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A refinery's strategic journey towards sustainability

A refinery's strategic journey represents a delicate balance between profitability, environmental commitments, and technological advancements

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Energy consumption is a key cost factor in refinery economics. About half of the refiner's operating costs are dedicated to meeting the demands of energy consumption.[1] Adding to this complexity, a Reuters report revealed that 43% of surveyed global workers plan to leave the energy sector by 2025.[2]

Amidst this financial and labour landscape, a mid-sized refinery confronts rising energy costs, workforce shortages, and the pressing need to meet net zero global commitments by 2050. In addition, this journey unfolds in a setting of diverse perspectives and agendas among the leadership team and board of directors. Despite these obstacles, the refinery committed to cutting Scope 1 and 2 emissions by 30%, benchmarked against a 2019 baseline, as depicted in **Figure 1.**

Operating in a rapidly changing business environment, the board sought to balance profitability by understanding how the precise product mix, customer base, feedstocks, and technologies interact. To reinforce this initiative, the refinery's Chief Operating Officer (COO) emphasised, "We need to strategically invest for the long term, but we must also remain profitable in the here and now. If we cannot generate a positive cashflow today, how can we possibly raise the funds for the investment we need to make?"

Achieving a balance between present performance and long-term strategic investments required alignment, commitment, and a clear and executable plan. Optimising current performance while ensuring long-term success required the refiner to keep one foot firmly planted in the present and the other in the future.

The present – Project Catalyst

The refinery's leadership team conducted a comprehensive 'wall-to-wall' operations assessment. This evaluation uncovered several key focus areas, including soaring energy costs, reliability issues, and team demographic challenges. Over a six-week period, the following challenges were addressed:

- Asset reliability to overcome underinvestment
- Energy efficiency for quick wins
- Yield optimisation with digital twin software
- Turnaround optimisation for decarbonisation planning
- Recruitment and organisation to mitigate challenges
- Technology for digital transformation.

Rotating equipment issues significantly impacted asset availability and throughput. This issue led to decreased profit margins and hindered the site's ability to capitalise on a high-margin environment. The emphasis was on identifying reasons for underperforming asset reliability and building consensus on corrective actions.

While historical underinvestment played a role in current performance levels, the primary issue stemmed from a lack of root cause analysis and follow-up actions, combined with a lack of start-up readiness.

In Europe, rising energy costs have heightened the focus on energy optimisation for many assets.[3] A strategic energy and maturity review identified that the refinery overlooked the latest technology, monitoring tools, and efficient practices for energy management. Relying primarily on the operators' tacit knowledge, the asset fell short of industry benchmarks, including KBC's proprietary Best Technology Index. However, through comparative analysis, the team identified quick-win opportunities that required minimal or no capital expenditures to swiftly improve the asset's performance. These opportunities not only delivered immediate value but also contributed to the programme's overall funding.

Additionally, long-term, mid-to-high Capex improvements were identified and fed into the decarbonisation workstream. Addressing no or low Capex opportunities was integral to the refinery's success in optimising energy usage and achieving its goals.

