenges in selecting the right business use case or preparing a circular business model roadmap is the lack of quality data across the value chain. Without adequate access to data or information, the measurement and tracking of metrics as well as the implementation of circular economy principles becomes difficult to achieve.

The O&G industry is on the path to digitalizing operations and other functions. However, generated and measured data remain in silos. Digital transformation should enable seamless information transfer across value chains, which are trans-organizational and transnational in nature[24,25,26]. But first, they must address concerns of common data standards and protect sensitive personal and business data.

Here is how data, digital, and IT can support the O&G industry in transitioning to the circular business model:

Digital solutions to manage assets: Implementing digital solutions to manage real-world assets allows O&G organizations to closely monitor asset performance and accurately capture, measure, and report on all relevant metrics of circular economics. Future production environments will be data-driven decision environments that collect and use data to make quality decisions.

The data will come from (a) operations within (and beyond) an organization – such as product design and production, (b) processes, (c) information databases, (d) real-time data mining, and (e) event and equipment monitoring. State-of-the-art technologies such as digital twin can also enhance asset health and integrity management.

Transition to cloud computing: Data centers and servers are the building blocks of storing and transferring data from sources to the points of utilization. However, data centers contribute heavily to GHG emissions and generate e-waste at the end of service life, ending up in landfills. Public and enterprise cloud service providers can power the transition from on-premises data centers, thereby reducing the Scope 1 emissions of an organization. An added bonus is when the organization chooses cloud service providers that have long-term power purchase agreements (PPAs) with renewable energy producers.

On another note, server and electronic OEMs should also focus on reverse logistics such as repair and recycling of data center components, thereby reducing e-waste. This will be a win-win for all stakeholders.

Tracking plastic products: Using digital product identifiers, digital tags, and watermarks can help identify the origin and composition of the plastic/polymer and provide other details. When plastic/polymer products display such details, it greatly assists in sorting, tracing back to the manufacturer, recycling plastic waste, and reducing massive amounts of waste and embedded value leakage.

Use of AI and predictive analytics: Advanced analytics can be used to identify the mean time between failures and improve the asset lifecycle through reduction and re-use. AI can also help optimally utilize assets (such as use the right number of generators/pumps) to minimize carbon emissions. Advanced technologies can detect wasteful use of energy/electricity across facilities and turn them off when not in use, etc. There are several planning and execution use cases that AI can help drive, which will significantly reduce the carbon footprint of oil and gas companies.

Integrated digital platforms: In a platform economy, value is created in an ecosystem of partners that share business and operational data in a controlled manner. This requires a digital platform that connects demand and supply, thereby unlocking value from multiple points and addressing the needs of the customer. Industrial data platforms are an example of such digital platforms.

They enable informed and orchestrated supply chains and delivery of smart services. They also provide abundant and timely data streams across the supply and value chains, which could provide valuable insights for real-time predictive or prescriptive analytics. Such analytics can further streamline processes, decrease materials use and waste, identify where generated waste can be reused, minimize energy use, etc. When implemented and managed wisely, integrated digital platforms can accelerate the circular economy.

Extended reality: Extended reality (XR), which includes virtual reality (VR), augmented reality (AR), and mixed reality (MR),is expected to play a pivotal role in driving favorable environmental actions. It will allow decision-makers to experience the projected business scenarios that can be achieved by taking the circular economy path [24]. XR can help visualize the problems of a linear business model as well as the solutions offered by different circular business model use cases. XR can facilitate cross-functional consensus and operational and management buy-in, as well as set the right expectations when transitioning from theory to reality.

For example, XR can help users visualize the value chain of circular sourcing, usage, and return between oil and gas organizations and OEMs. It can also help visualize the design changes needed to achieve sustainable decommissioning, repair, reuse, recycle, and remanufacture of different end-of-life assets. XR can also help optimize the use of construction material to reduce waste.

