Question 7: Comment on your experience with the value generation potential of each of the refinery gasoline processing units - reforming, naphtha hydrotreating, isomerization, alkylation, and FCC-gasoline post-treating. What interplay exists between the units that can be leveraged?

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The naphtha catalytic reforming unit can be partially unloaded, by subtracting from its traditional feedstock the higher-boiling C6 hydrocarbons, including naphthenes, benzene and hexane.

Typically, the optimum allocation of this material unloaded from reforming is the isomerization unit. The deriving set-up of reforming and isomerization has the potential of generating value in several ways and in no way destroys any value. However, also in case of an allocation of the above material different from the isomerization, its unloading from reforming keeps a significant value generation potential.

The main components of the optimum reforming + isomerization set-up generated value are the following:

-hydrogen net production gain,

-gasoline yield gain,

-gasoline octane number gain, changeable at will into an additional gasoline yield gain,

-compliance, with margin, with the most severe limits of gasoline benzene content in the world, such as the 0.62 vol% content required by the United States Environmental Protection Agency, in the US resulting in saleable benzene content credits, significant energy savings, besides the hydrogen net availability gain one, emissions reduction of all of the pollutants and greenhouse gases types, in addition to the above, both in the gasoline production and consumption segments, also carrying out a gasoline lifecycle emission reduction of a few percent of CO_2 equivalent,

-higher octane gasoline production capacity increase,

-improvement of the engine operation and maintenance.

The case study experimental results pointing out the above and the relevant theoretical explanation can for instance be seen in PTQ and Digital Refining 2013 Q1, article “Improved hydrogen yield in catalytic reforming”, or in “Gasoline Processes”, 2011 NPRA Q&A and Technology Forum. With that said, a more detailed analysis of the generated value inherent to hydrogen net production gain looks to be useful. While it is clearly apparent the worldwide great value of hydrogen net production gain, a particular case instead has to be attentively examined: the case of North America. The reason for a particular attention is the North America availability of the very cheap shale gas.

Referring to the particular North America case, we premise that the optimum set-up of reforming and isomerization carries out the production of gasoline and hydrogen in lieu of fuel gas. With this due premise, we can conclusively deduce that the above hydrogen gain is much more convenient than the hydrogen production carried out by means of special units consuming the cheap shale gas (SMR). Precisely, neglecting here the gasoline-fuel gas replacement value, said hydrogen production gain is over three times cheaper, as far as the variable (operating) costs alone are concerned. In fact, in the case of the optimum reforming-isomerization set-up, the shale gas should be used, for combustion in the furnaces, in order to replace the fuel gas not produced anymore by reforming. In such a way the rate of substitution of fuel gas by shale gas is 1:1. On the contrary, any use of shale gas for producing hydrogen would require the consumption of more than 3 units of shale gas (taking into account all the energy flows, both consumed and produced by the SMR unit) per each unit of produced hydrogen (rate of substitution: >3:1). Moreover, depending on the specific refineries, the relevant hydrogen gain can even avoid the capital costs of either installations or revamps or even duplications of the special, highly energy consuming,hydrogen generation units.

On top of the value generation potential of the feedstock transfer interplay between isomerization andreforming, an interplay also exists between the whole of these two processes and FCC-gasoline post-treating.

The FCC-gasoline post-treating consumes hydrogen and energy and causes reduction of the FCC-gasoline octane number and yield, due to saturation of high-octane olefins. It is apparent that the above-described optimum set-up of reforming and isomerization, as it provides hydrogen gain, reduction of energy consumption and gasoline octane plus yield gain, counteracts the FCC-gasoline PT negative effects. Plus, it provides additional very low sulfur combined reformate-isomerate gasoline blending component, due to its yield gain, thus allowing a higher sulfur content of the post-treat FCC-gasoline for a given full gasoline sulfur content: this allows further reduction of the FCC-gasoline PT negative effects.

The two last paragraphs outline the qualitative aspect of the matter. As far as the quantities in play are concerned, HOP (Hydrogen-Optimization) analyzes and optimizes the operation and any asset of the specific refinery as a function of the specific refinery plant structure, supply slate and predicted FCC-gasoline PT upcoming additional needs of hydrogen, energy, gasoline octane and gasoline yield, also providing alternative cases results.

Here we owe an explanation: HOP is an Alliance established between Chemical & Energy Development and Prometheus, rendered very suitable by the worldwide hydrogen thirst that deserves the maximum operational efficiency. Chemical & Energy Development brings to the new Alliance its deep knowledge and practice of the specific, above indicated, technology and Prometheus brings to the new Alliance its deep knowledge and practice of planning and optimization procedures and of refinery engineering design. The provided gains, of hydrogen, energy, gasoline octane, gasoline yield and FCC-gasoline sulfur content, can be higher than the predicted FCC-gasoline PT upcoming additional needs and remain partially available for other foreseeable needs deriving from the

-existing or to be installed FCC pre-treats,

-heavy and sour crudes,

-medium-heavy products quality requirements; and

-tight oil.

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