A path to the future through holistic and integrated solutions

An energy transition report by Shell Catalysts & Technologies

SHELL CATALYSTS & TECHNOLOGIES
TRANSFORMING ENERGY TOGETHER

INTRODUCTION

As energy producers, how do you see the future?

Shell wants to accelerate its transformation into a provider of net-zero emissions energy products and services, powered by growth in its customer-facing businesses.

At Shell Catalysts & Technologies, we have always emphasized expertise and collaboration. Our mission is to work with customers and prospects alike to understand your unique positioning in location and market. We don't offer an answer to the uncertainties ahead, but we work with you to understand your goals and to present an integrated view of solutions.

In this resource, you will gain a glimpse into the collaborative mindset we adopt when approaching industry challenges including:

- the development of CO_2 impact assessment tools
- the integration of new assets into existing units
- the creation of a new-to-market product for renewable diesel feeds
- the evaluation of investment options across the Shell network.

We hope this will provide you with insight into how our experts help customers and prospects develop pathways for success.

Understanding what you need

Every project begins with a discussion of your requirements to identify potential areas for value creation. Energy producers, in particular, are responding to changes in product demand and the growing societal and legislative focus on decarbonisation. Although the decrease in product demand due to COVID-19 is temporary, market forecasts state that companies preparing for the longer-term decline in petroleum demand could strengthen their competitiveness in the coming years.[1] The time for change could be now.

We are working with energy producers who are using this period to invest in new market opportunities and to explore roadmaps for emissions reduction. These roadmaps are not only about utilising existing hardware or making optimisations, but also about the deployment of cutting-edge technologies. They often involve integrating existing assets with technologies of the future.

The challenge of creating this type of plan is that all of the solutions are not known at the start. That is why a successful roadmap relies on collaboration between parties that leverages their expertise. Our experts work with you and relevant teams across Shell's global organisation in an effort to solve some of the industry's most pressing energy transition challenges.

[1] "2021 oil and gas industry outlook," Deloitte, accessed 2 Feb. 2021, https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/oil-and-gas-industry-outlook.html.

SNAPSHOT 1

Assessing facilities' CO_2 impact with CO_2 intensity masterplanning

The challenge

Across the globe, energy producers are looking to invest in solutions that can lower the carbon footprint of their facilities and the products they produce. As governments are passing policies aimed at stimulating economic recovery from the COVID-19 crisis, they also have increasing focus on incentives for renewables and carbon pricing policies. Energy producers are looking to assess their baseline CO_2 impact as well as the cost calculations with incorporated carbon tax or credit.

SNAPSHOT 1

The approach with CO_2 intensity masterplanning

Shell has created various types of masterplans for over two decades. Masterplans are a high-level technical and economic assessment of business opportunities to help refiners face challenges related to future changes. The process involves taking a broad look at a facility to consider ways of improving the value of existing assets. They assess potential solutions aimed toward specific goals, such as bottom-of-the-barrel upgrading, sulphur treating or – as is the case with CO_2 intensity (CI) masterplanning – lowering the impact of CO_2 emissions.

Solutions for lowering carbon intensity can include increasing operational efficiencies such as furnace firing and heat integration, the adoption of renewable processes, which involves processing feeds that have a lower carbon footprint, and the integration of carbon capture and storage solutions, such as CANSOLV and ADIP-ULTRA.

[2] "Carbon Pricing Leadership Coalition: Realizing the Full Potential of Carbon Pricing in a Sustainable Recovery", World Bank Live, 22 June 2020, https://live.worldbank.org/carbon-pricing-leadership-coalition-realizing-full-potential- carbon-pricing-sustainable-recovery.

Applying owner-operator experience for CO_2 impact modelling tools

When looking at ways to decarbonise an entire facility, a holistic view is needed to consider how energy efficiency optimisations, lower-carbon technologies and renewable feeds can impact the carbon intensity number.

The Shell team is developing a modelling tool for an internal project that will calculate carbon intensity of different processes in a refinery, including the weight equivalent of CO_2 per pound/kilogram of product. As Shell is developing an internal reference case for the tool, the Shell Catalysts & Technologies team was interested to offer it to third-party customers and requested to expand its applications.

