CONTRIBUTION OF REFINERY CARBON DIOXIDE EMISSION TO GLOBAL WARMING

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ABSTRACT

The energy sector, including petroleum refining, is likely to feature in any legislation aimed at reducing CO_2 emissions. It seems that petroleum refinery contributes relatively small amount of CO_2 emission compared to other sectors such as transportations.

Recently, through presidential speech in Copenhagen, government of Indonesia has committed to reduce CO_2 emission to 26 percent in the year of 2020. Many technologies can be used for reducing CO_2 emission in refinery. These technologies include fuel replacement, gasification of heavy residue which leads to single point CO_2 capture, and CO_2 sequestration.

This paper tries to discuss how far CO_2 emissions contributed by refinery and possible actions that can be managed on the refinery to significantly reduce CO_2 emissions.

Key words: *global warming, refinery, CO2 emission, environment.*

I. INTRODUCTION

Production of CO_2 globally has been brought into discussions in recent years through declarations such as the Kyoto Protocol [(1)], and also by industries committing to tangible reductions. In essence, the Kyoto Protocol leads a global problem into a national policy, by setting emission targets for greenhouse gases compared with a baseline 1990 level, with a view to reducing global emissions.

How individual nations and industry react to the growing pressures to reduce CO_2 is still to be formulated and ratified. A key element is whether specific industries should be targeted and whether CO_2 trading should be allowed across national boundaries and/ or industries.

The energy sector, including petroleum refining, is likely to feature in any legislation aimed at reducing CO_2 emissions. It seems that petroleum refineries contribute relatively small amount of CO_2 emission compared with other sectors such as transportation. However, in this case the refineries may see real benefits and opportunities in adopting a CO_2 management and reduction strategy. This CO_2 reduction strategy is not only to get benefit from some of the economic gains of CO_2 reduction, but also in order to be seen as a "good neighbour". This CO_2 reduction strategy, for example, through energy conservation and CO_2 utilization, and applying technology. Such technologies, among others, are gasification, which allow heavy residue destruction, relatively easy CO_2 capture and other environmental benefits.

Recently, through presidential speech in Copenhagen, government of Indonesia has committed to reduce CO_2 emission to 26 percent in the year of 2020. This paper tries to discuss how far CO_2 emissions contributed by refineries and possible actions that can be managed on the refineries to significantly reduce CO_2 emissions.

II. SOURCES OF REFINERY CO_2 EMISSIONS

The petroleum refining industry converts crude oil into thousands of refined products, including lique-

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fied petroleum gas, gasoline, kerosene, aviation fuel, diesel fuel, fuel oils, lubricating oils, and feed stocks for the petrochemical industry. Petroleum refinery activities start with receipt of crude for storage at the refinery, folloved by all petroleum handling and refining operations, and they terminate with storage preparatory to shipping the refined products from the refinery.

The petroleum refining industry employs a wide variety of processes. A refinery's processing flow scheme is largely determined by the composition of the crude oil feedstock and the chosen petroleum products.

All emissions from the refinery originate from the feed stocks that are used. These feed stocks are the main crude oil(s) to be processed, and other imported feed stocks such as condensates or vacuum gas oils (VGOs), and supplementary natural gas for fuel or hydrogen plants. Carbon is found in the petroleum products that are produced, such as gasoline, diesel oil, etc., with the significant loses emitted into the environment. While most carbon emissions from the refinery will be in the form of CO_2, there are also other emissions, such as volatile organic compounds (VOCs), coke on catalysts and other minor emissions. Coke on catalyst is not really air borne emission, since it could be land filled. "Shadow" emissions may be from energy outside of the refinery. This could be CO_2 emissions derived from production of energy offsite. These CO_2 emissions are not emitted from the refinery itself, but are still important when considering the impact of the refinery operations.

Whilst there are many sources of air pollution (e.g. sulfur dioxide and fugitive emission) in the refinery, it seems that two processes in refinery have great contribution to CO_2 emission. These are hydrocracking and fluidized-bed catalytic cracking (FCC) processes[2] (see Figure 1).