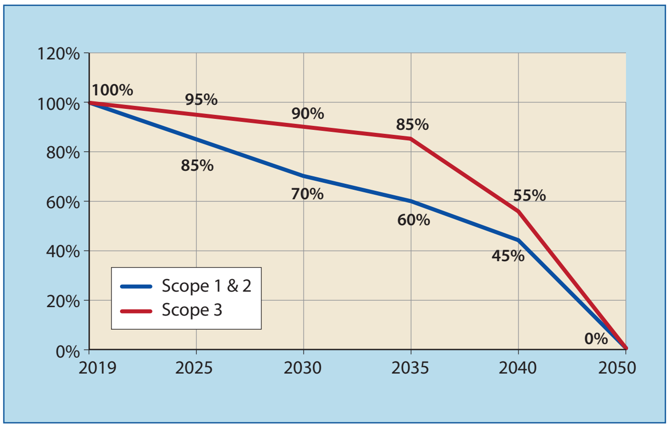

Figure 1 Scope 1, 2, and 3 emissions reduction targets

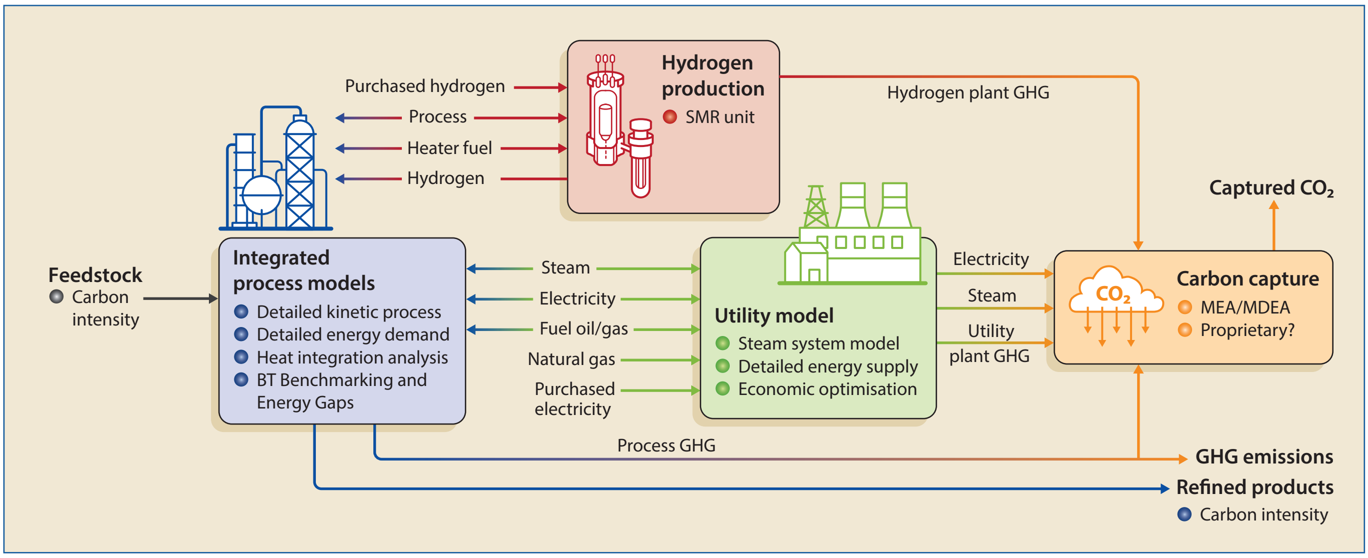

Figure 2 Integrated Process, Energy, Emissions and Economics Model (IP3EM)

By creating a digital twin of the refinery, yield optimisation opportunities could be thoroughly reviewed. This assessment revealed numerous areas where operating parameters and procedures could be improved. Furthermore, the focus on no or low CapEx opportunities played an integral role to the programme benefits and funding, similar to energy efficiency opportunities.

Refinery margin erosion is largely attributed to turnarounds.[4] This programme aimed to review both the overall turnaround philosophy and the detailed scope of the next two turnarounds. The focus was to identify activities that could be descoped, moved off the critical path, and optimised. Given two scheduled turnarounds between the assessment and 2030, the turnaround review was inextricably linked to the decarbonisation planning activities.

Many refiners struggle with dual challenges: an ageing workforce and difficulty recruiting young engineers and skilled operators.[1,5] In addition, the oil and gas industry is frequently perceived as contributing to climate change rather than being part of the solution in the energy transition journey.[3] The scale of the problem was assessed, which has led to developing mitigation plans to address potential gaps over one-, three-, five-, 10-, and 15-year time horizons.

Technology is crucial for streamlining operations, revolutionising work processes, and supporting necessary productivity improvements to mitigate ongoing resourcing issues. During this programme stage, the technology and digitalisation vision were outlined for the operating assets, consistent with the overall organisational vision. Having defined the vision, a gap analysis was conducted, leading to the development of a draft target application architecture. This strategic approach ensured the technology was leveraged optimally to achieve the refinery's goals.

After completing the assessment phase, the next step involved defining the resultant programme, Project Catalyst. The process of defining the programme involved overcoming the primary challenge of getting multiple stakeholders with differing perceptions regarding priorities, timescales, and resource requirements into agreement. To address this, several highly facilitated programme design workshops were held. These workshops were deliberately not high tech. The team intentionally used basic tools such as marker pens, sticky notes, a long sheet of brown paper, and coloured voting dots.

