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Low Carbon Pathways
CO_2 efficiency in the EU Refining System. 2030 / 2050

Executive Summary
(Interim report)

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Executive Summary (Interim report)

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This document is the executive summary of the Concawe report CO_2 efficiency in the EU Refining System. 2030 / 2050' that will be issued in 2Q 2018 replacing this document.

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ABSTRACT

This executive summary describes part of the work being conducted by Concawe with the objective to explore a range of *Low Carbon Pathways* with the potential to reduce the CO_2 emissions associated with both the production and use of refined oil products. This summary demonstrates that the effective deployment of different technologies has the potential to achieve a significant reduction of the CO_2 emissions associated with oil refining by 2050.

The gradual decarbonisation of the EU electricity grid will offer new ways to integrate low-carbon electricity into the production system, while CO_2 Capture technology will enable refineries to make CO_2 available for either storage (CCS) or use (CCU) thereby integrating the EU refining system into a circular economy. External factors such as future energy prices together with more effective R&D programs will play a role in boosting the deployment of the key technologies identified.

It is important to note that this works is not intended to be a roadmap for the whole EU refining industry. Factors such as the CO_2 efficiency of existing facilities coupled with local and structural constraints will determine individual refineries' preferred route to contribute to mitigate climate change. Whilst this report summarises opportunities to improve the CO_2 efficiency of the EU Refining system, other studies are underway which examine the potential for integrating different, non-petroleum derived feedstocks.

KEYWORDS

Refineries, CO_2, energy, efficiency.

INTERNET

This report is available as an Adobe pdf file on the Concawe website (www.concawe.eu).

CONTENTS

Page

1. EXECUTIVE SUMMARY (INTERIM)

Oil refining is an inherently energy intensive activity which has been operating in Europe for over 100 years, providing other industries and final end-users with a wide range of different fuels and products relevant to society.

In December 2015, COP21 in Paris made an important step to address the risks posed by climate change and to keep the global temperature increase to *“well below 2°C”* and drive efforts to limit it even further to 1.5 degrees. As their contribution, the European Union defined their Nationally Determined Contribution and agreed on a binding target for the EU and its Member States of at least 40% domestic reduction in greenhouse gases (GHG) emissions by 2030 compared to 1990. To achieve these goals, the EU is exploring different mid-century scenarios for a low-carbon economy by 2050. To support the EU low emissions strategy, Concawe is exploring cross-sectorial Low Carbon Pathways where the EU refining industry collaborates with existing and emerging industries in an integrative way to substantially reduce the CO_2 emissions associated with manufacturing and the use of hydrocarbon intermediate and final products, thereby continuing to provide value to the EU economy in the coming decades.

1.1. SCOPE OF THE STUDY AND APPROACH

This report summarises the opportunities for different technologies to substantially improve the CO_2 efficiency of the existing facilities within the current EU refining system.

In this context, this study was undertaken with purpose of:

- Establishing the current status of EU refineries in terms of energy intensity and CO_2 emissions intensity, including a brief historical perspective and a comparison with the situation in other world regions,
- **Exploring the future of EU refining towards 2030 and then further to 2050**, and describing plausible CO_2 intensity reduction pathways by addressing the following questions:
    - What can realistically be achieved through incremental continuous improvement projects?
    - What is the potential for significant new technologies to enable step changes in CO_2 intensity?
    - What is the potential for hitherto untapped synergies with other sectors?
- The demand scenario (quality and quantity) was fixed throughout the study implying a constant intrinsic energy intensity. The study therefore concentrated on the impact of energy efficiency and CO_2 intensity reduction measures.