CO_2 emissions are dominated by those resulting from burning of fuel in fired heaters (approximately 50%) and in utility boilers (approximately 20%). In practice, the refinery will have a large number of process heaters scattered around the site. This makes "end pipe" solution for CO_2 capture is difficult, extremely expensive and even impractical. However, there is potential for capture of the CO_2 produced from power generation, hydrogen production and utilities, which represents approximately half the refinery CO_2 emission.

III. CO_2 REDUCTION

Literature search indicates that refinery contributions of CO_2 emission are very small comparing to those other activities utilizing petroleum (see Figure 2).

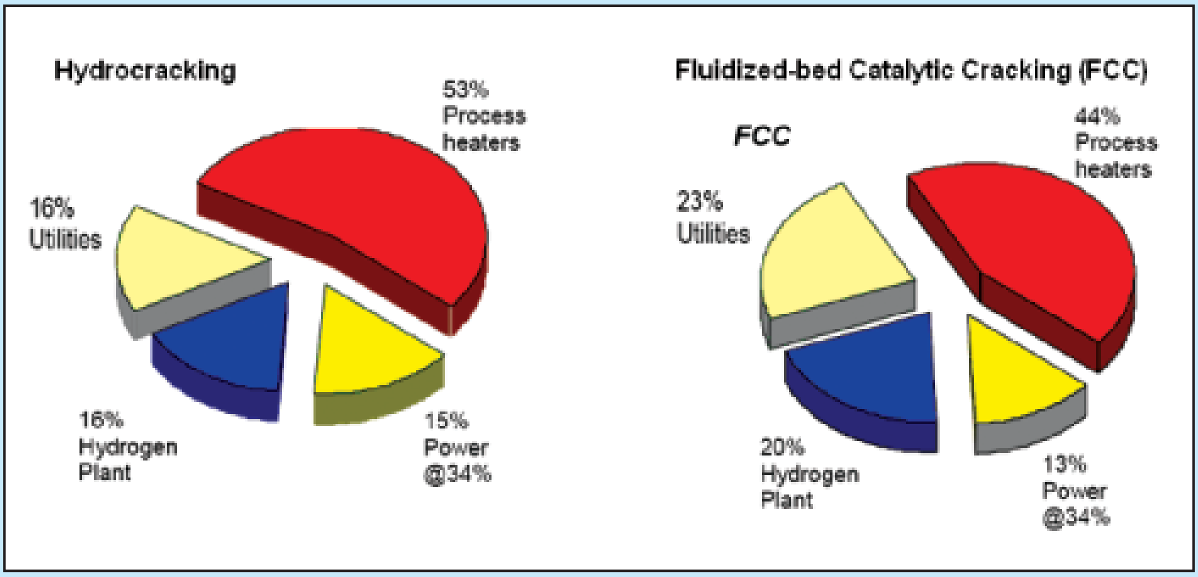

Figure 1
Sources of refinery CO_2 emission

Figure 2 shows that approximately 90% of CO_2 emissions are derived from combustion of the final product (e.g., utilization of petroleum for energies, such as power plant and vehicles). The refining activity itself is only contributing around 5%. This 5% of CO_2 emissions in the refinery is dominated by process heater which contributes around 45 to 50% (see Figure 1). CO_2 emissions from the refinery might not be measured exactly, since it depends on the final products and the variety process that are utilized(3). Besides, a significant amount of CO_2 is emitted in flares and incinerator which is poorly measured. As approximation, model such as CORINAIR can be used that suggests utilizing factor of 3.14 kg of CO_2 per ton of refinery feed(4).

Although, a relatively small contributor to CO_2 emissions in the oil sector overall, the refinery can be expected to come under pressure to reduce emissions. Legislators appear to group the refining activity with the power generation sector and other stationary sources. The key to understanding the emissions from the refinery is to understand the carbon balance of the refinery.