Prioritising specific interventions was based on the corporate goals, legislative frameworks (such as maintaining a safe and compliant operation) and individual benefits aligned with opportunities (such as maximising the transformation investment). Engaging team members across the organisation led to the development of a practical programme where each workstream was assigned monthly deliverables that were captured on a 4m-long poster. This poster, shown in **Figure 2**, served as a key management tool to communicate the programme's progress and ensure that everyone from the control room to the board room understood the project.

The future – Project Horizon 2050

Building on the Project Catalyst programme, a similar exercise was conducted to ensure the refiner met their decarbonisation targets. This initiative resulted in Project Horizon 2050. It should be noted that the 'One Foot in the Present – Project Catalyst' and 'One Foot in the Future – Project Horizon' workshops were held concurrently. The COO's vision was to transform the refinery into a future-ready asset capable of meeting customer and societal demands in a sustainable, affordable, and reliable way, including a decarbonisation roadmap for reaching net zero with technology leading the way.

The main objective of Project Horizon 2050 was to develop an agreed-upon decarbonisation roadmap that balanced short-, medium-, and long-term initiatives to achieve the refiner's decarbonisation goals. To secure the success of the roadmap and achieve net zero emissions by 2050, three pillars – strategy, operations and technology – were defined, along with interim milestones.

The implementation of the refiner's roadmap needed to be anchored on technology and aligned with the other two pillars to ensure sustained actions and results. This approach meant balancing current operations with a forward-looking strategy.

As outlined in Project Catalyst, the roadmap started with examining operations and implementing energy efficiency to provide quick wins while balancing emissions reduction with profitability. In this case, it involved reviewing existing assets and operations to ensure optimal functionality. This would achieve around a 15% emissions reduction, at best 20%. However, to reach the desired mid-30% emissions reduction target and net zero by 2050, a clear strategy, outside-the-box thinking, and alternative solutions were needed to drive organisational change.

To achieve this first milestone of 30% emissions reduction, the refiner built a green hydrogen plant to replace part of the hydrogen produced at their steam methane reformer. This step required various options to be evaluated to determine the impact each alternative would have on energy, emissions, and economics. Besides developing a solid business case and a set of digital tools to analyse the green hydrogen plant, additional actions and opportunities were explored to achieve net zero emissions, such as electrification, carbon capture storage and utilisation, and hydrogen firing.

Moreover, testing and verifying results were essential to achieve top performance. As a result, tools capable of incorporating the latest site modifications were essential for real-time energy and emissions optimisation. By incorporating these measures, the refinery worked towards achieving its emission reduction goals and contributing to a more sustainable future.

Technology leads the way. Against this backdrop, and to ensure alignment between strategy and current operations, two main technologies were adopted: the Integrated Process, Energy, Emissions and Economics Model (IP3EM) and digital energy management system.

The first technology implemented was the IP3EM. This tool optimises renewable power options to reduce Scope 2 emissions while incorporating future Scope 3 projects.

As shown in Figure 2, this refinery-wide model comprehensively considered energy demanded from processing, utility production and supply, and process and utility-generated emissions. Powered by a process simulator with necessary modules, it addressed present and future energy transition challenges. Moreover, the IP3EM model also assessed the economic impact of the different alternatives being evaluated and guided the refinery throughout its entire decarbonisation journey.

The IP3EM revealed key benefits such as analysing refinery margins, return on investment using emissions reduction scenarios, and accurately identifying and quantifying major sources of Scope 1 greenhouse gas (GHG) emissions.

Several projects were considered. The IP3EM was key to assessing the impact of Scope 1 and 2 emissions, energy consumption, and economics regarding furnace electrification, hydrogen firing, a green hydrogen plant (electrolyser), and oxygen firing. Moreover, the analysis also included future business cases that accounted for Scope 1 and 3 emissions. These projects included carbon capture and utilisation (CCU) for sustainable aviation fuel, CCU urea production, and a potential renewable hydroprocessing plant.

The second technology involved implementing a digital energy management system to serve as the programme's foundation. This software optimised the energy system in terms of economics and emissions to sustain long-term value.

Simultaneously cutting costs and GHG emissions started in a predominantly centralised, hydrocarbon-based energy generation setting. During the energy transition, processes improved, renewable energy vectors were introduced, and assets were decentralised.