According to the GHG Protocol, this assessment addresses the refining CO_2 emissions covered under *Scope 1* (Direct emissions) and *Scope 2* (Indirect emissions from production of purchased energy such as electricity). Other indirect emissions associated with the final use of refining products (*Scope 3*) are excluded from the scope of this analysis and will be addressed in upcoming reports (Low Carbon Pathways project)

Refineries will continue to find ways of reducing CO_2 emissions through a combination of operational measures and targeted investments as well as by taking advantage of external opportunities. A bottom-up approach, looking at each of the 80 refineries currently in operation in the EU, would be impractical and would raise confidentiality issues. Instead, this study adopted a top-down approach, identifying which emission-reduction technologies and external opportunities might be available to EU refiners and what impact they might have at the 2030 and 2050 Horizons on the CO_2 intensity of the whole EU refining sector.

1.2. OPPORTUNITIES TO IMPROVE CO_2 EFFICIENCY OF EU REFINING SYSTEM

A variety of options were identified which were clustered into 3 main categories:

Table 1. Summary of the CO_2 efficiency opportunities identified (*Examples*)

A. Energy Efficiency (EE)	
Refinery **process efficiency**	○ **Continuous improvement** through implementation of a combination of measures and small projects involving some capital expenditure. Examples include catalyst improvements and hardware improvements such as new motors, heat-exchangers, etc. ○ **Major capital projects:** Larger efficiency improvements reflecting changes to the technical configuration of individual refineries (e.g. extensive revamps of existing facilities, new process plants). ○ Inter-unit heat integration
Energy Management Systems combining equipment (e.g. energy measurement and control systems) with strategic planning, organisation and culture.	
Increased recovery of refinery **low-grade heat** for export and electricity production	
B. Use of Low Carbon Energy sources (LCE)	
Benefit from **decarbonisation of the** gas and electricity **grid**	
Reduction of **liquid fuel** burning	
Improved r**ecovery of Hydrogen and LPG** from fuel gas	
Increased use of **imported low-carbon electricity**	Partial replacement of own generation by imported low-carbon electricity.
	Increased use of electricity for general operations a/o rotating machines
	Substitution of fired heaters by electric heaters
	Production of hydrogen with electrolysers using imported renewable electricity
C. CO_2 capture (CC)	
Capture of a portion of the total CO_2 emitted by refineries. The potential role of a CCS scheme together with steam reforming plants (SMR) to produce a low-carbon intensity Hydrogen is explicitly explored.	

1.3. RESULTS: POTENTIAL REDUCTION OF CO_2 EMISSIONS AND ENERGY SAVINGS

Different rates of deployment of technology, energy prices and the degree of decarbonisation of the electricity grid were explored for the two time horizons, 2030 and 2050.

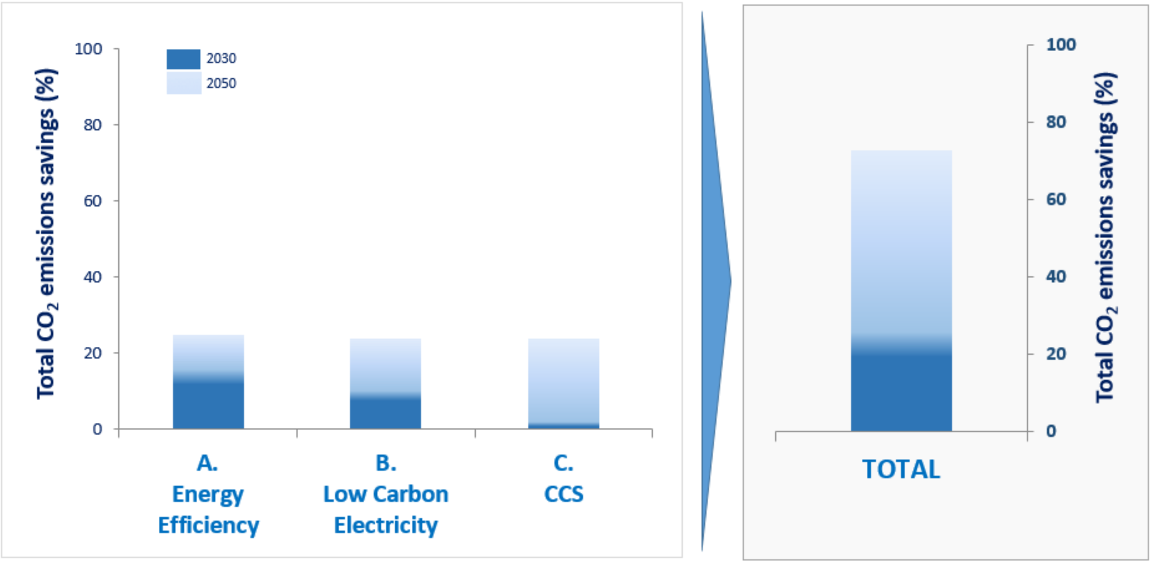
The starting point for the 2030 horizon (2030 reference case) was based on actual and detailed refinery data. This was incorporated into a model which could integrate all options in a systematic and consistent way and arrive at a range of plausible CO_2-intensity reduction figures for the whole EU refining sector.

