How to Select the Best Crude Oils for Your Refinery

Introduction
In a generally low-refinery-margin environment an optimal selection of your feedstocks is essential. The feedstock of a refinery typically consists of:
Crude oil and condensates
Intermediate feedstock imports (such as platfeed, platformate, gasoil, …)
Blending components (such as additives, MTBE, ETBE, alkylate, isomerate, FAME, ethanol, …)
Chemical feedstocks (such as methanol for MTBE production and returns from petrochemical plants)
Natural gas (for steam reforming)
Hydrogen (for hydrotreating, hydrodesulphurisation and hydrocracking)
Others

Volume-wise, crude oil is by far the dominant feedstock. It typically accounts for minimal 95% of the refinery intake.

To meet market demand for fuels (such as LPG, gasoline, kerosene, diesel, heating oil, fuel oil, …), bitumen, chemical feedstocks (for steam cracking) and lube-oils, most refineries run on multiple types of crude. This, as there is no single crude available that can be economically refined into all products required. Moreover, some crude oil products can be made from specific crudes only. For example, low-sulphur gasoline is (less-costly) produced from a low-sulphur crude. Bitumen production needs specially selected high-sulphur crudes. Chemical feedstocks for a steam cracker require high-paraffinic low-sulphur crudes, etcetera.

Crude Assays and Crude Acceptance Matrixes
To facilitate the selection process (feasibility), Crude Assays and Crude Acceptance Matrixes are used. Crude Assays give us information about the bulk crude properties and indicate the key properties (yield and quality) to be expected in the fractional components when the crude oil is distilled and refined. Using the crude assay data, the qualities of crude and products/components can be compared with the site-specific limits and requirements. A summary of this data for all crudes reviewed by the refinery leads to the Crude Acceptance Matrix (CAM). The output of this CAM-process is a 'Crude Category' (such as 1. acceptable, 2. constraints to be discussed first, 3. not acceptable).

Optimisation steps
There are several steps to follow while selecting the optimal crude package:

1. Determine the market product demand (short- and long-term), offtakes, specifications/qualities, and netbacks at refinery fence (tranche-ed and including premiums/discounts). Mind seasonal effects. The refinery hydrocarbon margin and upgrading economics are determined by the price differentials (cracks and spreads), such as crude – product, gasoline – naphtha, gasoil – fuel oil, gasoline – gasoil.
2. Get clarity on the availability and capacities of the refinery units' hardware (turndowns/slowdowns, maximum capacities, unit yields, utilities performance, specifications, operational costs including catalysts, environmental constraints, …).
3. Determine the feedstock availabilities including their amounts, properties/qualities, and their refinery-fence landed prices.
4. Optimizing the feedstock intake is typically done with a linear program (LP) model. An LP model is a mathematical model of the refinery, simulating and optimises all refinery unit yields, unit capacities, utilities consumption, and the like, as well as product blending operations of the refinery. It maximises profit by also selecting the 'best' feedstocks. Make sure the LP is in the first place correctly simulating the refinery performance for all scenarios within the pre-defined operating window.

The profitability of a refinery is to be evaluated in the company's total value chain, i.e. from 'well to wheels'. This includes crude exploration & production, trading, supply & distribution, refining, to marketing & retail. The facilitating optimisation process is called Sales & Operations Planning (S&OP).

Crude Added Value (CAV)
Typically, the Refinery Economist selects the margin-wise optimal (and of course feasible to process) crudes from the trading offers using his refinery LP. The margin contribution of a crude is calculated versus a pre-defined reference crude (or crude diet). The so-called Crude Added Value equals:

CAV = Margin Crude X – Margin Reference Crude [$/bbl]

The CAV is the key number in determining which crude to buy for a refinery as it represents the best estimate of the margin generated at the time the deal is made. Generally, of importance is the crude price/quality ratio (not solely price or quality).

Crude Indifference Value (CIV)
These CAVs are usually calculated by dedicated software systems in the Supply & Trading organization (to include freight, insurance, inspection, taxes, duties, fees, …) with input from the Refinery Economist. The required input is amongst others the Crude Indifference Values. The CIV is the difference in products values at the same crude price. Therefore, the CIV does not depend on crude market price — just on the product prices and yield slate (depending on hardware configuration. i.e. refinery complexity) and are usually calculated by the refinery LP based on crude marginal margin values. Now one can write for the CAV (the CAV and CIV of the Reference Crude are zero by definition):

CAV = CIV Crude X – (landed purchase price Crude X – landed purchase price Reference Crude) [$/bbl]

Generally, the refinery prefers those crudes with the highest CAV, but mind the whole value chain optimisation aspects!

Refinery Appraisal
After processing the crudes, refinery appraisal is the process to evaluate how the refinery performed versus plan, typically a monthly plan and a yearly plan. The objective is to learn where one did well and where not. This to be able to take corrective actions for better performance in the future. Each organisation likely has its own appraisal process. But a well-equipped refinery should have a so-called ‘backcasting process’
(or ‘retro-analysis’) that uses multiple LP runs to verify the impact of various ‘buckets’ such as prices, feedstocks, refinery capability, products, others/unexplained. This goes thus beyond the comparison of simply ‘Actual’ versus ‘Plan’ missing the necessary granularity to improve.

Which crudes and/or condensates do you take for your refinery?