Ultimately, the goal is to achieve net zero GHG emissions in a largely renewable energy system by maintaining decentralised, low CO_2 emissions energy generation, transportation, as well as storage and utilisation.

The case in **Figure 3** demonstrates a utility system that blends traditional with renewable energy sources. This scenario emphasises the importance of aligning short-term scheduling with real-time operations for maintaining feasibility and profitability.

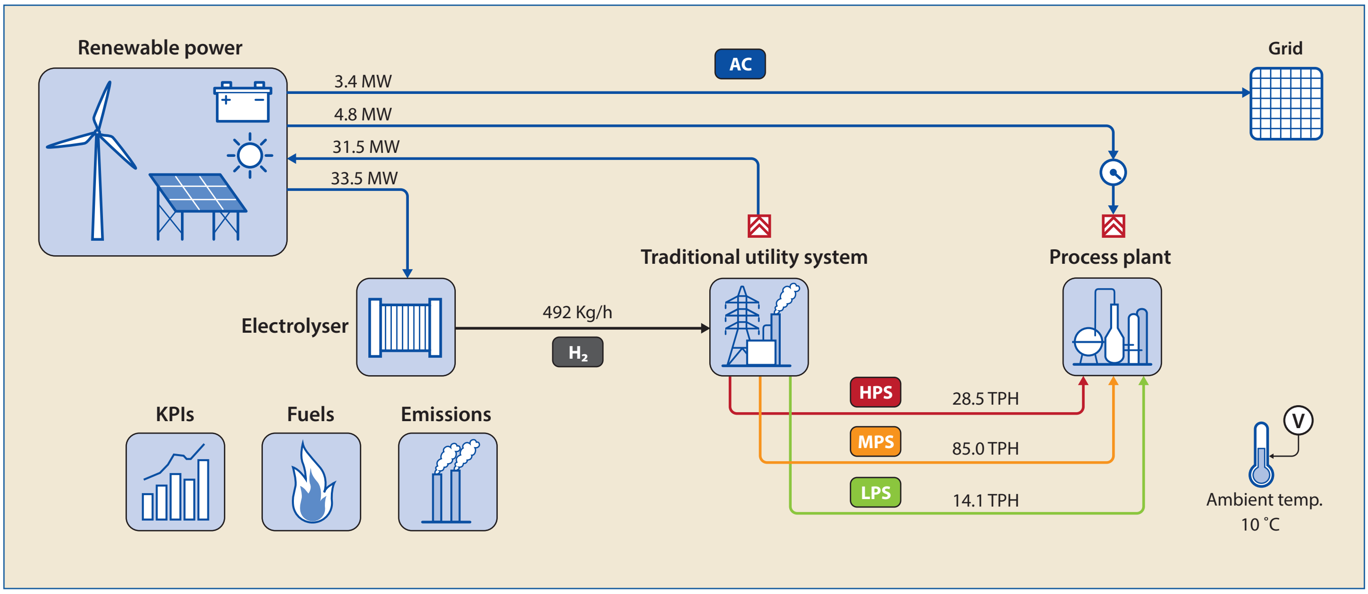

Figure 3 Renewable and traditional energy management system

Resilience and innovation

In conclusion, the mid-sized refinery's strategic journey represents a delicate balance between profitability, environmental commitments, and technological advancements despite facing numerous challenges.

Through Project Catalyst, the refinery addressed operational deficiencies while optimising energy usage and managing talent. These initiatives set the stage for the refinery's long-term success. By incorporating no or low Capex solutions, the refinery not only improved immediate performance but also laid a foundation for sustained success.

The simultaneous execution of the One Foot in the Present and One Foot in the Future workshops via Project Horizon 2050 demonstrated the refinery's ability to balance financial viability with energy transformation.

The adoption of cutting-edge technologies, such as the IP3EM model and the proprietary Visual MESA Energy Optimizer, showcased the refinery's commitment to precision and efficiency. With a phased emissions reduction strategy and initiatives like green hydrogen production and digital tools, the refinery is set to meet net zero global commitments by 2050 and position itself as a leader in sustainable energy practices.

Visual MESA Energy Optimizer is a mark of KBC.

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