Different assumptions were made to assess the impact of each option and the results are expressed in terms of both energy and CO_2:

- The degree of achievable CO_2 emissions reduction compared to the 2030 reference case
- The degree of energy consumption reduction compared to the 2030 reference case
- The potential of each option was scrutinised in some detail, considering:
    - ○ The underlying technologies, their current and future state of development,
    - ○ The internal and external factors (practical and financial) that might favor or constrain the adoption of such measures.

The figure below shows the cumulative total emissions savings (i.e. including emissions from production of imported electricity and hydrogen production) for the main opportunities identified above. Each column shows the cumulated potential for a specific category for the 2030 horizon with increasing deployment towards the 2050 horizon.

Figure 1. Potential % CO_2 emissions savings.



Note. Legend: 2030 Horizon (Solid colour) with a higher deployment for the 2050 Horizon (Colour degradation reflecting the uncertainty associated to the longer-term timeframe considered).

Assuming that the EU refining capacity is maintained at the 2030 level, when all options are exercised, the total **EU refinery CO_2 emission intensity can be reduced by 20 to 30% by 2030 and up to 70% by 2050**, compared to the 2030 reference case. The **capex required** to achieve this for the whole EU refining system is **estimated** at ***minimum*** **40,000 M€.** This estimated cost only refers to the generic cost of the different technologies and opportunities identified. The actual cost of implementation would be determined by the specific conditions of each individual asset.

The basic assumption for the 2050 horizon is that the maximum level of **realistic deployment** will be achieved for each identified opportunity at the EU level, assuming no change in the activity level of the sector. The degree to which the available options will be deployed will depend on several factors such as external market conditions, evolution of energy and CO_2 prices and future regulatory framework. These factors will influence technology improvements and the effective commercial viability and deployment of the opportunities identified. The combination of options practically available will be, to a large extent, unique to each site, dictated by several factors such as existing configuration or location.

A more detailed analysis of the main opportunities in terms of CO_2 savings are identified shows that:

- By the 2030 horizon, the bulk of the savings will stem from process energy efficiency and a series of other step changes associated to improvement measures. External opportunities only start to make a significant impact in the 2050 horizon.
- Underlying energy efficiency improvements of up to 15% by 2030 and 25% by 2050 may be achieved. This is equivalent to an annual improvement of about 0.7% per year on average for the whole period to 2050, slightly above the average for the past 25 years but in line with more recent data.
- Successful implementation of CO_2 capture (and storage or usage) appears crucial to reducing EU refineries emissions. Before CCS projects are included, the total 2050 emission savings would be 50% compared with 70% if feasible CCS were effectively deployed across the whole industry sector. However, the degree of penetration of CCS and the associated timeframe remains uncertain due to factors such as the number of sites able to implement it with accessibility to permanent storage facilities.
- The progressive availability of low-carbon electricity in the average EU mix could open a number of routes for large emission-savings by substitution of fossil energy by electricity. These routes could reduce EU refinery emissions by up to 25% by 2050, bringing the total electricity consumption of the sector close to 180 TWh/a, which could represent as much as 5% of the electricity currently generated in Europe. However, this would be conditional on the effective large-scale deployment of renewable electricity in Europe at an affordable price for industrial users.
- Recovery of low-grade heat can make a small contribution through either internal production of electricity or export to e.g. district heating schemes.