Success Stories

Some `oil and gas organizations have taken an early start in adopting the circular business model. They have also initiated the inclusion of circularity principles in some parts of their value chain. Here are some top success stories:

Exhibit 5 Success stories of implementing circular business model in Oil and Gas industry

The Road Ahead

Wherever possible, oil and gas companies must disengage from the linear industrial model and embrace innovative solutions towards a circular economy. They should address the internal challenges and identify appropriate avenues in the existing value chain where circularity principles can be applied. Globally, many governments, regulators, and industry bodies are taking various steps towards circularity, which could address some of the external challenges and make circularity more conducive and economical for wider adoption. Companies with higher circularity adoption will be incentivized through lower carbon taxes or greater opportunity for collaboration, leading to a strong circular ecosystem.

Some early adopters in the O&G sector have taken the lead in identifying opportunities to adopt the circular business model within their operations and are making tangible investments in this space. Other oil and gas organizations can learn from these early adopters, choose from different strategies, assess the feasibility through a cost-value analysis, and identify and measure the right metrics to track progress. It is also imperative to choose the right technology solutions that measure the value-addition, course-correct when needed during the implementation, and sustain circularity. The insights gathered from analyzing data will help organizations measure their key circularity indicators and identify other potential opportunity areas in their value chain.

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References

1. White, O. et al. (2022) War in Ukraine: Twelve disruptions changing the world. McKinsey&Company. Available at: https://www.mckinsey.com/capabilities/strategy-and-corporate-finance/our-insights/war-in-ukraine-twelve-disruptions-changing-the-world

2. ESG may surpass $41 trillion assets in 2022, but not without challenges, finds Bloomberg Intelligence | Press | Bloomberg LP (no date) Bloomberg.com. Bloomberg. Available at: https://www.bloomberg.com/company/press/esg-may-surpass-41-trillion-assets-in-2022-but-not-without-challenges-finds-bloomberg-intelligence/

3. ESG assets may hit $53 trillion by 2025, a third of global aum | Insights | Bloomberg professional services (2021) Bloomberg.com. Bloomberg. Available at: https://www.bloomberg.com/professional/blog/esg-assets-may-hit-53-trillion-by-2025-a-third-of-global-aum/The Circularity Gap Report, CGR 2022. Available at: https://www.circularity-gap.world/2022#Download CGR 2022 (circularity-gap.world)

4. Organisation for Economic Co-operation and Development (OECD). (2018). Global material resources outlook to 2060: Economic drivers and environmental consequences (pp. 1-24, Rep.). Paris: OECD. Retrieved from: OECD website.Kellas, G. (2021, March 31). How carbon pricing could reshape upstream oil and Gas Economics. | Wood Mackenzie. Available at https://www.woodmac.com/news/opinion/how-carbon-pricing-could-reshape-upstream-oil-and-gas-economics/

5. Towards the circular economy vol. 1: An economic and business rationale for an accelerated transition to a circular economy business | Report. Available at: https://ellenmacarthurfoundation.org/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an

6. Product-life factor (Mitchell prize winning paper 1982). The Product-Life Institute. Available at: http://product-life.org/en/major-publications/the-product-life-factor. Product-Life Factor (Mitchell Prize Winning Paper 1982) | The Product-Life Institute

7. The Circularity Gap Report, CGR 2021. Available at: https://www.circularity-gap.world/2021. CGR 2021 (circularity-gap.world)

8. United Nations. (n.d.). The 17 goals | Sustainable Development. United Nations. Available at: https://sdgs.un.org/goals

9. Putting CO2 to use | Report | IEA. Available at: https://www.iea.org/reports/putting-co2-to-use

10. Points, P. (no date) Produced water joins the circular economy, Sustainable Stories. Available at: https://blog.veolianorthamerica.com/produced-water-joins-the-circular-economy

11. Closing the loop – the circular economy, what it means and what it can do for you. PWC. Available at: https://www.pwc.com/hu/en/kiadvanyok/assets/pdf/Closing-the-loop-the-circular-economy.pdf

12. Closing the loop: Models for a Plastics Circular economy. Kearney. (n.d.). Available at: https://www.kearney.com/chemicals/article/-/insights/closing-the-loop-models-for-a-plastics-circular-economy