Our experts aim to strategically collaborate with refineries to calculate their carbon footprint. The modelling tool can be used to support the business case behind lower-carbon technologies by demonstrating the monetary impact of decarbonisation in different unit configurations and technologies such as the Shell Renewable Refining Process (SRRP) or the Shell Blue Hydrogen Process (SBHP).

Typically, masterplans involve consideration of various refinery configurations to optimally achieve the stated goal. CI masterplanning follows a similar process; by applying the modelling tool, our experts can show customers various configuration layouts through digital functionality like adding units and subtracting processes, and how the application of Shell technologies could impact their overall carbon footprint.

Decarbonising facilities by integrating lower-carbon technologies

We do not focus our recommendations on stand-alone technologies, but look at ways to decarbonise both supply chain and operations. This may require the integration of multiple lower-carbon assets, adjusting the product mix or introducing new technologies to further reduce a facility's overall carbon footprint.

Refineries that produce grey hydrogen, for example, can reduce their carbon emissions by capturing the CO_2, thereby producing blue hydrogen. This solution could help hydrogen producers reduce the product cost when the carbon tax is incorporated.

Additionally, they could use renewable feeds to charge the hydrogen plant and further reduce their carbon intensity. Incorporating renewable feeds – which can be produced within a refinery employing the Shell Renewable Refining Process – could reduce the typical carbon intensity of hydrogen production by half. The end-product could also be considered renewable hydrogen with higher market value.

With CI masterplanning, our experts aim to demonstrate how multiple lower-carbon applications can work together throughout a refinery to reduce overall carbon intensity.

SNAPSHOT 2

Utilising revamps expertise for renewable diesel production

The challenge

As demand for traditional fuels has decreased, refiners have been running units at lower capacities and severities, which limits the overall profitability of the operation. We have customers in regions such as Europe, Canada and some states in the U.S. who have incentives to increase the consumption of renewable diesel compared to diesel derived from fossil feeds. Most refineries in the U.S. must meet renewable identification number (RIN) obligations or pay penalties for not achieving renewable fuel quotas. They have a margin improvement opportunity to repurpose crude oil diesel units to make renewable diesel, which have higher market value.

SNAPSHOT 2

The approach with the Shell Renewable Refining Process

We are working with a U.S.-based refinery to convert two hydrotreaters that were originally built to process fossil feeds. With the Shell Renewable Refining Process (SRRP), the existing hydrotreaters can be repurposed to make a less carbon-intensive product by converting soybean oil into diesel, which can be sold into any diesel market in any season. SRRP's advantages also include improved energy efficiencies, optionality for Sustainable Aviation Fuel production, maximum yield selectivity and increased reliability.

Why customer collaboration is essential

SRRP is often applied to greenfield projects, where there are little to no constraints to designing a project in the most optimal configuration. The U.S.-based refinery is unique in that it is a brownfield project, which involves integrating SRRP with existing assets. A main challenge our experts face is: how do we integrate this technology into units that were designed for something else?

Brownfield projects can be more profitable than greenfield projects because they involve utilising existing assets. From a technical perspective, they are often considerably more challenging than greenfield projects because they have more constraints that must be considered in order for the units to be repurposed in the most optimum way.

Revamping existing assets requires greater involvement from the customer than a new build. Because the customer has been the owner and operator of the units for many years, they have a greater understanding of what their units are capable of, and that knowledge must be transferred to the Shell team. Our discussions include:

- What equipment do you have, and what is your experience in running that equipment in its existing form?
- What challenges/bottlenecks do you face?
- Which equipment is exhibiting problems?
- How can those issues be addressed as we incorporate the equipment into the new design so that the revamped equipment is optimal and energy efficient?

SNAPSHOT 2: CONCLUSION

Leveraging the comprehensive expertise of Shell for brownfield projects

Similar to other projects, various groups from Shell Catalysts & Technologies are involved in specific aspects of the solution with the U.S.-based refinery. During the collaborative discovery process, our cross-functional teams had the main goal of uncovering how to make the project commercially attractive from a capital expenditure point of view. The customer did not have a lot of capital to spend but they recognised the importance of addressing the carbon intensity of their facility to meet future governmental mandates and sustainability targets.

The customer tapped into our teams' expertise with our licensing team as their main point of contact. The licensing team worked to understand the potential cost-savings of the brownfield project as opposed to building a completely new unit. The fact that they had existing hydrotreating assets that were being underutilised made these units ideal for consideration in renewable service.