There are two issues which influence the refinery CO_2 production, i.e:

- Fuel replacement
- The need for hydrogen

In recent years many refineries have replaced some refinery fuel from heavy, high sulfur fuel oil towards refinery fuel gas/natural gas. Actually, the driving force for this switch has been SO_2 reduction. Regardless of operational costing, replacement from heavy fuel oil to natural gas has an impact on CO_2 emissions, e.g., from approximately 0.20 tone to 0.25 tone CO_2 per Mton fuel oil (20% reduction). The use of hydrogen-rich fuel can reduce CO_2 significantly (to approximately 0.075 tone CO_2 per Mton fuel oil). But replacement with hydrogen-rich fuel has to be considered for cost effectiveness and in some cases is difficult to implement on an existing refinery.

The demand for hydrogen on the refinery continues to grow because of the specifications for sulfur content in transportation fuels that consequently results in increased hydroprocessing of products. It also because of processing of higher sulfur crudes lead to increase the need for hydroprocessing.

The demand for hydrogen in the refinery has also been continued when there are introduction of residue upgrading technologies which require hydrogen in the primary conversion process. Hydrogen is also used for product stabilization and sulfur reduction.

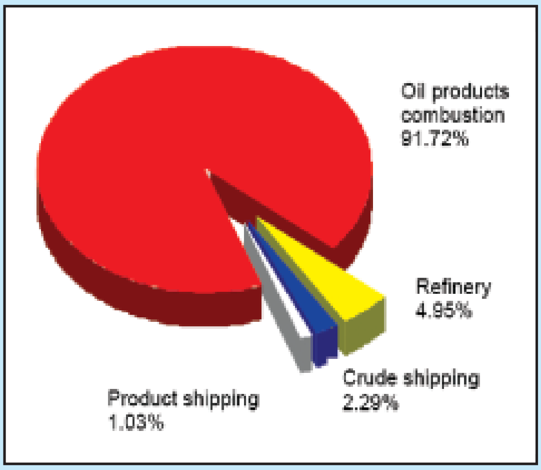

Figure 2
Typical breakdown of CO_2 emissions in the oil industry

The need for hydrogen has lead to many refineries for recognizing the value of hydrogen and the need to optimize its use through hydrogen analysis. However, often additional hydrogen production is unavoidable. This will be resulting in a significant increase in CO_2 on the refinery. This CO_2 may need to be captured or CO_2 reductions have to be compensated.

Approximately 10 tons of CO_2 per ton of hydrogen are produced. This figure is higher compared to other processes such as steam methane reforming of natural gas or gasification of heavy residues. However, the CO_2 produced in the hydrogen production processes can be captured relatively easily and be sequestrated or utilized.

In addition, gasification of residues can be used to provide utilities and hydrogen production, whilst at the same time allowing a single point source for CO_2 capture, such as amine treating process(5). Gasification is a clean, highly efficient to power generation and hydrogen production. Gasification can allow the refineries to decrease production of heavy fuel oil, which is one of the major generators of CO_2. Moreover, through the development gas-to-liquids (GTL) technologies, synthetic gas (syngas) that is produced could be used to selectively produce diesel oil, the transportation fuel that is much in demand.

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Another technique for CO_2 reduction is CO_2 sequestration[6]. CO_2 sequestration for enhanced oil recovery (EOR) offers an exciting opportunity for both upstream and downstream oil businesses. Enhanced oil recovery is able to extend the useful life of oil fields increasing production significantly. Many refineries are located on or nearby coasts and many are near operating oil fields.

The upstream sector would clearly benefit from additional oil output. This benefit, for examples, includes a share in upstream revenues from the incremental oil production from EOR, and CO_2 trading across national boundaries.

III. CONCLUSIONS

Although CO_2 emission from refineries is relatively small (e.g. for approximation 3.14 kg of CO_2 per ton of refinery feed), refineries are actively emitting CO_2 and giving CO_2 impact of their operations and it is expected that refineries will come under increasing pressure to reduce or capture CO_2.

"End of pipe" solutions for CO_2 reduction from process heater are expensive and on most refineries impractical to implement.

On typical FCC and hydrocracker based refineries gasification of low value refinery residuals could be used to raise utilities and hydrogen, allowing the relatively easy capture of the CO_2 emissions on the refinery.

Another solution for capturing CO_2 could have value as an upstream enhanced oil recovery material sequestrated. CO_2 capture and utilization in this way may also provide CO_2 trading benefits to refineries.

V. ACKNOWLEDGEMENT

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