13. The rise of circularity: How the GCC is transforming from the inside for the outside. PwC. Available at: https://www.pwc.com/m1/en/publications/the-rise-of-circularity.html

14. Alnuaim, S. (2021) Circular economy: A sustainability innovation and solution for oil, gas, and Petrochemical Industries, JPT. Available at: https://jpt.spe.org/circular-economy-sustainability-innovation-and-solution-oil-gas-and-petrochemical-industries

15. View of end-of-life management of oil and gas offshore platforms: Challenges and opportunities for sustainable decommissioning. Available at: https://ojs.sijm.it/index.php/sinergie/article/view/1219/420

16. Taking on the circular economy in oil and gas. Offshore Technology Focus: Issue 83: June 2021 (2021) Offshore Technology Focus | Issue 83 | June 2021. Available at: https://offshore.nridigital.com/offshore_technology_focus_jun21/circular_economy_oil_gas

17. How Aramco's circular economy thinking can help the planet. Aramco. (n.d.). Available at: https://www.aramco.com/en/magazine/elements/2021/circular-economy

18. The circular business model. Harvard Business Review. (2021, June 15). Available at: https://hbr.org/2021/07/the-circular-business-model

19. Circular metrics for business. Insights | Circle Economy. (n.d.). Available at: https://www.circle-economy.com/resources/metrics

20. Introduction to the circular transition indicators framework. Insights | Circle Economy. (n.d.). Available at: https://www.circle-economy.com/resources/introduction-to-the-circular-transition-indicators-framework

21. Introduction to the CIRCelligence indicators framework. Insights | Circle Economy. (n.d.). Available at: https://www.circle-economy.com/resources/introduction-to-the-circelligence-indicators-framework

22. Sen, A., Meini, L., & Napoli, C. (2021). Beyond energy: Incentivizing decarbonization through the circular economy. Oxford Institute for Energy Studies. Available at: https://ora.ox.ac.uk/objects/uuid:3ea41f40-51eb-4768-8b83-4f6d94079dfd/files/r2514nk77c

23. Circular transition indicators v2.0 – Metrics for business, by business. World Business Council for Sustainable Development (WBCSD). (n.d.). Available at: https://www.wbcsd.org/Programs/Circular-Economy/Metrics-Measurement/Resources/Circular-Transition-Indicators-v2.0-Metrics-for-business-by-business

24. How technology can enable the circular economy. Available at: https://ellenmacarthurfoundation.org/tech-enablers-series/part-1. How technology can enable the circular economy (ellenmacarthurfoundation.org)

25. Foundation, E. M. A. (2021, July 16). The power of digital technologies to enable the circular economy. Medium. Available at: https://medium.com/circulatenews/the-power-of-digital-technologies-to-enable-the-circular-economy-5471d097ee7f

26. Stefan Sipka et al. Building a circular economy: The role of information transfer (n.d.). Available at: https://epc.eu/content/PDF/2021/DP_the_role_of_information_transfer.pdf

27. Circular economy: What why how where? OECD. Available at: https://www.oecd.org/cfe/regionaldevelopment/Ekins-2019-Circular-Economy-What-Why-How-Where.pdf

28. Oghazi, P., Mostaghel, R. (2018) Circular business model challenges and lessons learned - An industrial perspective. Sustainability, 10(3): 739 Available at: https://doi.org/10.3390/su10030739

29. TotalEnergies publishes its Sustainability & Climate 2022 progress report. Available at: https://totalenergies.com/info/totalenergies-publishes-its-sustainability-climate-2022-progress-report

30. Five commitments to the circular economy. TotalEnergies.com. (2017, February 1). Available at: https://totalenergies.com/news/five-commitments-circular-economy

31. How Aramco's circular economy thinking can help the planet. Aramco. (n.d.). Available at: https://www.aramco.com/en/magazine/elements/2021/circular-economy

32. What is circular economy and why is it important? REPSOL. Available at: https://www.repsol.com/en/sustainability/circular-economy/index.cshtml

33. Circularity in our strategy. Eni. (n.d.). Available at: https://www.eni.com/en-IT/circular-economy/circularity-strategy.html

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