The Well-to-Tank CO_2 intensity of final fuels and non-fuel products can be substantially reduced by 2050 if these technologies are deployed across the industry.

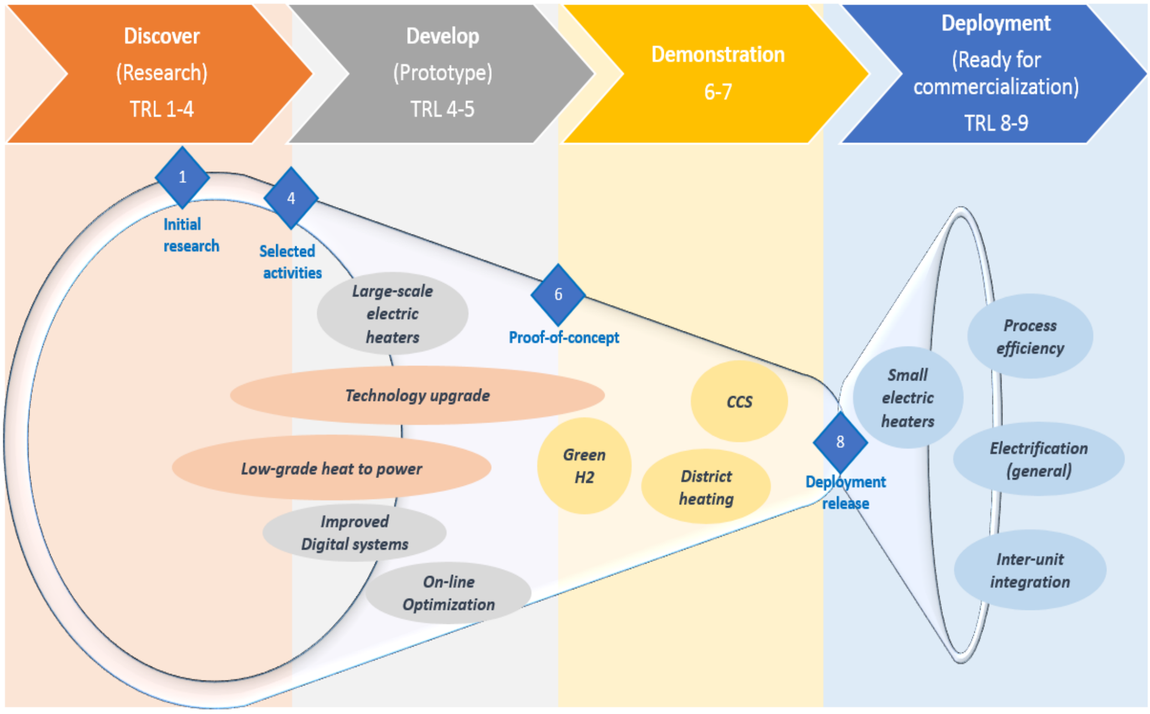
1.4. R&D AS A KEY ENABLER

The opportunities to reduce the CO_2 intensity of refinery products identified in this study will require technological development to make the potential a reality at reasonable with the time horizons (2030 and 2050).

This study points to a number of areas in which the refining industry and its technology providers can offer continuous improvements and step out projects. In addition, this report highlights a number of areas where a new type of cross sectorial collaborative R&D is likely to be required to accelerate the development and integration of technologies including green hydrogen and CCS.

Even with such collaborative R&D, refineries will need to attract the investment required to revamp existing or build new plant and the required infrastructure to integrate the developing technologies. This will require a supporting regulatory framework and an economic environment that justifies such investments.

Figure 2. Technology development: Deployment status of various technologies.



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