The catalyst team and reactor internals team proposed solutions regarding the different types of catalysts needed for the reactions as well as the revamping of existing reactors to process a different type of feed. Equipment specialists looked at existing assets and metallurgy, such as columns, heat exchangers and piping, to assess how they could be used in the new process. Through the discovery process, we worked with the customer to understand how re-use of existing assets could provide them with a speed-to-market advantage. They would be able to capture value sooner at significantly reduced capex compared to greenfield construction.

SNAPSHOT 3

Producing higher-value products with new-to-market technology

The challenge

Corn ethanol plants in the U.S. are faced with dual motivations.

1. They are incentivised to decarbonise through value generated from carbon credits.
2. They are looking to diversify risk by moving away from their primary product, ethanol, which has high market volatility. They are looking to produce higher-value products that are in a more stable economic environment, such as corn-derived protein feed or corn oil.

SNAPSHOT 3

The approach with Shell Fibre Conversion Technology

We are working with several corn ethanol plants on diagnostic business development for Shell Fibre Conversion Technology (SFCT). SFCT is a technology that can be bolted on to existing corn ethanol plant assets to produce a higher-value 2G ethanol. Protein feed and distillers corn oil (DCO) are co-products that are enhanced by this technology with DCO serving as feedstock for renewable diesel units. It can create unique products and molecules that are placed in the highest value markets.

Shell Catalysts & Technologies is currently in the process of bringing SFCT to the market. SFCT is not a fixed offering, but rather, we are seeking to build the first commercial SFCT plant.

In order for this to be built, the customers we work with must be aware of the risks and all the various elements that need to work in synchronicity. We need to be able to learn along the way and to continuously improve and optimise the offering to the market we have. In this phase, the customer helps us shape and articulate the benefits this technology can bring to their business.

The continuous discovery process in R&D

The value that SFCT has to the corn ethanol industry was an unexpected discovery for our team. The technology behind SFCT is unique to Shell Catalysts & Technologies because it is first-of-a-kind in regards to the recycling of chemical streams, enzymes and use of a particular yeast.

In the early phases of SFCT's 10-year development, the technology was based only on converting fibres consisting of long chains of sugars into sugar polymers. Our researchers found that this invention was exceptional at converting long sugar fibres into single sugars under very mild conditions, and our business development team first investigated applications to sugar-only or fibre-only feedstocks. These applications were not yet economically viable, however.

We soon found that SFCT can be applied to the processing of a wider range of fibre components, including switchgrass, corn ethanol and sugarcane. SFCT became of great value to the corn ethanol industry because of its potential value uplift compared to competing technologies.

SFCT has steered Shell Catalysts & Technologies into a new market, which is requiring our technical team to adapt into a commercial team. Although our researchers did not have the exact application in mind when they first began ideating what became SFCT a decade ago, our business is constantly evolving with our technologies and our customers' changing needs.

SNAPSHOT 3: CONCLUSION

Leveraging the value of Shell for flexible investment opportunities

When working with Shell on a new-to-market technology, customers may not only be interested in an application's potential benefits, but also the option of creating an integrated agreement. Shell Catalysts & Technologies is not only a technology provider but works across Shell to offer a range of investment options to our customers.

We operate as one Shell with Catalysts & Technologies focused on driving value for our partners. New Fuels is Shell's investment arm that can co-invest in solutions with qualifying customers. Trading and Supply, Shell's trading business, can help to place products in the highest-value markets internationally.

We offer many different options that offer customers investment flexibility. This framework allows Shell Catalysts & Technologies to offer the technology as a stand-alone application, as well as to work across the organisation in opportunity development.

Continuing the conversation

Take action to power transformation

While we don't have all the answers, our experts are starting conversations and taking action to power the transformations that will shape tomorrow's energy, petrochemical and industrial sectors.

Our commitment to Make Every Molecule Matter means that we apply the knowledge of our molecular science experts to create the technologies and processes that will power the energy transition. But this is just the beginning and we still have many questions to answer. We hope you will join us on this journey by getting involved and working with us to develop more and cleaner energy solutions. Subscribe to the Make Every Molecule Matter newsletter for more information.

SUBSCRIBE NOW

SHELL CATALYSTS & TECHNOLOGIES
TRANSFORMING ENERGY TOGETHER